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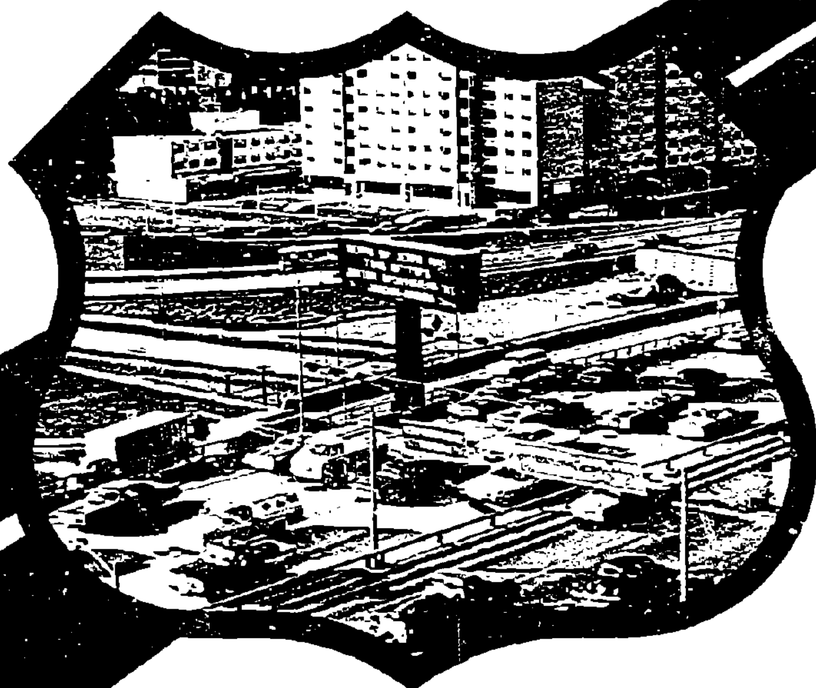
SAFETY AND ENVIRONMENTAL DESIGN CONSIDERATIONS IN THE USE OF COMMERICAL ELECTRONIC VARIABLE-MESSAGE SIGNAGE

June 1980

Final Report



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Prepared for
FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Environmental Division
Washington, D.C. 20590

FOREWORD

This report reviews and evaluates existing research and reported experience relating to the use of electronic variable-message signage for outdoor advertising in roadside areas, and the effects of such uses on highway safety and environmental design. The report identifies various characteristics of commercial electronic variable-message signage (CEVMS) for which it suggests that national standards should be developed in the interest of fostering usage that will minimize adverse impacts on safety, the visual quality of highway environment, and highway investment. The concluding section of this report outlines a series of further research studies to extend and validate the current basis for policy and technical decisions. An annotated bibliography, included as an appendix to the report, provides a reference tool for further research in this field.

This report is being distributed to FHWA headquarters, regional and division offices, as well as to research and program offices in State highway and transportation departments, public and private research reference centers, and interested professional and industry organizations.

for D. Solomon
Charles F. Scheffey
Director, Office of Research

NOTICE

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16. Abstract

This study reviews existing reported research and experience regarding use of commercial electronic variable-message signs (CEVMS), and evaluates research findings and methods in terms of implications for highway safety and environmental design. Aspects of CEVMS design and use that are capable of adversely affecting highway safety and/or environmental quality are identified and discussed in terms of the adequacy of existing research and experience to permit formulation of quantified standards for safe and environmentally compatible use.

This report notes, with illustrations, the principal forms of variable-message signage developed for official traffic control and informational use, and the major forms of variable-message signage utilizing electronic processes or remote control for display of commercial advertising and public service information in roadside sites.

Studies of highway safety aspects of outdoor advertising which are based on analysis of accident data are evaluated and reasons for apparent conflicts of their findings are discussed. Studies of highway safety aspects of outdoor advertising generally and CEVMS specifically based on human factors research and dealing with distraction and attentional demands of driving tasks are discussed in relation to issues involved in the development of standards.

17. Key Words
Variable-message signing; commercial electronic variable-message signage (CEVMS); outdoor advertising; safety; highway aesthetics; highway investment; driver distraction.

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EXECUTIVE SUMMARY

Historical Background

National standards and Federal-State agreements providing for control of outdoor advertising prohibit display of commercial signs that use flashing, intermittent or moving lights, or that have animated or moving parts. In 1978 the Congress amended the Highway Beautification Act to provide that it would not be considered a breach of such agreements to permit signs to display information which is "changed at reasonable intervals by electronic process or remote control and which provide public service information or advertise activities conducted on the property on which they are located."

This research report, prepared by the Federal Highway Administration's (FHWA) Office of Research, is intended to provide background information for the development of standards for the use of on-premise commercial electronic variable-message signs (CEVMS) displaying such public service information and advertising messages along Interstate System highways. The report is based on a critical review of reported research, operational experience, and legislative history relating to CEVMS and to outdoor advertising generally.

The Technology

Currently available technology and display media enable the electric sign manufacturing industry to offer a wide variety of CEVMS to advertisers. This study has considered four basic types of signs which the signing industry has indicated best represent current CEVMS technology. These are: (1) alternating time-and-temperature displays, often incorporated into otherwise static on-premise signs; (2) "multiple message center" signs, capable of displaying, on a single sign cabinet, a wide variety of messages in words, digits, or symbols, either in a predetermined repetitive sequence or via real-time control; (3) "automated reader board" signs, in which messages on continuous tapes are shown on display panels and may be controlled remotely to change the styles and colors of a message, and produce a repeated series of constantly changing messages; and (4) the so-called "UNEX" signs, developed by one manufacturer, which are capable of producing a virtually unlimited range of graphic or alpha-numeric messages on a grid of optical shutters which are electronically and/or remotely controlled. The sign types considered in this study may be used for on-premise advertising either by being mounted on walls or rooftops, or as free-standing structures on single or multiple cabinet supports. These signs can display a variety of colors, character sizes and styles, and many other characteristics of graphic display media such as contrast and shading, but the four mentioned above are those which the industry seems to feel best represent CEVMS technology.

The 1978 amendments to the Highway Beautification Act provide an opportunity for the electric sign industry to increase the use of CEVMS along the Interstate System. This report discusses the potential implications of such increased use in the context of the three areas of public interest that Congress sought to protect through the Highway Beautification Act, namely:
(1) promotion of highway safety;
(2) preservation and enhancement of natural beauty along highways; and
(3) protection of highway investment.

Highway Safety Considerations

The review of reported research on highway safety considerations pertaining to roadside advertising demonstrates that studies based on accident investigations have generally had limited value because of: (1) lack of specific data relating accident locations to roadside features and traffic operational situations; or (2) sampling or statistical deficiencies. In addition, studies relying only or mainly on accident data often do not reflect such occurrences as "near misses" or traffic impedences that are widely recognized as relevant to safety, and which may or may not be attributable to the presence of roadside advertising. While some accident studies have reported a positive relationship between accidents, high driving task demands, and the presence of roadside advertising, other studies have reached opposite conclusions. Although a trend in recent findings has begun to point to a demonstrable relationship between CEVMS and accidents, the available evidence remains statistically insufficient to scientifically support this relationship.

Human Factors Considerations

Human factors research techniques for measuring and explaining driver behavior in varying traffic and environmental situations are capable of providing more precise, reliable, and valid data about the potential effects of roadside advertising signs on safety. For example, using both field investigations and simulation techniques to measure eye movement patterns and microperformance variables, driver responses to selected stimuli such as CEVMS can be examined relative to information processing capacity and driver task demands. The literature examined from related fields indicates that, under favorable driving conditions (traffic, weather, road, and vehicle condition, etc.), there is likely to be little adverse impact on performance due to the presence of roadside advertising signs since the driver retains sufficient spare processing capacity to attend to such signs without compromising his performance on his primary (vehicular control) task. Under very low task demand conditions (extremely light traffic, uniform pavement and geometric design, great distances between decision points, etc.), the presence of unusual environmental features, (possibly including roadside signs), may serve to stimulate the motorist as he drives. However, as the demands of the driving task increase, roadside advertising must compete with more vital information sources (such as official signing, delineation, other traffic, weather, road, and vehicle conditions) for the driver's attentional capacity. Since this capacity is finite, a CEVMS with high attention-getting properties (and this is a primary criterion against which a successful CEVMS is judged by advertisers) may distract the driver from his primary task long enough for him to make an error which could lead to an accident.

The enormous flexibility of display possessed by CEVMS makes it possible to use them in ways that can attract drivers' attention at greater distances, hold their attention longer, and deliver a wider variety of information and image stimuli than is possible by the use of conventional advertising signs. Exploitation of this potential by advertisers seeking to reach an audience of highway users increases the risk of overloading drivers' capacities to process information, and, consequently, the likelihood of driver error under road and traffic conditions in which drivers may already be heavily stressed. Although the nature of these risks has been recognized in the research literature, further study is needed to quantify and categorize it.

Aesthetic Considerations

Harsh visual contrast with the ambient environment is generally considered to be unaesthetic, as is a dense clustering of signs and sign structures. The existence of these conditions in many commercial areas has led to criticism of on-premise signing practices in the past. Manufacturers of CEVMS claim t their signs are designed and construc to avoid characteristics that are gen ally associated with deterioration of the visual quality of roadsides, and that these signs have the added capability of reducing the need for the separate conventional signs of multip businesses since CEVMS can display th messges in repeated series on a singl sign. To date, however, these claime benefits have not been empirically tested. The capability of CEVMS for commanding and holding attention perm them to dominate their surroundings, involves the risk of incompatibility with the natural or man-made environm in which they reside. It should be noted that the "electrical spectacula displays most often associated with Times Square or Las Vegas, and more recently with major-league sports stadiums, are, in fact, electronic variable message signs. Without the proper control, there is little reasc to believe that signs such as these will be kept away from the highway right-of-way.

Highway Investment Considerations

Direct impairment of the public inves ment in scenic enhancement of highwa rights-of-way results from trimming, destroying, or removing trees and sh in order to increase the visibility c billboards on adjacent land. A substantial record of unauthorized and unlawful destruction exists, the cost of which have been difficult to reco under current laws and enforcement methods. In a few States vegetation removal is authorized under agreement between State highway agencies and si owners, but experience is not suffici to evaluate either long or short terr effects on highway investment. Where excessive numbers of on-premise elect signs compete with official traffic control devices, additional expendit sometimes have been necessary in ord to make the latter readily recognizal by motorists. Excessively numerous c poorly designed, maintained, or locat outdoor advertising signs may indire damage highway investment through th association with the deterioration o roadside land use and value. Where changes in roadside land use and val result in premature functional obsol scence of adjacent highways, highway investment is adversely affected. Currently CEVMS represent substantia business investments and are concentrated in urban commercial and industrial districts where high ADT volumes are customary. These factor have reduced the risk that they will directly or indirectly affect highwa investment. As use of CEVMS is extended to suburban and rural locations, where land use may be in transition, these factors can be expected to have less effect, and risks to the highway investment from use of CEVMS may be similar in kind to those associated with billboards generally.

Conclusions

Based on this review of reported research and operational and legislative experience, it appears that the following aspects of CEVMS can affect some aspects of traffic safety, highway investment, and the quality of the roadside visual environment, and therefore should be considered in any development of standards for use of such signs.

Longitudinal location

Spacing and density

Lateral location

Interaction with traffic signs

Duration of on-time

Duration of off-time

Duration of message change interval

Total length of information cycle

Rate of intensity or contrast change

Flashing signs and lights

Brightness and contrast

Animation and message flow

Size of sign and lettering

Primacy of information

Maintenance requirements

Operational experience with CEVMS should be compiled and evaluated, and well-designed and funded research studies should be carried out in order to remove the uncertainty that now exists regarding many aspects of this form of signage and its impact on traffic safety, environmental quality, and highway investment.

I. PURPOSE

The purpose of this report is to provide background information for the development of standards relating to the use of commercial electronic variable-message signs (CEVMS) for display of public information and commercial advertising in roadside areas. The report is based on a critical review of existing research literature, relevant experience of State highway and transportation agencies regarding such signs, and legislative history relating to CEVMS and to outdoor advertising generally.

This study was undertaken by the Environmental Division of the Office of Research at the request of the Office of Right of Way, Federal Highway Administration in October 1978, and completed in December 1979.

II. SCOPE OF STUDY AND METHODS USED

This report deals with applications of commercial electronic variable-message signage (CEVMS) as it currently is permitted in roadside areas where outdoor advertising is controlled pursuant to the Highway Beautification Act, as amended in 1978. For purposes of this control, the Federal law currently defines on-premise signs as "signs, displays or devices, including those which may be changed at reasonable intervals by electronic process or remote control, advertising activities conducted on the property on which they are located." 23 USC 131 (c)(3).

The relative newness of the current uses of electronic variable-message signage for general information and commercial advertising purposes, plus the fact that their development has been scattered among at least a score of sign manufacturers working independently, has meant that relatively little research and development literature on such signs has been reported in generally available publications. Some insights into the safety and operational aspects of these signs may be gained from the technical and human factors research dealing with applications of variable-message signage for highway traffic operations control and information. Similarly, some insights into the visual and economic impacts of these signs on the highway and its environment may be gained from general experience with outdoor advertising in roadside areas. Staff research efforts, therefore, have included consideration of relevant parts of studies and experience in these areas.

The specific tasks undertaken in this staff study were as follows:

a. Review the applicable research literature on variable-message signage, and prepare a bibliography of such literature.

b. Identify the types of CEVMS now in use, and indicate the probable range of their applications in on-premise advertising signs in roadside areas as currently authorized by Federal law.

c. Assess the current state of knowledge and practice regarding the impacts of these applications on highway safety, visual environmental quality (aesthetics), and public highway investment.

d. Evaluate the current state of knowledge and practice regarding its adequacy as a basis for development of standards for regulation of on-premise CEVMS under State laws for control of outdoor advertising.

e. Indicate major gaps in current knowledge of the impacts of CEVMS on highway safety, aesthetics, and highway investment. Indicate further research needed to deal with these deficiencies.

III. WHAT ARE "ELECTRONIC VARIABLE-MESSSAGE SIGNS," AND HOW ARE THEY USED?

A. Definitions. Basically, the term "variable-message signage" describes a class of signboards, displays, or devices capable of showing a series of different messages in a predetermined sequence. This characteristic distinguishes them from painted billboards or poster panels, on which the message can be changed only by repainting or repapering the display space with a new message. It also is in contrast with conventional electric signs that are erected on or near sites or buildings where industrial or commercial activities take place, and which display a single message which may be visible day or night with the aid of illumination from an internal or external source. Defined in these functional terms, this class of signage includes a wide variety of designs and applications. Indeed, any electric sign which displays alternating messages, either for commercial advertising, traffic control, or information, meets this definition. The definition, of course, also includes the "electrical spectaculars" that entertain as well as inform visitors to such places as the casino district of Las Vegas or the Times Square district in New York.

The term "electronic variable-message sign" refers to a subclass of variable-message signage which (1) utilizes electric lights or movable parts to display messages in words, numbers, or symbols, (2) changes such messages at selected intervals of time, by (3) using a message-changing mechanism which may be controlled remotely by wire or radio and programed for either automatic operation or manual activation. This technique of signing has been used in official signage for control, guidance, and information of motorists, and in commercial signing for advertising and for display of public service messages. Obviously, not all electronic variable-message signs possess all of the capabilities described here. The sign shown in Figure 1 of this report is somewhat unusual in that it is an on-premise sign adjacent to an Interstate highway, and it possesses all three of the display characteristics discussed here. Its top portion is a fixed electrical panel with two faces displaying the product logos. Its center section revolves, and thus displays two alternating, internally illuminated product messages. Its lower portion is an alternating time and temperature display, with the words "TIME" and "TEMPERATURE" appearing as appropriate. It is located adjacent to a horizontal and vertical curve, a high accident location along an urban expressway.

B. Traffic Control and Information. The concept of designing signs so that parts of their messages can be changed at selected times is a familiar one in traffic engineering (Dorsey, 1977; Highway Research Board, 1971, Petrykanyn, et al., 1979). In the field of traffic control and information, some highway agencies have utilized this concept for more than 20 years. Early variable message signs utilized slats to hold sliding inserts. Development of mechanized signing followed, and included two-message flap signs, multi-message roller or scroll signs, and rotating drum assemblies, all of which depended on motor-operated mechanisms for changing sign displays. In the early 1960's refinement of lighting and control sources made it feasible to present more elaborate message displays using luminous tubes, magnetic discs, or electric light bulbs, among others. The lamp matrix technique, for example, involved arrangement of light bulbs in a rectangular grid, and control of their illumination by digital electronic circuitry to form letters, numbers, logograms and other graphics. By the late 1960's, electrical, electromagnetic, mechanical and static elements were being combined in signs that were available as off-the-shelf items for both highway agencies and commercial advertising companies. (See Figures 2-6 for typical examples of such signs in traffic control operations.)

In the 1970's the principal refinement of this type of signage has been the development of relatively inexpensive computerized control mechanisms which can be built into the sign cabinets. This has provided the capability to compose message changes manually from a keyboard or through preprogramed computer units, and it permits increased message storage capacity and improved techniques of message verification.

C. Commercial Electronic Variable Message Signs (CEVMS). Parallel to the applications of electronic variable-message signing technology to the field of highway traffic information and control, the uses of this technology for commercial advertising and entertainment also developed steadily. The doctrine of marketing holds that advertising signs should be used not only to identify businesses and give information about goods and services, but also to project a favorable image of the advertiser to the public. Accordingly, advertisers have often sought customized signs for their businesses, and the electric sign manufacturing industry has met this desire by offering its customers a wide variety of distinctive sign designs. Often these signs have taken the form of variable message displays, in which the factors of color, brightness, contrast, and message length (to name a few) could be varied along with the presentation of a virtually unlimited variety of alphanumerics and graphics. The broad range of such signs, illustrated throughout this report, is probably familiar to most Americans.

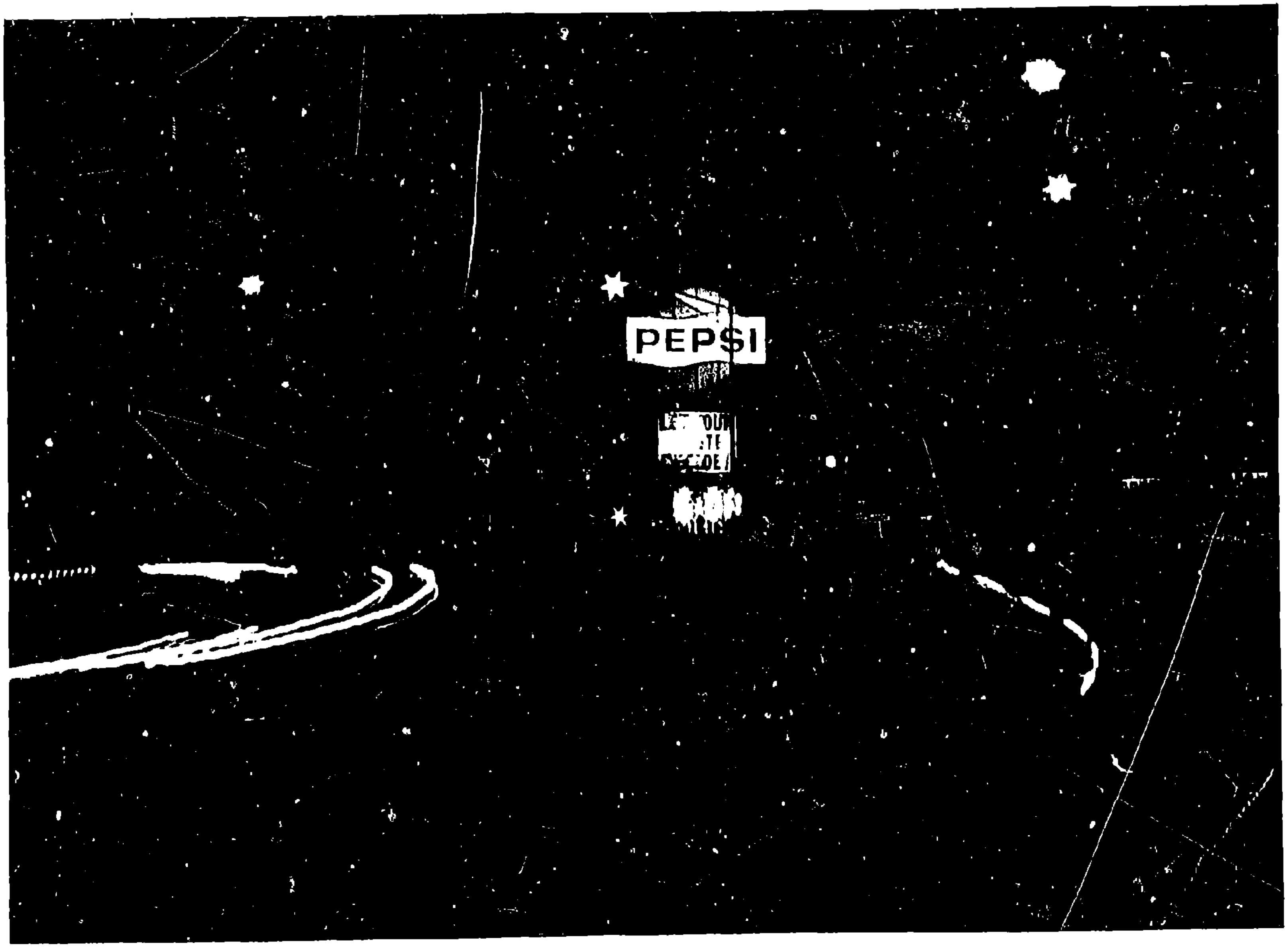

Figure 1.

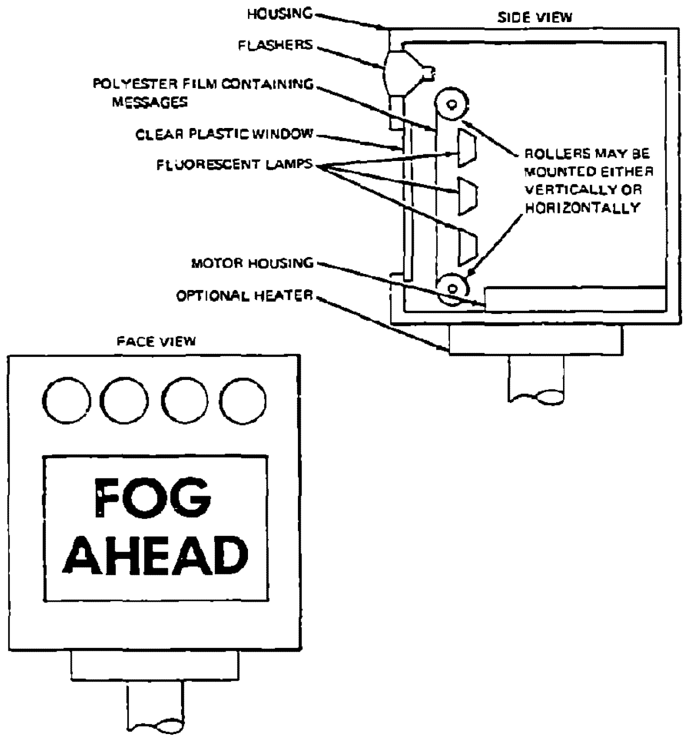

Figure 2A. Scroll-Type Sign. (Source: Petrykanyn, et al., 1979)

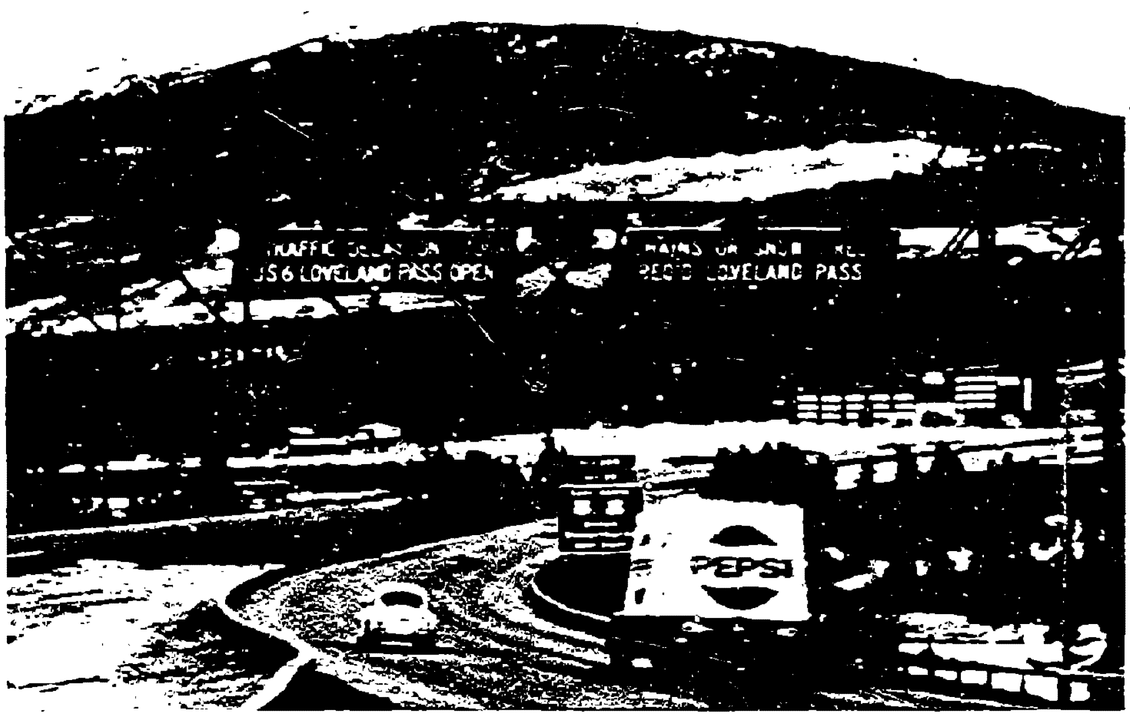

Figure 2B. Scroll Sign Installation on I-70 Near Dillion, Colorado. (Source: Dorsey, 1977)

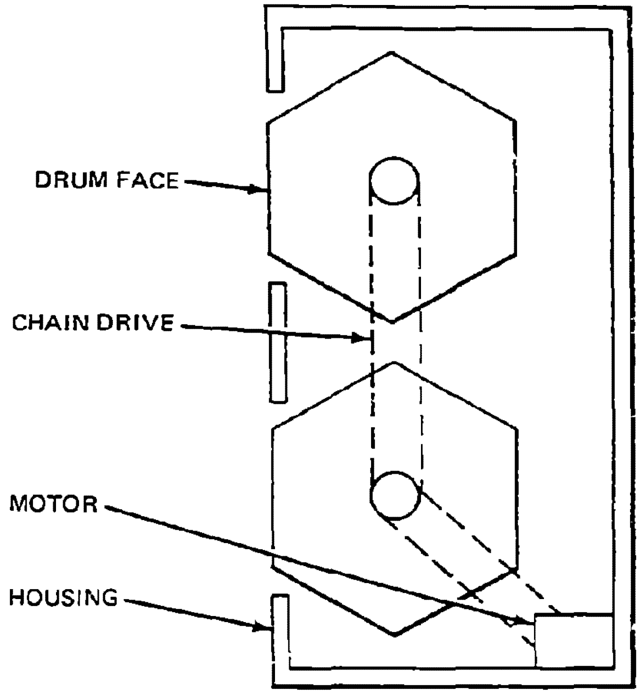

Figure 3A. Rotating Drum Sign. (Source: Petrykanyn, et al., 1979)

Figure 3B. Rotating Drum Sign Installation in Dallas, Texas. (Source: Dorsey, 1977)

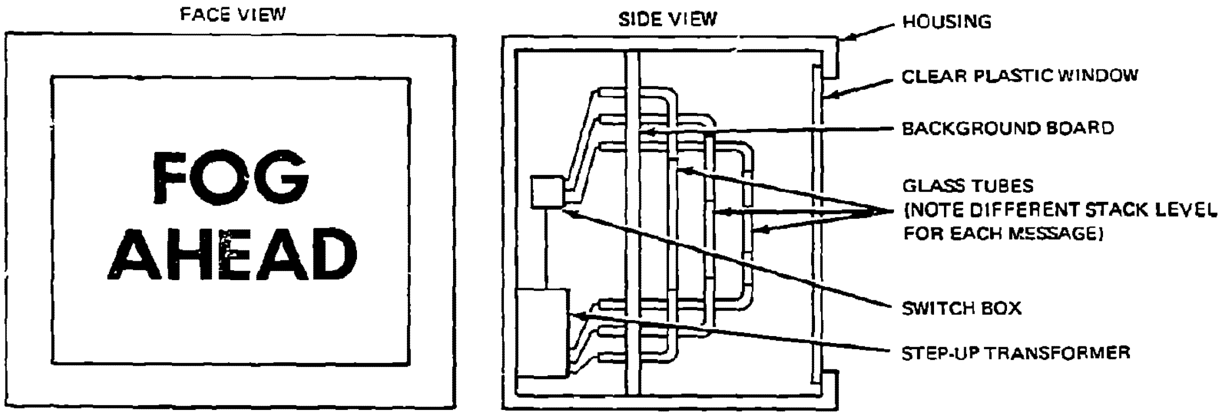

Figure 4A. Neon Variable Message Sign.
(Source: Petrykanyn, et al., 1979)

Figure 4B. Neon Sign Installation on I-5 Near Albany, Oregon. (Source: Oregon Department of Transportation)

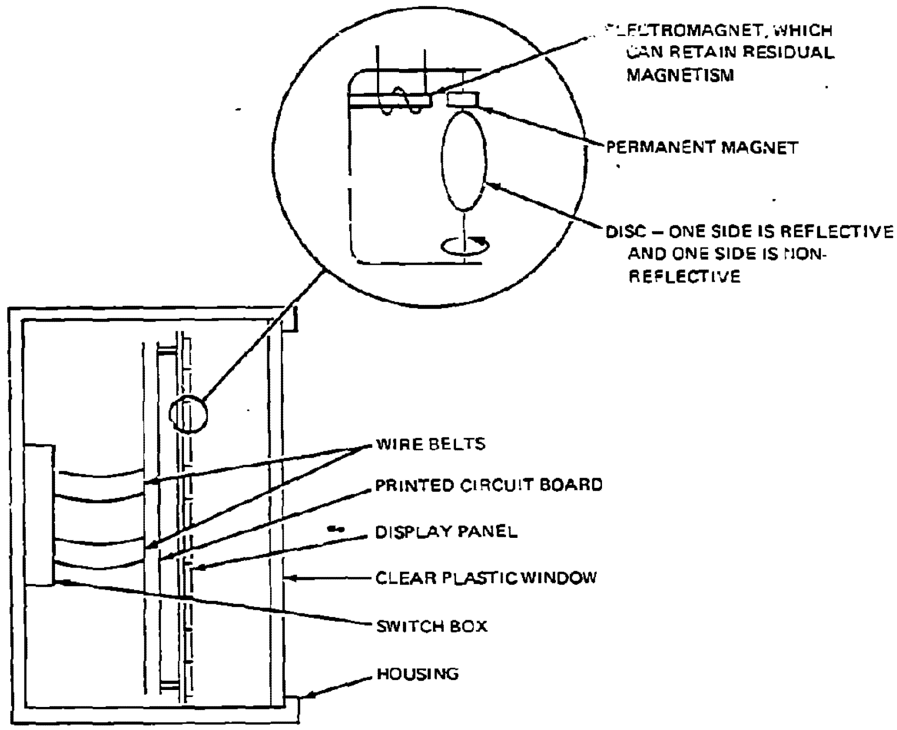

Figure 5A. Electromagnetic Disc Matrix Sign. (Source: Petrykanyn, et al., 1979)

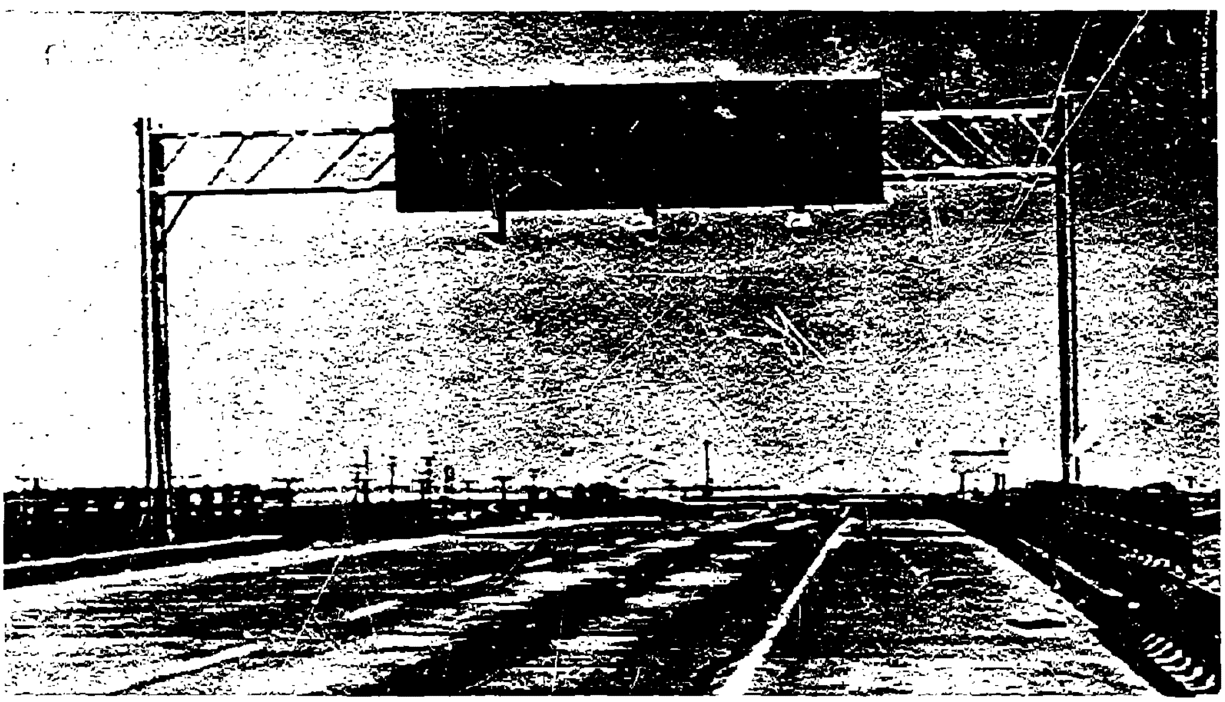

Figure 5B. Disc Matrix Sign Installation on I-80 Near Laramie, Wyoming. (Source: Dorsey, 1977)

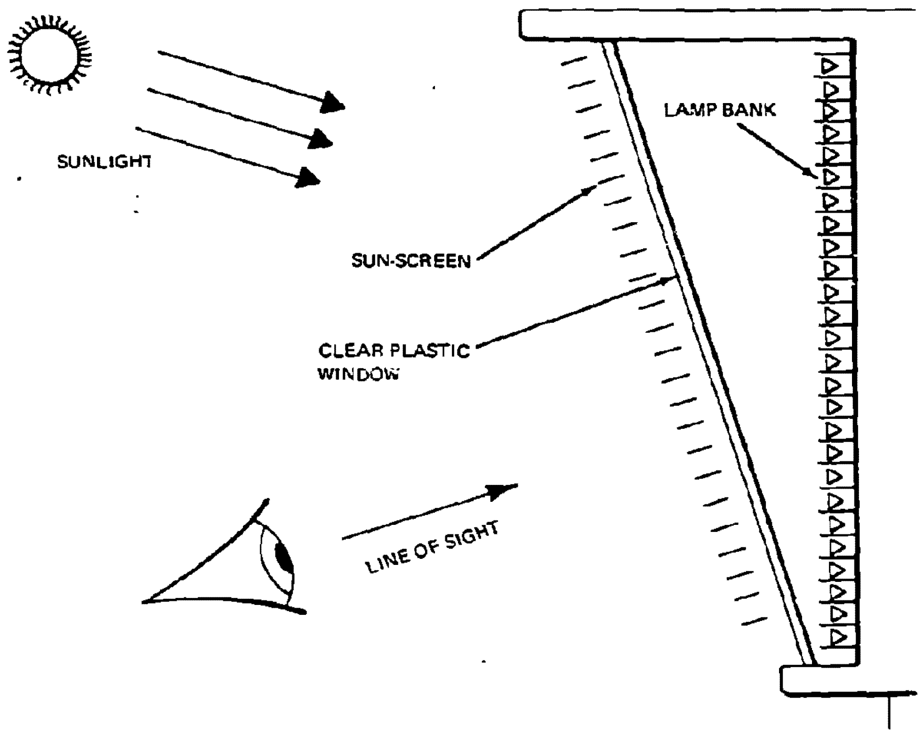

Figure 6A. Lamp-Matrix Sign. (Source: Petrykanyn, et al., 1979)

Figure 6B. Lamp-Matrix Sign Installation on the Santa Monica Freeway in California. (Source: Dorsey, 1977)

CEVMS may vary from the relatively simple time-and-temperature displays, to the "electrical spectaculars" that often typify entertainment districts of major urban centers, and the variations of these spectaculars are increasingly found in newer sports arenas and stadiums.

Detailed descriptions of the electric sign manufacturing industry's accomplishments in CEVMS technology may be found in other engineering and technical literature. For the purposes of this report, which is addressed to the problem of evaluating the basis for standards, it is appropriate to focus on those types of CEVMS that are most likely to be used for highway-oriented advertising. To some extent the selection of illustrative types must be arbitrary since many factors ultimately determine industry trends and business preferences; but the electric sign manufacturing industry has emphasized the moderated designs and uses of its products rather than the spectacular ones. Therefore, from the range of CEVMS possibilities mentioned above, the four types described below were chosen based upon the industry's own statements in a symposium on urban signage sponsored by the U.S. Department of Housing and Urban Development (U.S. Department of Housing and Urban Development, 1976).

Alternating Time and Temperature Displays. The first generation of CEVMS is illustrated by the alternating time and temperature displays that have achieved wide use in on-premise signing of banks and other financial institutions. Sometimes referred to as "jump clock signs," these signs generally utilize a matrix of electric light bulbs which can be controlled to form digits showing current time and temperature in alternating changes every few seconds. Digital changes to update time and temperature are made automatically by clocks and temperature sensors in the control mechanism built into each sign.

The popularity of these signs has been based on the relative simplicity of their design, construction, installation and maintenance, and on the fact that they display information that attracts wide public interest. Also, when the variable-message panel is closely associated with the name or identifying symbol of the sponsoring business, these businesses feel that they share in the favorable feeling of reliance that the public tends to associate with this type of information.

Multiple Message Center Signs. A second generation of the CEVMS is illustrated by the so-called "message center" sign, in which the variable-message panel is substantially larger than in the "jump clock" sign. In some designs, it may even comprise the entire face of the sign, except for a logo or name. The display panel can be programed to transmit virtually an unlimited variety of information; and the amount transmitted in any single display is limited only by the size of the sign's display panel.

The solid-state electronics and computerized information storage capacity of the "message center" sign allows it to be a freestanding structure away from buildings, and one growing use of these signs is in the parking lots or entrances to shopping centers where they can be seen from the adjacent highway. According to a manufacturer of this type of sign, it

> . . . allows businessmen, for the first time, a means of alternating promotional copy with messages that support civic projects and events important to the local economy--it would be financially impossible for smaller businesses, especially, to maintain this dual type of communications program using standard media.
>
> . . .[T]his type of display [can] make a significant contribution to the elimination of clutter. For example, a Mark 300 Message Center can store and present more information than 25 billboards, yet its display panel is less than 10 percent of the size of a single, 24-sheet poster panel. With such efficiency they are finding more and more use in commercial applications, especially in strip zoning business areas (American Sign and Indicator Corporation, 1976).

The extent to which this feature of message center signs actually results in reducing the density of on-premise signs in a commercial or "business strip" zone has not been demonstrated in practice. In this respect, message center signs in shopping center plazas, where density and variety of signs attached to structures often are controlled by the landowner/landlord's architectural design concept or a local sign code, may not be typical of the major use that is to be made of this type of sign. Where there is no requirement on a commercial establishment to use the message center sign instead of a series of static-message signs, market forces do not appear to have brought about this result.

The prospect that the message center type of sign will accomplish its communicative function on "less than 10 percent of the size of a single 24-sheet poster panel..." appears to apply only to the manufacturer quoted above because at least one competing manufacturer has developed its service based on use of message center signs mounted on free standing towers erected beside urban freeways and displaying a cabinet 60 by 25 feet in size.

Remote Controlled "Automated Reader Board" Signs. A third generation of CEVMS is represented by the socalled Dial-A-Sign Automated Reader Board Display, developed by the American Sign and Indicator Corporation. This sign utilizes alphanumeric characters which are silk-screened onto continuous mylar tapes. A complete alphabet is contained in each module of the panel on which the message is displayed. The series of messsage displays may be programed and controlled by means of a portable, hand-held unit. Use of such control and programing techniques reduces the need for many structural features previously needed for physical security of on-premise electric signs mounted on buildings or free-standing. Also, flexibility regarding the styling of letters and colors increases the adaptability of these signboards to building surfaces and styles. Among the major users of automated reader board signs are convention facilities, shopping centers and malls.

"UNEX" Signs--Electronic and Computerized Control Systems. A fourth generation of CEVMS, representing the type that the electric sign industry indicates it intends to promote in the immediate future, is illustrated by the patented system known as "UNEX," developed by the American Sign and Indicator Corporation. Essentially, the system utilizes a display panel comprised of a grid of optical shutters that are electronically controlled to provide an unlimited range of message changes from a computerized memory source. Control systems can operate multiple displays, and are capable of displaying the same or different mesages at any of several locations.

The "UNEX" technology utilizes a system that provides flexibility and versatility in the display of messages, letter styles and languages, and can mix graphics and word messages. These graphics may include display objects, designs, and basic photographic reproductions. Messages are displayed in clear light with high resolution that enhances the capability for use of graphics. The common light source used in the display can also be regulated in its intensity and color as daylight conditions vary.

The "UNEX" sign manufacturer emphasizes that this form of signing avoids the primary objections that have been expresssed about electric signs, namely: flashing lights, garish colors, and lack of aesthetic quality and compatibility with immediate surroundings. For prospective users, they note that the "UNEX" technology will have the effect of:

> allowing the users of reader boards or attraction panels to display graphics as well as multiple character fonts and styles. Messages can be electronically stored and programed remotely from the office of the business that is utilizing the display panel. This will offer an unprecedented convenience with special merchandising opportunities that relate to time.
>
> Obsolescence of the displays is virtually nonexistent because of the programing capability. One

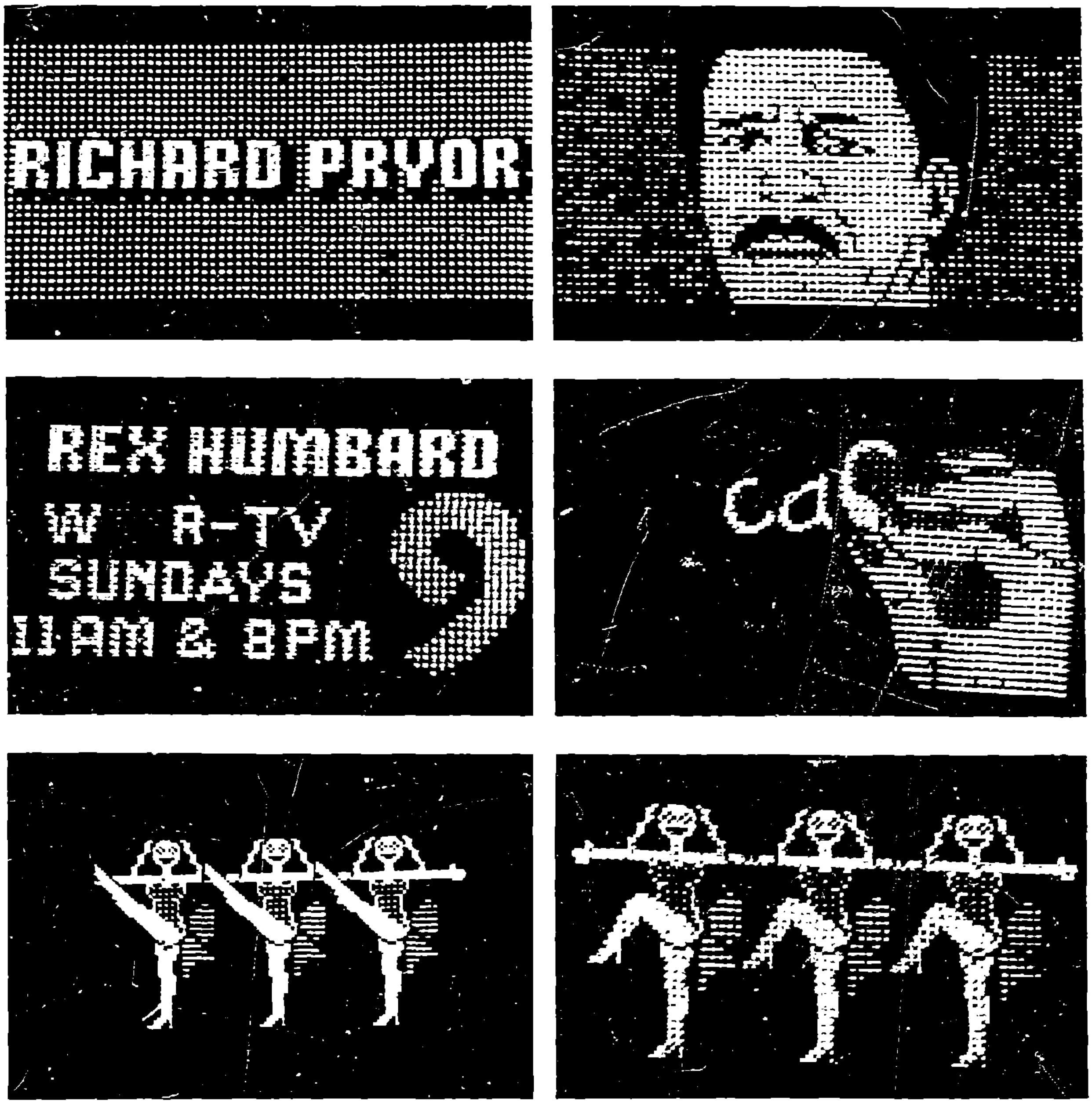

Figure 7. An Off-Premise CEVMS in New York's Times Square Which Entertains as well as Advertises. (Actual Sign is in Full Color). (Photographs: J. Wachtel)

display can portray any message in any language, letter style and in any letter size, thus eliminating the essence of visual information obsolescence (American Sign and Indicator Corporation, 1976).

Summary. Development of CEVMS to the level of refinement that the electric sign industry has now achieved gives business users of outdoor signs a greatly increased capability for visual communication with their target audience. It has been customary to speak of this type of sign in terms of "jump clock" panels and the segmented series of phrases that make up the "message center" displays. These types of signs, however, now represent only the earliest generations and simplest examples of this category. The present interest of the electric sign industry is to promote use of its most advanced systems, utilizing remotely-controlled, computer-programed matrices of lamps or optical cells on which an unlimited variety of messages in words and graphics can be displayed against a broad range of backgrounds.

Several aspects of this prospect should be considered when sufficient data can be compiled from operational experience. These include the costs of signs, installation, operation, and maintenance. The action of market forces also needs analysis to evaluate the prediction that CEVMS can reduce proliferation of static message signing, and to assess the availability of this signing to various segments of the business community.

Also to be considered is the expansion of functions that is reflected by the successive generations of CEVMS. The first generation utilized "jump clock" displays for public service information, and so projected a favorable general image for the business using the sign. The second generation "message center signs" raised direct commercial advertising messages to a position of parity with public service messages. Either type of message, however, had to be displayed in a series of segments or phases, the length of which depended on the size of the lightbank panel. Normally the message had to be short, and delivered in telegraphic style. The capability of later generations of CEVMS to combine words and graphics, lightbanks or matrices of optical cells, and a virtually unlimited program memory, opens the possibility of going far beyond display of simple advertising information. Increased familiarity with the techniques now available may encourage advertisers to think that "entertainment" which enhances the "attractiveness" of commercial messages now is a desirable function for on-premise signing. Prototypes are already in use, in on-premise and off-premise situations. The photographs in Figure 7 were taken several seconds apart from a sequence appearing on a CEVMS in Times Square, New York City.

Consideration of the implications of increased future use of CEVMS require that all of the foregoing factors be put in perspective. The moderate, low-keyed uses that have characterized the relatively simple types of CEVMS in the past may not continue in the future as more complex and versatile types of displays are promoted. Past experience with the operation of market forces as arbiters of prevailing use does not encourage the belief that they can assure compatibility with public interests associated with highways, or be of much aid to efforts of the electric sign industry to steadily improve the design quality and communications effectiveness of commercial advertising practice (Oliphant, 1976). Accordingly, the next sections of this report will discuss the role of regulatory standards in protecting the public interests that are affected by CEVMS, and the research basis for developing appropriate standards.

IV. REGULATION OF COMMERCIAL ELECTRONIC VARIABLE-MESSAGE SIGNAGE: POLICY ISSUES

A. Legislative History of the 1978 Amendments to the Highway Beautification Act. Efforts of the electric sign industry to expand the the use of EVM signing in commercial advertising have raised questions regarding the eligibility of such signs for display in areas where outdoor advertising is controlled by State laws enacted in compliance with the Highway Beautification Act (23 U.S.C. 131) and related regulations.

Pursuant to the outdoor advertising control provisions of the Federal-Aid Highway Act of 1958, national standards applying to advertising signs permitted in areas adjacent to Interstate System highways prescribe the following prohibitions: (National Standards, 1960)

> No sign may be permitted which contains, includes, or is illuminated by any flashing, intermittent or moving light or lights.
>
> No lighting may be permitted to be used in any way in connection with any sign unless it is so effectively shielded as to prevent beams or rays from being directed at any portion of the main-traveled way of the Interstate System, or is of such low intensity or brilliance as not to cause glare or to impair the vision of the driver of any motor vehicle, or to otherwise interfere with the driver's operation of a motor vehicle.
>
> No sign may be permitted which moves or has animated or moving parts.

Other related provisions prohibit signs which appear to direct traffic, which imitate or resemble official traffic signs, or which prevent drivers from having clear and unobstructed views of official signs and approaching or merging traffic.

All of these prohibitions were incorporated into the bonus agreements entered into by the 23 States that currently participate in the outdoor advertising control program under the 1958 Federal-Aid Highway Act. Such agreements have remained in effect under successive highway beautification acts and Federal regulations (23 USC 131(j)). Therefore, in bonus States, commercial use of EVM signs has been subject to these prohibitions, and generally has been barred by them.

The Highway Beautification Act of 1965 replaced the program of bonus incentives for control of billboards with a program that promoted State compliance with national standards by use of financial penalties. The national standards contemplated use of State zoning to establish and maintain "effective control" of roadside areas. The concept of effective control authorized States to permit certain types of signs in the controlled areas, including directional signing in rural areas, general commercial advertising in zoned and unzoned commercial and industrial areas, and on-premise signing wherever it occurred. National standards containing prohibitions against use of flashing, intermittent or moving lights were issued for directional signs and for outdoor advertising in commercial and industrial areas, but no national standards were issued for on-premise signs (23 USC 131(c)(3)). The main basis for control of on-premise signing in the 1965 Federal law, therefore, was implicit in the necessity of developing a working definition of this class of sign. The definition in the Federal highway regulations, which serves as the minimum scope of the exemption, is as follows:

> A sign which consists solely of the name of the establishment or which identifies the establishment's principal or accessory products or services offered on the property is an on-property sign (23 C.F.R. 750.709).

Recent efforts of the electric sign industry to expand the commercial use of EVM signs along Interstate System highways have raised questions of whether these signs would be prohibited under States' bonus agreements. State highway agencies understandably have been cautious in the absence of clear Federal guidance. In 1978, failing to obtain immediate favorable rulings from FHWA, the National Electric Sign Association sought and obtained an amendment of the Federal law which was designed to permit CEVMS. This amendment revised the exemption for on-premise advertising signs in controlled areas to read as follows:

> signs, displays, and devices, <u>including those which may be changed at reasonable intervals by electronic process or remote control</u> advertising activities conducted on the property on

which they are located . . . (underlining indicates new language added) (23 USC 131(c)).*

In addition, as a means of obtaining modification of existing prohibition of such signage in Federal-State bonus agreements, the provisions of the present law dealing with standards for such agreements were amended as follows:

> Any State highway department which has, under this section and in effect on June 30, 1965, entered into an agreement with the Secretary to control the erection and maintenance of outdoor advertising signs, displays and devices in areas adjacent to the Interstate System shall be entitled to receive the bonus payments as set forth in the agreement, but no such State highway department shall be entitled to such payments unless the State maintains the control required under such agreement: Provided that permission by a State to erect and maintain information displays which may be changed at reasonable intervals by electronic process or remote control and which provide public service information or advertise activities conducted on the property on which they are located shall not be considered a breach of such agreement or the control required thereunder. Such payments shall be paid only from appropriations made to carry out this section. The provisions of this section shall not be construed to exempt any State from controlling outdoor advertising as otherwise provided in this section (23 USC 131(j)). (Underlining indicates new language added.)

Nothing in the 1978 amendments relating to CEVMS changed the status of these signs when used in off-premise advertising, either as directional signs or as general outdoor advertising in zoned or unzoned commercial and industrial areas. The national standards for these forms of signage prohibited use of flashing, intermittent or moving lights, and moving or animated parts; and FHWA interpreted CEVMS as falling within the scope of these prohibitions.

The practical effect of these amendments was limited to the national standards for bonus agreements relating to on-premise signs adjacent to highways of the Interstate System where, as earlier noted, questions had been raised as to whether CEVMS were to be considered as signs using flashing lights or animated or moving parts. By this change in the minimum standards States having bonus agreements were authorized to permit CEVMS to be used in on-premise signing, but no State, bonus or non-bonus, was required by the Federal law to permit them if it chose to adopt regulations that were more restrictive than the Federal standards.

The legislative history of this action emphasized the distinction between conventional electric signs utilizing flashing, intermittent or moving lights and the type of signs on which the only movement is a periodic change of message against a solid, colorless background. This distinction was elaborated by the following statement of the National Electric Sign Association (NESA) in the legislative hearings (National Electric Sign Association, 1978, pp 246-247):

> An electronic information display does not flash or animate static information. The only movement is the changing of information against the solid colorless background. The face of the display can either be a lamp matrix board or a solid matrix of optical shutters which can be individually opened or closed under computer control, exposing light to form graphics or messages as a unit. Time, date, temperature, weather, directional information, or other public service or commercial messages of interest to the traveling public may thus be offered efficiently with constant light level control and low energy cost.

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*One of the goals of this report will be to establish a satisfactory definition of the word "reasonable" as used in the passage of the law cited above.

> Electronic information displays are engineered for maximum legibility and readability. Their light is produced by soft incandescent bulbs screened with a special louvred sun screen to reduce glare. Most such displays contain automatic dimmers, so that, as daylight decreases, the intensity of light they emit is reduced.... Thus the 'garish' quality of some bright lights at nighttime, offensive to some, is eliminated.

An example of the type of sign described as an electronic information display by NESA is shown in Figure 8A. Although the NESA testimony cited above states that electronic information display technology will eliminate "the garish quality of some bright lights at nighttime," the legislative language that was used to legitimize CEVMS contains no assurance that this result will be achieved. The sign shown in Figure 8B qualified as an electronic information display under the 1978 amendment and, at the same time, illustrates the qualities that are objectionable in many highway environments.

Congressional authorization of the use of CEVM signing in on-premise outdoor advertising provides general criteria and specifications for these displays, but leaves several important tasks to be performed by the agencies administering the law. Initially, working definitions and standards are needed for the key terms of the Federal law, such as "reasonable intervals" for message changes, "electronic processes," "remote control," and others. Also, since Federal law authorizes States to impose stricter limitations on the display of outdoor advertising than are required for compliance with Federal standards, a frame of reference for evaluating State actions relating to this form of signage is needed by Federal officials.

The Federal interest in on-premise CEVMS, as currently authorized in 23 U.S.C. 131, is indicated by the stated purpose of this legislation, namely: ".... to protect the public investment in .... [Interstate and Federal-aid primary] highways, to promote the safety and recreational value of public travel, and to preserve natural beauty." Accordingly, regulation of CEVMS on business premises should be considered in terms of the following aspects: highway safety, human factors, visual or aesthetic effects, and highway investment impacts.

The activity of the electric sign industry at the State level during recent legislative sessions did not result in making available any significant amount of research data or documented experience regarding commercial EVM signage, either from the industry or public highway agencies. State highway and transportation agencies generally lacked funds, manpower and time to undertake major studies of the impacts of the proposed expansion of this sign use. Efforts to introduce this subject into the National Cooperative Highway Research Program for FY 1980 also were unsuccessful. Accordingly, at the request of the FHWA Office of Right of Way, the present staff study was initiated by the Office of Research to review existing relevant technical and policy research literature, reported operational experience, and professional opinion regarding application of EVM signing to advertisement of on-premise activities in areas adjacent to Interstate highways.

B. Public Interest in Highway Safety. Considerations of the general health and safety of the public, and of highway traffic safety in particular, have regularly been cited to justify regulation of outdoor advertising signs. With equal regularity, this justification has been the subject of controversy, chiefly because of the difficulty of obtaining conclusive proof of the conflicting claims.

In the earliest billboard ordinances, references to health and safety asserted that billboards in urban settings were obstructions to open view of streetside spaces, and thus provided places for criminal activity, accumulations of litter and discarded articles, untended growth of weeds or shrubs, or neglected and deteriorated

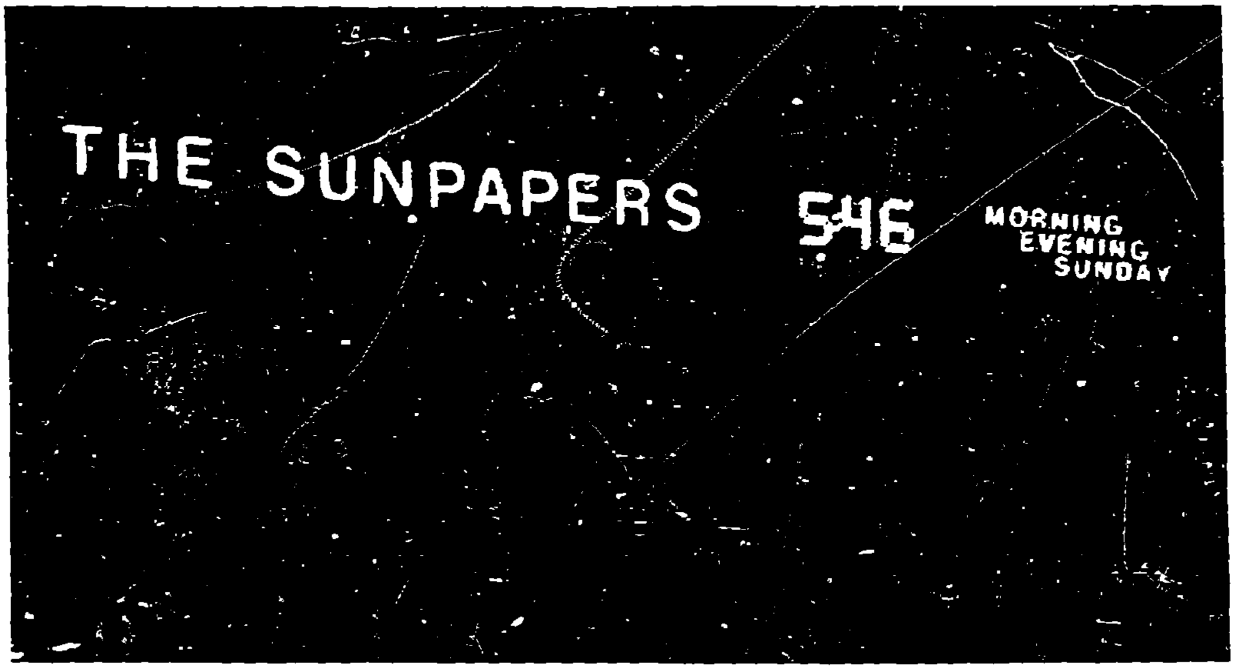

Figure 8A. A "Typical" Commercial Electronic Information Display as Defined by NESA. (Photograph: J. Wachtel)

Figure 8B. An "Electrical Spectacular" CEVMS Incorporating a Running Message Cabinet and an Alternating Time and Temperature Display. (Photograph: J. Wachtel) structures--all conditions that were undesirable and often considered nuisances. Statistical verification of the incidence of these conditions rarely was attempted or demonstrated when billboard restrictions were challenged in court. In these cases, courts generally upheld decisions of regulatory bodies (usually local governments), relying on testimony or other evidence that instances of such conditions had in fact occurred. Courts did not substitute their own judgment for that of the legislators as to the seriousness of the risks involved.

In this way, the courts' acceptance of the conclusion that public health and safety were promoted by restriction of billboards in specified zones has reflected the general public's view that associates billboards with other types of land use that are objectionable under certain circumstances, and the public's willingness to have billboards restricted in the interest of preventing proliferation of such conditions. The fact that some instances of undesirable conditions, including cases of dilapidated and poorly placed signs, were cited was sufficient to warrant the conclusion that more instances might occur unless prevented by law.

Where highway traffic safety specifically was considered, essentially the same rationale has been used. Attempts to identify and quantify the impact of roadside advertising on traffic safety have not yielded conclusive results. Research studies of accident data generally have dealt with those situations in which a failure of the vehicle, the driver, or the highway can be directly identified. Identification and measurement of the causes of these failures, often at secondary levels, have received little attention and had little success. This has been reflected in the evidence presented when courts have been asked to rule on the reasonableness of billboard restrictions to promote or preserve traffic safety. After listening to contradictory testimony of expert witnesses, courts frequently have fallen back on the readily understood logic that a driver cannot be expected to give full attention to his driving tasks when he is reading a billboard, and therefore it is not unreasonable for a legislature to seek to reduce the risk of distraction in areas where high driving concentration is needed.

Essentially the same rationale has been applied to potential safety hazards involved where placement of signs obstruct sight distance, or where the design or message content of signs may create confusion by resemblence to official traffic control or routing information. In these cases, the actual extent to which sight distance is impaired or driver confusion is increased has been difficult to measure empirically, but the desirability of reducing the risk of the occurrence of these conditions is universally accepted.

Accordingly, where expert witnesses have disagreed in their interpretation of empirical data on the extent or impact of conditions associated with roadside advertising, courts have deferred to legislative judgments that the public interest in safety justifies prevention of the growth of those forms of roadside development, including advertising signs, that can reasonably be expected to result in traffic operational environments which make driving more difficult or unsafe.

The foregoing observations on the handling of "the safety issue" involved in roadside advertising generally describe the practical approach that courts and regulatory bodies have taken when forced to deal with a subject on which empirical data are inconclusive. That this is not a particularly desirable basis for dealing with the "safety issue" in control of roadside advertising is evident. Whether it is the best basis that the existing state of research can provide for policy-making may be an arguable question. Other sections of this report present a detailed analysis and an appraisal of the major safety and human factors research on this question. Until a more convincing preponderance of findings is presented, however, the existing approach may be expected to apply where the reasonableness of standards for on-premise CEVMS are judged by the courts.

C. <u>Public Interest in Protection of Environmental Quality</u>. The public interest in preserving or promoting the aesthetic compatibility of man-made and natural features of the environment is recognized as a justification for regulating outdoor advertising. Whether aesthetic considerations are legally sufficient to justify regulatory action where they are the <u>only</u> basis for such action is a question on which courts have differed (Dukemenier, 1955). Usually, however, this question does not arise because aesthetic objectives are present in conjuntion with the public interest in health, safety, and economic welfare. In such cases, the presence of aesthetic objectives has regularly been accepted as a legitimate contributing basis for reasonable regulatory standards.

The "reasonableness" of regulatory standards for aesthetic aspects of on-premise signing is typically tested in terms of their relevance to acknowledged problems associated with unregulated signing practice. One aspect of unregulated signing which is recognized as objectionable relates to the design, location, and condition of signs. The National Electric Sign Association has emphasized this aspect as follows:

> It is important to stress that regulations only on physical dimensions of signs will not in themselves solve environmental requirements.
>
> To date, most sign codes have not recognized the need to control removal of obsolete signs, maintenance and repair of existing signs, as well as the material, actual manufacturing quality, and installation specifications of signs.
>
> Our guidelines suggest regulation of these items within a code and we believe that such control will greatly improve the overall visual impact--eliminating such things as poor construction, unsightly wiring, abandoned signs, dirty and broken signs, and other elements which contribute strongly to the visual appearance (Commission on Highway Beautification, 1974, p. 617).

The Association's recommendations included development and adoption of a system for determining permissible size, setback, height, density, and "other factors affecting on-premise signs," and relating them to the viewing public.

While it is relatively easy to formulate acceptable standards aimed at improving the installation, operation, maintenance, and repair of on-premise signing, standards to assure the compatibility of on-premise signs with the architectural style of the buildings or sites where they are located, and with the natural and man-made visual environment of their immediate vicinity, have not been so widely or easily accepted. Yet, principles for designing on-premise signs that are "married to the architecture" are known and used by professionals in the field of design, and can be expressed in standards for regulation of on-premise signage (Commission on Highway Beautification, 1974, p. 621). (Although not as far advanced, standards for design and measurement of aesthetic compatibility with the natural environment are also becoming more objective.)

There is general acceptance of the foregoing policy objectives by the electric sign industry, the design professions, and environmental planners. Differences among them appear to arise when details of specifications and enforcement procedures are considered. Electric sign industry spokesmen have argued that standards should be promulgated and enforced locally, with industry practices serving as guidelines where standardization is called for.

Extension of the general policy favoring environmental compatibility of on-premise signing to CEVMS is likely to be complicated because of the broad range of types and functions of signs that must be considered. In the early generations of this signing technology, standards to assure structural and operational soundness could be formulated fairly easily. These signs were fairly simple in design and structure. The newness of such signing minimized the environmental impacts of obsolescence in the signs. Moreover, the popularity of these signs with banks and financial institutions tended to encourage conservative design and compatibility with architectural styles.

These same conditions may not prevail where later generations of CEVMS are concerned. No comparable experience record exists for some of the remote-controlled, computer-programed equipment used in these sign types, and substantial differences potentially exist in the compatibility problems of signing which seeks to advertise and entertain as compared to that which provides standardized public service information.

D. Public Interest in Protection of Highway Investment. The congressional declaration that one of the purposes of the control of outdoor advertising is to protect the public investment in highways was not specifically documented in the legislative history of the Highway Beautification Act. Nor was this concern substantially clarified in congressional hearings which were held in 1967 for the purpose of studying the way in which this law would be implemented. A working appreciation of the investment that the law is intended to protect, and the outdoor advertising activities against which protection is considered necessary, may, however, be inferred from the testimony compiled in congressional hearings held periodically since 1965 to consider problems of administering billboard control.

What emerges from this body of data and opinion, plus the earlier report of the White House Conference on Natural Beauty (1965), is a national feeling of pride in the appearance of the Interstate System highways, the first sections of which came into operational use in the early 1960's. In rural areas, where these highways were built almost entirely on new locations, motorists were keenly aware of the terrain and natural features of the highway corridor. Rights of way were wider; attention was given to selective retention of natural vegetation and landscaping measures taken during construction; and a general feeling of spaciousness resulted from the fact that roadside development had not yet occurred, or, if it had begun to occur, it was new and attractively designed.

In urban and suburban areas, a similar feeling resulted from the fact that the wide rights of way and clean geometric design of these highways dominated the motorists' visual environment, and sometimes provided for him a form of linear open space that was rare in man-made urban environments that often tended to be overcrowded, or seemed to develop without any distinctive character or unifying quality in their appearance and design.

This experience was a striking contrast to the feeling that resulted from driving through the roadside ribbon development that could be found in many corridors of highway travel during the 1940's and 1950's, and which resulted from largely unplanned and uncontrolled use of roadside land. Stated another way, the nation in 1965 had seen a system of new highways, which, because of their new location, their new and better geometric design, and their success in achieving a new level of visual quality through landscaping, gave motorists a feeling of openness and uncluttered (or, at least, well planned) roadsides. the public liked the result of this investment and wanted to prevent it from gradually being lost as roadside development pressures inevitably increased.

Thus the highway investment that Congress in 1965 sought to protect was of two sorts: one was the money spent on actual measures for scenic enhancement of the roadsides (i.e., removal of nonconforming billboards and junkyards, landscaping, and protection of scenic views), and the other was the broader range of additional expense involved in designing and building to better quality geometric design so that highways more successfully harmonized with the natural environments in which they were located.

In hindsight it may be asked whether this was an impossible objective. Is it ever possible to preserve the appearance and feeling of newness and visual quality for very long when pressures to the contrary build up through highway use and resulting development of roadside land? Is visual quality something that can be preserved only in systems of parkways and special-purpose scenic roads? There is no evidence that the necessity and feasibility of protecting this highway investment was seriously challenged. Indeed, the 1967 Economic Impact Report to Congress concluded that the measures called for by the Highway Beautification Act would have a high degree of permanency (Bureau of Public Roads, 1967).

At the same time, the report warned that monetary or economic values provided "only a rough and inexact measurement" of the benefits to be obtained by investing in highway beautification (U.S. Senate, 1967, p. 26), and similar handicaps applied to any attempt to calculate in dollar terms the impacts on such an investment of modifying any of the program's protective provisions. This situation has not significantly changed since 1967. But, as noted in connection with the objectives of safety and preservation of natural beauty, the fact that adverse effects of excessive or poorly designed or located outdoor advertising have not been quantified and measured has not prevented the Congress from recognizing that there is a public interest in preventing or reducing the risks of such impacts by imposition of reasonable standards and controls. Nor has it prevented the courts from upholding the validity of regulations that are reasonable to achieve this objective. As with other instances of sign control, however, specific regulatory standards for on-premise CEVMS must always be tested by their relevancy to this public interest in the circumstances to which they apply.

V. IMPLICATIONS OF THE USE OF CEVMS: A STATE-OF-KNOWLEDGE ASSESSMENT

A. Highway Safety Considerations.

General. The relationship between roadside advertising signs and highway safety has been studied and debated in the literature for nearly three decades, and researchers are only now beginning to approach a consensus. CEVMS in particular have received little overall attention because of their newness and relative rarity alongside highways. Thus, this section will address all types of advertising signs, with specific application to EVM signs made when applicable. By far the majority of research has focused upon the question of distraction of the motorist's attention by the presence of commercial signs alongside the highway. Some discussion, but relatively little actual research, has been concerned with the question of whether there are beneficial effects of such signage for stimulating the motorist during an otherwise tedious and fatiguing drive, and for alerting him to the presence of unusual roadway geometrics (such as a sharp curve) ahead. (Of course, the same effect, if any, might be achieved by the proximal location of other roadside objects such as buildings, trees, utility poles, junkyards, etc.) Although each of these areas will be discussed, the greatest coverage will be given to the distraction issue, since that has received the most attention in the research literature.

Examination of the relationship between roadside advertising and traffic safety has been undertaken both in the laboratory and in the highway environment. The major studies discussed below will be categorized in this manner and in approximate chronological order.

Minnesota Department of Highways-Field Study: 1951. One of the earliest field studies which sought to systematically examine the relationship between accidents and the presence of advertising signs along the highway was conducted by the Minnesota Department of Highways (1951). The research was begun in 1947 at the request of the National Safety Council and the Bureau of Public Roads. Among the findings reported as significant, two are relevant to this report: (1) "An increase in the number of advertising signs per mile will be accompanied by a corresponding increase in accident rate" (p. 31); and (2) intersections at which four or more (advertising) signs were located had an average accident rate of approximately three times that for intersections having no such signs. The study was quite comprehensive in that road sections and intersections were matched for such features as geometry, width and type of surface and shoulder, traffic volume, and grade. Study was made of 713 accidents along 420 miles (675.78 km) of two-lane roads which carried fewer than 500 vehicles per day. Accidents were studied with respect to: traffic volume, 85th percentile speed, access points, grade, tangent versus curve, sight distance, degree of curvature, length of tangent preceeding a curve, type of intersection, presence of roadside business, and advertising signs.

Characteristics of advertising signs evaluated included: distance from road centerline (the majority were less than 60 feet (18.29 m) away), size, shape, color and illumination or reflectorization of the sign, and number of signs per mile of tangent or curve (signs placed along curves amounted to 50 percent greater than those on tangents). Although the report discusses the significance of its findings and presents considerable data in the form of tables and graphs, the statistical methods employed are not satisfactorily explained, and it was not possible for this reviewer to evaluate the adequacy of the experimental design or to reanalyze the data. It is unfortunate that this situation exists because the large amount of data collected and the number of variables taken into account would seem to indicate that valid and meaningful results should have been obtained. It should also be noted that fewer advertising signs are now found as close to the road centerline as was the case when this study was peformed. This fact would likely result in a relatively lower impact of such signs, given equal size, color, and other attention-getting characteristics. The authors' final point, in discussing the significant increase in accidents at four-way intersections having four or more advertising signs as compared to similar intersections with fewer than four signs, is that "the effect of driver distraction is more potent at such intersections where greater driver alertness is required because of the larger variety of vehicle maneuvers taking place" (p. 33). This is one of the earliest research findings that indicates some interactive effect of the presence of advertising signs and the demand level of the driver's task. We shall return to this issue later. Those readers interested in a further exposition of this study and of its statistical procedures may wish to read Staffeld (1953) and Weiner (1973).

Rusch (Iowa State College) - Field Study: 1951. Rusch (1951) examined accident data on State and Federal highways in Iowa for 1947 and 1948. The purpose was to determine whether there was a relationship between the number, location and character of accidents, and the immediate presence of roadside business and advertising.

Among the statistical and experimental controls employed were: geography and population of the areas of study; traffic density on the routes examined; and roadway geometrics and pavement condition.

Three zones were defined: The "A-B distance" was a segment containing at least 90 percent of the advertising and roadside business on that particular approach. The "X distance" was the one-mile segment immediately downstream of the A-B distance. The "Y distance" was the one-mile segment (when available) downstream of the X distance.

It was hypothesized that accidents would be more likely to occur in the A-B distance than in the others, and that the character of the accidents within the A-B distance would differ from those of the other two segments.

The data used for analysis were that provided on Iowa State Highway Commission forms, considered by the author to be complete and accurate when the reports were completed in detail. Three accident classifications were established for this study: (a) accidents attributable to business were only those which occurred as a direct result of entering or exiting the place of business; (b) accidents due to inattention were those that, according to the accident report, "might easily have been avoided had the driver devoted full attention to his driving" (p. 48), (excluded were accidents occurring under adverse weather conditions and accidents caused by mechanical failure); and (c) "other" accidents were those attributed to numerous other causes, as well as those for which incomplete data existed.

Results showed that the number of accidents in the A-B segment for each of the two years studied was more than double the number in either the X or Y distances. When corrected for mileage per segment (i.e., accident rate per one hundred miles), the rate was again higher for the A-B segment than for the others. A third finding was that "inattention" accidents predominated over both "business" and "other" accidents in the A-B segment, but the "other" category surpassed the "inattention" and "business" categories combined for both the X and the Y segments. This result was consistent across both years of study. Despite a lack of statistical sophistication by which tests of significance might have been made, the direction of the data seems clear.

Michigan State Highway Department-Field Study: 1952. Under the same sponsorship as the Minnesota study was a similar effort conducted by the Michigan State Highway Department (1952). Interestingly, Michigan's findings were nearly opposite to those obtained in Minnesota. That is, their main conclusion of relevance to the present report was that: "Advertising signs have practically no effect whatever on the accident experience of this road" (p. 29). While the methods and procedures employed were generally similar, and although Michigan seems to have utilized more rigorous statistical procedures (i.e., the use of the partial correlation coefficient in addition to simple and multiple correlation analysis), several experimental weaknesses limited the usefulness of the research. First, the researchers did not isolate environmental features from their context, thus allowing the data to become confounded. For example, gasoline service stations seemed to account for a disproportionately large share of accidents; but, since many of these stations were located at intersections (96 out of 121 studied), the authors could not legitimately attribute these accidents to one feature as opposed to the other. Second, as pointed out by Weiner (1973), the authors failed, despite their sophisticated statistical approach, to indicate which, if any, of their findings were statistically significant. In one area, however, Michigan's results appeared closer to those found in Minnesota. Despite the conclusion that advertising signs in general did not show a substantial correlation with accidents, one subcategory did. The group of illuminated signs, which included neon and "flashing neon" types, showed an "appreciable association with accident locations" (p. 6).*

Lauer and McMonagle (Iowa State College)-Laboratory Study: (1955). Lauer and McMonagle (1955) undertook one of the earliest laboratory investigations in this area, seeking answers to questions of both safety and aesthetics. Their study, at the Driving Research Laboratory of Iowa State College, attempted to demonstrate a relationship between the presence of advertising signs along the road, the sign's angle relative to the approaching motorist, the driver's "efficiency at the wheel," and his perception of natural beauty. Equipment consisted essentially of a moving belt terrain model simulator in which the environment remained fixed with the exception of the presence or absence, and placement of billboards. The facility is not described in any detail in the report of the experiment, and the reader is referred back to studies conducted in 1937 for such a description. Even Claus and Claus (1974), who devote over five pages (including three photographs of the equipment) to an uncritical but strongly positive review of the study, do not describe the laboratory facility, but refer the reader back to the 1937 report. An examination of that report, however, (Johnson and Lauer, 1937) discloses only the following information: "(the apparatus) consists of a miniature car driven over a roadway laid out on an endless leather belt. The small car is guided by the subject from full-sized standard car controls" (p. 85). The reader must examine a still earlier report (Lauer and Kotvis, 1934) to gain a more complete understanding of the apparatus and its operation by the test subject.

Although it is well known that face validity is not always required for a successful simulation, and that part-task simulators such as that at Iowa State College may yield excellent construct validity within the limits of their application, it is obvious that, for several reasons, the experiment

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*The definition of a "flashing sign" is, even at present, in dispute. This issue will be discussed again later in this report.

under discussion was so fraught with errors of conception and execution that it sheds no real light on the relationships between roadside advertising, aesthetics, and traffic safety, and any such conclusions may be unjustified. Some of these reasons may be stated as follows. First, the 1955 report describes details of the experiment in only a vague manner. The one independent variable, sign presence and placement, had three levels: (a) number of signs, (b) signs placed at a 15 to 30 degree angle to the roadway, and (c) signs placed at a 15 to 45 degree angle. The subject's task was "efficient observation of a landscape covered with signs and that of a landscape with no signs at all" (p. 323). Although the reader is told that landscape features present on the model included fields, shrubs, farm buildings, bridges, and animals, among others, it is not stated whether these were the landscape features to be observed. "Efficient observation" was operationally defined as reaction time (p. 323). The results, summarized in one paragraph, were that the presence of numerous signs in the driver's field of vision "in no way influenced efficiency at the wheel adversely" (p.324).

No data indicating statistical significance are given. Second, the authors state that subjects noticed as many or more landscape features when signs were present as when they were absent. Their conclusion from this is that "the theory that various signs along the highway will detract from the natural beauty does not seem to hold" (p. 324).

These two findings are clearly not warranted. A task requiring a driver to indicate his awareness of one or more rural landscape features bears little resemblance to highway safety or to roadside aesthetics (the awareness of roadside features can hardly be said to be the same as a judgment of the scenic beauty of the landscape in which these features exist). That the simulator reproduced a very limited and atypical landscape, and that the nature of the moving belt presentation required many "passes" over the same modeled landscape (the 1934 study utilized 10 revolutions of the moving belt, and the 1955 study does not report this information), further restricts the generalizability of these laboratory results. Finally, and perhaps most important, there is no indication that this simulation technique had been validated against relevant real-world criteria. Claus and Claus' (1974) statement that "it was known from prior research that (these) laboratory results were reliable reflections of human reactions in real situations" (p. 135) cannot be supported, since the only data cited for reliability and validity of this facility were related to control tasks very different from the measures employed in this study. In their assessment of this research, the Clauses conclude with two curious statements. They reason that the validity and applicability of the Lauer/McMonagle methods are still demonstrable today because: (a) a growing number of judicial decisions acknowledge that advertising signs do not cause accidents, and (b) in a recent "good highway study," the New Jersey Garden State Parkway made use of their methods. These statements are puzzling because the Lauer/McMonagle work was done in a laboratory, whereas the cited work done for New Jersey was conducted in the field with no methodological comparability. More will be said about this New Jersey study below. Finally, in light of this discussion of the Lauer and McMonagle study, it is difficult to understand how these authors could compare their laboratory findings with the field data gathered in Michigan (ignoring the field data from Minnesota and that of Rusch at their own research institution) and conclude that "the studies each confirm that there is no significant relationship shown between outdoor advertising signs and highway accidents" (p. 329).

<u>New York State Thruway (Madigan-Hyland)-Field Study: 1963.</u> More recently, the New York State Thruway Authority commissioned the engineering firm of Madigan-Hyland, Inc. (1963) to examine accident data from 1961 through 1962 "to determine the relationship, if any, between the number of accidents and the existence of advertising devices along the route of the expressway." Data were obtained from on-site accident reports, which included information on type of accident, location, and probable cause. Only those accidents were included

which the investigating State Trooper had attributed to "driver inattention." It was determined, a priori, to exclude from analysis accidents which occurred at toll barriers or interchanges. These accounted for approximately 25 percent of the "driver inattention" accidents along the thruway, but it was reasoned that irrelevent factors, such as searching for toll money, could confound the analysis of such accident data. A correlation analysis indicated that 32.6 percent of the 1,550 driver inattention accidents for the two years studied occurred on the 13.1 percent of the Thruway's 1,118 mile (1 800 km) roadway upon which motorists were exposed to advertising devices. On those portions of the roadway exposed to advertisements, an annual average of 1.7 driver inattention accidents per mile (1.06 per km) occurred whereas on those portions free of advertising, the average was 0.5 of an inattention accident per mile (0.31 per km). Although not well controlled statistically, traffic volume was also taken into account in the analysis. Table 1 shows the number of driver inattention accidents per mile (km) in a "heavy density area" (the New York Division) and in a "medium density area" (the Albany and Syracuse Divisions). Obviously, without more precise definitions of traffic densities and careful controls of environmental variables other than advertising signs, no statistical analyses can be applied to these data. And while it is true that the Madigan-Hyland study can be criticized for its poor statistical and experimental control, some of the adverse comments directed at this research may be unjustified.

For example, in the introduction to his own restudy of the New York Thruway accident data, Blanche (1963) states: "Madigan-Hyland did not consider such other variables as traffic volume, . . . (or) road characteristics such as 'on' and 'off' ramps" (p. 8173). As discussed above, this is simply untrue. Further, in those sections of the roadway reexamined by Blanche, "there was a peaking of accident locations where on and off ramps were close together," and "approximately 72 percent of the accidents occurring on the first 45 miles of thruway occurred at locations which were within two-tenths of a mile of an on ramp, an off ramp, a bridge, a service area, or a toll area" (p. 8173).

Table 1. Madigan-Hyland Data on Driver Inattention Accidents Per Mile (km) Along the New York State Thruway.

Advertising Devices	Traffic Density: Medium	Traffic Density: Heavy
Visible	0.40 (0.25)	2.9 (1.8)
Not Visible	0.26 (0.16)	2.0 (1.2)

Since the accident locations investigated by Madigan-Hyland specifically excluded interchange ramps, toll plaza areas, and perhaps service areas as well (this was not stated in their study report), it should be obvious that the two investigations studied very different populations of accidents. It should also be noted that Congressman Henderson (1963), in his introductory remarks to Dr. Blanche's analysis in the Congressional Record, criticized Madigan-Hyland for its reliance upon inattention accidents, since this term was often used as a "catchall" by the investigating officer. Similarly, in their support of the Blanche analysis in the same publication, Brody characterized inattention as "a broad and elusive psychological phenomenon" (p. 8174), and McMonagle questioned "the soundness of this item on the accident report" (p. 8175). That Blanche used exactly the same inattention accident records, and only for one year compared with Madigan-Hyland's two, seems to have escaped the notice of those experts who commented so favorably on his report. Finally, the Madigan-Hyland report was strongly criticized for what appeared to be an a priori bias on the part of the researchers. The statement that ". . . it was recognized that advertising devices are a factor in accidents principally because they distract the motorists' attention" (p. 1) was considered by Claus and Claus (1974, p. 130) to effectively negate the study's value, since they felt that it indicated that the conclusion was assumed to be true from the start. It is curious that no such criticism has been made of Blanche's work, since he quite obviously set out to disprove the earlier findings. In summary, the Madigan-Hyland report was statistically and methodologically weak. But the Blanche analysis, while it overcame some of the statistical limitations of the earlier effort (particularly the substitution of partial for simple correlation), presents opposite conclusions that seem no more justified than were those of the study which it attacked.

Blanche (New Jersey Garden State Parkway)-Field Study: Undated. Shortly after his comments on the Madigan-Hyland report, Blanche undertook an analysis of the relationship between highway accidents and physical design features on the New Jersey Garden State Parkway. Dr. Blanche's report, discussed but not referenced by Claus and Claus (1974, pp. 140-141), is titled "A Study of Accidents on the New Jersey Garden State Parkway." The Claus and Claus "review" states that the researchers "worked under the direction of D. Louis Tonti, Executive Director of the Parkway" (p. 140), and indeed the title page of the report states: "In Cooperation with the New Jersey Highway Authority." A simple reading of the text indicates, however, that the Highway Authority cooperated with the researchers only to the extent of making their relevant records available. On the other hand, Blanche alludes, but never specifically states, that sponsorship of the research came from the Outdoor Advertising Association of America (see pp. i, ii, and eight letters following the appendix). If this is the case, an a priori bias on the part of the researchers is a distinct possibility. This potential bias is further reinforced by the fact that, throughout the report, Blanche refers to the earlier field work of the Michigan State Highway Department (1952), and the laboratory study conducted at Iowa State College and reported by Lauer and McMonagle (1955). The reader may recall that both of these studies reported no relationship between advertising signs and accidents. Blanche fails, however, to make any reference to the study conducted by the Minnesota Department of Highways (1951) which was performed under the same program as the Michigan study, but which found a positive and significant correlation between advertising signs and accidents, or to the Rusch (1951) work. More will be said about these studies shortly.

Blanche cited several reasons for his choice of the Garden State Parkway. It traverses urban, rural, and resort areas; it is a high-speed, high-density, divided, limited-access road; it includes a wide variety of physical and environmental characteristics; it has a good safety record; and the researchers were assured of access to excellent and comprehensive data. The research methodology was similar to that used in previous studies and will not be discussed here in any detail. Basically, simple as well as partial correlation coefficients were computed from coded data indicating accident sites and environmental features, identified within two-tenths and one-tenth mile intervals respectively. The researchers included all business and advertising signs in their investigation which were within 1350 feet of the highway.

In addition to the fact that their inventorying methods give this reader little confidence in their accuracy is the interesting information that they included signs which were as much as twice as far from the road as the Federal Government then considered to be the regulatory distance. It is logical to assume that, other factors being equal, the farther a sign is from an observer, the less its impact is likely to be on his behavior. Not surprisingly, the findings of this study were that accidents on this highway were related significantly to traffic volume and not to any environmental features including business and advertising signs. (The same study was reported, in abbreviated form, in Traffic Safety - Blanche, 1965.)

Contrary to the implication conveyed in Claus and Claus (1974, p. 140) that Blanche and his colleagues had not only worked "under the direction of" officials of the Garden State Parkway, but that their findings were accepted and approved by these officials, are a series of letters written in 1966 by Sylvester C. Smith, Jr., the Chairman of the Parkway. These letters were sent to those firms which owned or maintained advertising signs along the Parkway. The letters read in part:

> The New Jersey Highway Authority appeals to your better judgment.
>
> This Authority, which operates the Garden State Parkway, asks for your cooperation in the removal of advertising signs visible to the motorists on its high-speed highway.
>
> We are convinced that such commercial signs along the Parkway route represent a real detriment to its serviceability and safety--let alone its scenery. They distract from the Parkway's natural attractiveness, from its traffic and safety signs, and generally from the task at hand of driving with full awareness on a high-speed roadway.

The immediate stimulus for this letter is unknown. Its timing, however, less than a year after publication of the Blanche analysis in Traffic Safety, makes it almost a certainty that the author (the second highest officer for the Highway Authority) was aware of the Blanche report, and seems to imply that the Highway Authority did not concur in Dr. Blanche's conclusions.

Faustman (California Route 40)-Field Study: 1961. Adding further to the growing controversy was a study undertaken by Faustman (1961) in an attempt to overcome the limitations of previous field research. He correctly argues that the substantial differences in findings of earlier studies resulted directly from the number of environmental and design variables examined and the extent to which such variables were controlled in the data gathering and analysis phases. Faustman briefly discusses the Minnesota, Michigan, and Lauer and McMonagle (Iowa State) studies, and then describes six key ways in which his study sought to control the factors that led the Michigan and Minnesota researchers to obtain such different results. The 40-mile (64.4 km) section of U.S. 40 in California chosen for his analysis had "essentially the same design and traffic characteristics throughout" (p. 2):

1. Four-lane divided; 60 mph (97 kph) geometric design standard; consistent lane and shoulder width.
2. Complete access control for at-grade intersections.
3. Approximately equal traffic volume and speed.
4. Generally level terrain through a strictly rural area.
5. Few roadside developments; concentrated near important intersections.
6. Equal enforcement and accident reporting.

Advertising sign, traffic accident, and volume data were obtained for a five-year period and plotted within quarter-mile (0.4 km) sections of the highway. "Only exactly comparable quarter-mile (0.4 km) sections were analyzed" (p. 3). These included only level, tangent sections with no intersections or access points. As the study sections both with and without billboards were interspersed throughout the route, time-of-day and weather variables were considered to be applicable equally to all road sections. The major finding was that the average accident rate for the 34 sections with billboards (0.988 per million vehicle miles) (1.59 per million vehicle kilometers) was 40.9 percent higher than for the 42 sections without billboards (0.701 (1.13)). Faustman concluded that his findings could have been accounted for "only on the basis of the distractive influence of advertising signs" (p. 4).

Unfortunately, despite Faustman's careful attention to controlling variables on the road, his statistical analysis was not sufficiently rigorous to warrant the conclusions which he reached. Accordingly, Dr. Sidney

Weiner, a Mathematical Statistician with the Federal Highway Administration, undertook a detailed reanalysis of Faustman's data (1973). Weiner felt that it was impossible to determine from Faustman's presentation of the data whether the larger number of accidents in the billboard sections was due strictly to billboards; to the different total traffic volume in these sections versus those without billboards; or to a combination of both. After revising the summary table to portray the data on a section rather than an aggregate basis, Weiner performed a linear regression analysis of accidents against total vehicle miles and number of billboards. The analysis showed that the vehicle-mileage effect was the same for both types of sections, and that the number of billboards had a significant effect on the number of accidents. Weiner's data enabled him to compare accident rates as related to billboards for any sections with comparable exposure values. For example, for sections with 8.2×10^6 vehicle-miles (1.3×10^7 vehicle kilometers) of exposure, the data shown in Table 2 would result.

Table 2 Weiner's Reanalysis of Faustman's Data.

No. of Billboards	Expected No. of Accidents in a 5-year Period	Cumlative Increase in Accident Rate (%)
0	5.92	-
1	6.65	12.3
2	7.38	24.2
3	8.11	37.0
4	8.84	49.3
5	9.57	61.7

When Weiner applied an analysis of variance to the regression coefficients, he found that vehicle miles and billboards were both significant. In summary, Weiner performed a statistically sophisticated and justified reanalysis of data collected by Faustman under field conditions which were perhaps the best controlled of any of the reported studies on the subject of billboards and accidents. To the best of this writer's knowledge, these two reports, written 12 years apart, have received no comment or criticism in the substantial body of literature that continues to grow on the subject.

Certainly there are problems with the Faustman study that should lead to caution in the generalization of these findings. For example, it is not known whether the distance of advertisements from the road was considered; and, as we have seen, this variable alone could have accounted for much of the difference in findings between earlier studies; whether the particular highway evaluated was typical of other roads; or whether these data collected in rural environments would be applicable to higher density areas.

Weiner also analyzed the earlier Minnesota and Michigan studies. With regard to the Minnesota effort, he considered the study to be well organized and well presented, but flawed in the same way as was Faustman's work. That is, it was not clearly demonstrated whether the accident rate was due to advertising signs, traffic volume, or both. Weiner dismissed the Michigan study as an attempt to deal with a huge number of components with a statistical analysis "too weak to be given any serious consideration. For example, although partial correlations were formally calculated for each of the many components, no statistical test was performed to see if any of them were significant" (p. 4). In other words, Weiner considered the results of the Minnesota study more justifiable than those of Michigan, although still in need of reanalysis. His conclusions, therefore, are in opposition to those of Blanche.

<u>Ady (Chicago)-Field Study: 1967</u>. Relatively few studies have been identified which dealt specifically with the relationship between changeable message advertising signs and accidents. Ady (1967) examined three illuminated, changeable message advertising signs (six additional sign locations were chosen, but lacked sufficient data for study), and

examined the accident history before and after sign installation along high speed expressways in the Chicago area. An analysis of covariance compared accidents in the signs' "perceptual area" to similar areas immediately upstream and downstream of these highway segments. The covariance technique allowed the researcher to control statistically for such potentially confounding variables in the sign versus no-sign segments as traffic volume and road geometry. Results showed no significant differences in accidents between sign and no-sign areas for two of the three signs. The presence of the third sign, however, was accompanied by significantly higher accidents than occurred in adjacent non-sign highway segments. The author describes this sign as a large rectangle with alternating lights, presenting several different messages for an automobile manufacturer. When the sign was first erected, "bright white advertising lights were used for the . . . message" (p. 10). Due to a very rapid increase in the local accident rate, however, State highway officials asked that the lights be changed to blue. This change took place about six months after initial installation, during the study period. It is not known what effect, if any, this change had on the results of Ady's research.

In his introduction to the study, Ady discusses two seemingly opposite psychological theories of attention. Broadbent's approach argues that human sensory receptors have a limited channel capacity, and that the introduction of a novel or distracting stimulus into an ongoing task can command the individual's attention and cause a degradation of this attention to the original task.

Hebb, however, has argued that there are many sensory pathways to the cortex and that, particularly when an individual is understimulated, the introduction of distracting stimuli may increase his alertness and improve his attention to a task. Clearly, these two theories are not mutually exclusive. Broadbent's position seems to imply that a distracting stimulus such as an illuminated, flashing, and/or moving advertisement may have no adverse impact on a driver's ability to attend to his primary task unless that driver is already approaching his finite channel capacity. This may occur, for example, under conditions of high speed, dense traffic, adverse weather, unexpected highway geometry, or unfamiliar territory. Under such conditions, the introduction of a novel or distracting stimulus may overload the driver, and lead to a temporary loss of attention which could result in an accident. On the other hand, Hebb (and others) have shown that in the absence of stimulation, such as in isolated areas or very low volume traffic, fatigue may increase with a corresponding decrease in attention or vigilance. Under these circumstances, the introduction of a novel stimulus might actually improve the driver's alertness by arousal of the neural system.

The results of Ady's study may be interpreted as supportive of Broadbent's theory. The one sign that was associated with a significantly higher accident rate was located in an already high-stimulus area. It was sited "on a very sharp curve where there is an important arterial expresssway emanating from the central expressway. Also it is placed at the end of a bridge segment . . ." (p. 10). This environment, further complicated by the presence of the variable message, alternating-light sign, could well have caused a perceptual overload of many drivers, especially under adverse weather and/or traffic conditions. Information about the proximal environment of the two non-significant signs is not presented in the report. Ady hypothesizes, however, that these locations did not present excessive stimulation to motorists.

There are obviously several limitations to the generalizability of Ady's findings. First, the sample included only three signs, and their representativeness is unknown. No data are given about traffic volume, actual numbers of accidents, or causes of these accidents as identified by investigating police. We have no objective data about any of the signs, such as size, distance from the road, flash rate, brightness, etc. And, despite the author's statistical controls, the novelty effect of the signs studied cannot be discounted since the study was conducted within the first year following their installation.

<u>Boston TELE-SPOT Decision: 1976</u>. Although not an experimental study in the strict sense, considerable information and accident data have been presented in the case involving a CEVMS (off-premise) installation adjacent to I-93 in Boston. The sign (see Figure 9), called a TELE-SPOT, was issued a permit in June 1972 and erected in February 1973. As installed adjacent to the elevated southbound lanes of I-93 (also known as the Central Artery or the Southeast Expressway), the sign consisted of two back to back displays, each measuring 32.5 x 14 feet (9.9 x 4.27 m), at a maximum height of 40 feet (12.19 m) above ground.

The sign contained 80 magnetic discs, called modules, arranged in four horizontal rows of 20 modules each. Each such module consisted of 35 "dots" arranged in a matrix of 7 rows by 5 columns. Each dot was painted "Day-Glo" yellow on one side, and black on the other. Testimony indicated that the Day-Glo paint, due to its unique properties, caused a displayed message to appear 25 percent more visible than would have been the case if standard white paint was used.

The message was formed by a computer-controlled magnetic pulse causing each dot to display its yellow or black face as appropriate. The pulse was transmitted at a rate of 30 modules per second, resulting in 2.67 seconds to change the entire message. The message was conveyed by light (either daylight or four fixed quartz floodlights per sign face at night) reflecting off the yellow paint.

The sign's permit was revoked by the Massachusetts Outdoor Advertising Board on May 23, 1973, approximately three months after the sign had been installed. The safety-related reasons given for the revocation, as stated by the Chief Engineer for the Massachusetts Department of Public Works, included, in part:

> We have studied the effects of the Telespot sign on Expressway traffic and have concluded that it introduces a distraction that is definitely detrimental and potentially crucial to these traffic flows.
>
> Specifically, the sign is too close to the traveled way....In order to read the sign, the driver's eye must stay with the sign and leave the roadway as opposed to a distant sign, which can be read with the roadway still within the driver's peripheral vision.
>
> Because of its proximity to the roadway, coupled with the fact that a lighted, variable sign does command attention, we recommend that the sign permit not be renewed (Massachusetts Outdoor Advertising Board, 1976, 3-4).

On June 1, 1973, a preliminary injunction was granted by the Superior Court forbidding the Outdoor Advertising Board from enforcing its revocation order without holding a formal hearing on the matter. This hearing was held on July 29, 1975, and resulted in a reaffirmation of the Board's earlier decision. The sign ceased operation in January 1976, and was removed in June 1978.

At a hearing, the Chief Engineer's earlier statements, mentioned above, were supported by accident data amassed over a 5 1/4 year period by the Metropolitan District (Police) Commission. These data were made available for the entire Southeast Expressway, broken down by direction of travel and whether the sign was visible or not. Data for a period of three years prior to erection of the sign and 2 1/4 years afterward were included. Accidents tabulated included only those causing personal injury and/or property damage in excess of $200. Accident cause was not specified. According to Metropolitan District records, the only change in the highway environment during the time period studied, other than the introduction of the TELE-SPOT sign, was a change in the average daily traffic count. Accordingly, these figures were included in the analysis.

The findings of the Outdoor Advertising Board after considering these accident data were as follows:

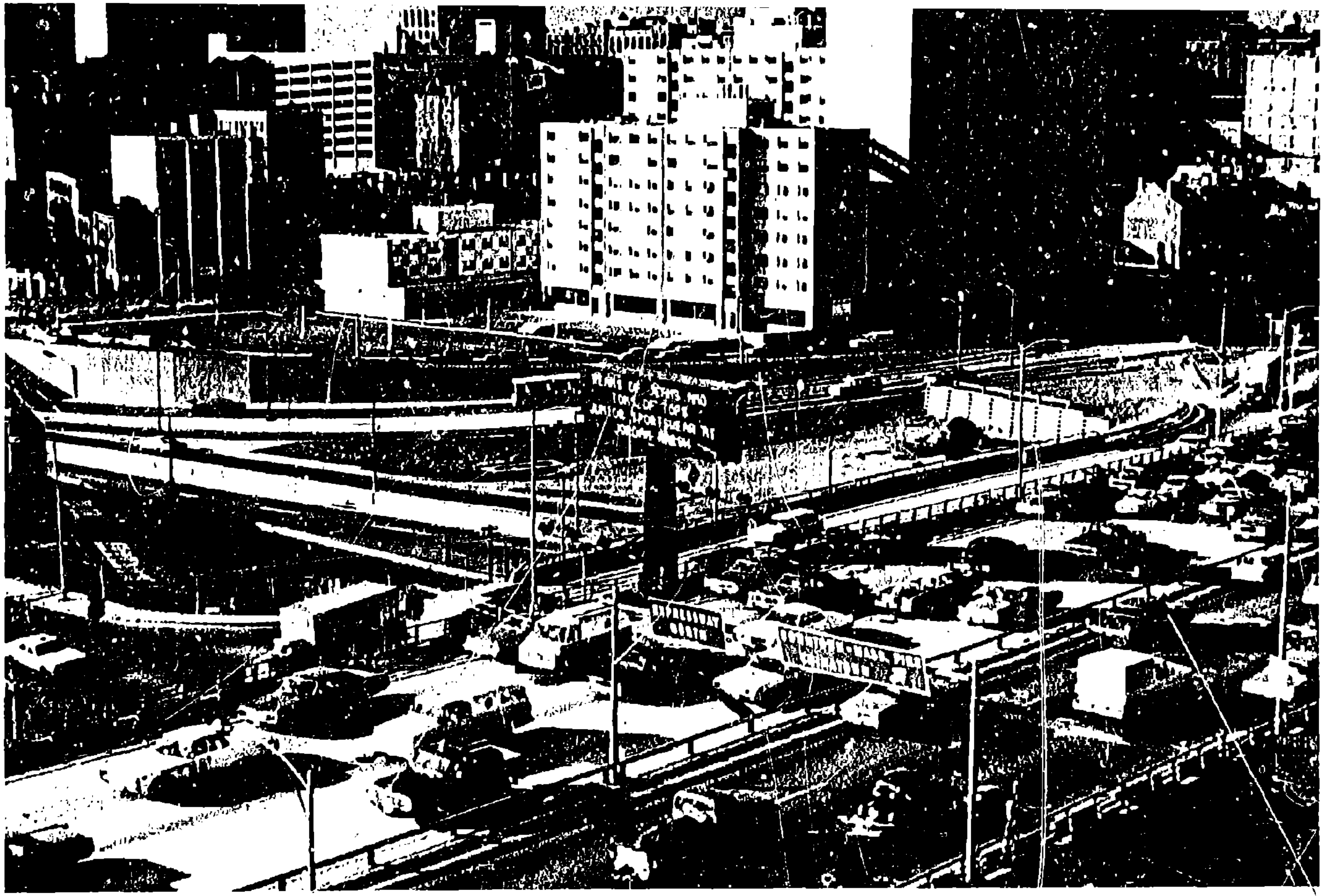

Figure 9. TELE-SPOT Off-Premise CEVMS Adjacent to I-93 in Boston. (Source: Massachusetts Department of Public Works.)

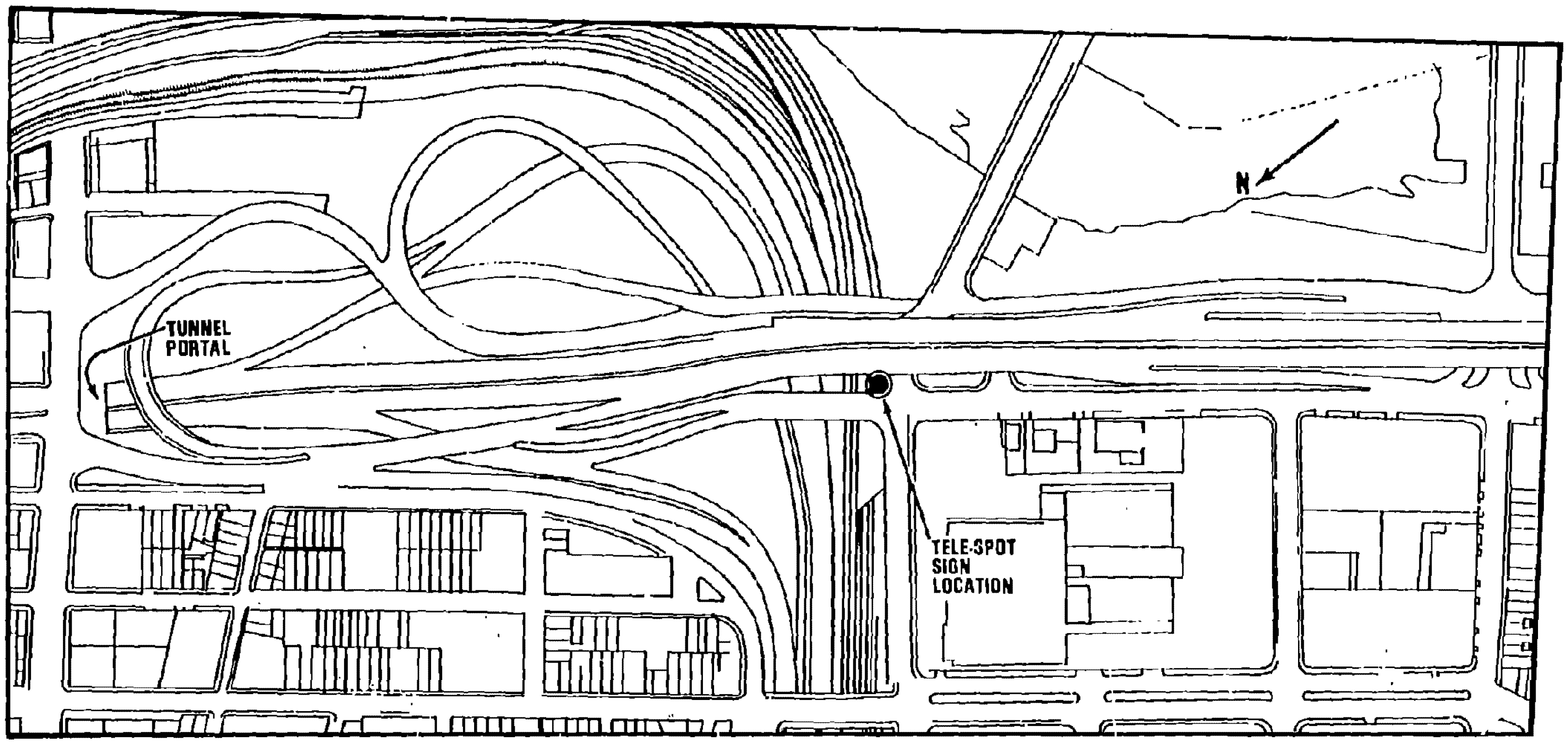

Figure 10. Map Depicting Relationship of I-93 TELE-SPOT Sign to Freeway. (Source: Adapted from Massachusetts Department of Public Works)

1. There has been a reduction in the accident rate in the area where the TELE-SPOT sign is visible since the sign has been erected.

2. This reduction has been part of an overall reduction of the accident rate on the Expressway . . . over the same period.

3. The reduction in the accident rate where the TELE-SPOT sign is visible is at least 10 percent less than the rate of reduction on this section of the Expressway as a whole. We find that this difference translates to five accidents per year on the southbound lane of the Expressway, and six accidents per year on the northbound lane, on those sections where the TELE-SPOT sign is visible. We regard this difference as significant (Massachusetts Outdoor Advertising Board, 1976, pp. 6-7).

For these reasons, and others not related to the present discussion, the Board's earlier decision to revoke its permit for the sign was affirmed.

It should be noted that this particular sign was located in an area that might be considered one of high driver workload. It was installed adjacent to an elevated freeway section, in the midst of complex on and off-ramps and official signing, and shortly after southbound motorists had exited from a tunnel. Average daily traffic counts for this roadway about the time the TELE-SPOT sign was installed were approximately 115,000 vehicles. (See Figure 10.)

As the reader may recall, the Minnesota study of 1951 also reported a significant interaction between high task demands and the presence of roadside advertising, when accidents served as the dependent measure. This small consensus, occurring as it does between three investigations of vastly different design and scope, is hardly sufficient as a basis for major decisions. Although it is a beginning, it would appear that one must look beyond field-based accident investigations in order to find the kind of reliability and validity required for decisions of this importance. Before broadening the search, however, let us briefly examine why accident evaluations have not proven to be more fruitful.

<u>Limitations on Research Using Accident Data</u>. In addition to various methodological and statistical faults which may have confronted the studies examined above, there are several general, but still significant, limitations affecting the use of post-hoc accident statistics for <u>any</u> type of on-the-road study. Most of these problems too have confronted researchers investigating the effects of advertising signs upon driver behavior--and, as we have seen, such studies have been undertaken for nearly 30 years. Problems associated with this type of research include, but are not limited to, the following:

1. Not all accidents are reported, and, those that are, are subject to wide variations in police reporting standards and procedures. Thus, the same accident might be classified very differently from one reporting jurisdiction to another, or even within the same jurisdiction between different officers or at different times. Thus, accident sampling is generally biased.

2. The precision with which an accident location is identified is often insufficient to relate it to a specific environmental landmark.

3. The environmental context in which the independent variable is located may not only be significant in terms of its impact upon that variable's effect, but may be very complex, difficult to define, and impossible to quantify. Furthermore, our measurement generally restricts the consideration of any particular object/background interaction to a static situation, when in fact all such interactions are experienced by motorists as parts of a larger, constantly changing experience. Thus, generalizations from any such "stop-action" measurement approach should be undertaken with extreme caution.

4. Accidents are relatively rare events. As such they are not only difficult to measure, but may in fact not be representative of difficult situations on the road. "Near misses," for example, as measured by such techniques as traffic conflicts or critical

incidents may be better indicators of hazards than accidents in the area. As has been stated by many authors (see, for example, Johnston and Cole (1976)), another alternative to accidents that is also of concern to traffic officials is impedance to vehicle movement that may occur if a motorist responds to a roadside hazard or distraction by moving more slowly, thus "enabling him to sample his surround environment more frequently per unit distance traveled" (p. 4). Obviously, the use of accident data does not reflect this type of driver behavior; in fact, it is possible that such motorist response has a beneficial result on accident statistics.

B. Human Information Processing and Human Factors Considerations

General. For the above reasons, the use of field studies with accidents as the main dependent variable has been legitimately criticized. Limitations such as these have undoubtedly been major factors in the often conflicting findings between the field experiments discussed earlier in this section. More recent research has responded to these challenges in two major ways. First, it has utilized, to an increasingly great extent, dependent measures of driver behavior in the field that are more closely related to the driver's actual performance than those (such as accidents) which may be mediated by a host of intangible or difficult-to-quantify variables. (In human factors terminology, this is referred to as proximal rather than distal measurement.) Two of the most promising and successful of these techniques are eye movement behavior and (in marked contrast to the opinions expressed in Claus (1974)), measures of moment-to-moment task difficulty or, in terms of its information processing basis, spare capacity. Second, recent research has relied increasingly upon laboratory simulation as an analogue to the real world. Despite some limitations on generalizability of findings, and questions of concept and construct validity of both independent and dependent variables, the use of increasingly sophisticated simulation techniques and research paradigms may help to provide a new understanding of the complex relationship between driver behavior and characteristics of the roadside environment. Let us examine some of these experiments.

Johnston and Cole-Laboratory Study: (1976). One of the most comprehensive laboratory studies of the relationship between distraction and simulated driving behavior was undertaken by Johnston and Cole (1976) under the auspices of the Australian Road Research Board. In the report of this study, the authors began with a careful discussion of early on-the-road studies and the conflicting results obtained, and proceeded to develop a brief but excellent summary of psychological research in the areas of distraction, human information processing, and spare capacity. Experimental use of the latter concept is being employed in an increasing number of investigations of variations in skilled performance under the influence of different environmental conditions (see, for example, Zeitlin and Finkelman, 1975). Spare capacity is defined as a condition in which "the subject is operating at less than his full [information processing] capacity and can cope with the demands of an additional task performed simultaneously. If the demands of the additional task exceed his spare capacity, the speed or accuracy of performance at one or both tasks may suffer" (p. 6). Supporters of the outdoor advertising industry (see, especially, Claus, 1974, pp. 6-11) have called the concept of information overload as it concerns the potentially distracting effects of roadside advertisements "a spurious issue" because "the human brain is marvelously designed to filter out information that is uninteresting, irrelevant, or useless. Because of the phenomenon of selective attention . . . we are never overwhelmed by the available information" (pp. 8-9). This argument is incorrect for two important reasons.

First, in many situations where commercial advertising signs are located along highways, the concern for safety occurs precisely because of the human selective attention process. As an example, if a motorist is tired or hungry, or his car is about to run out of gas, much of his available processing capacity may be consumed by the search for suitable facilities and consequently the reading of signs describing such facilities. Thus, signs conveying such information may well assume primary rather than secondary importance, and the search for such signs demands that other commercial signs be examined for relevance by the motorist. The amount of spare capacity available for the nominal primary task of driving may therefore be diminished. If this situation occurs at a critical time or location, such as a freeway interchange, a slippery pavement, a tire blowout, or an unsafe act by a nearby driver, insufficient processing capacity may be available at that moment to deal with the situation adequately, and an accident could result. Second, it has been shown that even irrelevant stimuli can compromise the driver's task under high-demand conditions. This being the case, the rapidly developing electronic technology of the advertising industry, coupled with sign designers' increasing application of human factors principles to gain and hold the motorist's attention through the use of size, color, message, display, placement, and now movement and change of the display, may combine to create potentially dangerous situations under certain highway and traffic conditions. Let us return to a consideration of the Johnston and Cole research.

A series of five interrelated experiments was designed in which three major parameters were systematically varied. The subjects' primary duty was a tracking task--the response with a joystick control to the visual presentation of left- or right-pointing arrows. Response times and errors were measured. The temporal sequences and randomness of appearance of tracking stimuli constituted the differences in experimental conditions. A secondary, detection task was employed in experiments 3 through 5. Here, small spots of light were presented infrequently in the periphery of the visual field, and the subject indicated his awareness of them with a pushbutton. The distraction stimuli consisted of 20 different sequences (2 for practice and 18 for the actual study) of 12 slides each, showing colorful advertisements that the authors chose for representativeness of "product advertising which might appear on a roadside billboard" (p. 11). The projected distractor images could be presented at different locations in the visual field, and either as stationary images or with movement to simulate the effect upon the motorist that might occur in a moving vehicle. In some cases the distractors were flashed on and off to increase their distracting properties. The actual details of the experiment, including the multifactorial analysis of variance used for statistical significance testing, are too complex to be discussed in the present report. The reader may wish to consult the original study for this information. A summary of the experimental conditions is shown in table 3.

It was found that the presentation of high information content but irrelevant information as a visual distraction degraded performance on two types of visuomotor tasks: tracking performance deteriorated in two of the five experiments; and response times to the detection task increased significantly on the last three experiments. When tracking and detection were both required in the presence of distraction, tracking performance improved, which seems to indicate the existence of a task-induced alertness. The introduction of temporal uncertainty into stimulus presentation of the tracking tasks, and the reduction of contrast of detection targets on that task, both resulted in poorer performance. It was also found that the distractors produced a large increase in response times to faint peripheral stimuli. This, the authors believe, was a function of disability glare, and should serve "as a strong argument for regulation of the luminance and size of displays such as advertisements which are extraneous to the driving task. Some requirement for a reduction in luminance at night should also be considered" (p. 20).

Several difficulties with these experiments may have reduced the more general utility that the study might have had, and its specific applicability to driving in the United States. First and perhaps most important, the tracking task permitted only an average tracking score to be obtained for each sequence. The

Table 3. Experimental Design: Johnston and Cole.

Experiment No.	No. of Subjects	Primary (Tracking) Task	Distraction Stimuli	Secondary (Detection) Task
1	10	Input rate of tracking stimuli 0.5 and 1.0 Hz for a duration of 100s. Temporal certainty (identical intervals between stimuli).	12 stimuli per track accelerated to a position 45° to the left of the fixation target not flashing.	None
2	6	Input rate 0.5 Hz with regular, random, and episodic temporal uncertainty.	12 stimuli per track positioned stationary above tracking task display. Flashing at 1.24 Hz. 50% duty cycle.	None
3	14	Input rate 9.5 Hz random temporal uncertainty.	As for Experiment 2.	Detection of high contrast infrequent spot stimuli 7½° to right or left of the tracking display. Spatial and temporal uncertainty. Five detections per track.
4	15	As for Experiment 3.	As for Experiment 2.	As for Experiment 3 but with variation in spot luminance and contrast.
5	14	Input rates 0.5 Hz, 1.24 and 1.4 Hz with random temporal uncertainty.	As for Experiment 2.	As for Experiment 3.

authors felt that profound changes in performance might have been observed if they had been capable of evaluating the effects of individual distractors. This would also have been a more accurate simulation of a highway driving situation. Second, despite results of the first experiment, which showed a significant decrease in tracking performance as information input rate was doubled (indicating poorer performance as perceptual loading increased), it was decided to use the lower rate for subsequent experiments as it was felt that this was closer to an actual highway driving situation. Thus, it was not possible to investigate in detail the relationship between high task loading, visual distraction, and the secondary (detection) task which would have provided additional evidence to support or refute one of the authors' concluding suggestions that "distractions should be minimal where vehicle operators may be loaded more heavily than usual" (p. 21). And third, the distracting stimuli, chosen by the authors because they were thought to be representative of typical colorful advertisements that might appear on roadside billboards, and because they were considered to be "sufficiently commanding to distract an operator's attention from a visual task" (p. 11) seem to be rather unrepresentative of American advertising signs in that they are graphically bolder and more sexually explicit than roadside advertisements tend to be in this country. In addition, the test subjects tended to describe the distractors as bright, colorful, and interesting, although they were generally unable to read even the largest text on them. This suggests either excessive task demands during the study, unrepresentative advertising stimuli (which one would expect to be designed for maximum legibility), or poor photographic reproduction of these stimuli.

Despite these limitations, Johnston and Cole's research is one of the best controlled studies yet made that directly addresses the question of the relationship between distracting visual stimuli along the highway and performance on tasks designed to simulate driving control behavior. In addition, their work seems to have stimulated additional experimentation by others, to which we will now turn.

Holahan, et al., Laboratory and Field Studies: 1978. In 1978, Holahan and his associates undertook two studies in this subject area--one in the laboratory, and a second which might be considered a verification effort in the real world. After briefly discussing the contradictory findings and methodological weaknesses of many field studies investigating the relationship between visual distractors and traffic accidents, Holahan et al. (1978a) cite the need for a well controlled laboratory evaluation of the effects of certain dimensions of the background (distracting) environment on reaction time in responding to a traffic signal. This dependent measure was chosen because it was thought to relate to both attentional deficits and accident risk in real driving situations. The background dimensions selected were: number of distractors (2, 4, 6, 10); color of distractors (several combinations of red, orange, blue, green, black); and location of the distractors relative to the target stimulus (proximate, distant). Each distractor was a replica of a commercial sign with a different white, four-letter word printed on it. The words were chosen for their "moderately high English language occurrence" (p. 410). The stimuli were projected as color slides onto a grid placed before each of the 56 test subjects individually. A trial consisted of a presentation of a randomized sequence of pairs of distractor combinations. Each pair included one with the target stop sign present and one with it absent. The subject's task was to press a "stop" or a "go" button, as appropriate for target presence or absence. Instructions were to react as quickly as possible, while avoiding mistakes.

The results of a three-way analysis of variance (ANOVA) were strongly supportive of all hypotheses, as follows: (a) Mean reaction times (RTs) increased with greater numbers of distractors; with proximate versus distant locations; and with a predominance of red and orange distractors present in the field; and (b) All two-way interactions between background dimensions were statistically significant. Proximity showed an "overwhelmingly strong effect" (p. 411), indicating the subjects' inability to differentiate the stop sign from the array of background distractors. On the other hand, in the distant condition, strong effects were seen due to both number and color. The authors interpreted this to indicate that in the distant case the subject used more of a scanning process to evaluate the stimuli in the field.

The authors conclude that the location of distractors relevant to the target signal is of major importance. When close to the target, any number or color of such distractors is likely to reduce the driver's ability to react effectively to that target. When distractors are farther away, a large number of them and/or the presence of colors similar to those of traffic control devices "may operate as potential traffic hazards" (p. 412).

Of course, in any laboratory simulation, there may be problems of generalizing results to the real world. For example, rapid reaction time to a stop sign is only one of many critical behaviors necessary for traffic safety and accident avoidance. Rarely do we find distracting stimuli in the real world that are of similar apparent size to stop signs, yet this potentially important variable was not manipulated. It is unclear why the dissimilarly colored distractors were limited to the "cool" colors of blue, green, and black, when it is likely that advertising signs can and do appear in a wider variety of colors including brighter ones such as white or yellow. Obviously, we cannot know what effect, if any, the use of such colors might have had on the results. And, even given the limitations of a reaction-time task, the requirement was to press a button on a small panel in front of the subject--a far different task than is generally encountered while driving. Despite these criticisms, however, this is a reasonably well controlled laboratory study, employing a task and an array of stimuli at least conceptually related to an important aspect of driving in the presence of roadside distractors.

The same senior author has also attempted a field evaluation of findings obtained in the laboratory. Holahan et al. (1978b) investigated the relationship between signs located in the vicinity of urban intersections and accidents at those intersections (an investigation closely related to the work done in Minnesota 27 years earlier). Independent variables examined included number, size, and color of signs. Predictions, as in the laboratory study reported above, were that increasing numbers, larger sizes, and greater similarity of color between signs and target traffic control devices (stop signs and traffic lights) would all relate positively to traffic accidents. Only urban intersections were chosen, and these were coarsely matched for geometry and traffic volume. Sizes and colors of signs were categorized in only two ways: small signs were defined as those whose size was equal to or smaller than a standard stop sign, whereas large signs were defined as those obviously larger than a stop sign; signs were defined as red or non-red according to their predominant color. "At-fault," daytime accidents (primarily failure to stop or to yield right of way) were used as the dependent variable.

Of the many findings reported, several are of direct relevance to the present report. First, although there is strong evidence that distracting signs are related to accidents at intersections controlled by stop signs, there is none to link such signs with accidents at intersections controlled by traffic lights. The authors suggest that this may be due to several reasons, including: the predominant location of the signal on an arm extending over the intersection versus that of the stop sign on the right-hand curb; the similarity of the communications medium between commercial signs and stop signs, whereas signal lights are of very different configuration; and the greater size similarity between commercial and stop signs, as opposed to the often very disparate sizes of commercial signs and traffic signals. Second, at stop sign-controlled, high-accident intersections, several characteristics of signs demonstrated a significant partial correlation (controlling for traffic flow) with accidents. These characteristics were those which were representative of large size commercial advertising signs. The authors suggest that, where restrictive legislation controlling the number and size of commercial signs in the vicinity of stop signs cannot be enacted, engineering alternatives, such as larger or brighter stop sign material, or neutral background shields to isolate the stop sign from its surround, should be considered. Despite certain limitations in experimental design, and the failure to control for many possible intervening variables, the results of the study seem well founded. The authors' summary statement may be particularly relevant for our purposes: ". . . these results underscore the need for the traffic engineer to accept broader legislative and engineering responsibility for the <u>total</u> traffic environment, including both the public roadway and the contingent environmental context in order to cope effectively with the dramatically increased visual complexity of today's roadside environment" (p. 8).

Finally, let us look briefly at a research approach that has been used with increasing sophistication and success over the last two decades, in examinations of the types of independent variables and driver behaviors of direct relevance to our present task. The methodology in question is the measurement of driver eye movements. With one known exception (Lehtimaki, 1974), no eye movement research has been identified that specifically studied roadside commercial signs as stimuli. Some, however, have come close, including an earlier effort by Bhise and Rockwell (1973).

Bhise and Rockwell - Field Study: 1973. Although concerned exclusively with official highway signs, this carefully designed and controlled comprehensive series of studies may provide us with the best methodology available for analysis of the problem being addressed in this report. The research technique developed by Rockwell and his associates at Ohio State University and refined over the years involves the recording of driver eye movements under actual field conditions. The methodology was developed primarily to evaluate systems for displaying road sign information to motorists. Except for some minor potential difficulties in extending this technique to the measurement of driver reading of commercial signs (to be discussed below), the approach would appear to be directly applicable to our needs. Further, it can overcome the majority of difficulties which have plagued much of the research discussed in this report. Its major advantages are as follows:

1. The system may be used in the field, thus overcoming the claimed disadvantages and restrictions on generalizability of simulation data. On the other hand, the system is also suitable for use in a controlled laboratory setting, and thus may be employed when the advantages of simulation (lower cost, greater safety, examination of proposed but nonexistent alternatives, control of potentially confounding variables (e.g., weather or traffic variables, to name a few) are considered desirable.

2. The use of an instrumented vehicle enables the collection of simultaneous synchronized data on eye movements, driving performance, and the driver's view of the roadside environment.

3. Since eye movements are to a large extent involuntary, the measurement is free of bias. When appropriately combined with performance measurement (such as steering response), a powerful dependent response variable is obtained.

4. Data can be obtained for the signs (or other roadside features) of interest without specific instructions to test subjects. Thus, prejudicial behavior due to instructional set or the subject's perception of the purpose of the study may be all but eliminated.

5. With the exception of the burden imposed by the equipment, the test subject is free to look and respond in a natural manner. He need be given no artificial tasks to perform (although certain such tasks, such as subsidiary loading, may yield meaningful additional data), and the results obtained are real-time, precisely measurable, and directly attributable to his voluntary behavior in a specific situation.

From the summary statement of results from the Bhise and Rockwell study, the reader can see the potential utility of their methods for the problem of studying the relationship between salient characteristics of advertising signs (those relating to their "attention-getting" characteristics as mediated by the enhanced capabilities of CEVMS presentation) and certain parameters of the driving environment (those that relate to the extremes of either minimal stimulation or of overloading the motorist). Some of these relevant results are as follows:

1. An important variable for both sign design and evaluation is the maximum time/distance from a sign at which a motorist first begins to acquire information from it. This time/distance decreases with an increase in visual loading caused by increases in traffic density.

2. After their initial fixation on a sign, drivers generally time-share between it and other objects on the road. This time-sharing process is dependent upon many situational factors, including: time/distance to first fixation, traffic density, message characteristics, relevancy of information

to the driver, etc.

3. For road and signing conditions defined as "confusing (and) inadequate" sign reading behavior begins later, lasts longer, and is more concentrated during the time-sharing interval.

The implications of these findings for the study of advertising signs in particular are unknown, although the relevancy of this type of information and the applicability of the method seems clear. There are some potential limitations to this approach, some of which have begun to be overcome recently. These possible limitations should be considered before FHWA conducts research using eye movement methods.

1. The system used by Bhise and Rockwell was restricted to measurement of a 20° by 20° visual scene ahead of the driver. This is probably inadequate to allow for the measurement of eye fixations on advertising signs located nearer the periphery of the visual field. State-of-the-art equipment, similar to a system presently being developed for FHWA, should permit measurement up to 60° horizontal by 40° vertical. The adequacy of these broader visual field coverages will have to be evaluated empirically.

2. The Bhise and Rockwell system employs rather cumbersome and uncomfortable head-mounted equipment. It must be individually fitted to subjects and can be used only for relatively brief periods of data collection. Some potential subjects cannot be fitted with the equipment at all. Here too, some newer designs permit freedom from head-mounting, and may therefore provide much greater flexibility of subject selection and utilization.

3. The degree to which the presence of test equipment and instrumentation modifies a subject's behavior in an experiment is not fully known. Much has been written about this topic, but it is beyond the scope of this report.

4. The fact that a driver fixates on a sign (or any other roadside object) does not necessarily mean that he is reading it or processing information gained from it. The availability of motorist performance data can be of considerable help in this situation, but researchers must be careful to correlate the two data sets.

Lehtimaki-Field Study: 1974. As mentioned above, one study, written and reported in Finnish (Lehtimaki, 1974) did incorporate the use of eye movements as a means of observing motorist response to roadside advertising signs. At the present time, only a brief abstract of the study is available in English, although this office is presently having the full report translated. The experiment, which included motorist interviews and vehicle speed measurement in addition to the eye movement recording, was summarized by the author's English abstract as follows: "The effect of roadside advertisements on driver behavior was verified. Categorical or direct influence on traffic safety was not confirmed but the roadside advertisements seemed to have some risky characteristics." Obviously, without an understanding of the actual experiment, no evaluation can be made of the conclusion as stated. Such an analysis must await receipt of the translation.

To a considerable extent, traffic operations personnel are in competition with advertisers for the motorist's attention. Clearly the intent of most advertising is to sell a product or service, and in the highway environment the target customer is the motorist. Since considerable amounts of money are expended on such advertising (the Boston TELE-SPOT sign discussed eralier cost approximately $220,000), it is to the advertiser's advantage to communicate as effctively as possible with the largest possible audience. Researchers have studied this problem at length, and, as reported by Burtt 30 years ago, cited in Forbes, et.al. (1965), have long since concluded that, in the field of advertising, "relative size and intensity, brightness and color contrast, motion or brightness change, are physical factors especially effective in attracting visual attention. Brightness contrast, change and motion are especially effective when a sign is seen in peripheral vision" (p. 53).

According to Hebb's theory discussed earlier, the presence of distracting stimuli may serve a beneficial alerting effect in circumstances where the driver is performing something approaching a vigilance task (i.e., a long-duration, low-stimulation task such as driving at night on a low volume rural freeway). Unfortunately this is the least likely location for an advertiser to place a sign--particularly a state-of-the-art CEVMS, as the audience is small and the potential return on investment is low. Although the research studies reviewed in this report present various apparently conflicting findings, they seem to indicate that under routine driving conditions there is little, if any, correlation between driving performance and the presence of roadside advertising signs. However, a growing consensus agrees that, as the demands of the driving task increase, and roadside advertising must compete with these demands for drivers' finite attentional capacity, the risk of overload is a real one. Demands such as heavy traffic, complex interchanges and geometrics, lack of familiarity with the area, high prevailing speeds with considerable inter-vehicle variation, and adverse weather may interact to load the driver's information processing capability to its limits. The presence of distracting stimuli in the motorist's visual environment, particularly those stimuli designed by professionals for high visibility, legibility, and attention-getting characteristics, as described by Burtt as early as 1948, may overload the driver, even if only momentarily, and lead to an accident or a breakdown in freeway traffic operations. Recent on-the-road studies using proximal driver response measures such as the eye movement research of Rockwell and his colleagues, accident analyses, and well controlled laboratory studies such as those of Holahan, and Johnston and Cole, have tended to clarify the situation and put it into perspective. A piecing together of theory with the research reported herein seems to indicate that, when attentional demands of the driver's task are very low, the presence of a "distracting" or "attention-getting" stimulus (be it an advertising sign or perhaps any other visible roadside object) may contribute to maintaining driver alertness.

In the middle range of traffic and roadway conditions, such signs appear to have no clearly discernable pattern of impact. In high task-loading situations, however, recent research seems to be reaching a consensus that the impact of such distractors is decidedly negative. And, where discussed, those sign characteristics that might intuitively be thought of as most distracting are indeed the ones that seem to cause the greatest impact. Unfortunately they are also likely to be the features that advertisers consider most effective in attracting and holding the attention of the passing motorist.

The task that remains for FHWA is to better define and delineate those highway and traffic situations in which the danger of attentional overload from such distractors is high, and to better identify those characteristics of distractors which contribute to the overload. The possible facilitating effects of such signs under low stimulation conditions should also be examined and delimited.

Figure 11 illustrates an oversimplified conceptual model of the impact of roadside advertising signs on motorists' performance under different degrees of attentional demands imposed by the driving task.

With the caveats mentioned earlier, it is recommended that a carefully controlled field study be undertaken first. Ideally, this would employ three major dependent variables with several submeasures of each. The major dependent measures would be eye movement behavior, relevant driving performance dimensions in an instrumented vehicle, and processing load/spare capacity as defined by subsidiary task performance. The FHWA's advanced Traffic Evaluator System (TES) could also be employed to gather traffic operations data in the vicinity of signs of interest. Major independent variables, of course, would consist of the presence of CEVMS (as well as conventional advertising signs) along the route, and controlled levels of primary driving task

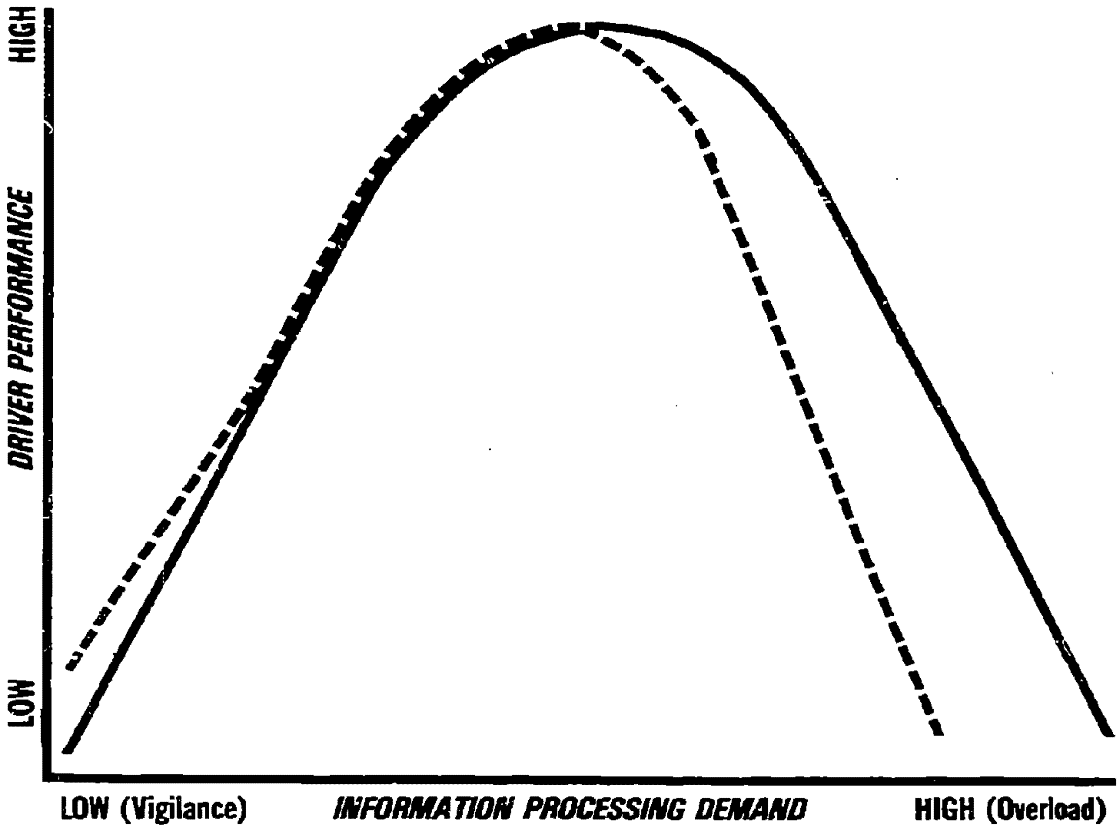

Figure 11. Conceptual Model of the Impact of Roadside Advertising Signs on Motorists' Performance Under Different Degrees of Attentional Demands Imposed by the Driving Task.

demand (as mediated by such factors as traffic volume and speed, weather, roadway geometry, etc.). Based upon trend data established from this field study, a laboratory experiment would then be undertaken which would explore in greater detail the contribution to driver performance of specific sign-related characteristics and interactions of these independent variables. The end result should be the first unambiguous understanding of the relationship between CEVMS along the highway and the performance of motorists in the vicinity of such signs. With this knowledge, guidelines for permitted or prohibited use of such signs could be objectively established.

It should be pointed out that before any such study is begun, a clear understanding of sign variables and characteristics must be adopted. Despite statements from the advertising industry and its supporters that the use of CEVMS technology will result only in signs of the highest aesthetic and human factors standards (see, for example, Claus (1974) and American Sign and Indicator Corporation (ASI) (1976)), it is obvious that the technology makes possible almost limitless capabilities of such display characteristics as alpha-numeric and character style, color, brightness, motion, etc. For example, the issue of flashing signs, one aspect of billboard control which was not amended in the 1978 amendments to the Highway Beautification Act continues to cause much controversy. Interestingly, flash characteristics of signs seem, theoretically, to be one issue that both the industry and highway safety specialists agree is in need of control, yet major differences exist with regard to means of such control and even to the definition of the term "flashing sign." Specific regulation of flash rate has been particularly susceptible to challenge by the signing industry. Claus (1974), for example, addresses her paper titled "Psychological Research and Government Control" at only one of four aspects of a proposed California law potentially affecting CEVMS--a limitation on the time interval (maximum of one every four seconds) between changes of sign copy display. Other aspects of the law, which Claus did not challenge, concerned: motion or apparent motion; intervals between messages; and changing of illumination intensity. Specifically, Claus states that: "If the literature is not clearly and unequivocally supportive, the four-second limitation can be viewed as arbitrary and should be reconsidered" (p. 7). Although her review of the literature is incomplete, and her premise of seeking "unequivocal support" for a four-second rule is obviously geared to win her argument, Claus' case against the arbitrary decision point is well taken. Her suggestion that a reasonable regulation would restrict the upper bound on the length of information display rather than the lower bound is without foundation. Nevertheless, it calls attention to the very basic disagreements that exist in this area of inquiry. ASI (1976) agrees that: "The term 'flashing' in its technical sense must be indicated and precisely defined by a sign ordinance" (p. 5). This firm then proceeds to offer, within the same report, three contradictory definitions, none of which provides the precision which they claim is mandatory. In contrast to Claus' discussion, the human factors literature is filled with well controlled, empirical studies which can provide supportable evidence concerning the safety and communications aspects of flashing lights and signs. Although inclusion of this literature is beyond the scope of the present report, to ignore it when future legislation or research is considered will only allow the controversy to continue unabated. The present authors agree that precise definitions must be established and agreed to, not only for flash characteristics, but for the many other display parameters that may now be (or later become) under dispute. Flash rate was selected as the topic to exemplify this controversy because it has received attention from the industry, it has been the subject of legal disputes, and human factors psychologists do possess considerable information about the subject. More will be said about flashing signs and lights, and about recommendations for needed research, later in this report.

Summary. In summary the literature on highway safety and, in particular, human factors, has demonstrated two major areas of concern over the impact of roadside advertising on motorist behavior. First, theories of distraction of attention put forth by Hebb and Broadbent, and discussed by Ady (1967), among others, would appear somewhat complementary in their applications to the present problem. According to Ady, "it would appear that Broadbent's theory is tenable when we have driving conditions in which the individual is bombarded with many perceptual stimuli: heavy traffic volume, complex expressway systems, and directional signs in metropolitan areas. Hence, the addition of distracting stimuli, such as illuminated advertising signs, should produce severe vigilance decrement . . ." (pp. 9-10). Ady further argues that Hebb's theory, which deals with vigilance in the absence of distracting stimuli (such as in isolated, night, and/or low traffic areas) would not dispute conclusions extended from Broadbent's work. It is suggested by the present writers that the application of Hebb's work to such isolated traffic areas might demonstrate a facilitating effect of highly visible objects near the roadside, including advertisements, since they might serve to alert the driver and enhance his vigilance performance. Several recent studies, especially those of Holahan, et.al., (1978a,b) and Johnston and Cole (1976) have lent further credence to Broadbent's theory. To the best of our knowledge, no empirical work has been undertaken in an attempt to examine Hebb's theory in a rural traffic environment.

The second major area of human factors research demonstrated to be relevant to studies of roadside advertisements and traffic safety is that of human information processing and overload. Laboratory and field research, including that of the authors just cited, as well as others such as Bhise and Rockwell (1973), has demonstrated an interactive effect explainable both by an information processing demand that may momentarily exceed the individual's channel capacity to process that information, and by Broadbent's work discussed above. The implications again relate to the potentially negative consequences for highway safety and traffic flow of permitting highly stimulating, distracting stimuli that may present information irrelevant to the driver's immediate task to be located along road segments in which demands on motorists may already be high.

It is important to note that commercial signs have not been "singled-out" for criticism by highway safety experts. In his comments on a study by Dudek and Messer on design considerations for a real-time freeway information system, King (Dudek and Messer, 1971) discusses the concept of motorist information needs. These are, in order of "primacy" or importance: microperformance (including control aspects of the driving task such as steering and speed control); situational (guidance tasks such as car following, overtaking, and passing); and macroperformance (navigational needs including trip planning and direction finding). Judgments regarding primacy are made on two criteria. First is the likely consequence of nonreceipt of the required information. This ranges from the potential for catastrophic failure (such as an accident) if microperformance needs are not met, to a relatively minor difficulty such as lost time, for a macroperformance information loss. The second criterion used to determine primacy is time frequency of need occurrence. Again, microperformance information needs are of the highest importance, as such data are needed almost continuously; whereas macroperformance information is needed infrequently (and, in fact, such needs should often be satisfied prior to driving) and thus is of the lowest importance. One additional distinction is required, and that is between objective and subjective primacy. The latter is, of course, driver determined, and may or may not be in accord with objective primacy. King asserts that, by attending to a particular information source, a driver has established a subjective primacy. The degree to which this coincides with objective primacy is an indicator of the success of the information system.

To the extent that the two measures of primacy do not coincide, the driver has placed himself in a potentially dangerous position. "Diverting attention from a rapidly diminishing gap to a sign for route information is indicative of poor subjective primacy. A well-designed information system must attract the driver's attention to the primary need when competing needs exist and release his attention when the need is satisfied" (p. 13).

Similarly, another study of official motorist communication systems concluded that when it becomes necessary for the driver to scan the roadway and directional signing to prepare himself for future maneuvers, such as reaching his destination exit, "no real problem is created if the driver has the capability of accepting and processing the additional information. If, however, the lanes are relatively narrow, the geometry complex, and the traffic dense, time must be taken from one or both of ... [his two primary tasks] resulting in a reduced level of vigilance on tracking and operation which in turn results in an additional accident potential. This might mean that the inattention that is usually cited as the 'cause' of most accidents is truly attention to another element of the driving task" (Woods and Rowan, 1969, p. 16).

It should be obvious that those roadside advertisements which provide directional information (such as the route to follow in order to find a hotel or restaurant) may be thought of as part of the macroperformance information subsystem. On the other hand, those signs which simply advertise a product or service, or even those which present "public service" information such as time and temperature, are really communicating with the motorist at an even lower, or fourth level. It would be neither unfair nor harsh to describe such communications as irrelevant to the driver's task. Objective research undertaken to answer questions about the effects of roadside advertising on driver behavior should also yield meaningful insights about official signing, and vice versa.

C. Visual Quality and Aesthetic Aspects of the Highway Environment

Standards for Aesthetic Analysis. Although the issue of aesthetics has often been linked with questions of highway safety (and rightly so), that will not be the focus of this section. Indeed, when discussing the relationship between roadside advertising and traffic safety, we have shown that much controversy exists over how to properly measure driver variables such as distraction and information processing. The contribution of aesthetics, thought to be a subjective and often elusive concept, is even more difficult to measure with available methods, although some such attempts are underway.

Rather, if we were to follow the trends established in numerous recent publications on highway aesthetics, we might conclude that the major goals of highway planners and designers are to promote the comfort and well being of highway users by preserving and enhancing the natural scenic beauty of the areas through which the highway passes. Recent emphasis on landscape assessment and visual resource management (VRM) exemplifies this respect for the natural environment. It is argued that a generally unobstructed view from the road be provided, and, to the extent possible, such design objectives as traveler orientation, visual stimulation, enhanced understanding of the landscape, and facilitation of route choicemaking be sought (Hornbeck and Okerlund, 1973) through an objective consideration of a landscape's vividness, intactness, and unity (Jones and Jones, 1977). For an example of the application of VRM techniques to an actual highway project, the reader is referred to "Colorado I-70 Scenic Lands" (Federal Highway Administration et al., 1975).

Efforts at enhancing the aesthetics of the roadside environment are not limited to rural areas. In fact, several cogent publications have dealt expressly with highways in high density areas. In "The Freeway in the City," the Urban Advisors to the Federal Highway Administrator cited as one of their major recommendations the following: "Encourage a high level of visual quality in every proposed freeway. Each highway plan reviewed should demonstrate careful consideration of aesthetic values, a systematic approach by which such are to be achieved, and evidence that the highway in fact provides a continuing sequence of rewarding visual experiences" (Urban Advisors, 1968, p. 20).

The controversy over where and under what circumstances roadside advertising can be regarded as compatible with natural and man-made surroundings is long-standing. The New York case of Rochester v. West in 1900 (164 N.Y. 510, 83 N.E. 673) illustrates the early attempts to define a standard of compatibility in legal rules. Courts have preferred to make these judgments case-by-case, and the long line of such cases has continued until the present time.

It is readily observable that the extent to which billboards are incompatible with the visual environment may vary according to the location, design, and condition of both the sign and its surroundings. However, determination of compatibility seldom has been based on objective and rational analysis. Criticisms of observable poor practice in outdoor advertising have tended to condemn it in all of its forms. (Beyond the Eye, 1973, p. 1440.)

Sears (1964) questions "why the businessman follows evenings spent in some cultural or creative activity with days in which he erects more billboards and bigger signs ..." (p. 54). Barker (1972) quotes an observation that "the main offense of the billboard is that it offends everyone's taste by intruding upon the landscape" (p. 1). The American Society of Civil Engineers, in its publication titled "Practical Highway Esthetics" (1977), states: "The most pervasive and inappropriate visual pollution comes from outdoor product advertising. This is a problem chiefly of the primary and interstate highway systems where traffic is heavy enough to provide large captive audiences for the advertisers" (p. 10). Other commentators, subordinating functional distinctions to aesthetic considerations, have declared: "Since almost all billboards are aesthetic evils, if aesthetic grounds were its primary motivation a legislature would prohibit billboards altogether" (Beyond the Eye, 1973, p. 1449.)

Not all appraisals of outdoor advertising have been negative. Barker (1972) strongly criticizes billboards for aesthetic reasons, but he cites the opinion of a professional urban designer that, despite their "vernacular vulgarity," billboards are necessary, dynamic expressions of urban life that should be accepted and integrated into our architecture. Gossage (1960) concludes that the legal reasons for prohibiting commercial advertising signs in roadside areas are much stronger than the aesthetic reasons. If, he argues, the main points of the anti-billboard aesthetic criticism are that billboards block one's view of the scenery and therefore are unsightly, it becomes legitimate to consider all those things that are even less pleasing to look at than billboards. "There are quite a few: ramshackle barns, flophouses, poolrooms . . . . Since the world is absolutely stiff with arguably uglier objects it may be some time before the billboards come down; presumably the last billboard will stand on top of the last shack" (p. 16).

These observations are appropriate, for it is easy to cite examples of man-made roadside features that are poorly designed or are deteriorating from neglect. Admittedly all of these examples impair the highway's visual environment in their own ways. Their significance, however, is not that the existence of one type of offensive feature provides an excuse for others, but that the existence of good and bad examples of each type of roadside development furnish a frame of reference for developing standards to achieve the best level of visual quality in roadside areas. Investments in good design of man made development or natural environment deserve protection, and there is a need both for preservation of private roadside investment and the rural landscape where highway geometric design or selective landscaping has been undertaken.

Unfortunately, there is very little research information with which to make such judgments. The Lauer and McMonagle (1955) laboratory study discussed earlier was one of the first, and still one of the only empirical investigations to even address the issue of the aesthetics of roadside advertisements. But its sole reference to the subject was reported as follows:

> The driver would notice as many or more other objects and features of the landscape when the signs were present as when they were absent. In other words, the theory that various signs along the highway will decract from the natural beauty does not seem to hold (p. 324).

A careful reading of the entire report, as well as several reviews of it, yields no additional information beyond that quoted here. Thus, the present writers are forced to conclude that Lauer and McMonagle were not justified in reaching <u>any</u> conclusions about the impact of roadside advertisements on the driver's perception of natural beauty.

Although the relationship between aesthetics and roadside advertising has been the subject of much comment over the years, the amount of empirical research undertaken, as stated above, has been minimal. Very likely, this is due to the perceived subjectivity of the variable and the attendent difficulties in defining and measuring it. Despite the fact that the chairman of the New Jersey Garden State Parkway could issue an appeal to the advertisers' better judgments because he was convinced that advertising signs were a detriment to the parkway's scenery, natural attractiveness, and highway beautification efforts; and despite ASI's (1976) expressed intention to "design aesthetically pleasing public service information displays that conform to a quality environment in the visual sense" (p. 1), neither could directly support their views with any significant body of empirical research.

With a simulation technique similar to one employed previously by Winkel, et al. (1970), Sims and Schmid (1977) performed a study to test the "probable effectiveness" of parts of the sign code adopted four years earlier by the city of Dallas, Texas. They sought to examine the ordinance's utility in achieving two of its stated goals: (a) improving the efficiency of information transmission from environment to user, and (b) improving the visual appearance of the environment. We will address only the latter issue here. In their study, Sims and Schmid employed a method developed by the senior author to simulate, via perspective drawings of the predicted scenes, the appearance of the areas under study as they might look after implementation of the sign ordinance.

Five color slides chosen from many, representing different types of urban commercial development, were translated into black and white drawings. From certain assumptions of what changes might be made due to implementation of the code (e.g., sign owners would make the least possible number of changes) the drawings were altered. This resulted in five sets of before-after renderings, (ten sketches in all), one of which was presented, at random, to 285 undergraduates. Subjects in another group received a full before-after set of two scenes, again chosen at random, and were asked to make direct comparisons. Response measures consisted of four different questionnaires: a 21-pair polar adjective scale to measure affective response; an activity checklist on which subjects reported which activities they perceived to be possible at the site; a behavioral preference list on which they checked a seven-point scale indicating how they would feel about carrying out common activities at the site; and a seven-point like-dislike overall preference scale. Results were largely inconclusive with the exception of those obtained from one site--a depiction of a typical four-lane commercial strip, with most signs in the 5 to 15 foot (1.562 to 4.57 m) setback range (see Figure 12).

For this study, affective response was more positive in the "after" mode, as was the individuals' willingness to carry out everyday activities, and the effectiveness of information transmission from sign to subject, despite the fact that signs had been reduced in size and number in keeping with the code requirements. The authors conclude that "only very stringent regulations offer promise for producing any noticeable changes in the visual appearance of the environment. So-called reasonable regulations which do not substantially reduce the number and size of signs and very strict(ly) control their location would not seem to be worth the public and private effort and expense involved" (p. 318).

How adequate was the simulation technique used by Sims and Schmid? Although they reported on earlier validation efforts by the first author, it should be recognized that there were several difficulties in using their approach, and that these potential limitations might have led to erroneous conclusions. These substantive problems, discussed quite objectively by Koebel (1978), were related primarily to the photographic and artistic techniques employed, and to the use of still renderings when highway signs are almost always observed by an individual in motion.

As Sims and Schmid's method relied heavily upon the photographic/artistic simulations, Koebel discusses the slide/rendering-production procedure at length. He cites the work of the British architect Fairbrother, who has written extensively about the differences in "seeing" between the camera and the human eye. The camera's image bears little resemblance to that perceived by the eye because: (a) the eye tends to ignore the obvious, such as the foreground in a scene; and (b) the eye concentrates on those features of a scene which are most useful to us as the observer--for example, the eye tends to perceive the distance as much more extensive than the foreground, to exaggerate vertical dimensions, and to see things as higher than they are. The camera suffers none of these "interpretations" which are imposed by the human perceptual system. Further differences occur in viewing angle and viewing dynamics. With normal head and eye movements, a person can see approximately 155 degrees to the right and left, 90 degrees up and 112 degrees down. In contrast, the camera lens provides a fixed angle of view. In order to more closely approximate the human visual field, wide angle lenses are often used in the slide preparation. Unfortunately, this increases still further the discrepancies between eye and camera. With wide angle lenses, the size and scale of foreground objects are unduly emphasized at the expense of size

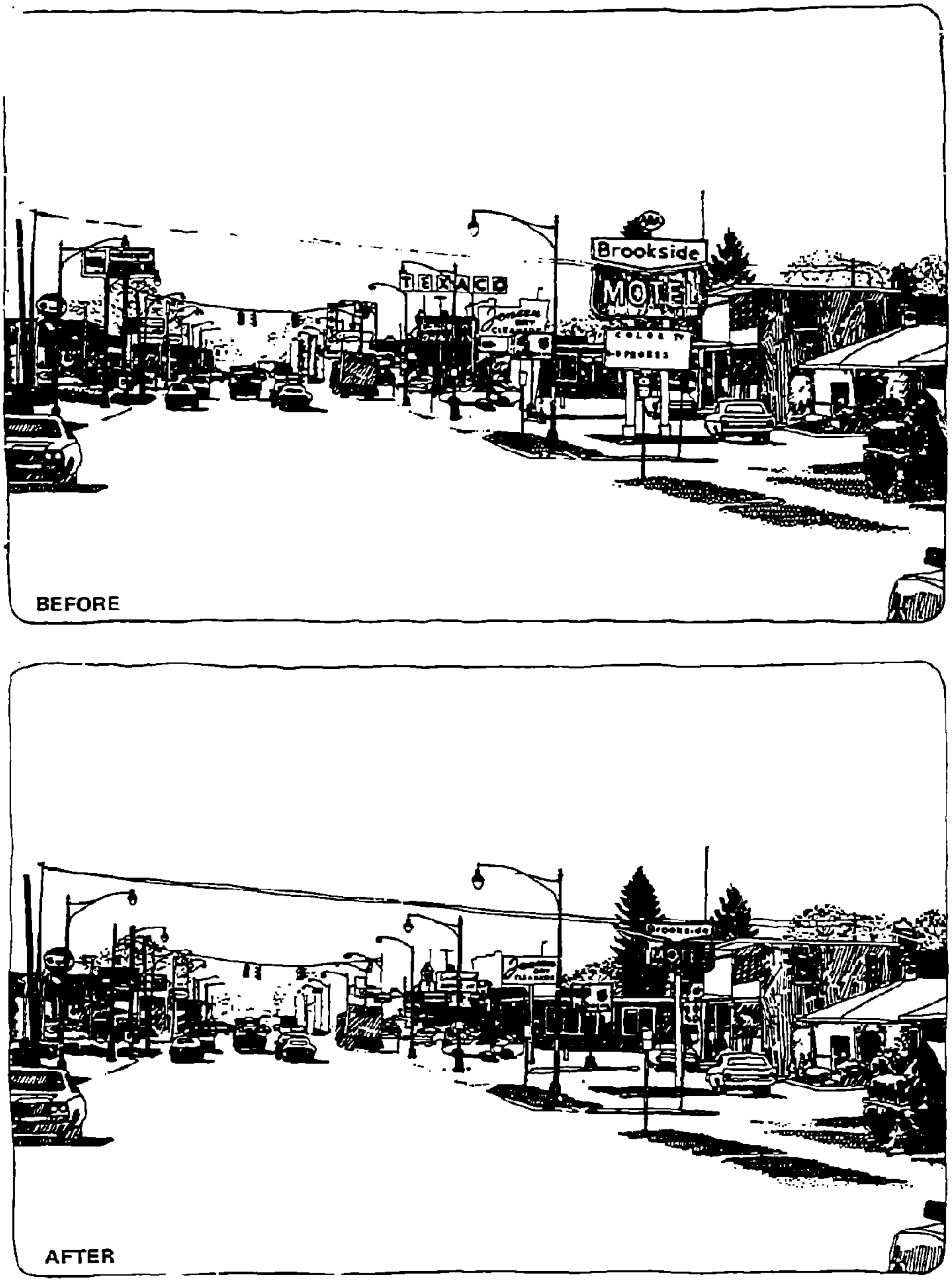

Figure 12. Before and After Views From Sims and Schmid.

and detail of objects in the middle ground and far distance. This has a pronounced effect on the depiction of detail of the many signs which appear in this range. Motion too, has important consequences for vision. Nearby objects appear to be moving rapidly and cannot be seen separately. The driver has less time to view his surroundings, and, the higher the vehicle speed, the greater the degree of concentration required and the farther ahead the driver must visually fixate. Also, as speed increases the angle of vision shrinks as the eye concentrates on the smaller detail in the distance. This is a very different situation from the experience of leisurely viewing slide-derived drawings made from an unmoving, fixed perspective. When combined with the angular perspective distortion of wide angle lenses discussed above, these differences may be critical to the validity of the simulation technique.

There are additional problems with this technique. The measurement of "information flow" is dependent upon message content legibility. But subjects in the Sims and Schmid experiment complete the check-list at their own pace, able to make continuous reference to the particular drawing which they are evaluating. Thus, information flow tends to be correlated with legible message content within the picture area, and this is dependent upon the number of legible signs. The larger the number of such legible signs, the greater the information content, and the more favorable the subjects' ratings of the scene (and hence, the sign code) will be. Related to this difficulty is the fact that the questionnaire respondent is able to examine all signs in the scene regardless of their foreground, middle range, or distance location, whereas a driver in the real world tends to give viewing priority to signs in the vicinity of the eyes' point of regard at any given time. This fixation point, as discussed above, is dependent upon travel speed. As a result of the perspective distortion introduced in the photographic simulation, however, the area most critical to the driver's vision while he is in motion will be the area of the visual scene most inadequately represented in the laboratory.

For all of the above reasons, as well as several minor ones such as the lack of color and the loss of contrast and other detail due to the line-drawing technique, Koebel raises some serious questions about the viability of this technique for the valid assessment of user attitudinal and affective response to roadside advertising signs. The Highway Aesthetics Laboratory of the Federal Highway Administration is developing a methodology that should be applicable to aesthetics questions such as those discussed here. It is hoped that this methodology will be able to overcome many of the limitations discussed above.

Sign Manufacturing Industry Evaluation of CEVMS. Given the task of evaluating the aesthetics of EVM advertising signs through a comparison with their non-electronic counterparts, it is instructive to learn what the signing industry itself states about this issue. If the industry's public statements, reports, and congressional testimony can be accepted at face value, it is evident that (a) it strongly believes that EVM signs are, by definition, a vast improvement in aesthetics over their predecessors; and (b) it agrees that certain prohibitive or restrictive controls may be acceptable for certain types of advertising signs, both EVM and traditional. Let us examine these points in greater detail. With regard to aesthetics, the following statements from American Sign and Indicator Corporation's 1976 publication are illustrative of the position taken by "the world's largest designer and manufacturer of electronic information displays" (p. 1):

> Architectural and planning professionals have long been concerned with the aesthetics of most signs; however, the 'Great American' signs eliminate the primary reasons for their concern--flashing, garish colors and lack of aesthetic quality and decor compatibility. The 'Great American' displays do not flash, move, scintillate, or travel. They are designed for displaying complete graphic messages (p. 3).

In the context of commercial signage, electronic information displays offer many advantages

> to their users regarding the visual environment. First, these displays . . . can be used as a means to reduce sign clutter. In many modern cities and towns, signs are thought by some to have proliferated beyond control. Signs seem to be greater in number, color, and size than are necessary, according to some observers. Given this situation, electronic information displays are particularly important for they use space with remarkable efficiency. A meaningful message can easily be displayed within a small space. This area is designed so that changes in copy may be made regularly and with little effort. . . . if the message containing several segments were to be placed on permanent 'fixed copy' signs, it would have to cover a large display copy area (p. 4).

> They are engineered for maximum legibility and readability. Their light is produced by incandescent bulbs which are relatively soft and are screened with a special louvered sunscreen to reduce glare. Most such displays contain automatic dimmers so that as daylight decreases, the intensity of the light they emit is reduced . . . . this means the 'garish' quality of some bright lights at nighttime, so offensive to some, is eliminated (p. 4).

> Another source of problems with some signs is the unsightly condition created by the lack of maintenance. . . . Rarely does one see an electronic unit fallen into disrepair, as these displays are invariably leased with a maintenance agreement as part of the lease contract. Also, electronic storage and retrieval of messages will continue to solve the environmental problem of unmaintained signs that have broken or missing letters, and to help eliminate the need for supplemental storage (p. 5).

> We attempt to design our displays in a manner which enhances the physical appearance of a setting, while assuring the customer of maximum visual impact (chapter 3, p. 1).

Congressional testimony by the National Electric Sign Association (NESA) (1978) repeated nearly verbatim the third citation herein, and closely reflected much of the other material presented in the earlier ASI report.

Outlining its position on the need for regulation of the use of outdoor advertising in roadside areas, the ASI document includes the following statements:

> We (are) aware of the environmental problems that have been caused, and could continue to be caused, by the unrestricted and abused use of signage. Sound policies must prevail which will provide for adequate and necessary sources of public information, while at the same time allowing for the reasonable controls of signs to prevent excesses in design, size, and number (p. 1).

> We feel it is our corporate responsibility to work with local governments in the development of stringent yet sensible sign legislation that will help maintain a well-balanced social <u>and</u> economic future for the communities we serve (p. 1).

> (After defining "flashing," "animated," "chasing," and scintillating" signs): . . . it is important that the proper definitions of these sign types be included in ordinances which attempt control over them. Clear and distinct definitions are important for the enforcement and administration of any sign code. A sign owner or sign user who wants to act in accordance with a local sign ordinance must be able to refer to the language used and to know with certainty what he must do to bring his sign into conformity with the law (chapter 2, p. 2).

The Claus (1974) report, which has been discussed earlier, was directed at legislation pending in California which would have placed into law a limitation on the time interval between copy changes on signs, i.e., the sequencing of the changing messages. Her argument was based primarily upon the arbitrariness of the ruling, but that discussion is not germane to the issue of aesthetics. What <u>is</u> relevant to this topic, however, is that Dr. Claus chose not to criticize other aspects of this legislation, two of which related directly to the aesthetics question. Under these two orders, a sign would be prohibited if: (a) "The proposed display has any illumination which is in continuous motion or which appears to be in continuous motion," and (b) "The intensity of illumination changes" (p. 3). Thus, by refraining from comment on these two legislative provisions, Dr. Claus, through her affiliation with the Institute of Signage Research, expresses the signing industry position that, whereas "arbitrary" regulations of message timing and sequencing may be objectionable, restrictions on illumination intensity change and motion or apparent motion are not.

Consistency with this position may be found in other industry statements and publications. That is, the issues of illumination intensity change and display motion are the bases of the industry's attempts to distinguish EVM signs from earlier designs, and lead them to suggest that the EVM designs are being unfairly restricted due to confusion with these other signs on the part of legislators. The ASI (1976) document has a more complete explanation:

> Since neon was first used in the 1920's, Americans have been exposed to a variety of sign types including those which have flashing, chasing, and scintillating lights. Normally, such displays repeat a pattern that is unchanging and reappears at a constant level of brightness. The purpose of these signs has traditionally been to attract attention to a particular business, product, or service.
>
> Although these types of signs have a general similarity, there are differences. The technical definition of a 'flashing' sign is a single flash at regular intervals, in which the duration of light is less than the duration of darkness (note--this is the U.S. Coast Guard definition). 'Animation' on a sign is the showing of motion or action. 'Chasing' is the effect produced by using three electrical contacts which cause lamps to come on in a one-two-three sequence again and again. (Chasing is the technique which has characterized borders on movie theatre marquees for many years.) 'Scintillation,' another familiar effect, is produced by a random pattern of turning bulbs on and off to produce a twinkling appearance.
>
> Some people feel these signs contribute to clutter in our visual environment. From their enthusiasm to control such signage comes legislation which works against a totally distinct type of sign display. We are referring to the electronic information or public service displays such as time and temperature units and message centers. The reason for the confusion is that electronic displays are characterized by changing light patterns, but their function and the essence of their form is very unlike the animated, flashing and other 'moving' signs discussed above.
>
> Electronic information displays, unlike signs which flash a static or unchanging message or display of lights, present information of a variable nature. This may include time, temperature, and/or a wide range of other public service or commercial information messages (chapter 2, pp. 1-2).

There is little argument that CEVMS of the type described by ASI can be an aesthetic improvement over their predecessors. While some would argue that early forms of commercial signage, such as the cigar store Indian and the barber pole, had "historic, symbolic, and universally understood connotations that added a flavor and character to the street scene" (Sears, 1964, p. 55), and others believe that: "In some settings, such as in Times Square or Las Vegas, the (garish) signs . . . are appropriate and acceptable features in the landscape" (ASI, 1976, chapter 2, p. 2), some EVM signs may well possess functional and aesthetic advantages over these other displays.

If these positive qualities of EVM signs were always present, and if the distinctions between them and earlier displays which could "flash," "animate," "chase," and "scintillate" were as clear and consistent as the industry claims they are, many of the aesthetics questions might cease to be of concern. Unfortunately, this may not be the case. A few examples should suffice.

1. Maintenance can be a problem. Burned out bulbs or light banks, or breakdowns somewhere in the interface between the operator and the sign itself can result in a display face that is both unsightly to the viewer and more difficult to read (see Figure 13).

2. Obviously, not every sign installation will incorporate automatic dimmers for dawn, dusk, or nighttime operation; nor will all such signs be designed for maximum legibility, readability, or viewer comfort. Despite ASI's protest (chapter 2, p. 1) that it was the purpose of the traditional signs to "attract attention to a particular business, product or service," it is obvious that, by definition, this is the purpose of all advertising, no matter what the medium or the message. Even time and temperature displays (invented by ASI) advertise the name of the business providing the sign, though they do provide a public service message as well. To the extent that a CEVMS is still an advertisement, one of the goals of design and installation of that sign must be to attract attention to it. It may be questioned whether aesthetics will be given high priority by all those responsible for signs if and when aesthetics objectives are thought to be in conflict with attention-getting objectives.

3. The strong arguments made by the industry that, while EVM signs are characterized by changing light patterns, "their function and the essence of their form is very unlike the animated, flashing, and other 'moving' signs" (ASI, 1976, chapter 2, p. 2) discussed earlier may be true for many installations, but it is far from true in others. In fact, the industry's own statements about the versatility of EVM displays should serve as an indication that such displays can be programed to perform all the flashing, animation, chasing, and scintillating effects that have been so heavily criticized by those within as well as outside the industry. The following claims, for example, have been made by ASI for their own EVM products:

> . . . electronically controlled to provide unlimited changes from an electronic memory source such as a computer (p. 3).
>
> One control system will operate multiple displays and is capable of displaying the same or different messages at any location (p. 3).
>
> The displays will be available in selectable colors to provide added emphasis . . . " (p. 3).
>
> These feature a display panel which can be programed to transmit a virtually unlimited variety of information (p. 2).
>
> . . . provides total flexibility and versatility insofar as the displaying of messages, letter fonts, letter styles, and languages (p. 3).
>
> One of the major advantages . . . is its ability to display objects, designs, and basic photographic reproductions along with messages (p. 3).
>
> . . . changes in copy may be made regularly and with little effort (p. 4).

Anyone who has attended a major league sports event at a stadium equipped with a modern electronic scoreboard has been exposed to the state of the art in EVM technology. These displays are capable of producing all of the visual effects that ASI claims have been "overcome" by new technology; yet it is obvious that these scoreboards possess the capabilities that they do precisely because of this very technology. Figure 14 depicts a modern stadium scoreboard "in action." Figure 15 is taken from an ASI promotional brochure directed at airports and airlines. Here too, some of these signs' versatility is shown, including their ability to portray graphic images, alphanumerics, and foreign languages, all of which can be quickly changed by the actions of one console operator in a remote location.

The introduction of electronics and computer technology into the signing field has gone beyond opening the field to new display types as exemplified by some of

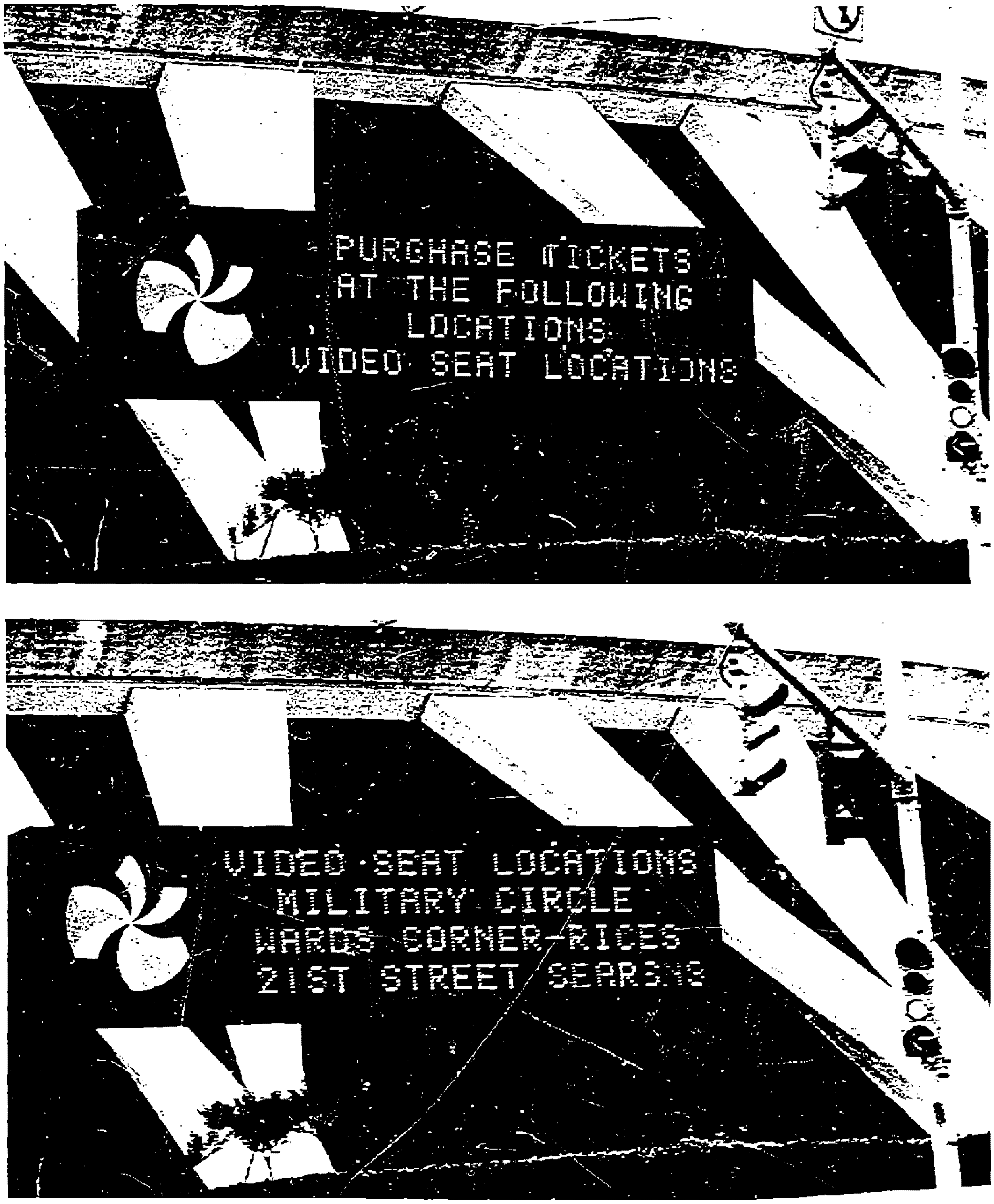

Figure 13. Burned-Out Lamps on a Message Center Sign Utilizing Sequential Display. (Source: Virginia Highway Research Council)

Figure 14. A Modern Sports Stadium Remotely-Controlled Lamp Matrix Scoreboard "In Action" (Photographs: J. Wachtel)

Figure 15. Some Applied Examples of the Versatility of EVM Display Technology. (Source: American Sign & Indicator Corporation)

(NOTE: The examples shown above are photographs of actual locations with mock-ups of UNEX displays superimposed. They are intended to illustrate only the clarity and functional utility of such signs. Therefore, allowance should be made for distortion of sign size in mock-ups.)

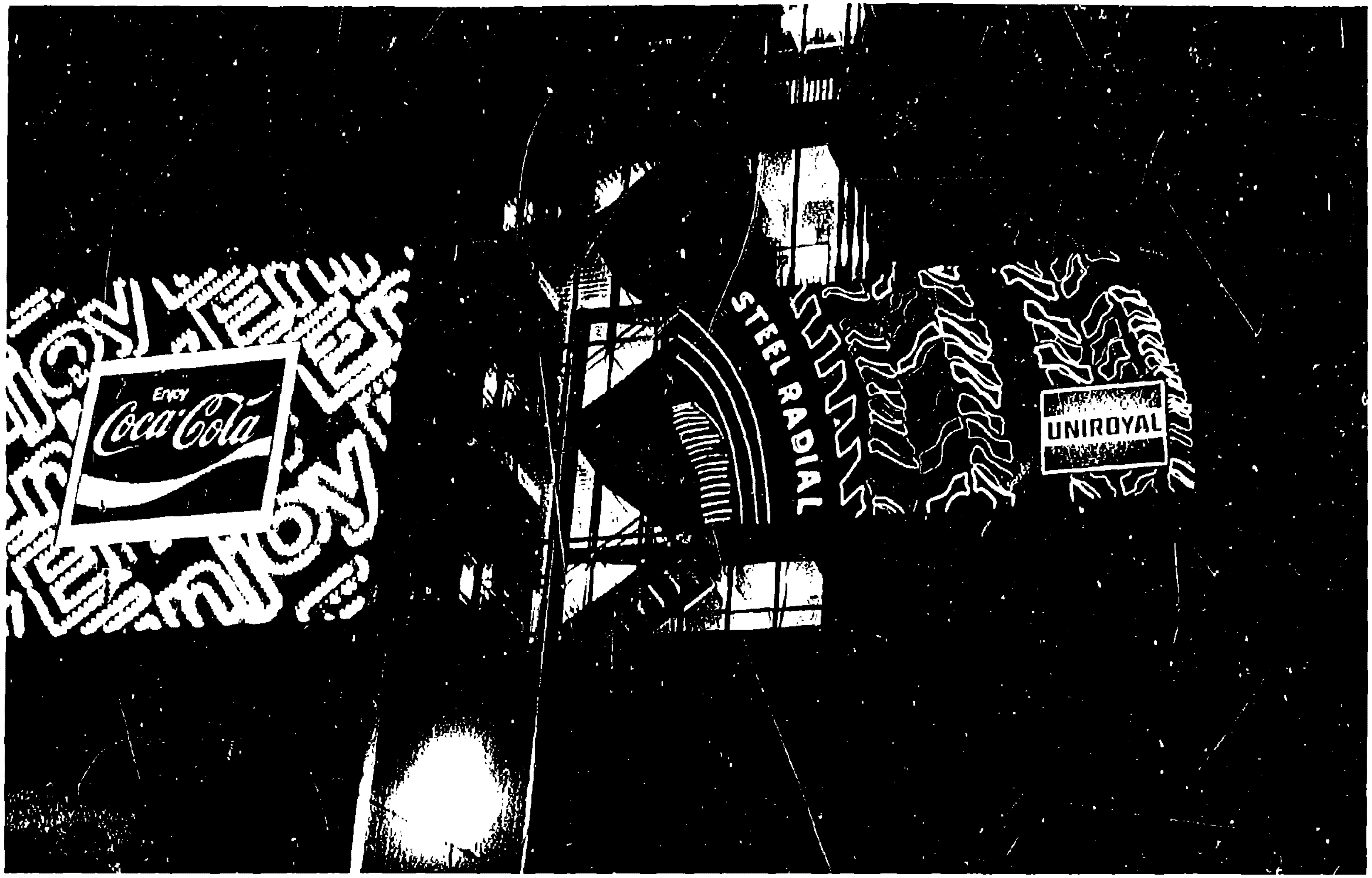

Figure 16. Two examples of the blend of older illumination technologies (neon and twinkling incandescent lamps) with state-of-the-art computer control. These two signs are commissioned works of art on a shopping center facade in downtown Toronto. (The photograph cannot do justice to the brilliant colors of the actual signs). (Source: Toronto Eaton Centre)

the ASI products. It has also expanded the versatility of older technologies, some of which have been thought to be nearly obsolete. Figure 16 for example, depicts two computer-controlled advertising signs in Canada. Both were commissioned works of art, installed on the facade of a new downtown shopping center in Toronto. The Uniroyal work is an 11 x 22 ft (3.4 x 6.7 m) sign which simulates, in 16 colors of neon, the rolling motion of a tire. The display is controlled by a microcomputer which produces a continuously changing program lasting four hours. The 20 x 24 ft (6.1 x 7.3 m) Coca-Cola sign is also computer controlled. "Its center section punctuated by twinkling lights simulates the effervescent bubbles of a glass of Coca-Cola, while pattern sequences of white lighting around the border invite us to 'enjoy' the famous beverage" (Toronto Eaton Centre, undated).

When considering the need for standards regulating the use of CEVMS, the potential impact of this combination of electronic and computer technology is a critical issue. Where public interests requiring protection are identified, protective standards should be performance-oriented, since their purpose is not to impose a ceiling on technology, but only to restrict its uses in situations where unnecessary risks to the public interest would result. Accordingly, claims of the electric signing industry that CEVMS should not be equated with earlier types of moving, flashing, scintillating and animated electric signs--all of which drew justified criticism when they proliferated in roadside areas--miss the central issue in this problem of defining governmental responsibility. The relatively inconspicuous time-and-temperature displays for bank buildings, which the electric sign industry emphasizes as prime examples of CEVMS use, represent only one very elementary application of currently available technology. At the present time, and in the foreseeable future, the application of electronics and computer technology to CEVMS enables the electric signing industry to offer a wide range of signs, with displays that may be visually innovative and increasingly compelling, while reliability increases and costs decline. Some of the same firms that produce the kind of state-of-the-art electronic stadium scoreboards shown in Figure 14 of this report plan to erect CEVMS utilizing the same technology alongside highways.

Faced with a technology that enables signs to flash, change intensity, create apparent movement, and display an almost unlimited variety of information, the basic question is whether the limits on use should be determined by government regulation or by the judgment of individual advertisers. It would seem clear that government regulation should be focused on achieving the stated objectives of the national policy embodied in the Highway Beautification Act, namely, maintaining the amenities and enhancing the visual quality of highway environments, improving the safety of motorists using the Nation's highways, and protecting the public highway investment. Innovations in technology and commercial art forms can and should go on in their proper spheres. The description of "Times Square" and "Las Vegas" signs as unique forms of contemporary electronic art, universally known and widely appreciated, is meant seriously. The two signs at the new Toronto Eaton Centre, described above, would be at home in such environments. They were commissioned and designed using the most modern methods and equipment, to blend art with advertising. The Centre's management has taken the position that: "Matching the 'Life in the City' theme of the Centre, this street gallery of Canadian artists' work adds a further vitality and dimension to the heart of Toronto's lively core" (Toronto Eaton Centre, undated). One can readily agree with this statement, and with the inference that while such signs may fit well into the environment of the urban core they are out of place alongside the highway.

Here the issues of aesthetics and safety must be reunited. At some point along a continuum, the on-off duty cycle of a visual display, the illumination intensity change, the maximum output brightness, and other related features make a CEVMS ineffective as an information source, yet more successful as a visually compelling mechanism for attention-getting. And while we have no inherent quarrel with an advertiser's right and desire to communicate his message to the motoring public, the declared purposes of the Highway Beautification Act require that an advertiser's license to use innovative, attention-getting visual displays aimed at motorists on adjacent highways shall not be exercised at the expense of either traffic safety or damage to the public's right to and investment in environmental quality. The many characteristics of EVM displays that work together to create an overall visual impression can be combined in different ways to yield very different responses from viewers. Sign designers, highway safety specialists, and human factors professionals have available an excellent data base from which to determine those characteristics of such signs that are most efficient at communicating a message. There is some information, but relatively little supportable data, to indicate which combinations of sign characteristics and environmental contexts contribute to potential distraction of the motorist, and under what circumstances this distraction might become hazardous. There is still less documentation about the impacts of this sign/environment interaction on judgments of roadside aesthetics, although techniques are being developed and tested to expand knowledge in this area.

We are in substantial agreement with ASI (1976) that "clear and distinct definitions (of sign types and characteristics) are important for the enforcement and administration of any sign code" (chapter 2, p. 2). We also concur with Claus (1974) that highly specific regulations should be based, to the greatest extent possible, upon empirical evidence.

In order to achieve this dual objective of empirically based, and distinctly defined, regulations, a multistage process is required. First, unambiguous definitions and criteria will have to be developed for all major sign operating characteristics, environmental variables, and motorist response dynamics. The terms "animation," "chasing," and "scintillation" have been fairly well defined by ASI (chapter 2, pp. 1-2), and a consensus is likely. The term "flashing," however, has been defined at least three different ways in the ASI report, and even more ways in other publications. Since regulations based upon display on-time and interstimulus interval have been quite controversial, a clear, uniform definition is mandatory.

The operational use of terms such as distraction, safety, motorist performance, and aesthetic response must be defined. Second, different levels of the independent variables of signing/environmental interactions must be presented to test subjects in a controlled setting, and dependent variables (such as distraction, micro-performance, aesthetic response) must be carefully measured and interpreted.

Earlier, it was suggested how an experiment might be conducted to answer questions of safety. Motorist affective response to sign/environment aesthetics could be reliably measured with reasonably little additional effort.

A brief series of related field and laboratory experiments will yield sufficiently valid and reliable information to enable the Government to promulgate regulations dealing with EVM advertising signs that are in the best interests of the motorist, and those who live, work, or recreate near highways while providing the advertising industry with guidelines that are technically and administratively acceptable. To this end, it is suggested that any committee formed to monitor such research invite the industry to designate a representative to serve on it.

D. <u>Highway Investment Aspects</u>

<u>Matching highway needs and investments</u>. Evaluation of the implications of increased use of CEVMS on "protection of highway investment" should commence with an appreciation of how Congress viewed this particular matter in the Highway Beautification Act. As traditionally used in the Federal-aid highway program, "highway investment" has been discussed in terms of meeting "highway needs" which have been defined in terms of improving the efficiency, economy, convenience and safety of transport operations. These needs could be quantified readily, and goals of improved

performance could be stated precisely so that costs, or investment, could be computed with confidence. Even as this traditional view of highway needs has expanded to reflect increased concern for the impacts of highway programs on non-users, air and water quality, noise, and cultural or environmental landmarks, quantification of needs and translation of these needs into goals and investment requirements has been accomplished directly or through accepted proxies. Although the state of the art for this approach to highway planning and programing is acknowledged to have its shortcomings, it continues to serve (Juster, 1976).

Insofar as overall goals, or needs, in connection with the highway system's visual environment have ever been defined--and their best expression probably was in the report of the White House Conference on Natural Beauty in April 1965--it was the consensus of professional and public feeling that the major travel arteries of the Nation (the Interstate and Federal-aid primary systems) should be designed and built with the best visual environment that could reasonably be achieved. This meant preventing further proliferation of two forms of roadside features that had been widely subject to restriction in the past, namely outdoor advertising signs and junkyards, systematically eliminating these features where they already existed in locations where they were deemed to be visually inappropriate, and actively enhancing the visual quality of roadsides by landscaping or acquisition and maintenance of roadside land that contained or contributed to special scenic quality. In short, the goal seemed to be a national desire to perpetuate an agreeable experience with the earliest segments of the Interstate System, built almost entirely on new location, with design standards that emphasized surroundings which, at least outside urban centers, were not yet crowded with dense roadside development.

Although the public and Congress "knew what it liked," there was no consensus as to the specific program goals or the investment required to achieve them (Peterson, 1967). Planning and programing the investment in highway beautification often has appeared to be a process of proposing alternatives and reaching compromises based on conflicting reactions to them. In addition, there is the separate difficulty of compiling data on the interaction of the roadway and the roadside land use which had to be drawn from numerous scattered sources, sometimes applying only indirectly to the measures being evaluated.

Measuring investment in highway beautification. The first attempt to describe the investment in highway beautification was the Bureau of Public Roads' Staff Report on Economic Impact of the Highway Beautification Act, prepared in 1967 in response to a congressional directive (BPR, Economic Impact Study, 1967). It described the effects of the proposed investment in terms of foreseeable benefits to highway users, the outdoor advertising industry, roadside businesses, and local communities. Some of the principal conclusions of the study were as follows:

o The benefits of the Highway Beautification Act are primarily in the form of roadside beauty, which is extremely difficult to measure directly (p. 1).

o The outdoor advertising industry recognizes that fewer signs per mile increases the value of each individual sign (p. 112).

o Motorists often rank scenic beauty over operating cost, travel time, and comfort in importance (p. 180).

o Motels and hotels often experience better business conditions along scenically enhanced highways (p. 187).

o Private developers realize the importance of uncluttered highways (p. 194).

o Property values near parkways are higher than along other roads (p. 195).

o The absence of billboards is associated with higher land values (p. 202).

o Good landscaping eases maintenance problems and costs (p. 203).

o Expenditures for scenic enhancements will benefit some local economics (p. 209).

o The benefits of the Highway Beautification Act appear to exceed costs when considered on a per driver basis (p. 211).

o Increased interest in highway beautification is a benefit of the Highway Beautificaton Act of 1965 (p. 224).

o Enhanced land values along scenic routes should strengthen local tax bases (p. 235).

Assuming that the establishment of billboard and junkyard controls and the elimination of existing nonconforming signs and junkyards under those controls would be accomplished in a ten-year time frame, the report projected dollar amounts of total public investment at two alternative levels, varying according to the amount of scenic enhancement undertaken. Either program, it suggested, would have a high degree of permanency in assuring the quality of the visual environment of the Interstate and Federal-aid primary systems (U.S. Senate Doc. 6, 1967 Cost Estimate). Since the compilation of this 1967 Cost Estimate, FHWA has periodically updated its projection of the cost to complete the program, based on reports of funds spent in removal of nonconforming signs and State inventories of signs yet to be removed.

Outdoor advertising's indirect impacts on highway investment. Evaluation of the damage, if any, to highway investment that would result from the absence of the controls called for in the Highway Beautification Act was not attempted in the 1967 Cost Estimate. Further, no systematic study of the risks of damage to highway investment in the event of relaxation of the law's controls appears to have been made since that time. Inferences from the provisions of the law and its legislative history can, however, supply hypotheses regarding risks of damage to highway investment in the event that increased numbers of advertising signs are permitted in roadside areas.

Congressional selection of billboards and junkyards for control suggests that they were considered as acceptable proxies for evaluating the visual environment of highways. The absence of these features contributes to a superior visual environment; and as their presence increases, the quality of the visual environment is reduced (Norton, 1967; White House Conference, 1965). Accordingly, the investment made to preserve and enhance visual quality was thought to be best protected by imposing effective prospective controls and eliminating these features where they contributed to impairing environmental quality. It was acknowledged, however, that this principle must be applied discretely since the actual impacts of advertising signs might differ according to many factors.

This aspect has traditionally presented difficulties in the description of environmental risks and the formulation of legislative standards. Some have argued that these difficulties are insurmountable, as there can be no agreement on the definition of "beauty" when it is all in the eye of the beholder. However, describing when and how visual quality is impaired is not a process that demands initial and universal acceptance of a definition of "beauty" (Dukemenier, 1955). There are visual patterns in every type of roadside development, and the pertinent inquiry is whether outdoor advertising signs in their particular settings result in disrupting these patterns significantly (Fagin and Weinberg, 1968).

Most off-premise advertising signs are vulnerable to this charge since they are not natural uses of the land on which they are located. Studies of roadside land value and land use have shown that the presence or absence of signs has no significant effect on the market value of land (Norton, 1967). Frequently billboard advertising is an interim activity occurring on land in transition from one type of use to another. This has been suggested as a factor explaining why one study of outdoor advertising found that 80 percent of the landowners surveyed held the view that removal of existing advertising signs would not decrease the value of their property (Berry and McNece, 1969). Rental income to sign owners and landowners is distinguished from land value since it comes entirely from a sign's ability to project its visual message into the stream of traffic on an adjacent highway. Without the highway the sign has little or no value to its owners or their clients. It is thus a form of highway use rather than other land use (Wilson, 1942). On-premise signing is less likely to be an unrelated, and therefore disruptive, element in the visual environment because of its close connection with the existing use of the land, and, its physical relationship to the buildings used in that activity. But, as has been discussed elsewhere in this report, the design, density, and condition of on-premise signing may make it a source of discord rather than harmony in the man-made environment of its site (Ministry of Housing and Local Government, 1966).

How do outdoor advertising signs, located on privately-owned land outside the right-of-way and lacking any physical invasion of the roadway, damage highway investment? Detailed explanations are not spelled out in the legislative history of the Highway Beautification Act, but at least two scenarios have been suggested. One is that roadside outdoor advertising constitutes a visual invasion of the highway users' view which, under prevailing circumstances, can be distracting and disturbing, and, aside from any considerations of safety, may reduce the pleasure which is one of the viewer's purposes for travel. Where highways are located in open surroundings, this intrusion may destroy the harmony of an otherwise natural setting. Where highways traverse developed areas, the intrusion may destroy the pattern of man-made features that comprise the highway environment. Impairment of these visual patterns by outdoor advertising signs may occur because of the location of the signs, or because of their excessive density, or because of their poor design or state of repair.

The validity of this scenario is generally accepted (White House Conference, 1965; BPR, Scenic Roads Study, 1966). It has, however, proved to be difficult to get similar acceptance of a methodology for quantifying the value of visual quality or of a recreational experience based on the visual environment. Although various proxies may be suggested, precise measurement of the damage done to highway investment by destruction or degradation of the highway users' view from the road generally has not been attempted.

A somewhat different scenario is based on the hypothesis that excessive or poorly designed or maintained outdoor advertising detracts from the value of roadside land, and thereby contributes to functional obsolescence of adjacent highways. Relatively little research on this subject has been reported, but some generally observable experience is pertinent. The strong preference of prudent real estate developers for locations with pleasant surroundings is well known (White House Conference, 1965; Thiel, 1968). Zoning ordinances generally keep outdoor advertising signs out of neighborhoods where environmental quality and economic value are accorded high priorities (Berry, 1969). Even where permitted by zoning, excessive, poorly located and designed, and/or inadequately maintained signing may destroy visual quality. Where, therefore, visual clutter or deteriorated advertising signs are allowed along roadsides, several results are predictable. Since physical appearance is a prime factor in motorists' selection of establishments that they will patronize, traffic tends to bypass the visually unattractive areas in favor of other more attractive ones (Moore, 1968). As this continues, businesses seeking new locations also bypass these neighborhoods in favor of others. Working in the manner of Gresham's law, a downward spiral of land values in the unattractive commercial strips ensues until ultimately market forces dictate that redevelopment is warranted.

Meanwhile at least three forms of adverse impacts may be suffered by the highways adjacent to these deteriorated commercial strips. First, where this economic trend results in reduced average daily traffic (ADT) for the highway, the physical condition of the highway may suffer as priorities for reconstruction and maintenance are shifted to highway segments having higher ADTs. Second, where the ADT for a highway serving a commercial strip remains high, but the traffic uses that highway to pass through the strip rather than to obtain access to local businesses, the functional efficiency of the highway suffers. Its original design as a local land-service highway becomes a handicap as its actual function changes to a through-traffic facility, and this functional obsolescence hurts the public investment in that highway. Third, the deterioration of land values is reflected in local tax revenues which, in many instances, are relied upon to maintain the streets and highways.

Exploratory studies of the economic behavior of roadside land values suggest that this scenario may be oversimplified, but essentially it is sound. On close examination, the presence of billboards may be not so much a cause of deterioration of land use (and land value) as it is a symptom of it. A more complete analysis of the dynamics of land value would have to take into account other forces such as trends in actual land use, zoning (potential land use), and the ADT on adjacent or nearby highways (Norton, 1967). And a full appreciation of these indirect impacts on obsolescence of the highway requires a discriminating analysis of their functions and those of the adjacent land (Godschalk, 1967). The effects of increased or changed use of roadside advertising signs on highway function must be correlated with the effects of other roadside features such as utility fixtures, access points, parking areas, building facades, landscaping, and street furniture. Although methodologies for evaluating observer perception of these various types of roadside development have been suggested, the translation of these perceptions into increments of market value for roadside land and the calculation of consequent damage to highway investment have not been undertaken (Little, 1968).

It obviously is an undesirable state of affairs to have the highway investment element of the national policy for control of outdoor advertising based on hypotheses that cannot readily or completely be documented and evaluated in quantitative terms. Yet, as noted in regard to safety and environmental compatibility, the fact that adverse effects of excessive or poorly designed and located signboards have not been quantified and measured has not prevented wide recognition of a public interest in preventing or reducing the risk of such impacts through imposition of standards and controls. Nor has it prevented courts from upholding the validity of regulations that appear to be reasonable measures to achieve this objective.

Enough has been done through exploratory research on the indirect impacts of outdoor advertising to result in a consensus of professional and public concern about these effects, and, as with other instances of sign control, specific regulatory standards for on-premise CEVMS may be tested by their relevancy to this public interest in the particular circumstances to which they apply.

Direct Impacts on Highway Investment. Entirely aside from the indirect impact that outdoor advertising may have on highway investment, there are certain practices that sometimes accompany outdoor advertising which affect highway investment directly. These practices relate to protection of the effectiveness of official traffic control devices, roadside vegetation control and the impairment of access control due to the erection and maintenance of signs.

Unrestricted on-premise outdoor advertising in ribbon development areas has, in some locations, resulted in a form of direct impairment of the highway investment through reduction of the effectiveness of traffic control systems as well as the quality of the visual environment. This occurs where proliferation of advertising signs along urban or suburban streets and highways makes it necessary to enlarge traffic lights or signs, or place dark shields in back of traffic lights to make a "target" that is more quickly identifiable in the competition with commercial signs for the motorist's attention. Where such traffic engineering improvements are necessary, they generally are provided by the local government. Although instances of this action have been reported, no nationwide survey of their incidence or the dollar amount of their additional cost to the highway investment has been undertaken.

"Vegetation control" refers to the trimming or removal of trees or shrubbery in roadside areas in order to increase the visibility of outdoor advertising signs from the highway. The vegetation in question may be inside the right-of-way or on privately-owned land outside the right-of-way. For the owner of an advertising sign, the test of whether the visibility of a sign will be improved by removal or trimming of vegetation is a pragmatic one in which the ownership of the vegetation and other matters may be incidental. As a result, conflicts may arise between the desires of an owner to increase the visibility of his sign and the State highway agency's landscaping plan or the environmental surroundings of the highway. Unless such conflict is resolved cooperatively by the parties concerned, the highway investment may suffer direct, specific, and sometimes irreparable damage.

Instances of systematic unauthorized defoliation of roadside areas, both inside and outside rights-of-way, have been reported. One of the best documented cases occurred in Florida where the State Department of Transportation followed a policy of leaving native vegetation undisturbed in roadside areas, assisting tree growth along the margins of the right-of-way, and adjusting roadside mowing schedules in certain areas to encourage growth of native grasses and shrubs. However, as the number of roadside advertising signs along these highways increased, evidence of destruction of substantial amounts of this vegetation occurred and were reported to the Commission on Highway Beautification by the State Department of Transportation as follows:

> In order to make these signs more attractive to potential advertisers, the outdoor advertising people have resorted to unusual actions to make their signs visible to the traveling public. Small mowing machines have been brought into the roadsides of limited access highways to cut shrubs immediately in front of billboards erected beyond the right-of-way line.
>
> Where vegetation blocking the view of signs has been too large for these small mowing machines, trees have been destroyed by cutting them down completely or cutting into the bark so they soon die and have to be removed by the highway maintenance crews....
>
> Trees which are cut down sometimes have been left lying where they stood on the right of way, and sometimes they have been tossed over the fences.... [T]rees and shrubbery on private property have received the same treatment as foliage located on the highway right-of-way when outdoor advertisers feel that they interfere with the visibility of their signs. Generally such trees are cut down rather than killed and left to be removed. The reason is that landowners who provide sites for advertising signs are not likely to remove dead trees from their land whereas the highway department's maintenance crews do this for the right-of-way.
>
> A major method of destroying trees which block the view of billboards is through the use of herbicides or soil sterilants. This may mean something as simple as salt.... Sterilizing chemicals, when spread on the ground, get into the sap systems of the trees and kill them. Indiscriminate poisoning of trees may also spread to other areas through surface water runoff, and may lead to destruction of pastures or pollution of ponds and streams (Commission on Highway Beautification, 1974, v. 1, p. 50).

While no State-wide surveys of the effects of unauthorized or excessive vegetation control have been found, an indication of the magnitude of the cost that these practices inflict on the public is provided by the 1972 findings of the Florida Department of Transportation that on two of its major highways, I-75 and the Florida Turnpike, over 1,500 mature trees were found to be destroyed.

Reduction or elimination of the costs of systematic or excessive defoliation of roadside areas to increase billboard visibility is difficult. State highway maintenance crews cannot, as a practical matter, keep under surveillance all of the roadside mileage potentially subject to this form of abuse. Also, a State's ability to successfully prosecute unauthorized destruction of trees within the right-of-way is substantially reduced by the fact that the evidence furnished often is circumstantial and, where more than one sign benefits from the act, it may be inconclusive. Finally, the legislative protection of roadside vegetation and the penalties for their violation are generally relatively weak.

The Florida Department of Transportation's report on unauthorized destruction of roadside vegetation noted that these actions sometimes were performed by small mowing machines brought onto controlled-access rights-of-way. This suggests that violation of prohibitions against stopping or parking along limited access highways (in the reported instance an Interstate System highway and a turnpike) occurred in connection with tree-cutting both on and off the right-of-way. Such actions, where they occur, are universally recognized as violations of regulations that are essential to the safety of this type of highway. There is evidence that such regulations may regularly be ignored by outdoor advertising companies in routine servicing of billboards located at sites which, for some reason, are not convenient to approach across the privately-owned land on which they are erected. Photographic documentation of one illustrative instance of this practice shows that, after parking its truck on the highway shoulder, the outdoor advertising company's maintenance crew bridged a drainage ditch with a plank, climbed the fence at the edge of the highway right of way, and proceeded to its work on the billboard erected in the adjacent field (Colan, 1978).

Unauthorized destruction of roadside landscape vegetation, sometimes accompanied by violations of access controls, probably is the most flagrant form of injury to the highway investment that is associated with the presence of outdoor advertising in roadside areas. Such actions, however, can be converted into authorized forms of roadside maintenance by the simple legal device of establishing a formal agreement between a sign owner and the State highway agency, pursuant to which the sign owner is permitted to control vegetation in the vicinity of his advertising sign. Some outdoor advertising companies have sought to establish such agreements with State highway agencies with Federal approval. The present position of FHWA is that vegetation control is a form of maintenance, and States may make such agreements if they see fit as part of their overall maintenance responsibility (FHWA Memo, March 15, 1977). This policy has been construed as authorizing State acquiescence in sign owners' programs of trimming and cutting to increase visibility of their billboards, with the cost of such maintenance paid by the sign owner. Thus, under a regulation on "Vegetation Management at Advertising Sites" now pending approval by the Florida Department of Transportation, the tree destruction reported as illegal in 1972 might well be repeated elsewhere as an authorized and officially approved form of "vegetation management."

Whether carried out illegally or with approval and authority of a State highway agency, however, the destruction of roadside trees and shrubs directly damages the public highway investment. It is distinguishable from the pruning and removal that accompanies normal landscape management because its purpose is not functional support of the highway in accordance with roadway-roadside design concepts, but rather enhancement of the visibility and commercial attractiveness of particular billboards. Arguably it is, at worst, a use of the right-of-way for non-highway purposes, and at best, an increased burden on the right-of-way which adds to its cost.

Calculation of net gains or losses from vegetation management agreements for the benefit of roadside billboards is complicated by the inability to readily compare such things as the replacement of a mature 18" (457.2 mm) diameter hardwood at one location with a 2" (50.8 mm) diameter conifer at another site. Also, it is difficult to assess the full range of consequences of such rearrangement of vegetation on surface water runoff, wildlife habitats, ground cover, and the quality of the highway visual environment. Yet consequences of this sort directly affect both long- and short-term investment in the highway system.

Costs to the taxpayer of unauthorized destruction of vegetation also are difficult to calculate, but for the additional reason that they are deliberately carried out in secret, and may only be discovered later by highway agency maintenance crews. Some indication of the range of costs that are involved in typical cases, however, is provided by reported examples of occasional prosecutions of outdoor advertising companies for unauthorized destruction of roadside vegetation. In 1979 a Seattle, Washington court assessed damages in the amount of $40,000 (plus $1,000 as a fine) against a billboard company for illegally cutting 200 trees owned by the city (Seattle Post-Intelligencer, 1979). In 1978, at five sign sites in Tennessee, it was estimated that over $125,000 worth of trees were cut following the Tennessee Department of Transportation's refusal to issue a selective cutting regulation as requested by the outdoor advertising industry (Nashville Tennessean, 1978). The Tennessee Department of Transportation is reported to have estimated that more than $1 million worth of trees were cut in front of billboards during 1977 (Nashville Tennesseean, 1978). Also, in 1978, in a case that was documented fully, the unauthorized cutting of about 200 cottonwoods along I-35 in Kansas was estimated to have destroyed about $33,000 worth of vegetation within the right-of-way (Minneapolis Tribune, 1978).

While the foregoing reported instances illustrate the range of costs involved in this unauthorized destruction of vegetation, to date no nationwide survey of these costs has been made. That such a national total would be substantial is, however, clear from an FHWA finding that the 30 State highway agencies reported 1,466 instances of destruction of vegetation within Interstate System rights-of-way in front of outdoor advertising signs in 1977. Of these instances, 34 involved new plantings only, and 1,432 involved a mix of new plantings and existing vegetation retained during highway construction.

Application of highway investment costs to CEVMS. To what extent may increased use of CEVMS contribute to impairing the public highway investment which Congress sought to protect by enactment of the Highway Beautification Act?

Manufacturers and sellers of CEVMS have claimed that their signs are better in design, performance, and appearance than the examples of "garish," deteriorated and excessive electric signing that generally, and properly, are criticized as unsightly and unsafe (National Electric Sign Association, 1978). To the extent this occurs in practice it could reduce the likelihood that increased use of CEVMS will contribute to the symptoms of deterioration of the value of roadside land development, and indirectly affect highway investment.

The CEVMS industry also has noted that its signs are capable of remote control, so that messages may be changed without the necessity of physically servicing the sign itself. The stronger structure of CEVMS cabinets and support components may make them less vulnerable to weather damage than conventional billboards. On the other hand, the electronic, electrical, and mechanical components themselves, as well as the many light bulbs used in a wide variety of CEVMS types, will obviously require periodic service visits. Thus, the likelihood that highway access controls may be disregarded during maintenance activities remains a potential and, perhaps, an increasing risk.

Finally, the CEVMS industry may emphasize that it seeks sign locations that are at established business sites, in shopping centers, and along arterial highways and streets in commercial or industrial areas. In such locations the need for vegetation control may not arise. To the extent this occurs in practice, the direct cost of removing landscape vegetation to increase the visibility of signs or sites could be reduced.

If this aspect of the CEVMS industry could be counted on to prevail in the actual use of these signs, the threat of adverse impact on highway investment might, on balance, be reduced. The trouble is that self restraint in marketing CEVMS is likely to prove every bit as difficult as in marketing other types of electric signs. In a conference on urban signage, sponsored by the electric sign industry and the U.S. Department of Housing and Urban Development in 1976, the difficulty of improving urban signage was attributed in major part to the businessman's preferences. The problem was put this way:

> ....the last group responsible for bad signage, and that is the group by far the most responsible... are the customers....
>
> Any sign salesman will tell you that almost without fail, should he suggest a fascia sign, 4 feet (1.22 m) high and 30 feet (9.14 m) long, to fit the store front, the customer's first two questions will be 'How much will it cost?' and 'How big can the letters be?'

Quite understandably, commissioned salesmen tend to go along with their customers' preferences (Oliphant, 1976).

Although the outdoor advertising industry has emphasized the desirability of qualifying, and perhaps even licensing, sign designers to ensure application of good design standards in the administration of local zoning and building code provisions relating to advertising signs, it is realistic to recognize the strength of the economic and competitive forces that work against such a system (Oliphant, 1976).

The risk to the public highway investment from outdoor advertising therefore is, as it always has been, in the lack of market incentives or industry self regulation to prevent excessive and poorly designed or constructed signing, and in the risks that accompany sign maintenance activities. This is what Congress saw clearly in the early experience with ribbon development along arterial highways which it sought to prevent or remedy by the Highway Beautification Act (Godschalk, 1967; Petersen, 1967). And this is what continues to be the risk that must be faced in any authorization for increased use of CEVMS, either in the present authority for on-premise usage, or in any possible proposal for extended use at off-premise locations in the future.

In closing this section, it should be noted that, despite general recognition of these risks, the Highway Beautification Act of 1965 exempted on-premise signs from mandatory State control, and relied on local regulation to provide the needed protection. This has appeared to be a significant omission, as noted in the 1970 "Restudy of the Highway Beautification Program:"

> In urban and suburban areas, most of the signs visible from the highway are on-premise signs, advertising goods and services at that location. In one study, 90 percent of the signs were of this type, as opposed to advertising now controlled under the Highway Beautification Act. It seems obvious that if visual clutter is to be reduced in these areas, consideration must be given to control of on-premise signs (Restudy, 1970, p. 16).

Generally, local planning and land use controls have not been equal to dealing with the pressures to develop land in the major urban and suburban corridors. Strip commercial development, often with lavish use of on-premise signs, is common in these corridors. The growing use of CEVMS, as discussed in this section, may do little to improve this overall situation.

VI. APPLICATION OF CURRENT TECHNICAL KNOWLEDGE TO DEVELOPMENT OF STANDARDS

When consideration is given to the development of standards governing roadside display of commercial electronic variable-message signing, it is suggested that standards should address at least those apsects of signing that are listed below. In this list no attempt has been made to indicate priorities or rankings of importance which these aspects should have in any set of standards. Nor does the discussion of these aspects indicate all of the situations in which they are interrelated. These are matters that will enter into the design of standards in accordance with policy decisions regarding scope, purpose, and other factors.

A. Longitudinal location. This refers to the location of signs along the highway in their relation to the major geometric design features of the highway. Such features include intersections, interchange entry and exit points, channelization features, traffic control devices (including official route markings and directional signing), highway structures (bridges, viaducts, overpasses), and design features which require a high level of attention to the driving task (sharp curves, lane drops, "weaving" areas, areas of reduced sight distance).

B. Spacing and density. This refers to the number of signs that are located within a specified linear distance in roadside areas in their relation to highway traffic safety and effective delivery of informational messages to motorists on the adjacent highway.

C. Lateral location. This refers to the distance that signs are set back from the highway, measured in distance from the edge of the main traveled way. Lateral location standards may also consider the angle of the face of a sign on which messages are displayed relative to the line of sight of motorists on the adjacent highway.

D. Interaction with traffic signs. This refers to both the location and design of signs as these factors may affect the operational effectiveness of official traffic control devices.

E. Duration of message on-time. This refers to the length of time that the full text of a message is visible to view on a variable-message sign panel.

F. Duration of message off-time. This refers to the length of time that the message panel of a variable-message sign displays no part of any message.

G. Duration of message change interval. This refers to the length of time between display of the full text of one message and display of the full text of the next message in a series of messages programed for a variable-message sign. It includes, but can be longer than the message "off" time, and might be equivalent to a visual "dissolve" in which one image fades from view while another appears. Thus, some visual portions of two sequential messages might be displayed simultaneously.

H. Total length of information cycle. This refers to the length of time required to display all elements of a pre-programed sequential message or a message series. Pre-programing may be in the form of a manually activated remote control device.

I. Rate of intensity or contrast change. This refers to variable-message signs in which the illumination or contrast does not change instantaneously, but increases to a maximum level and then decreases to a minimum in the course of changing messages. The rate of this change is the interval of time between the moment of maximum illumination intensity or contrast for one message and the moment of maximum illumination intensity or contrast for the message which follows it.

J. Flashing signs and lights. This refers to a cycle of intermittent illumination in which the phases are arranged so that the changes in illumination or contrast appear to be displayed in sudden bursts of light. The flashing character of a sign is determined by reference to the interval of time between its maximum and minimum illumination in the cycle of change for the messages displayed. Flashing signs may include those which present repetitive displays of the same message or a series of different messages displayed in sequence.

K. Brightness and contrast. This refers to the degree of intensity and contrast between a sign's message and its background, and is a factor affecting the legibility of sign messages. Optimum correlation of intensity and contrast maximizes legibility. Poorly correlated intensity and contrast may reduce legibility either by too little illumination and contrast or excessive brilliance (glare).

L. Animation and message flow. This refers to the sequential display of the elements of a message so as to give the appearance of their movement on or across the message panel of a sign.

M. Size of sign and lettering. This refers to the size of the cabinet and message panel of a variable-message sign, and the size of letters, numbers of other elements of messages displayed thereon. Size of lettering includes spacing and number of characters or lines, but does not include style of characters.

N. Primacy of information. This refers to the priority accorded to various types of messages displayed in roadside areas. Priorities are determined by correlation of motorist information needs, motorist driving tasks, and other information stimuli present in the roadside environment.

O. Maintenance requirements. This refers to the services that must be performed to maintain an electronic variable-message sign in optimum operational condition. It includes routine servicing and repair of mechanical, electrical, or electronic parts, but does not include major replacement or reconstruction of portions of the sign.

In developing standards for the foregoing design, structural, and operational aspects of electronic variable-message signing, the summary presented in Table 4 indicates the general relationship of these aspects to the public interests involved. Each of these 15 aspects of electronic variable message signing is discussed in greater detail below.

Table 4. Impacts of CEVMS on Traffic Safety and Visual Environment.

	Design, structural, or operational aspect	Operationally Unique to EVM Signs	Impact on traffic safety	Impact on visual environment
A.	Longitudinal location	No	High	Medium
B.	Spacing and density	No	High	High
C.	Lateral location	No	High	High
D.	Interaction with traffic signs	No	High	Medium
E.	Duration of message on-time	Yes	High	Medium
F.	Duration of message off-time	Yes	Low	Low
G.	Duration of message change interval	Yes	High	High
H.	Total length of information cycle	Yes	High	Medium
I.	Rate of intensity or contrast change	Yes	Medium	Medium
J.	Flashing signs and lights	No	High	High
K.	Brightness and contrast	Yes	High	Medium
L.	Animation and message flow	Yes	High	High
M.	Size of sign and lettering	No	High	High
N.	Primacy of information	No	High	Low
O.	Maintenance requirements	Yes	Medium	High

A. Longitudinal location. A critical safety consideration in selecting the longitudinal location of CEVMS is the preservation of motorist sight distance in the vicinity of intersections or other highway features and in traffic situations demanding specific attention to driving tasks. A second consideration, relating both to safety and effectiveness of communication, concerns the impact of commercial signing in roadside areas upon the time sharing capability of motorists when they must deal with the concurrent display of commercial advertising messages, traffic information and control messages, and directional information.

Empirical evidence from accident studies indicates that the presence of advertising signs is, in some circumstances, associated with traffic accident locations. Also, the bulk of the experimental and accident study evidence indicates that, notwithstanding a substantial capability for time sharing in reading and comprehending a series of messages, conditions can arise where this capability is overloaded. Elimination of messages having a low priority for safe microperformance of driving tasks (commercial advertising) facilitates concentration on messages with high operational priority (traffic control signing, route guidance, directional signing).

Because of the novelty and attention-commanding characteristics of conspicuous, high-contrast signs, a conservative criterion for estimating sight distance requirements should be employed when locating such signs. Guidelines for setting these requirements are contained in FHWA R&D Report 78-78, "Decision Sight Distance for Highway Design and Traffic Control Requirements" (McGee, et al., 1978).

B. Spacing and density. Notwithstanding the recognized ability of motorists to selectively filter out messages or other sensory stimuli that are extraneous to their immediate driving tasks and related directional information needs, human factors research indicates that the capability for processing information is finite, and under some circumstances may become overloaded. In such instances the result is distraction or failure to comprehend certain messages, and increased difficulty in maintaining information processing priorities according to driving task needs. Spacing and density of roadside signs affects the risk of overloading the driver's information processing capability, and the principle of "spreading" has been recommended in order to better relate the location of roadside signs to the information needs of driving tasks.

Evaluations of the impact of CEVMS on motorists' information processing capability under varying conditions also must take into account the exceptional readability, size, and variability in mounting heights of CEVM signs. It would appear to be possible to arrange two or more of these signs in such a manner that all would be visible and readable by a motorist simultaneously, where conventional signs or standardized billboards arranged in the same manner would not.

Applied to the matter of locating on-premise CEVMS in rural and other roadside areas where land development is not intense, the problem is subject to the same considerations that govern longitudinal location. In areas of roadside strip commercial development, or in other areas of concentrated development such as shopping malls with store fronts facing and visible from an adjacent highway, space for "spreading" is not generally available. CEVMS technology and design options, however, offer opportunities for accommodating several advertisers by sequential displays on a single sign panel. Sign manufacturers have cited this capability in connection with the possibility of reducing the density of separate signs in roadside areas having high commercial development, and it would seem to be appropriate for use in standards for CEVMS in areas where other forms of on-premise signing are or may be utilized.

C. Lateral location. Considerations of traffic safety make it necessary to prevent the placement of physical obstructions or fixtures that may constitute collision hazards immediately adjacent to the main traveled way of a highway. These areas, called "clear zones," typically extend to 30 feet (9.14 m) for conventional highways. Normally, it is to be expected that the location of electronic variable-message signs will not involve conflict with established clear zones, since in practice all will be located outside the right-of-way. Instances may occur in densely developed urban environments, however, where recommended clear zones may extend beyond the right-of-way line. In such cases the need to reduce potential collision hazards indicates that standards for lateral location of on-premise electronic variable-message signs should apply the clear zone principle.

In addition to reducing the risk of roadside collision hazards, standards for lateral location should reduce the time that drivers' attention is diverted from road and traffic conditions. Generally this suggests that signs should be located and angled so as to reduce the need for a driver to turn his head to read them as he approaches and passes them.

Lateral location of CEVMS must give priority to maintaining clear zones that may be necessary for the existing terrain and highway geometric design. Selection of lateral locations beyond these clear zones should relate sight distance to the total length of a sign's information cycle, permitting the viewer to see the entire cycle by a series of glances. Necessary sight distance for lateral locations should not be provided by trimming, destroying or removing trees or shrubbery from the right-of-way.

D. Interaction with traffic signs. Safety considerations require that traffic control devices and official directional signing have priority in the competition for motorists' attention while driving. Two types of situations may jeopardize this priority. One occurs where the design of commercial advertising signs is deceptively similar to official signs (see, for example, Holahan, et al., 1978a,b). The other occurs where the density and spacing of commercial advertising signs in roadside areas makes it difficult to quickly identify and select out official signs from others near them.

These situations were recognized in the National Standards for regulating outdoor advertising signs adjacent to the Interstate System, promulgated in 1960 under the Bonus law (23 FR 8793, November 13, 1958, as amended). The pertinent excerpts from these standards are as follows:

> § 20.8 (a) No sign may be permitted which attempts or appears to attempt to direct the movement of traffic or which interferes with, imitates or resembles any official traffic sign, signal, or device.
>
> § 20.8 (b) No sign may be permitted which prevents the driver of a vehicle from having a clear and unobstructed view of official signs and approaching or merging traffic.

These general provisions, applicable to both on-premise and off-premise outdoor advertising signs, are as necessary in the regulation of CEVMS as for conventional advertising signs. In determining when the design of advertising signs is similar to official signs, authoritative standards and specifications are furnished by the Manual of Uniform Traffic Control Devices. Determination of when the view of an official sign is obstructed or interfered with is an engineering judgment based on the circumstances of each situation.

E. Duration of message on-time. The length of time that the full text of a message is visible to view is directly related to the ease with which a motorist can comprehend it without interfering with his driving task. The longer a message is displayed, the more opportunity a motorist has to choose the moment when he can best divert his attention from driving to read a roadside commercial sign.

Selection of a reasonable minimum standard for the duration of message "on-time" should be correlated with the length of the message or message element. Experience of State highway agencies using electronic variable-message signs for road and weather information on Interstate System highways indicates that comprehension of a message displayed on a panel of three lines having a maximum of 20 characters per line is best when the on-time is 15 seconds.

In contrast, the customary practice of signing which merely displays time and temperature is to have shorter on-times of 3 to 4 seconds.

F. Duration of message off-time. The interval of time between sequential displays of messages or message elements directly affects the ease with which a series of messages or message elements can be comprehended by a motorist-viewer. As this interval of "off-time" is lengthened, the difficulty of maintaining the continuity of attention and comprehension is increased. In prescribing an operational standard, an interval should be selected which provides optimum conditions for comprehension without creating time-sharing demands that jeopardize the priority of attention to driving tasks.

G. Duration of message change interval. This issue is closely related to several others discussed in this chapter, including: rate of intensity or contrast change (which is incorporated herein); flashing signs and lights; and animation and message flow. It should be the intent of any regulations to bar those uses of CEVMS which may distract or overload the driver, while not prohibiting the changing of messages on such signs at reasonable intervals.

For purposes of discussion, the "message change interval" is that portion of the complete information cycle commencing when message "one" falls below the threshold of legibility and ending when message "two" in a sequence first reaches the threshold of legibility.

Present technology makes it possible for a displayed message to be removed from the sign face and a new message displayed in its place (with a blank period of predetermined length between the two) in such a brief overall time that the entire operation is barely preceptible by the human observer, particularly a driver in a moving vehicle. On the other hand, the same technology can be employed so that the time taken to present or remove a message can be extended. This can be achieved in several ways. For example, a multiword message can be "written on" or "erased from" the display face one character or word at a time rather than all at once. Second, on a sign capable of displaying message movement or animation, the first message can be moving across the sign while a new message is also moving in to take its place. Third, the illumination and/or contrast of the messages can be varied so that one message appears to fade or dissolve into the subsequent one.

Control of the message change interval should be regulated to ensure that this interval is not obtrusive regardless of the technique utilized to effect the change. In other words, if the message change is accomplished by a change in illumination intensity, this change must be accomplished in the shortest possible time permitted by the system hardware and software, with the further restriction that no discrete messages will ever overlap on the display, nor would one message ever appear to gradually fade or dissolve into the next. Likewise, regulations should ensure that no message would appear to be written on or erased from the display piecemeal, i.e., less than the entire message at once. If such a partial image-change technique is required by a particular control system technology, a maximum time limit should be set for the complete message change such that the passing motorist is unable to read (and is not "compelled" to try to read) the message during the change. It is suggested that the figure commmonly used as a measure of average glance duration, 0.3 second, be used here as a maximum permissible message change time limit (Williams, 1966).

H. Total length of information cycle. The goal being sought in the regulation of information cycle length is that of allowing the passing motorist to comfortably read the entire message without an excessive added burden to his information processing workload; and of minimizing the sense of anticipation felt by the motorist while waiting to see what the next display will be, which could compel the driver to fix his attention on the variable message sign at the expense of his other tasks.

Information cycle length can be a function of the type of sign used and the nature of the information being transmitted, as well as the actual amount of material to be communicated. At one extreme is the unchanging, fixed message sign. In this case there is no information cycle per se, so the driver may read the sign when it is most convenient for him, provided his transit time is long enough for the text length. The simplest sign which may be regarded as having a measurable information cycle is that of the two-message alternating display. The most common form of this is the time and temperature sign. If we define information cycle length as the time required for the complete message or series of independent messages to be transmitted (above the legibility threshold) on the sign, the time/temperature display could be conceptually represented as shown in Figure 17.

Clearly, this type of sign can have its information cycle length extended by the addition of a third message (e.g. the name of the business providing the sign), or by increasing the complexity of the present message (perhaps by displaying temperature in both degrees fahrenheit and centigrade). Adding to the message complexity requires a longer time commitment by the driver to read and interpret the sign. Adding an additional message not only increases this time commitment, but increases the compelling characteristic of the sign as well. This situation is exacerbated with the type of sign in which several sequential displays are required to form one thought (see Figure 13). Here, the motorist's compulsion to attend to the sign is greatly increased due to the psychological difficulty of leaving a task when it is incomplete. (This phenomenon is well documented in the psychological literature, and is known as the Zeigarnik effect.) The famous "Burma Shave" signs (see Figure 19) were early examples of the commercially successful use of this concept (Rowsome, 1972).

A different problem arises in the case of a sign where many independent messages are displayed sequentially. This might commonly occur in a regional shopping center, where the management erects an electronic, variable message sign and grants each member business "equal time" (see figure 20). When many merchants are involved, it is impossible to display every message in the short time that the sign is readable to the passing motorist. In order to minimize the compelling nature of the display caused by the driver's desire to read every message, and to prevent the motorist from committing potentially unsafe driving acts (drastic speed reduction, lane change, etc.) in a (possibly) futile attempt to do so, it becomes necessary to extend the total information cycle by constraining the message change interval at the low end. Specifically, it should be required that each message be held on display long enough for the sign to appear to be unchanging to any given motorist. While there is a high likelihood that a message change will occur within a particular motorist's field of view, the compelling qualities of the display will be minimized due to the long message "on-time" coupled with the fact that any one motorist will see at most one such message change during a particular trip.

A worst case condition occurs with a running message sign, in which the display is capable of continuous movement, and cannot be said to have a finite length (see Figure 21). As discussed in section K of this chapter, it is recommended that such signs be prohibited in those areas controlled under the Highway Beatification Act, as amended.

It should be noted that certain types of signs may possess information cycles even though their actual messages do not change. The two signs shown in Figure 16 display unchanging texts. The preprogramed changes of color, pattern, and sequence of their lamps, however, effectively create information cycles. In the case of the Uniroyal sign, this information cycle lasts four hours. Clearly, any signs which have an information cycle but do not change messages should not be permitted on the roadside.

In summary, signs which are capable of displaying motion or animation, and signs which display information cycles without changing the texts of their messages, should be prohibited under the Highway Beautificaton Act amendments. Those signs on which many independent messages are displayed sequentially should maintain a minimum "on-time" for each message calculated to be such that a motorist traveling the affected road at the 85th percentile speed would be able to read not more than one complete nor two partial messages in the time required to approach and pass the sign. In no case, however, should this on-time be less than four seconds. Since the average glance duration is generally accepted to be 0.3 second, a display time per message of four seconds would require less than 10 percent of the driver's available visual search time. A shorter display time could be too demanding when there are competing needs for the motorist's attention.

In the case of signs on which a complete message requires several sequential partial presentations the situation is more complex, but formulae can readily be derived to compute acceptable ranges of total information cycle lengths for different highway/traffic/signing conditions. For any chosen vehicle speed, sign size, and distance from the road, a total information cycle time (taking into account message "on," "off," and "change" time) could be derived from knowledge of the number of display changes required, and the number of words and lines per display. Since the display details will obviously change over time, the regulation should be based upon a hypothetical worst case, and should incorporate such stipulations into its text. Any formula to be developed for this type of sign would have as its criterion the capability for a motorist, driving at the 85th percentile speed, to read the sign's entire message (within certain limits) without any undue increase in his processing workload. This goal would have to be met no matter where in the display cycle the motorist was first able to read the sign.

It is believed that, if the driver is given sufficient time to read the complete message, and can be reassured that he has, in fact, seen the entire display, he will be less compelled to continue looking at the sign with a possible adverse impact on his driving performance. By extension, when the series of sequential messages is too long for a passing motorist to read, the potential compulsion should be minimized by greatly extending the display change cycle as discussed above. And, in those cases where the display changes without a change of message,

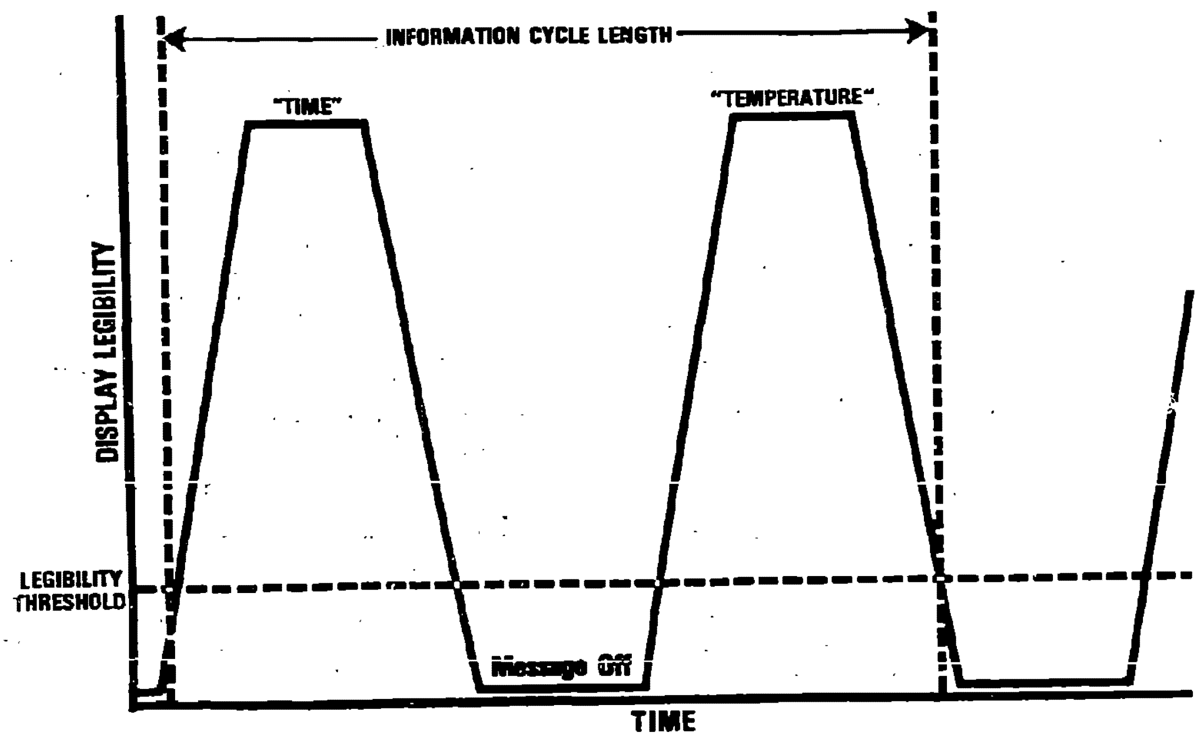

Figure 17. Length of Information Cycle

or where a message has the capability of continuous motion, the compulsion should be avoided by banning the signs from the roadside.

I. Rate of intensity or contrast change. Refer to Duration of message change interval.

J. Flashing signs and lights. The critical parameters for a sign or light to be designated as flashing concern the relative durations of the "on" and "off" phases of the signal, the pattern of these phases, the rise and decay time required for the signal to achieve maximum and minimum intensity, respectively, and the relative brightness of the "on" and "off" signal phases. In fact, a sign or lamp need not be completely extinguished between "on" phases to be designated as flashing. A perceptible change of brightness between the "on" and "off" phases is sufficient. The issues of signal brightness and contrast will be dealt with in another section. For the purpose of defining the operational use of the term "flashing" it does not matter whether the sign displays the same message repeatedly or if the message changes periodically or with each cycle. The main factor of concern is the attention-getting nature of the signal, as governed by its flashing characteristic, which, intentionally or not, can capture and hold the motorist's attention even before he can read the message.

The United State Coast Guard, in its list of "Characteristic Light Rhythms," (U.S. Department of Transportation, 1979, p. VIII,) depicts, graphically and verbally, 12 variations of light patterns in which the intensity of the light varies predictably over time. Although only one of these patterns is defined strictly as "flashing," the attention-getting result of each is similar; and for our present purposes each (as well as many other patterns which could be added to the list) must be considered to be a flashing signal (see Figure 18).

The objective of any regulation governing flashing signs or lights for roadside commercial use should be to minimize the likelihood of potentially hazardous attention-getting or distracting properties, while permitting signs which present messages which change over time. The safety goal is to permit the messages to be changed in an unobtrusive manner, so as to avoid introducing a novel or distracting visual element into the driver's perceptual environment.

To this end it is suggested that any commercial sign visible from the highway be specifically prohibited from flashing (as defined below) if it displays a message of unchanging text. The illumination of or within such a sign should be regulated to permit a maximum of two "on" and "off" phases within any 24-hour period, unless such illumination is controlled by a device which senses the outdoor, ambient illumination in the immediate vicinity of the sign. Such signs should be permitted to cycle on and off as the ambient illumination under natural conditions changes about a level as yet undefined. These two proposals may seem somewhat arbitrary, but they have been based upon analysis which considered daylight versus night conditions; weather; periods of rush-hour traffic; and business operating hours.

For all roadside commercial signs subject to regulation which present messages whose text changes over time, the safety goal of unobtrusive message changes can be met by optimizing two parameters: (a) maximization of the length of the signal "on-time" as a percentage of the total cycle; and (b) minimization of the flash rate or number of periods per unit time in which the signal is on. For example, a signal which is "on" 50 percent of the time (a 50 percent duty cycle) and has a flash rate of 10 cycles per minute would yield a display which is on for three seconds, off for three seconds, etc. Obviously, the goal of a near steady-state (non-flashing) signal can be achieved by maximizing the duty cycle to nearly 100 percent and minimizing the flash rate, possibly to a value of three per minute or less. A sign displaying a message requiring sequential displays, however, needs a flash rate high enough for the entire sequence to be read by the passing motorist without demanding an undue degree of the driver's attentional capacity. The duty cycle issue

Illustration	Symbols and meaning: Lights which do not change color	Symbols and meaning: Lights which show color variations	Rhythm description
	F.= Fixed...	Alt.= Alternating.	A continuous steady light.
	F.Fl.=Fixed and flashing	Alt. F.Fl.= Alternating fixed and flashing.	A fixed light varied at regular intervals by a flash of greater brilliance.
	F.Gp.Fl. = Fixed and group flashing.	Alt. F.Gp.Fl = Alternating fixed and group flashing.	A fixed light varied at regular intervals by groups of 2 or more flashes of greater brilliance.
 SHOWS NOT MORE THAN 30 FLASHES PER MINUTE	Fl.=Flashing	Alt.Fl.= Alternating flashing.	Showing a single flash at regular intervals, the duration of light always being less than the duration of darkness.
	Gp. Fl. = Group flashing.	Alt.Gp.Fl.= Alternating group flashing.	Showing at regular intervals groups of 2 or more flashes
	Gp.Fl.(1+2) = Composite group flashing.	....	Light flashes are combined in alternate groups of different numbers.
	Mo.(A) = Morse Code.	....	Light in which flashes of different duration are grouped in such a manner as to produce a Morse character or characters.
	Qk. Fl. = Quick Flashing.	....	Shows not less than 60 flashes per minute.
	I. Qk. Fl. = Interrupted quick flashing.	....	Shows quick flashes for about 5 seconds, followed by a dark period of about 5 seconds.
	E.Int.= Equal interval. *(Isophase)*	....	Light with all durations of light and darkness equal.
	Occ.=Occulting.	Alt.Occ. = Alternating occulting.	A light totally eclipsed at regular intervals, the duration of light always greater than the duration of darkness
	Gp. Occ. = Group Occulting.	....	A light with a group of 2 or more eclipses at regular intervals
	Gp.Occ.(2+3) = Composite group occulting.	....	A light in which the occultations are combined in alternate groups of different numbers.

Light colors used and abbreviations: W - white, R - red, G - green

Figure 18. Characteristic Light Rhythms (Source: U.S. Coast Guard, Light List CG-160, 1979)

can be resolved easily (the "off-time" figure required to be as brief as the actual time required to replace one message with another by the system hardware and software in conjunction with minimum performance standards), but an acceptable flash rate must be based upon research through which the tradeoff between the motorist's ability to read the entire message and a flash-rate low enough to avoid excessive attentional attraction can be optimized empirically. The resolution of this issue will also have to take into acount the maximum message length (total information cycle) that the motorist is expected to read, and his compulsion to read the entire text.

An initial approach to this problem might proceed as follows. Assume that the goal is that the "average motorist" (one traveling at the 85th percentile speed, perhaps) be able to read a sign's complete message during a fixed percentage (perhaps 30 percent) of the time it will take him to travel from the point at which the sign's message is first legible until he passes it. Then the flash rate would be determined to be that subdivision of the total information cycle length that allows the entire message to be seen once in that time period. For further discussion of this issue refer to H. Total length of information cycle.

K. Brightness and contrast. Like the issue of letter and sign size discussed in a later section, the major parameters affecting sign legibility due to brightness and contrast are well documented in the human factors literature. Two studies of relevance are "Sign Brightness in Relation to Legibility" (Allen, et al., 1966), and "The Luminous Requirements of Retroreflective Highway Signing" (Olson and Bernstein, 1976). Under daytime conditions it is usually irrelevant to talk about a sign that is too bright or contains too much contrast. At night, however, this is not the case. Here, the range of brightness acceptable for sign legibility depends largely on ambient lighting conditions. Brightly lit urban areas, the glare of oncoming headlights, or competition from nearby illuminated signs can all interfere with the driver's ability to read the message on a particular sign. Worse, a commercial sign of brightness and/or contrast that is too high for the particular circumstances of its placement can lead to the driver's inability to read nearby official signs or can temporarily destroy his night vision (of importance for hazard detection and seeing roadway delineation) under otherwise low-illumination nighttime conditions. Thus, it is crucial that upper limits on sign brightness and contrast be established for CEVMS in nighttime use. The advertiser should not be restricted on the low end of brightness or contrast under the reasonable assumption that he will take care to design a sign that meets at least the minimum standards of good human factors practice for ease and comfort of reading.

Although it is premature to discuss specific suggestions for upper limits of brightness and contrast in the present report since there are a great many variables which must be taken into account, results from the two studies cited above may be helpful. The Allen, et al., (1966) report, for example, found a noteworthy interaction between sign luminance and ambient illumination when the dependent measure was legibility distance. In their research, a sign of low luminance was seen better in low ambient illumination, and a bright sign was seen better in high ambient illumination. (Studies of the effectiveness of different within-sign contrast levels indicated that it would not be necessary to establish different luminance requirements or restrictions for signs with differently colored backgrounds.) The authors suggested general maximum sign luminance levels, and these are cited below. The reader should bear in mind that, although this was a well-controlled field experiment, neither the signs nor the subjects' task was directly related to the type of situation being addressed in the present report. These conclusions, therefore, should serve only as general guidelines:

> . . . the data suggested that high-luminance signs can change the adaptation level of the eye (or the pupil size, or both). This finding suggests that the

driver's vision would be impaired for other tasks requiring dark adaptation. It seems unwise to install unnecessarily bright signs which are unpleasant to the driver and may impair his vision. In the authors' opinion, an upper limit of 30 ft-L (102.79 cd/m^2) would seem desirable for rural locations, and luminances about 100 ft-L (342.63 cd/m^2) would definitely be too bright. For illuminated highways, luminances as high as 100 ft-L (342.63 cd/m^2) would seem permissible. In brightly lit urban areas luminances as high as 500 (1713.13 cd/m^2), or perhaps even higher, might be satisfactory (p. 33).

Lighting engineers and designers speak of two phenomena which may be caused by excessive illumination, and which are closely related. These are disability glare (the more severe), and discomfort glare. The former often results in a reduction in contrast of the visual stimulus (Allen, et al., p. 2), and may adversely affect the driver's ability to read a sign; the latter, as its name implies, makes the sign reading task less pleasant, and may affect the effort which a driver will make to read a sign. Glare sources, some of which were mentioned above, will additionally impair seeing at night since they can change the eye's pupil size and its degree of dark adaptation. Obviously, a brightly illuminated sign, or simply a sign of high luminance, may affect sign reading comfort or ability not only of its own message, but those of nearby signs and road markings as well. When it is remembered that a brightly lit advertising sign could act as a glare source, conceivably affecting the driver's ease of reading nearby official signs and markings, it becomes clear why regulations establishing upper limits on CEVMS night-time luminance must be set so as to avoid possible discomfort glare. Such limits are not easily defined, and should be subject to empirical validation.

L. Animation and message flow. The one characteristic of a sign or light bank which has perhaps the greatest potential for motorist distraction as well as a dominant visual impact on the aesthetic environment is motion or the illusion of motion of lights or other display features. Signs possessing such capabilities have been variously referred to as animated, chasing, scintillating, or travelling, among others. The unifying feature among them is the appearance of movement, either of lights themselves, or of letters, numbers, characters, or graphics which are often comprised of many individual light bulbs. The electronic, remote control of the displayed image which is a hallmark of the type of signs addressed in this report, coupled with the programable features of the state-of-the-art display technology being discussed, permit such signs to offer animation and message flow quite readily. Such signs can be visually captivating, and their traditional use on movie theatres, the Las Vegas and Times Square commercial strips, and, increasingly, on major sports stadium scoreboards emphasizes this point. Clearly, however, they have no place on or alongside our Nation's highways, where their very advantages can cause a serious problem of distraction of attention from the driver's task. It is recommended that signs which convey the appearance of movement or animation in any form should not be permitted in those areas controlled under the Highway Beautification Act, as amended.

Specifically excluded from this section, and addressed in other sections of this chapter, are signs in which the message may be changed, electronically or mechanically, by the appearance of complete substitution or replacement of one display by another, but in which the appearance of movement during message display, or of messages appearing to move across the display face, is not present. The distinction being made is that of a changeable message display, in which a message being presented is visually removed and then replaced with another, versus an animated, moving, or dissolving display in which part or all of a message displayed on the sign appears to move during the time it is intended to be read.

M. Size of sign and lettering. It is not the function of this report to prescribe to the advertising industry the optimum human factors display characteristics for their products. Yet, with regard to choice of character size, spacing, and typeface used on CEVMS visible from the highway, the goals of the highway safety specialist are closely aligned with those of the advertiser. The reason for this is straightforward. In order for the advertiser's message to be conveyed to the motorist quickly, clearly, and unambiguously, the display should be designed with full understanding of the constraints imposed by vehicle speed and vibration, diverse lighting and weather conditions, and the need for driver time-sharing among simultaneous, competing tasks. As the readability of a particular display is degraded, the likelihood of the message being completely and accurately read and understood diminishes. This is because the motorist will require more of his already limited time to read the sign because he begins to read it later than he otherwise would, or because he chooses to ignore it rather than struggle to read it.

Accordingly, commercial sign display characteristics relating to sign size and to character size, spacing, and typeface should be chosen with the guidance of one of the many excellent human factors design guides available for this purpose--with careful attention paid to the environmental constraints under which such signs will often have to be read.

Of course, it is entirely possible to erect a sign of a size and with characters so large that readability is no problem. On the other hand, such a sign would be likely to create a greater potential for motorist distraction, and would probably be judged more deleterious to the aesthetic environment as well. Thus, where existing regulations do not apply it will be necessary to develop guidelines for maximum limitations on sign and character size for commercial electronic variable message signs.

N. Primacy of information. Traffic safety and human factors research indicate that priorities must be maintained in providing information to motorists while they are driving. In regulating display of information in roadside areas, primacy must be given to messages that relate directly to driving tasks and to coping with traffic situations. This principle has been referred to earlier in the recommended regulation of longitudinal location of CEVMS in order to reduce the risk of driver distraction in the vicinity of interchanges, intersections, and other major driving decision points, and in the recommended location of such signs so as to avoid interference with the easy identification and recognition of traffic control devices.

Application of the principle of primacy to the problem of assuring the necessary functional balance of information displayed in roadside areas involves regulating the message content of signage. Traditionally, on-premise signage has been used for a wide variety of purposes, including identification of a business site, advertising goods or services for sale, entertaining viewers or providing public service information, and giving directions into and about the business site.

Electronic variable-message signs are capable of all of these uses. The necessity for primacy of information responsive to motorist's information and direction-finding needs suggests that their use should concentrate on messages that identify business sites, give directions into the site and its facilities (parking and loading areas, internal circulation pattern), goods or services available, and other information necessary to use the site (e.g., hours of operation).

The principle of primacy of information is recognized in the Highway Beautification Act's provisions for assuring that adequate directional signing and travel information are available to motorists. It also is applied in Federal regulations regarding priorities for removal of nonconforming signs, and in standards which prohibit in certain locations the display of information not related to motorist needs or traffic operations. But while relevant legislation and court decisions appear to be broad enough to permit promulgation of standards requiring CEVMS to give primacy to certain types of information, the problem of enforcing such standards is formidable. The ease with which CEVMS information displays can be changed, in some cases almost instantaneously, means that compliance with primacy standards must rely almost entirely on the self-restraint of individual sign owners and operators. While a sign

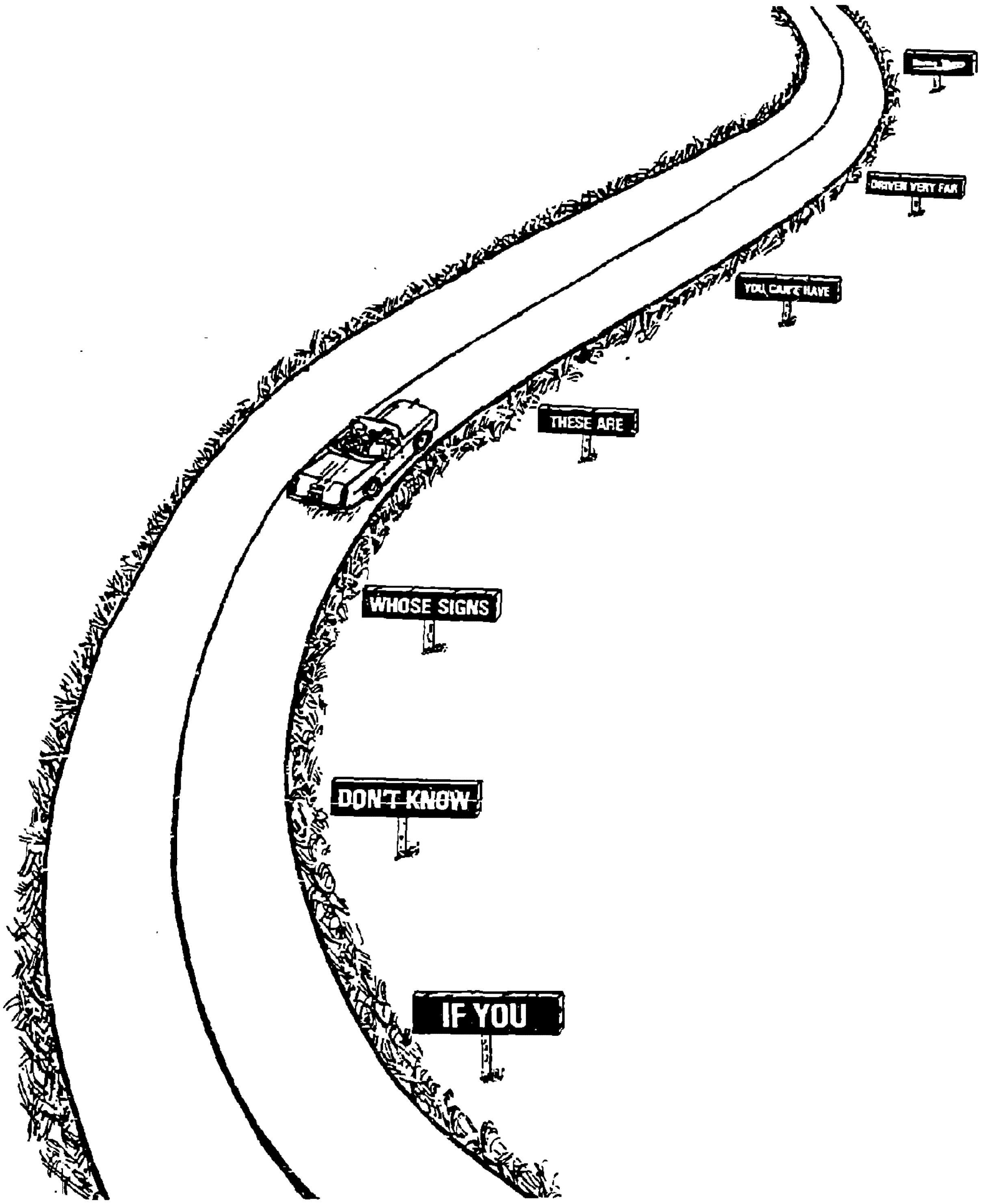

Figure 19. An Artist's Conception of the Classic "Burma Shave" Series of Advertisements. (Source: Federal Highway Administration with permission of American Safety Razor Co.)

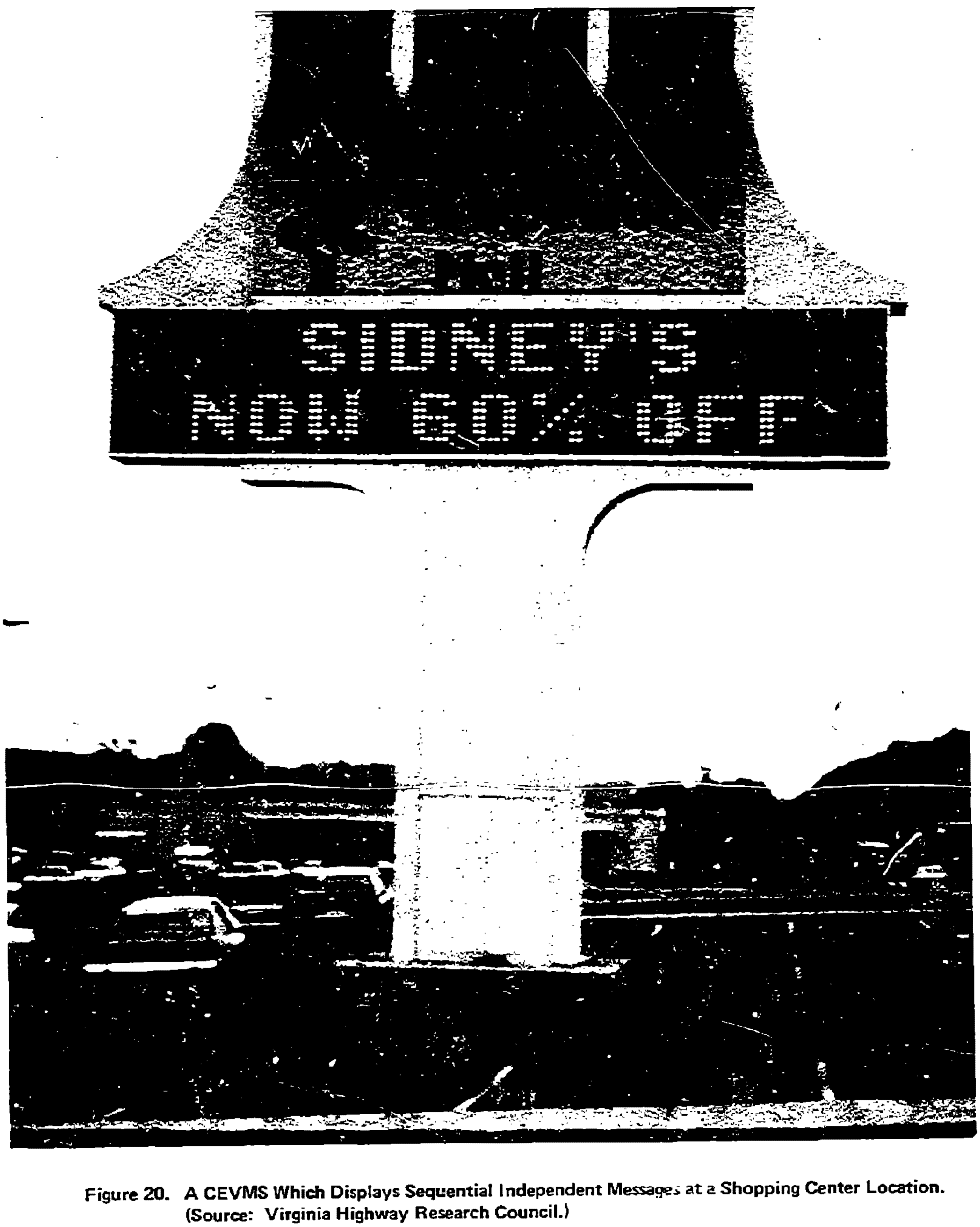

Figure 20. A CEVMS Which Displays Sequential Independent Messages at a Shopping Center Location. (Source: Virginia Highway Research Council.)

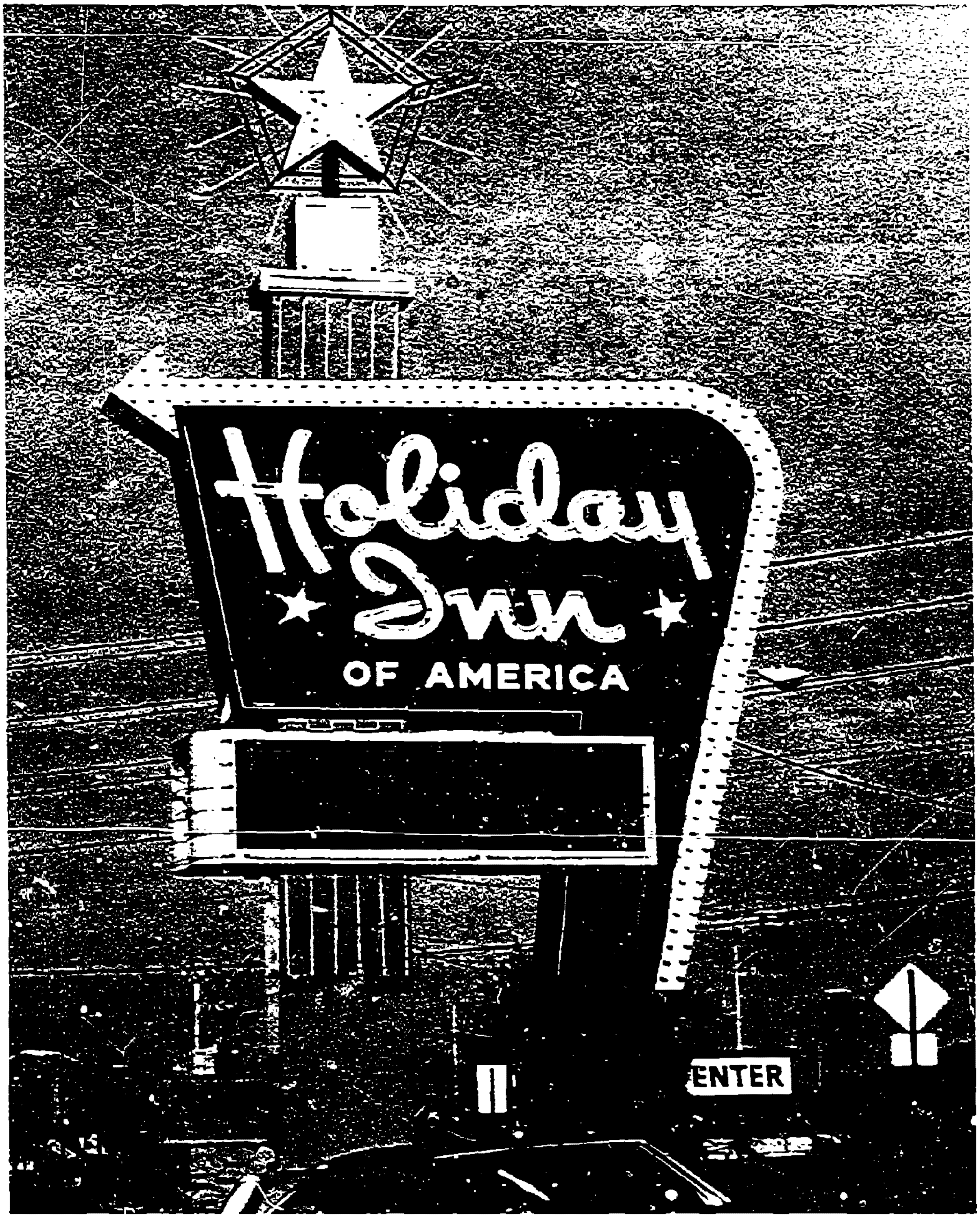

Figure 21. A Running Message CEVMS in which the Display is Capable of Continuous Movement. (Source: Virginia Highway Research Council.)

operator's record of responsibility in this matter might be considered a relevant factor in determining fitness for a license to display a CEVMS, the day-to-day detection and correction of failures to observe information primacy principles clearly is a difficult administrative aspect of this matter.

O. Maintenance requirements. Since the communication function of CEVMS requires that mechanical, electrical, and electronic elements be maintained in proper operating condition, it is essential that standards for such signage include a requirement that they shall be maintained in good repair at all times.

Where light bulbs comprising part of a message display are not working, they can present an unintelligible pattern which frustrates the viewer's expectations and holds his attention for longer than normal recognition and comprehension time. For motorist viewers this may be a particular safety hazard under certain traffic conditions. Similar risks may result where the message display panel uses mechanical devices or is controlled by electronic means and these elements malfunction.

The CEVMS cabinet should receive regular maintenance, and repair or replacement when needed, since this housing may affect both the operational and aesthetic aspects of the sign. Cabinets that are not weatherproof obviously increase the risk that mechanical, electrical, and electronic elements of the sign will be exposed to damage or deterioration. Also, when the exterior appearance of a cabinet is allowed to deteriorate it becomes an unattractive feature of the roadside environment, reflecting an unfavorable impression of both the sign site and the advertiser.

Standards may reasonably require that signs shall be kept in good operating condition and external appearance, and such standards are not invalid due to vagueness merely because they fail to specify the particular maintenance or repair measures that must be taken by sign owners. Moreover, such standards may also reasonably provide that failure to keep signs in good operating condition or external appearance will be a basis for forfeiture of permission for operation of such a sign.

VII. NEEDED RESEARCH

A series of three research studies is recommended in order to obtain definitive answers to those safety and environmental questions raised in the body of the report which, after prolonged debate in the research literature, still are not settled. The three questions, which correspond to the three research studies to be described below, can be broadly summarized as follows:

1. Is there a demonstrable relationship between the presence of roadside commercial advertising signs in general, and CEVMS in particular, and driver distraction, information processing ability, or workload?

2. If the answer to Question 1 is yes, can those features and characteristics of signs (described in Chapter VI of this report) which are thought to contribute to this established relationship be empirically identified, and can the critical parameters of each contributing feature be specified?

3. Through empirical testing, can a relationship be demonstrated between roadside commercial advertising signs, and specifically CEVMS, and the aesthetic impact of the roadside environment upon highway travelers and adjacent property users?

The research program suggested here responds directly to these three questions. Research Question 1, which is of the most critical and immediate importance as explained in the body of the report, is also the question which lends itself to the most straight-forward research approach with a very high likelihood of success in the shortest possible time. Further, if the results of the first study indicate no relationship between the major variables, the second question becomes moot, and its associated research study need not be undertaken. The third question needs to be answered in any case since its significance is independent of any possible driver performance impact of CEVMS that is addressed in the first two questions. It arises in any consideration of the possible need for standards because promotion of the quality of the highway's visual environment and protection of highway investment are major public interests which Congress recognized in the national policy of the Highway Beautification Act. It is an issue that affects both the motoring public and the communities traversed by the highway system, and it requires precise identification and measurement of aesthetic impacts so that consideration of these impacts may be regularly incorporated into the highway and community planning, design, and evaluation processes.

It will be suggested that the third study be undertaken in the Federal Highway Administration's Aesthetics Laboratory, using a research methodology presently being developed.

To comprehensively answer the first question stated above, it is proposed to conduct a field study on public highways employing the measurement technique of real-time driver eye movement recording in conjuncton with subsidiary tasks to measure driver workload. This study would be conducted by administrative contract, and could be completed within one year. As discussed earlier in this report, the use of eye movement recordings coupled with subsidiary task measures would result in a particularly powerful and highly appropriate experimental paradigm that will enable us to clearly identify and explain the relationship, if any, between CEVMS (and other roadside advertising signs) and driver performance under a variety of roadway, vehicle, and environmental factors.

If, as stated earlier, no definitive relationship can be found between the major variables of interest (assuming, of course, that a braod spectrum, including "worst case" features, of CEVMS can be identified and studied), there will be no need to seek answers to the issues posed in Question 2. In other words, it would be moot to study the contribution to driver performance of specific signing features and characteristics if no overall relationship between such performance and the presence of CEVMS can be detected in the field study. On the other hand, if a relationship is demonstrated in the field, it will then be necessary to examine in detail the specific characteristics (and interrelationships of such characteristics) of CEVMS which produce the performance effect.

The number of potentially significant CEVMS characteristics is large. (Fifteen were identified in Chapter VI, and others might be found in the course of the field experiment.) In addition, an adequate investigation would demand that several levels of each characteristic be studied. Because of the complexity and amount of data to be collected, it is suggested that this study be conducted in a controlled laboratory setting. Numerous well-proven experimental approaches are available for the type of analysis needed, including some of the same measures used in the field experiments. The lack of "apparent realism" caused by the laboratory environment will not be a detriment in this phase of the research because the general relationship between CEVMS and driving performance will have already been established in a real-world environment. The primary purpose of the laboratory investigation will be to identify those sign/environment characteristics that contribute to this general relationship. Such experiments have traditionally been very amenable to the precision of control that can only be achieved in a laboratory setting. The outcome of this phase of the research will be a clearer understanding of the relative contribution to driver behavioral response of the several specific characteristics of CEVMS discussed above and in detail earlier in this report.

The third phase of suggested research is directed toward answering the question of the aesthetic impact of CEVMS upon those travelers and other highway users (including adjacent property owners and users) who may be exposed to them. As discussed in this report, aesthetics has traditionally been an area of intense controversy because of what many believe to be its inherently subjective nature. This view, however, fails to do justice to the substantial body of research and doctrine that exists in the field of aesthetics. Examples of planning and design that are acknowledged to have achieved high levels of excellence generally are not the result of an inherently subjective process, and the major challenge for future research in this field is to develop guidelines capable of being used by public officials and private developers who must make decisions affecting aesthetic values on a daily basis. The Highway Aesthetics Laboratory, established within the Office of Research of FHWA, has as one of its early missions the development of a valid and reliable methodology for the objective assessment of highway-related aesthetics issues. The method is laboratory-based, employing high quality visual images of real-world stimuli or accurate scale models, and several refined behavioral and attitudinal response strategies.

Depending upon preliminary findings obtained from test subjects in the first two phases of this suggested reseach program, a specific experiment will be designed and performed in the Highway Aesthetics Laboratory. The findings of this experiment should contribute to an understanding of the affective responses of highway users to CEVMS as viewed in their environmental contexts.

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This annotated bibliography cites research reports that are not included in the main text or referred to in the list of references for this study. It is provided as a supplement to those sources and thus offers a more comprehensive coverage of the study.

1. Adler, B. and Straub, A. L. Legibility and brightness in sign design. Highway Research Record No. 366, 1971, 37-47.

"Sign brightness is a function of many factors including sign material and position, road alinement, and vehicle and headlight characteristics. A computer program was developed that incorporates these factors and determines sign brightness as a function of road distance. The distance at which the sign must be first legible is used in conjunction with the computed brightness and published empirical data relating brightness to legibility to calculate required letter heights. Minimum letter height requirements for road distances up to 2,000 ft. are presented. The cases reported include a straight road, high and low headlight beams, six sign positions, four horizontal alinements, and four vertical alinements. For nighttime legibility, it was found that required letter heights are much larger than the 50-ft-per-in rule indicates. Because of the widely varying sign brightness found in actual roadway conditions, each sign should be treated individually as a separate design problem." (Authors)

2. Bogdanoff, M. A. and Thompson, R. P. Evaluation of warning and information systems, part I, changeable message signs. Report FHWA-CA-RD-75-5. Los Angeles: California Department of Transportation, 1976.

This was an evaluation of 35 bulb-matrix changeable message signs erected in the median of the Santa Monica Freeway by CalDOT, to inform motorists of upcoming freeway conditions in order to reduce accidents, congestion, and driver frustration. A secondary system objective was induction of driver route changes. Aspects of the system evaluated in this report were: (1) public acceptance, (2) vehicle closing speeds, (3) lane changes, (4) route diversion, and (5) accident levels.

Three motorist acceptance surveys were conducted. Results indicated general motorist acceptance (47 percent approval, 33 percent neutral), with a majority finding the information useful. During the 1974 energy crisis, however, motorist acceptance of illumination and use of the signs during non-incident occasions (e.g., the sign message "NORMAL CONDITIONS") declined markedly. The report includes a lengthy analysis of closing speeds, lane changes, and route diversion. The system had a significant positive effect in all three areas. Its effect on accident reduction was less clear, but the data indicated a change to less severe accidents, involving property damage only. An analysis of equipment operation and maintenance is also included, including optimum spacing and location of sign units. Problems with intrasystem communication (use of leased phone lines connected to a central computer) and message flexibility (programing changes possible only if system shut down) were noted.

3. Claus, R. I. and Claus, K. E. (Eds.) Handbook of signage and sign legislation. Palo Alto, Califonia: Institute of Signage Research, 1976.

A series of papers prepared for the HUD-sponsored "Urban Signage Forum" in 1976. Includes in-depth discussion of sign industry history, economics, and marketing, as well as the legal history of sign control. Three papers address considerations of local planners zoning officials, and industry members in the development, adoption, and implementation of sign control codes by local governmental units. A suggested sign code is appended in which electronic changeable message signs are specifically defined, but not regulated any differently than other on-premise signs. An extensive bibliography of general references on signing, design, marketing, and the sign industry is also included.

4. Claus, R. J. and Claus, K. E. The on-premise sign industry, present status and future potential. Palo Alto, California: Claus Research Associates, 1974.

An overview of the industry, with numerous tables and graphs supplementing textual discusion of the growth, marketing potential, and economic benefits of this form of advertising. The effectiveness of on-premise signing is discussed in relation to trade area, business and tourist traffic, and specialized markets. Comparison of effectiveness and cost of on-premise signing is included, as well as a case study of this type of signing in the motel industry. A review of business trends in retail areas, along with rates of business failures is the basis for comments on future market potential for electric on-premise signs.

It is argued that on-premise signs serve informational and directional functions as well as merely business identification purposes; a fact sometimes overlooked by advertisers, sign designers, and industry regulators. New developments in design of changeable message signs and use of "photographics" may not only improve message-effectiveness, but cost-effectiveness of on-premise signing as well.

5. Duff, J. T. Accomplishments in freeway operations outside the United States. Highway Research Record No. 368, 1971, 9-25.

Survey of remotely controlled warning and information systems for ramp, corridor, and freeway control. Systems in West Germany, England, Italy, Japan, and France are reviewed. The authors discuss system objectives, system implementation and technology, and problems encountered in each of these countries.

6. Ewald, W. R. and Mandelker, D. R. Street Graphics. Washington, D.C.: American Society of Landscape Architects Foundation, 1971.

This book presents an innovative look at highway and street signing and suggests a system to regulate signs both for aesthetic reasons and to promote effective communication by the total network of street signing. Sign design, location, business identity, and message all become factors in sign control. Separate chapters address the physiology and psychology of vision and detail the proposed street graphics model ordinance.

The model ordinance permits time and temperature devices, but sets no limits on frequency of change of message. Signs which use lights which flash "intermittently" are permitted only for movie theaters and amusement/recreation services. The appendix contains sections of selected European ordinances controlling outdoor advertising.

7. Fee, J. A. C., Dietz, S. K., and Beatty, R. L. Analysis and Modelling of Relationships Between Accidents and the Geometric and Traffic Characteristics of the Interstate System. Washington, D.C.: Government Printing Office, 1969.

An analysis of accident data along the Interstate system in 24 States with an emphasis on the relationship to geometric design and traffic volume. A model is developed and presented for use as a general planning guideline. Includes only an incidental discussion of public/private signing.

8. Forbes, T. W. et al. Letter and sign contrast, brightness, and size effects on visibility. Highway Research Record No. 216, 1968, 48-54.

Four experiments were conducted to measure: (1) effects of sign size, brightness, and letter-to-sign brightness ratio, and (2) effects of competing commercial signs on highway sign visibility. Subjects were asked to perform both manual and observation tasks while watching a continuously projected highway scene under laboratory conditions. One experiment measured the effect of sign brightness against night backgrounds with competing illuminated advertising signs. Results indicated that more brightly colored signs were seen less well when placed adjacent to illuminated advertising signs, while visibility of darker signs increased when placed adjacent to illuminated advertising signs.

9. Forbes, T. W. et al. Traffic Sign Requirements II: An Annotated Bibliography. East Lansing, Michigan: Michigan State University, Division of Engineering Research, 1964.

An extensive (85 pp.) bibliography which includes detailed abstracts of articles on highway traffic sign requirements for maximum effectiveness of design. Articles are grouped by subject matter: (a) Methodology, Use and Understanding of Traffic Signs, (b) Detectability and Visibility, (c) Legibility, (d) Effects of Acuity and Dynamic Visual Acuity, and (e) Attention Factors. Most sources discuss official highway signing, but some deal directly with private advertising signs. Articles on sign lighting are included, but none on the technology of electronic signs.

10. Forster, H. Holosigns. Traffic Engineering, 38 (7), 1968, 20-24.

Two significant problems with present highway signing are: (a) its message capacity limitations, and (b) safety problems directly linked to the signs themselves, either as physical targets for errant drivers, or as poor communicators causing driver distraction. Holography, a light diffraction and reconstruction process which can

redirect an image to a new point, is a new technique which offers advantages over conventional signing. Safety advantages include: obviating the crash hazard, better location of messages for improved communication, allowing for selective presentation of messages. Sign information capacity advantages include: ability to present three-dimensional messages, increased effective sign areas, multiple message presentation in a mode not confusing to the viewer, and presentation of information at locations which are timely to the need for driver response. A discussion of the technique of holography with specific suggestions for use of holosigns (at exits, tunnels, overhead) is presented.

11. Goldblatt, R. B. Guidelines for flashing traffic control devices. Report No. FHWA-RD-76-190. Washington, D.C.: U.S. Department of Transportation, 1976.

"This report details the development of guidelines for the installation of certain classes of flashing traffic control devices. The devices studied were: continuous flashing, and vehicle actuated two-way and four-way STOP intersection beacons; continuous and vehicle actuated advanced warning (STOP AHEAD) beacons; and vehicle actuated beacons for speed limit control on curves.

The guidelines are based upon the results of a state-of-the-art review, extensive field work, accident studies, and analytical investigations. They are presented in graphical form with a set of procedures for their use." (Author)

12. Highway Research Board, Committee on Traffic Control Devices, Subcommittee on Changeable Message Signs. Changeable message signs--A state-of-the-art report. Highway Research Circular No. 147, 1973.

Survey and review prepared by the Highway Resarch Board's Committee on Traffic Control Devices' Subcommittee on Changeable Message Signs (CMS). The report identifies four major areas of potential application for CMS: regulatory, warning, guide sign, and information sign. Application to signing for motorists' services is included in the latter two areas. The subcommittee also surveyed current application of CMS throughout the United States. Results showed current use was overwhelmingly, but not exclusively, in regulatory and warning applications. A survey of manufacturers identified current technology being used, including the variable matrix, rotating drum and varicom type. Guidelines for CMS design, meaning and application, and location are proposed, to ensure a general uniformity of use and quality.

13. Highway Research Board (ed.): Land acquisition and control of adjacent area, Highway Research Board Bulletin No. 55, 1952.

This bulletin contains separate summary reports on both the Michigan and Minnesota studies of the relationship between highway safety and advertising signs cited elsewhere in this bibliography. The two pertinent reports are:

1. "Final Report on the Minnesota Roadside Study," by O. L. Kipp, at p. 33.

2. "Traffic Accidents and Roadside Features," by J. C. McMonagle, at p. 38.

14. Hodge, A. R. and Rutley, K. S. A comparison of changeable message signal for motorways, Transport and Road Research Supplementary Report 380, Dept. of the Environment, Dept. of Transport, Crowthorne, England, 1978.

"Five types of changeable message signal have been evaluated as part of the program of research into motorway signalling at TRRL. They were:

i. Standard DTp matrix indicator type 410A.
ii. DTp signal modified by addition of a surrounding colored ring.
iii. Willings 'Varicator' type W (roller-blind type).
iv. Solari Changeable Road Sign (roller-blind type).
v. 'Multi-light' fibre-optic matrix signal.

The characteristics assessed were legend recognition distance, reliabili constructional quality and costs.

In daylight the recognition distances of the numerals as tested on the matrix and roller blind signals were similar, but at night the latter were greater.

In good visibility, numerals of a given size on the better of the two roller-blind signals would have had th longest recognition distance of the signals tested . . .

In reduced visibilty the matrix signals had the better recognition distances.

In most cases the signals had a recognition distance adequate for motorway speeds. The matrix signals were cheaper and more reliable than the roller-blind signals.

Overall, it was concluded that he internally illuminated matrix signal (e.g., of the DTp type) with white-on-black legends, with or without a surrounding colored ring, would be the most suitable type of signal for use on motorways." (Authors)

Comparative color photographs of all five types are included.

15. Holder, R. W. Consideration of comprehension time in designing highway signs. Texas Transportation Researcher, 7 (3), 1971, 8-9.

A literature review of research on reading and comprehension time required for highway signs. Includes an analysis of design formulas and typical signs currently in use, as well as theories regarding eye movement and driver perception.

16. North Carolina Highway Safety Research Center. Do billboards cause accidents? The Accident Reporter, February 1974.

A news report of a computer search of North Carolina traffic accident records investigating accidents caused by distractions due to billboards. Key words used for the search of investigating police officers' reports were: "sign," "billboard," "advertising," "looked away," "eyes off the road," and "distracted." Conclusion: "nothing was produced which would clearly indicate that billboards are the causes of distraction and the subsequent crashes." The search was requested by the Traffic and Transportation Department of UCLA.

17. Sherman, R. A. Seeing habits and vision, a neglected area in traffic safety. Traffic Quarterly, XV (4), 1961, 609-628.

One of the most important driver tasks, but neglected areas of research, is the "seeing job" or "reading the traffic scene." This task is a function of developed seeing habits, habits which most drivers have not correctly developed. Experience with improved seeing habits in industrial job safety programs, as well as empirical evidence on habits of specific sub-groups of drivers (chauffeurs and commercial fleet drivers) indicates that training can improve seeing habits. An educational program should be undertaken stressing the importance of correct seeing in the driving task. Many accidents relate directly to the driver's misperception or misreading of the traffic scene. Better visibility can be achieved as well through engineering and highway environment controls. Motorist licensing tests can be improved to more carefully screen out those with inadequate seeing habits.

The author distinguishes types of motorist vision: "detection vision," using peripheral vision, and "identification vision." Both must be correctly used to most accurately read the traffic scene. To do this, eye movement must be constant, for intense concentration of central or "identification" vision on a particular item temporarily inhibits peripheral or "detection" vision--increasing driver inattention and the chance of an accident.

18. Shoaf, R. T. Are advertising signs near freeways traffic hazards? Traffic Engineering, (26), 1955, 71-76.

The effect of revised regulations of advertising signs in San Francisco is discussed. The former regulations prohibited any movement, flashing, or color change on the signs; the revision prohibits only signs with excessive attention-attracting or retention values. Previous studies indicate that the motorist can resist distraction caused by movement of up to 10 feet per second on signs 200 feet or less from the highway; greater movement should be prohibited, as should extreme light intensity changes.

19. Signs/Lights/Boston. City Signs and Lights. Boston: Boston Redevelopment Authority, 1971.

This report describes a two-year study of signing and lighting in Boston, including an analysis of the present "environmental information system," a description of demonstration experiments and prototype designs, and policy recommendations. The focus is on regulation at the local level of government. Generally, recommendations are for improvement and expansion of public lighting and signing, including the adoption of innovative information systems concurrent with stricter control of private signing.

One chapter discusses the proposed system for private signing based on the concept of "information zones." The objective of this concept is prevention of communication overload of both motorists and pedestrians, while ensuring that their information needs are met, and street safety is enhanced. Appendices include reviews of public and private signing, and an outline of proposed regulations. Electronic changeable message signs are neither specifically discussed in the text nor mentioned in the outline regulations, but the report provides an overview of problems and considerations for sign regulation at the local level.

20. Smith, W. L. and Faulconer, J. E. The visual environment: Its effect on traffic flow. Highway Research Record No. 377, 1971, 131-148.

This study was directed toward exploring the relationship between urban arterial traffic flow and the arterials' visual surroundings. The hypothesis was that the visual environment in which an arterial resides provides an input into the operation of a vehicle, and because it provides an input into this operation it might logically contribute to the output of the operation. The concern in this study was directed toward defining how various visual inputs from an arterial street's environment related to the operational output of the driver-vehicle system. Specifically, the question to be answered was: Does a poor visual environment for driving have a direct relationship to the breakdown in urban arterial flow? The visual input into the driver-vehicle system was defined by three generalized categories: (a) color contrasts of possible focal points, (b) dynamics of possible focal points, and (c) naturalness of focal areas. The effects that variance in these three categories of visual input had on the breakdown of the operational output of the driver-vehicle system was categorized by the number of accidents and the amount of interference to travel apparent along the study segments. The results of the study indicate that there does indeed exist a direct relationship between an arterial's visual environment and the ability of that arterial to handle traffic without a high number of accidents and/or a high rate of interference to traffic flow. (Authors)

21. Stockton, W. R. et al. Evaluation of a changeable message sign system on the inbound Gulf Freeway. Report No. TTI-2-18-75-200-1F. College Station, Texas: Texas Transportation Institute, 1975.

This was a study of three changeable message signs erected on the right-of-way by the Texas Department of Transportation, which were to provide motorists with information about upcoming freeway conditions in order to induce voluntary route diversion and thus lessen freeway congestion. Objectives of the project were: (1) Traffic Control, (2) Sign Design Evaluation, (3) Sign Communication Evaluation, and (4) Cost-Effectiveness Evaluation. Evaluation was accomplished through analysis of (a) traffic pattern changes and (b) results of a motorist questionnaire survey.

Findings indicated that motorists overwhelmingly approved of the signs and found them desirable. Preferences for particular messages (LANE BLOCKED, etc.) are reported. Significant voluntary diversion did take place. Motorists generally reported that they understood the signs and responded to them. However, the two frontage road signs, (message characters 6 inches high, formed by 6-watt lamp matrix, theoretical legibility 300 feet) were found to be ineffective, though the on-freeway sign (characters 14 inches high, 25-watt lamp matrix, legibility 700 feet) was effective. Specific information on sign size and design is included. Motorists did not learn a letter grade ranking system of highway conditions ("A"-45 mph Ahead, etc.) to make this effective, but did react to descriptive messsages (LANE BLOCKED). Prior motorist education to a letter grade system could reduce messeage length and system cost. Greater use of the system by the Transportation Department was recommended.

22. Street, R. L. et al. A background report, annotated bibliography and summary of reserch needs in the human factors aspects of driver visual communications. Report No. 606-2. College Station, Texas: Texas Transportation Institute, 1970.

"The purpose of this report is to present a literature survey and to summarize the pertinent work related to this project and to give appropriate recommendations related thereto. This effort covers two main areas: (1) Visual input requirements in the driving task; and (2) Human information processsing capability in complex tasks." (Authors)

An extensive bibliography follows a discussion of general theory of driver information systems and process, as well as research suggestions. The focus is on official highway signing.

23. Wyoming State Highway Department. Evalution of Variable Message Signs and

Linear Radio Systems on I-80 in Wyoming. Cheyenne, 1978.

This is a final report on a two-year study of variable messsage signs (VMS) and linear radio systems (LRS) along I-80 in Wyoming. Objectives of the study were to determine driver observation and understanding of the systems, review accuracy and completeness of the messages displayed, evaluate effectiveness of signs in causing traffic diversion to alternate routes, and determine driver preference for additional locations for these systems.

The VMS are installed in overhead panels and warn drivers of road conditions and hazards ahead. Data were collected from questionnaires distributed at motels and through trucking companies, and evaluation forms completed by highway personnel. A total of 231 questionnaires was used for statistical computations.

Almost all respondents observed the VMS; 80 percent of these reported they understood the messages. However, nearly 10 percent found the messages unclear either because of an insufficient time to read the message or a too-lengthy message. Department personnel did not develop specific data on optimum message length or display time, but recommended that messages be as concise as possible. Respondents generally found the messages accurate, but some conflict between the desire for additional information and the need for specific, concise messages was noted. Graphs and charts, included in the Appendix, further break down the responses, and a priority list of informational messages is presented, based on the comments of both drivers familiar with the route, and first-time users of the route.

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FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.