TTI-2-18-78-228-9/263-2

TEXAS
TRANSPORTATION
INSTITUTE

STATE DEPARTMENT
OF HIGHWAYS AND
PUBLIC TRANSPORTATION

COOPERATIVE
RESEARCH

FEASIBILITY OF CHANGEABLE MESSAGE SIGNS AND HIGHWAY ADVISORY RADIO FOR FREEWAY MAINTENANCE

in cooperation with the
Department of Transportation
Federal Highway Administration

RESEARCH REPORT 228-9/263-2
STUDY 2-18-78-228/2-18-79-263
TRAFFIC MANAGEMENT

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-81/43+228-9/263-2		

4. Title and Subtitle	5. Report Date
Feasibility of Changeable Message Signs and Highway Advisory Radio for Freeway Maintenance	July 1981
	6. Performing Organization Code
7. Author(s) C. L. Dudek, S. H. Richards, and M. J. S. Faulkner	8. Performing Organization Report No. Research Report: 228-9 263-2
9. Performing Organization Name and Address Texas Transportation Institute Texas A&M University College Station, Texas 77843	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. Study Nos. 2-18-78-228 & 2-18-79-263
12. Sponsoring Agency Name and Address Texas State Department of Highways and Public Transportation; Transportation Planning Division P. O. Box 5051 Austin, Texas 78763	13. Type of Report and Period Covered Final September 1977-July 1981
	14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with DOT, FHWA.
Study Titles: Traffic Management During Urban Freeway Maintenance Operations & Traffic Management During Freeway Reconstruction and in Rural Work Zones

16. Abstract

Changeable message signs (CMSs) and Highway Advisory Radio (HAR) are playing increasing roles in managing traffic. This report presents the findings of field studies conducted to determine the feasibility of using these traffic management tools during freeway maintenance.

The studies revealed that CMSs can be effective traffic management tools at freeway maintenance work zones when they are properly used. At lane closure work zones they may be used to encourage drivers to change lanes earlier. They may be used at other work zones to encourage drivers to divert to alternate freeway routes to avoid work zone congestion.

Studies were also conducted at a freeway maintenance work zone to evaluate the use of HAR for work zone traffic management. The studies revealed that the HAR had little or no effect on traffic operations at the work zone evaluated because the conventional signing at the work zone was excellent and the HAR functioned only as a supplemental information source. Also, the advanced signing used to encourage motorists to tune to the HAR broadcasts was inadequate.

Even though the HAR did not improve traffic operations at the work zone evaluated, the studies indicated that it may have good potential for work zone traffic management in other applications (e.g., for displaying long or complicated diversion messages at long-term work zones). The studies also revealed that existing HAR hardware performs adequately.

17. Key Words	18. Distribution Statement
Maintenance, Work Zones, Traffic Control Devices, Real-Time Displays, Changeable Message Signs, Highway Advisory Radio, Freeway Operations	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	31	

Form DOT F 1700.7 (8-72)

FEASIBILITY OF CHANGEABLE MESSAGE SIGNS AND HIGHWAY ADVISORY RADIO FOR FREEWAY MAINTENANCE

by

Conrad L. Dudek
Research Engineer

Stephen H. Richards
Engineering Research Associate

and

Michael J. S. Faulkner
Assistant Research Engineer

Research Report 228-9/263-2

Traffic Management During Urban Freeway
Maintenance Operations
Research Study 2-18-78-228

Traffic Management During Freeway Reconstruction
and in Rural Work Zones
Research Study 2-18-79-263

Sponsored by

State Department of Highways and Public Transportation

In Cooperation with the

U. S. Department of Transportation
Federal Highway Administration

Texas Transportation Institute
The Texas A&M University System
College Station, Texas

July 1981

ACKNOWLEDGMENTS

Study 288 was conducted with the guidance of a Technical Advisory Committee. The contributions of the Committee, whose members are listed below, are gratefully acknowledged:

W. R. Brown, Supervising Maintenance Engineer, D-18M
R. G. Biggs, Administrative Assistant, District 11
Walter Collier, District Maintenance Engineer, District 15
Milton Dietert, Senior Traffic Engineer, District 15
Larry Galloway, Engineer Technician IV, District 12
Hunter Garrison, District Maintenance Engineer, District 12
Henry Grann, Supervising Traffic Engineer, District 18
Herman Haenel, Supervising Traffic Engineer, D-18T
Bobby Hodge, Supervising Traffic Engineer, District 2
Tom Newbern, Traffic Engineer, D-18T
Russell G. Taylor, Engineering Technician V, District 14
Milton Watkins, District Maintenance Engineer, District 18
John Wilder, District Maintenance Engineer, District 14

Mr. Tom Newbern served as the technical monitor for Study 228. His assistance and counsel are greatly appreciated. Mr. Herman Haenel of D-18T served as the technical monitor for Study 263 and his guidance and assistance during the course of the research are acknowledged. The constructive suggestions by Mssrs. Tom Newbern and Blair Marsden of D-18T during the preparation of this report are also acknowledged.

TABLE OF CONTENTS

SUMMARY

CHANGEABLE MESSAGE SIGNS

Field studies were conducted during maintenance activities on I-35 in San Antonio to assess the feasibility of using changeable message signs (CMSs) for work zone traffic management. The studies evaluated the use of CMSs for 1) encouraging traffic to vacate a closed lane at a lane closure work zone and 2) diverting traffic around a work zone on an alternate freeway route.

Lane Change Study

The studies revealed that CMSs can be used at lane closure work zones to encourage more drivers to vacate the closed lane(s) farther upstream of the cone taper. However, CMSs should not be used in place of flashing arrowboards at these work zones. Arrowboards are very effective devices for advance warning of median and shoulder lane closures.

Diversion Studies

The San Antonio studies also determined that CMSs can be used to divert traffic around a freeway maintenance work zone on an alternate freeway route. A specific diversion message displayed on a CMS is most effective; however, a general warning message about a work activity will also encourage a significant number of motorists to divert if an alternate route is available.

HIGHWAY ADVISORY RADIO

Studies were conducted at a major maintenance work zone on a rural Interstate highway in Chambers County, Texas to evaluate the use of Highway Advisory Radio (HAR) for work zone traffic management. The studies revealed that the

HAR had little or no effect on traffic operations at the work zone because of two factors. First, the conventional signing at the work zone was excellent and the HAR functioned only as a supplemental information source. Second, the advanced signing used to encourage motorists to tune to the HAR broadcasts was apparently inadequate in terms of legibility and visibility.

Even though the HAR system did not significantly affect traffic operations at the work zone evaluated, the studies indicated that HAR may have good potential for work zone traffic management in certain applications. HAR may be best suited for displaying long or complicated messages (e.g., diversion instructions) at long-term work zones. Because of current Federal Communication Commission regulations and licensing requirements, HAR is not practical for most maintenance operations.

The studies also revealed that existing HAR hardware (with a monopole antenna system) performs adequately. Motorists, generally speaking, were satisfied with the quality of the broadcasts and supportive of this innovative approach to work zone traffic management.

CHANGEABLE MESSAGE SIGNS

INTRODUCTION

Changeable message signs (CMSs) are playing an increasingly important role in managing highway traffic. Their popularity and use have expanded during the last 10 years. In 1978, for example, 42 states reported using CMSs for applications ranging from warning of dust, fog, and ice to freeway traffic management (1). Recently, CMS systems have been placed on trailers and pick-up trucks, making them transportable. This characteristic, coupled with their high target value and versatility in message selection, have made the use of CMSs appealing for traffic management at maintenance work zones.

BACKGROUND

Studies were conducted in two Texas cities to evaluate the feasibility of CMSs for work zone traffic management. Preliminary field studies were conducted in Dallas (2) during several freeway maintenance operations. These preliminary studies showed that informational messages displayed on a CMS about roadwork (e.g., ROADWORK AT OXFORD AVE.) increased diversion off the freeway by 5.1% to 7.4% (expressed as a percent of upstream demand) in comparison to the natural diversion observed without a CMS message. Diversionary messages (i.e., drivers instructed to exit freeway) increased diversion by an additional 2% over that observed when informational messages were displayed

Following the Dallas studies, full-scale field studies were conducted in San Antonio to evaluate the effects of CMS messages on lane changes at a lane closure work zone. The effectiveness of CMSs in diverting freeway traffic to an alternate freeway route around a work zone was also evaluated. In the San Antonio diversion studies, unlike the Dallas studies, drivers were instructed to use a specific freeway diversion route.

The lane change and diversion studies were conducted during freeway maintenance operations on a four-lane section of I-35. Figure 1 shows the study area and the location of the two CMSs used in the studies. The CMSs were trailer-mounted, bulb matrix signs (see Figure 2).

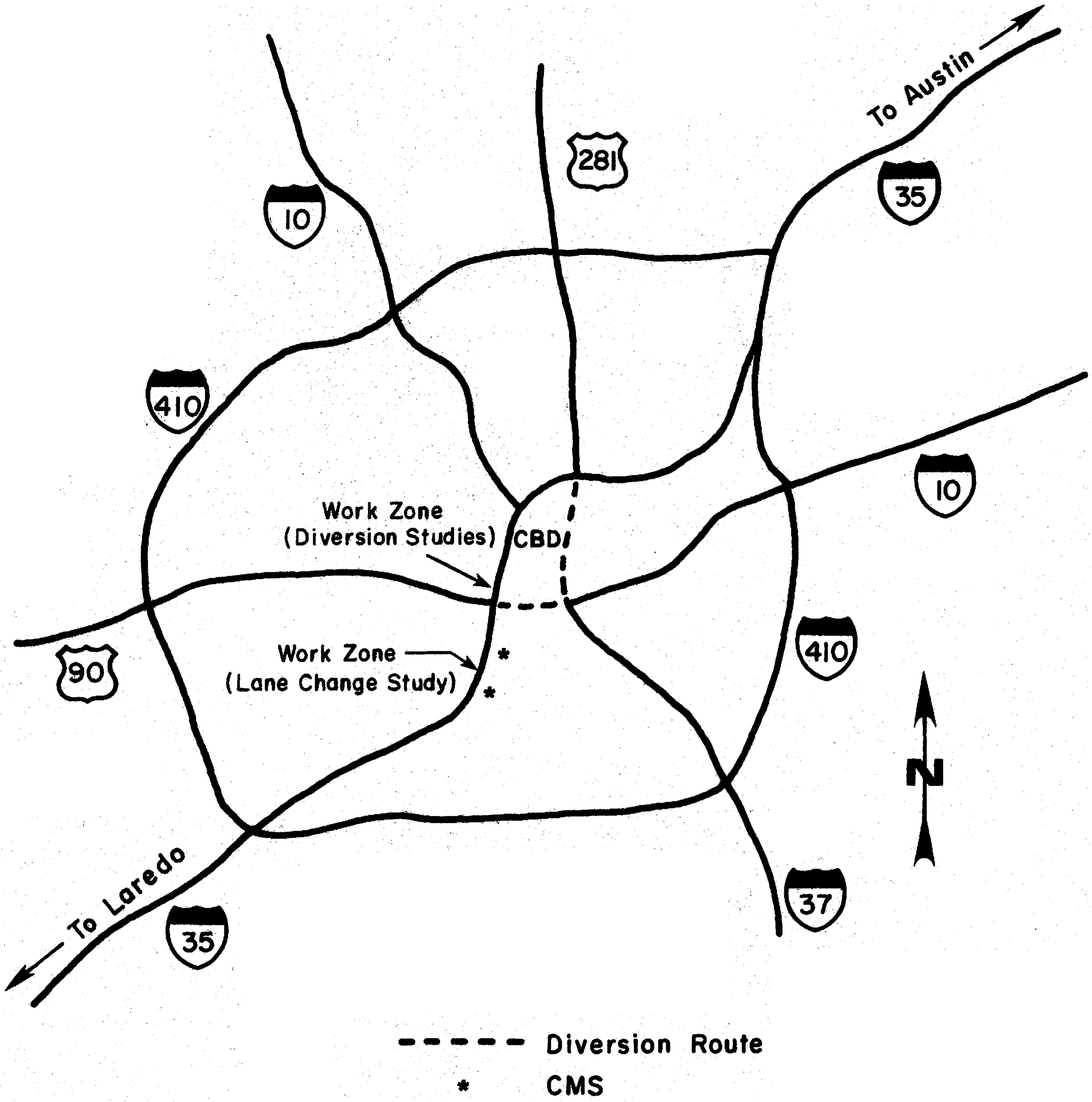
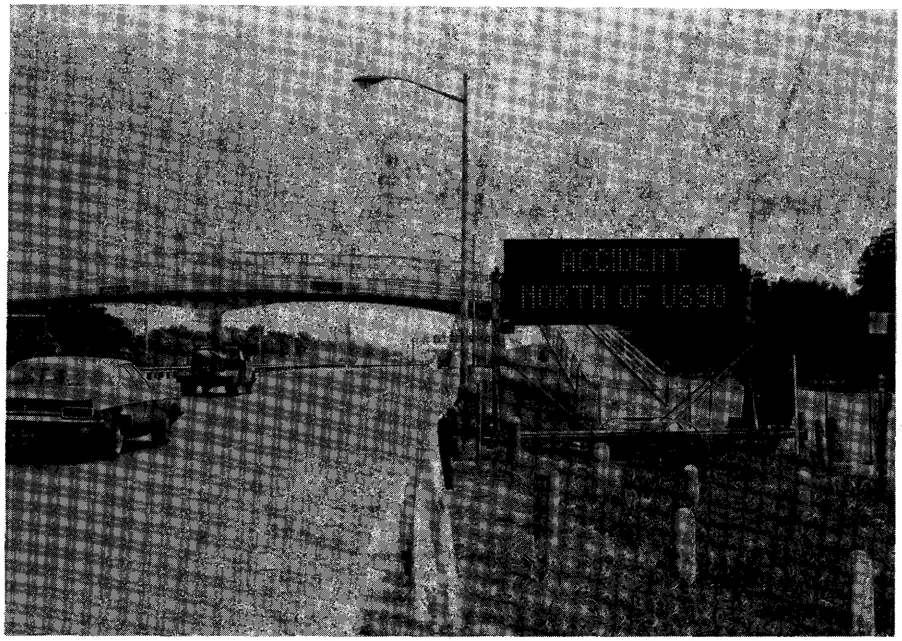


Figure 1. Location of Work Zones and CMSs for San Antonio Studies



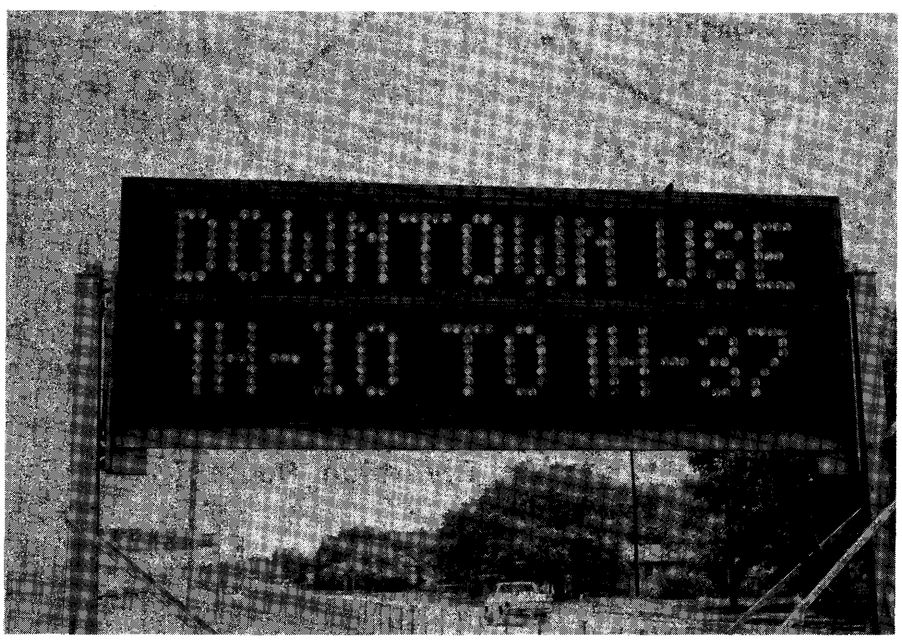


Figure 2. Changeable Message Signs Used in San Antonio Studies

LANE CHANGE STUDY

The lane change study was conducted on March 11, 1980 during pavement repair on I-35 in the vicinity of Division Street in San Antonio. During this study, driver reaction (i.e., lane changes) to lane closure information displayed on one two-line CMS was evaluated.

Study Description

A schematic of the lane closure work zone is presented in Figure 3. The schematic shows the location of the CMS and other traffic control devices relative to the work zone. It also shows the relative location of the lane distribution count stations established to collect lane change data.

Lane distribution counts were made by observers at eight freeway locations--one station upstream from the CMS, one at the CMS, and six downstream. In addition, traffic volumes through the work zone were counted in an attempt to measure the work zone capacity. (Volumes never reached capacity flow, however.)

In order to assess the effectiveness of the CMS in encouraging drivers to vacate the closed lane, the CMS was turned on and off alternately at approximately 20-minute intervals during a three-hour period. A message was displayed in two parts and read: ROADWORK AT DIVISION/LEFT LANE CLOSED. Each message part was displayed alternately for four-second intervals.

Two vehicles were driven through the study area--one to mark the time when the message was turned on and the other when it was turned off. As the drivers reached each count station, they alerted the observers by radio who would then record the time and volumes. This technique, used successfully during diversion studies in Dallas (3), "opens" and "closes" each

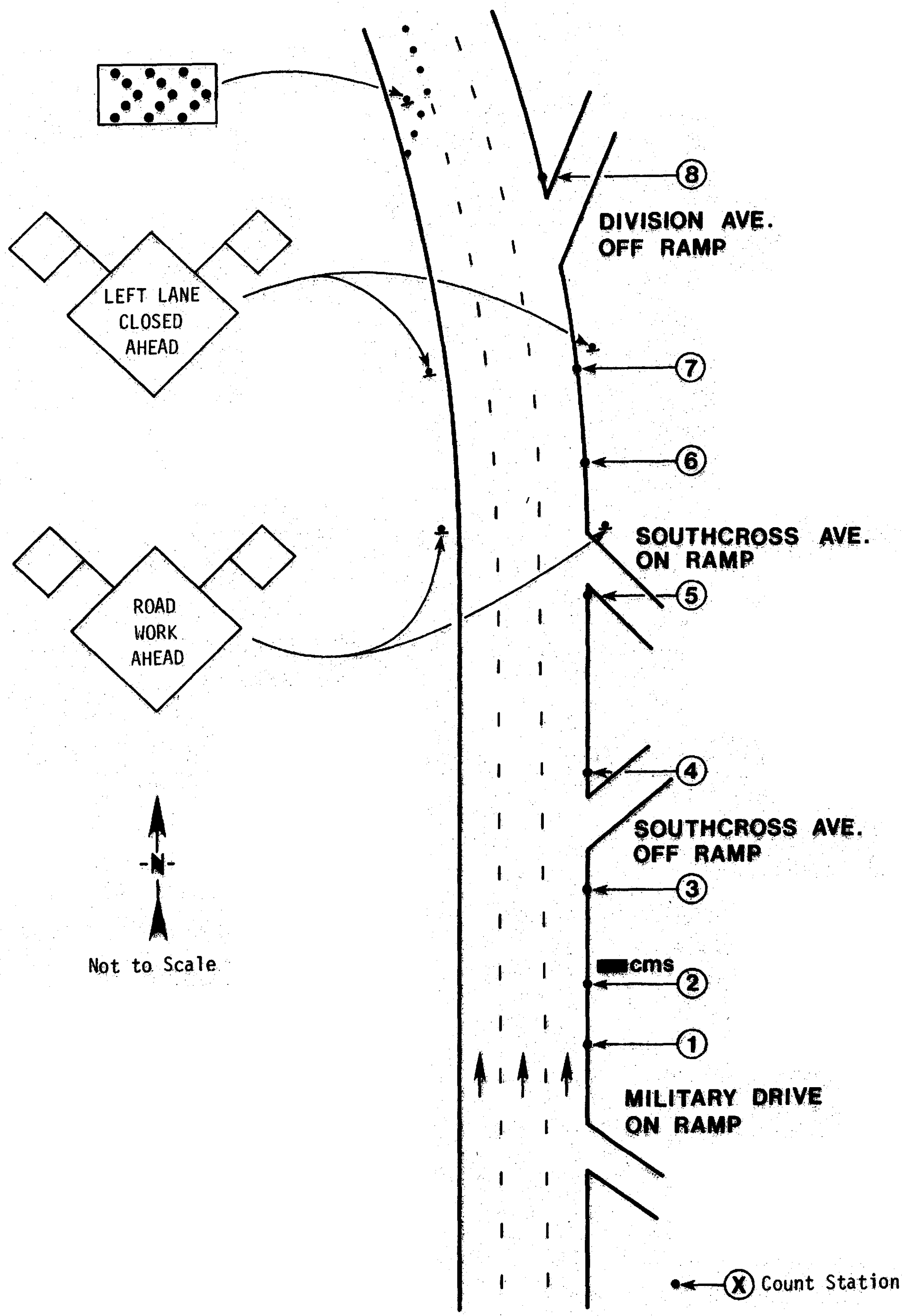


Figure 3. Schematic of Work Zone (Lane Change Study)

study period and separates those of drivers who had an opportunity to read the CMS message from those who did not.

Results

Figure 4 summarizes the volume data collected during the lane change study. It presents the hourly volumes on each ramp and freeway section during periods with and without a CMS message displayed. A review of the data shows that the volumes during both periods were comparable. Therefore, differences in volumes did not influence results.

The measure of effectiveness used to evaluate the CMS was the percent of vehicles that remained in the closed median lane as traffic progressed toward the cone taper. It was expected that, if the CMS was effective, a greater percentage of drivers would leave the closed median lane (and fewer drivers would enter the median lane) when CMS messages were displayed (compared to when the CMS was blank).

Figure 5 illustrates the percent of median lane traffic remaining in the closed lane at various distances upstream from the cone taper. The data are expressed in terms of the percent change in the median lane volumes at each count station in comparison to that originally in the lane at Station 1 located upstream from the CMS. Negative percentages indicate less traffic in the lane in comparison to Station 1; positive percentages reflect increased volumes in the lane resulting from more drivers moving into than out of the median lane.

The results reveal that the CMS did indeed encourage drivers to vacate or avoid the closed median lane. Although the percent volumes in the closed median lane at the various count stations were not low while the CMS message

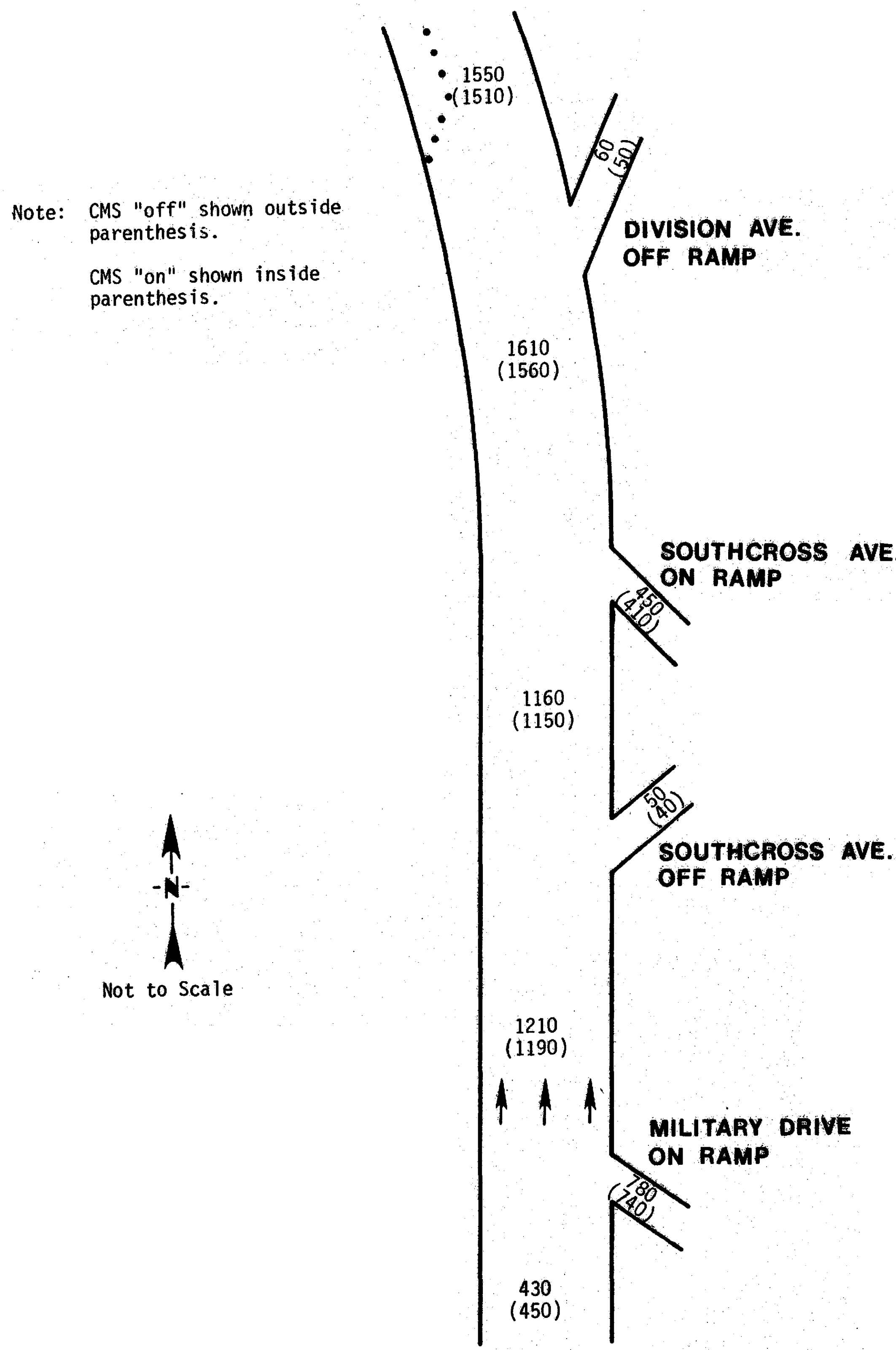


Figure 4. Hourly Volumes Observed During Lane Change Study

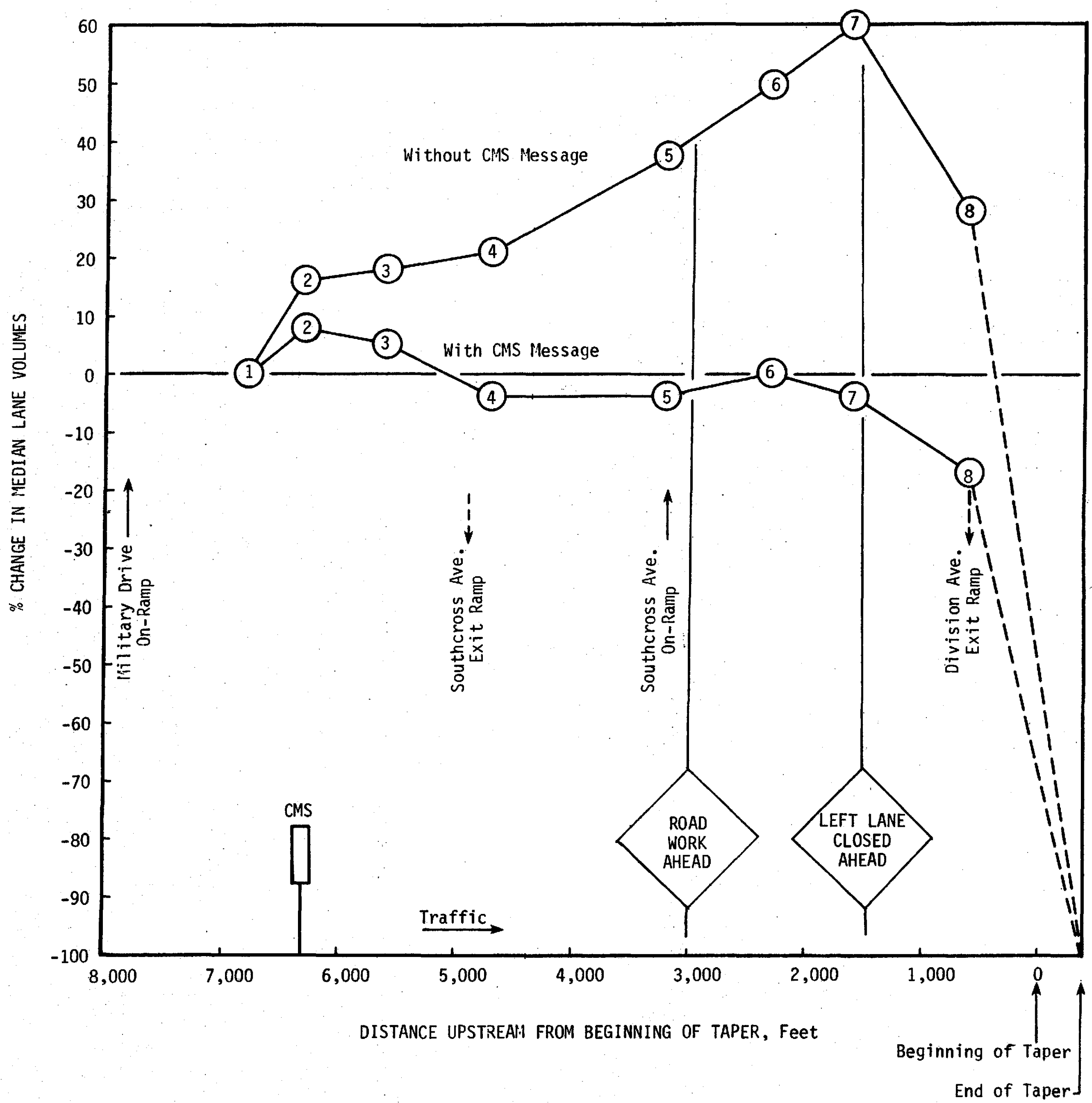


Figure 5. Volume Changes Observed in the Median Lane During Lane Change Study

was displayed, they were significantly lower than periods when the CMS was blank.

The curves in Figure 5 illustrating the percent change in volumes show that during normal periods (without a CMS message) there was a large increase in median lane volumes as traffic progressed from Station 1 to Station 8. Volumes at Station 7 were 60% higher than at Station 1. Volumes at Station 8, located 700 ft. upstream from the beginning of the cone taper, were 29% higher. (The drop in volumes between Stations 7 and 8 is attributed to the LEFT LANE CLOSED AHEAD sign and the driver's perception of the flashing arrowboard and lane closure.)

In contrast, while the CMS message was displayed, volumes at Station 7 were 4% lower than at Station 1. Volumes at Station 8 were 17% lower. When the 17% reduction at Station 8 was compared to the 29% increase that resulted with the CMS blank, the net effect was a 46% greater reduction in the lane volumes attributable to the CMS.

The volumes in the median lane at the various stations were relatively high because of several site specific factors including the following:

1. the relatively high proportion of traffic (compared to the freeway) on the Military on-ramp located a relatively short distance upstream from the CMS,
2. the presence of an additional relatively high volume on-ramp at Southcross Ave. located downstream from the CMS, but upstream from the cone taper,
3. the existence of a right-side lane drop downstream from the worksite, and

4. the relatively short decision sight distance to the lane closure.

These factors are discussed in more detail in the next paragraphs.

The freeway volumes in advance of the Military Drive on-ramp, located only 1500 ft. upstream from the CMS, averaged about 460 vph during the study. The volumes on the Military Drive on-ramp averaged 740 vph. Thus, the volumes were much higher than the upstream freeway demand. Observations in the field revealed that a large percentage of the on-ramp drivers moved into the center and median lanes almost immediately after entering the freeway. The high rate of lane changing resulted in a relatively high driver task load, and it is probably safe to assume that many drivers did not have an opportunity to read the CMS message.

Another factor that affected the lane distribution of traffic was the Southcross Avenue on-ramp. The ramp was downstream from the CMS and approximately 2600 ft. upstream from the cone taper. Volumes on the Southcross ramp during the study averaged 410 vph. Although this can be considered as being light traffic, it was high relative to the freeway volumes near the ramp. The freeway volumes downstream from the ramp averaged 1660 vph; 26% came from the on-ramp. Thus, at least 26% of the freeway drivers during the study did not see the CMS when it was activated.

The third influential factor was the right-side lane drop downstream from the work zone. Drivers familiar with the "loss" of the shoulder lane most likely travel in the two left lanes to avoid the possibility of becoming "trapped" in the discontinuous lane. Thus, it is speculated that the right-side lane drop influenced several drivers to travel in the center and median lanes.

The fourth influencing factor was the relatively short decision sight distance to the lane closure. Research (4) indicates that although the majority of drivers vacate a closed lane after reading the appropriate static work zone signs, a relatively high percentage (approximately 20%) will not leave the lane until they actually see evidence of the closure (e.g., cones or maintenance vehicles in the lane, arrowboards, etc.). Other research (4,5) also indicates that drivers must perceive a freeway lane closure at least 1500 ft. upstream from the cone taper; shorter sight distances do not provide adequate time for most freeway drivers in the closed lane to take appropriate actions.

Observations during the San Antonio studies indicated that the sight distance to the lane closure was less than 1000 ft. Although an arrowboard with a sequencing arrow was used in the traffic control set-up, the horizontal curvature of the freeway adversely affected the drivers' perception of the lane closure.

DIVERSION STUDIES

The diversion studies were conducted during the night on March 17th and 18th, 1980 at a median guardrail repair worksite on I-35 in San Antonio. The work required closing the inside lane of a two-lane section near the CBD. It was anticipated that the lane closure would result in a capacity problem at the work zone. Therefore, diversionary messages were displayed on the CMSs in an attempt to divert motorists around the work zone on an alternate freeway route.

Study Description

A schematic of the study area is shown in Figure 6. The traffic management strategy, using two two-line CMSs, was designed to encourage through drivers to avoid the work area by diverting to the new I-35 route (see Figure 6).

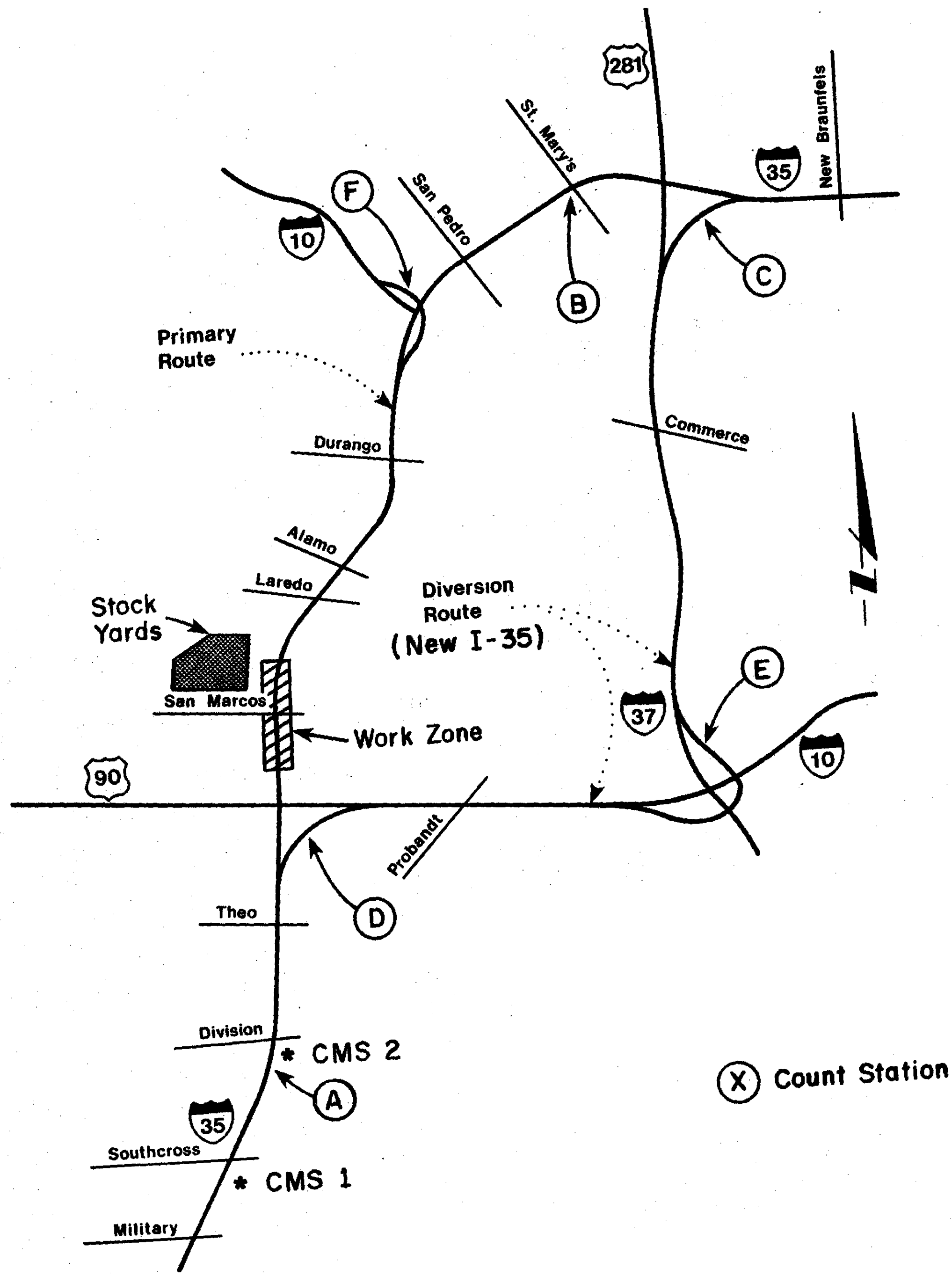


Figure 6. Schematic of Study Area (Diversion Studies) in San Antonio

The CMS messages designed for the study are shown below:

Diversion Message	Warning Message
ROADWORK AT STOCKYARDS	CAUTION
THRU TRAFFIC USE I-10E/I-37	ROADWORK AT STOCKYARDS

Messages were designed with the intention to use two CMSs. However, the plans were changed during the study when problems developed with the CMS closest to the diversion point. As a result, only the southernmost sign was used during the study.

The original plans also called for a diversion message and a warning message to be displayed for one full hour each on both study days. The latter message type (warning message) was incorporated into the study upon request of the SDHPT maintenance supervisor in charge of the roadwork. Again, CMS problems on both study days required changes in the field. The final message display times were as follows:

	Diversion Message	Warning Message
March 17, 1980	9:40-10:20 pm	10:20-11:00 pm
March 18, 1980	9:00-10:00 pm	10:00-11:00 pm

License plates of vehicles passing a network of recording stations were recorded continually throughout each study period to determine travel patterns of through drivers. The recording stations were selected to permit, as closely as possible, accurate determination of travel patterns on both the primary and diversion routes. License plate and volume recording stations are shown in Figure 6.

Results

The results revealed that there was an increase in the percentage of drivers using the diversion route while the diversion message was displayed. The effectiveness of the CMS diversion and warning message is best seen by comparing the percent of through drivers using the two routes when the messages were displayed. A summary of such a comparison is presented in Table 1.

It is interesting to note from Table 1 that the distribution of traffic on the primary and diversion routes was quite similar on both days. More important is the significant increase in the percent of through traffic using the diversion route while the diversion message was displayed. The combined Monday and Tuesday data show that 15% more through drivers used the diversion route when the diversion message was displayed in comparison to the times when the warning message was activated (62% versus 47%).

Discussion

Any conclusions reached from this study must be accompanied with qualifiers because of surrounding influencing factors. The results compare the effects of a diversion message to a warning message. It is possible that many drivers familiar with the geometric conditions on I-35 speculated that congestion existed in the area due to the lane closure. Thus, advance warning of the lane closure may have encouraged some drivers to voluntarily use the diversion route. If this assumption is correct, then the warning message may have masked the greater effects of the diversion message. Compared to no message at all, the diversion message may have shown a higher use of the diversion route. In retrospect, the ideal study approach would have been to compare the effects of both the warning and diversion messages to a blank sign.

TABLE 1. PERCENTAGE OF NORTHBOUND THROUGH TRAFFIC USING PRIMARY AND DIVERSION ROUTES

Message Type	Total Northbound Through I-35 Traffic at Division Ave.	Total Northbound Through I-35 Traffic at Division Ave.	Percent Using Through Traffic Primary Route	Percent Using Through Traffic Diversion Route
Monday, 3/17/80				
Warning	556	73	51	49
Diversion	436	46	37	63
Tuesday, 3/18/80				
Warning	985	98	54	46
Diversion	693	38	38	62
Monday & Tuesday, Combined				
Warning	1541	117	53	47
Diversion	1129	119	38	62
TOTAL	2670	290	47	53

Conversely, the time effects of the messages during long-term maintenance (several nights) were not studied. Once the drivers who regularly divert become aware of the absence of congestion, they may elect to remain on the primary route. Credibility may be an issue. On the other hand, it may be that drivers would divert just to stay away from the work zone section at night regardless of whether there is congestion. These statements are speculative; additional studies are necessary to validate these issues.

HIGHWAY ADVISORY RADIO

INTRODUCTION

HAR is a means of providing motorists with pertinent travel-related information over their standard AM car radios. Motorists traveling down a freeway are instructed by signs to tune their car radios to a specially designated frequency (usually 530 KHz or 1610 KHz). Upon tuning to the frequency, they hear a live or pre-recorded message broadcasted from a field transmitter. HAR is intended to supplement visual signing (e.g., conventional highway signs, changeable message signs, etc.) where signing alone is inadequate, inappropriate, or inefficient.

HAR has been used in at least eight states with varying degrees of success for applications ranging from airport parking control to hazard warning. Most installations to date have been permanent in nature. In the past, the use of HAR has been restricted somewhat by Federal Communication Commission (FCC) regulations. Its use has also been discouraged by certain operational problems (6).

In 1978, the FCC relaxed some of its restrictions on HAR, thus encouraging the use of HAR at temporary work zones. There have also been advancements in hardware and operational technology in recent years (7). HAR now appears to have great potential as a traffic management tool at some types of work zones; however, there has been very limited experience with HAR at work zones.

BACKGROUND

One of the first work zone applications of HAR in the United States was on a four-lane rural section of I-10, midway between Houston and Beaumont, Texas in 1980. A temporary HAR system was used to divert traffic around a resurfacing worksite. District 20 of the Texas State Department of Highways and Public Transportation (SDHPT) installed and operated this HAR system.

WORK ZONE DESCRIPTION

The work zone where the HAR was installed was approximately 14 miles long. There were continuous frontage roads through the work area. The resurfacing work required six months to complete.

The work zone had an Average Daily Traffic of 20,000 vehicles per day. Approximately 20 percent of this traffic was truck traffic and a large percentage was commuter traffic.

Traffic Control

Figure 7 shows the innovative traffic control strategy used to handle traffic at the worksite. The use of this strategy was prompted by the heavy traffic volumes at the worksite, the large percentage of trucks in the traffic stream, and the fact that the existing frontage roads could not structurally withstand heavy truck loads.

All trucks and buses over 5 tons were required to use one side of the mainlanes which was temporarily converted to a two-lane, two-way roadway. Passing was prohibited for the entire length of this two-way section, and the posted speed limit was reduced from 55 to 50 miles per hour.

Passenger cars, pick-ups, and vans were diverted from the mainlanes and required to use the parallel frontage roads to travel around the work area. The frontage roads, which normally carried two-way traffic, were temporarily converted to one-way operation. The posted speed limit on the frontage roads was reduced from 55 to 50 miles per hour.

To inform motorists of the special traffic conditions and diversion routes at the work zone, an elaborate system of signs was installed at the worksite. Channelization devices, including barrels, vertical panels, and paint markings,

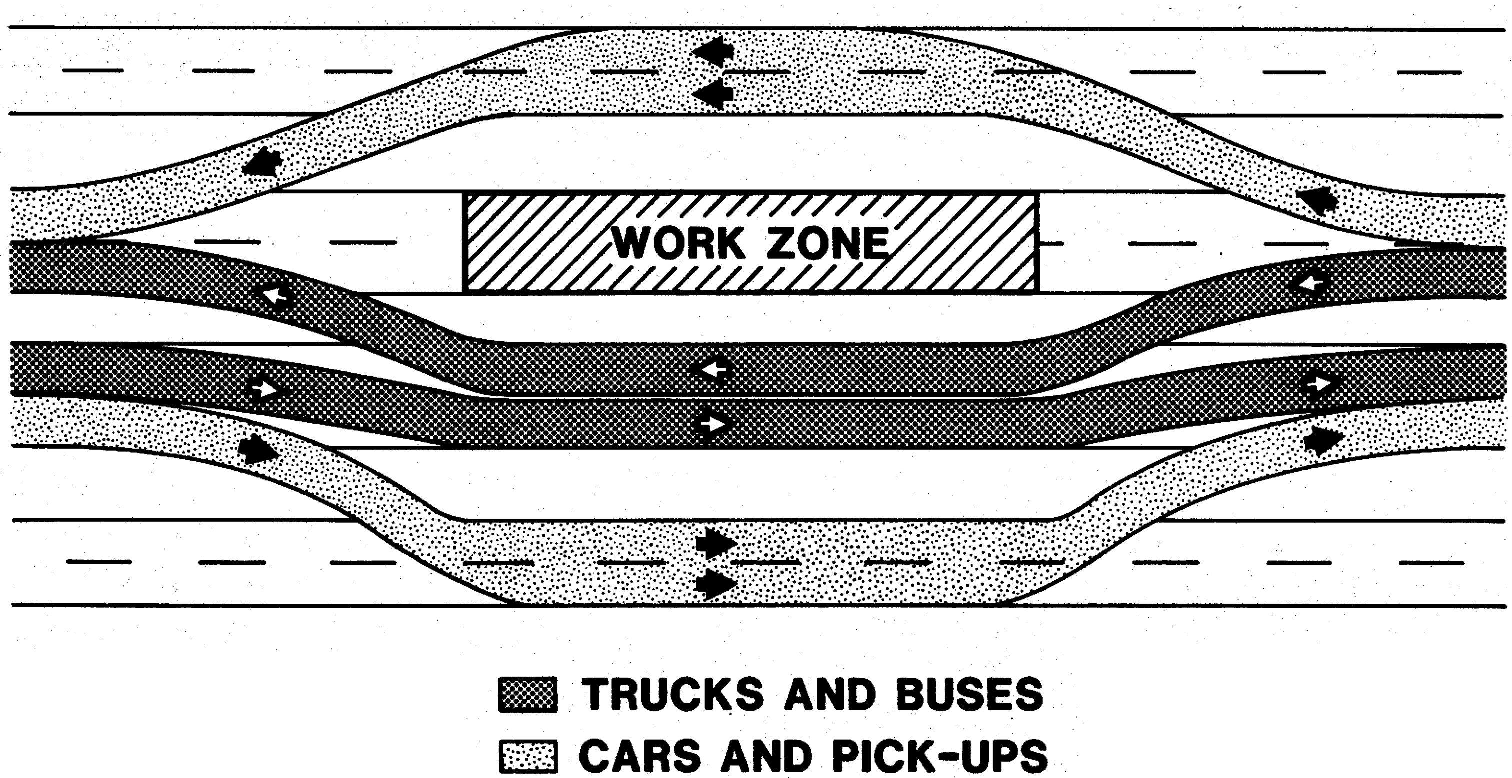


Figure 7. Work Zone Traffic Control Strategy at the I-10 Work Zone

were also installed at the diversion points on both ends of the work area. Figure 8 shows the traffic control devices used at the work site.

HAR INSTALLATION

From the inception of the innovative traffic control strategy, it was recognized that the strategy could create a new and unexpected driving experience for motorists. There was considerable uncertainty regarding the safety and operational efficiency of the strategy; therefore, plans were made to use a Highway Advisory Radio system to supplement the signs and channelizing devices.

The decision to use HAR came just before the project began. By the time the HAR equipment had been ordered and installed, and the system licensed, most of the work had been completed. The HAR system was in operation for less than one month at the worksite.

Equipment

Two 10-watt field transmitters, each with a single monopole antenna, were installed at the work zone (one on each end of the project). The transmitters broadcasted independently, but on the same frequency (1610 KHz). The same message was broadcasted from each transmitter. The message was recorded on 8-track tapes and continuously played.

Licensing

The work zone HAR system was operated on a special temporary authority license. The temporary licensing did not require submission of an FCC Form 400 or review of the license application by the International Telecommunication Union (ITU). The temporary license was granted 63 days after submission of the application.

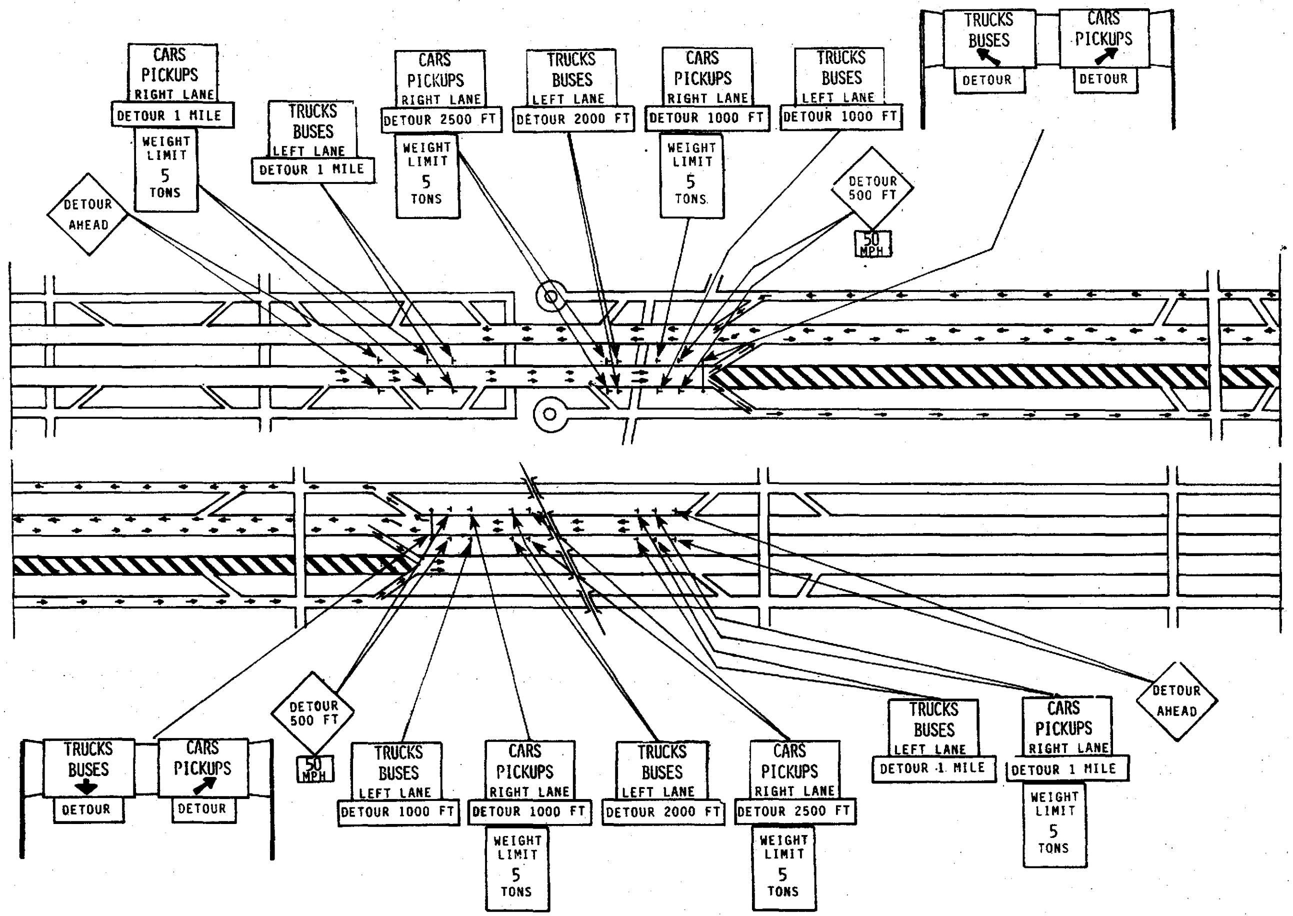


Figure 8. Signing Used at the I-10 Work Zone

Messages

The following message was broadcasted continuously to both east and westbound traffic from the two field transmitters:

> ATTENTION INTERSTATE HIGHWAY 10 TRAFFIC.
> DUE TO ROAD CONSTRUCTION, ALL TRAFFIC MUST DETOUR THREE MILES AHEAD.
> CARS, PICK-UPS AND RECREATIONAL VEHICLES MOVE TO THE RIGHT LANE AND PREPARE TO DETOUR TO FRONTAGE ROAD.
> TRUCKS AND BUSES MOVE TO LEFT LANE AND REMAIN ON FREEWAY AND ON THE TRUCK DETOUR ROUTE.
> THE TRUCK DETOUR ROUTE IS CARRYING TWO-WAY TRAFFIC SO DO NOT PASS.
> THE DETOUR IS ABOUT 7 MILES IN LENGTH AND ALL TRAFFIC WILL BE RETURNED TO THE FREEWAY AFTER THE DETOUR.

There was a 3-4 second silent pause between each repetition of the messages.

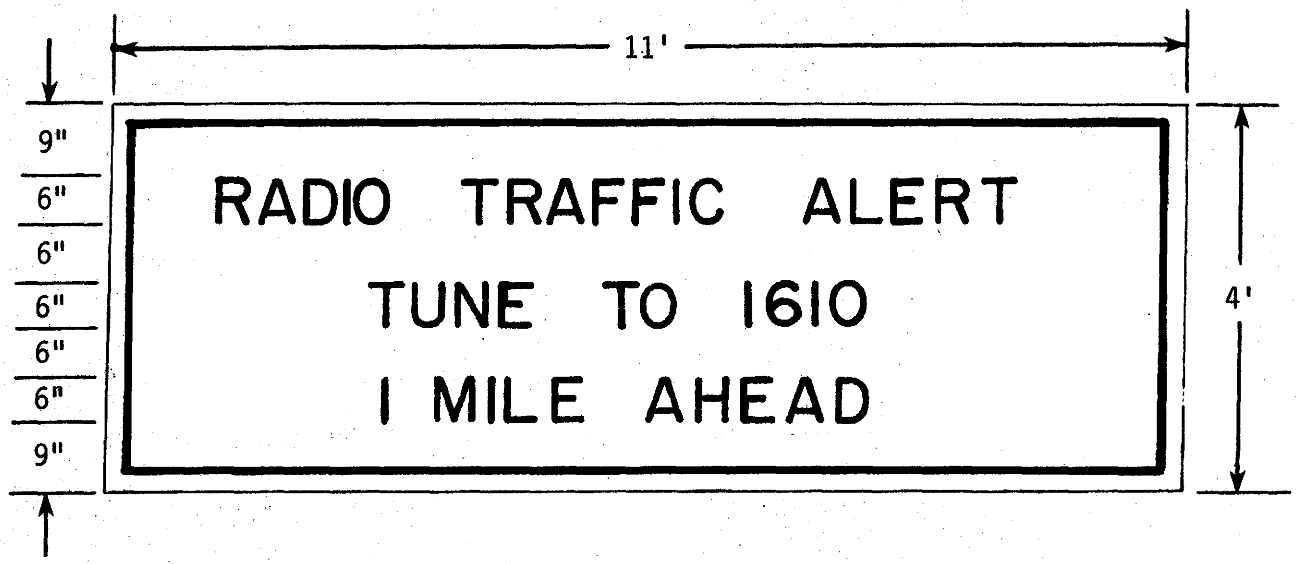
Two versions of the message were evaluated during the study. In one version, the message was read alternately by a man and woman who had no experience in public announcing. They spoke at a speech rate of approximately 130 words/minute. In the second version, the message was read by a professional male radio announcer who recited the message at a speech rate of 190 words/minute.

Broadcast Distance

Both transmitters broadcasted an audible message over a distance of several miles. In fact, the HAR broadcasts could at times be heard in Beaumont which was 20 miles from the work zone. This phenomenon was attributed to the presence of high voltage power lines near the work zone which amplified the radio signals. The two independent transmissions could be received simultaneously in the middle of the work zone and a jumbled, inaudible message resulted.

HAR Signing

Motorists approaching the work zone from either direction were informed of the HAR broadcasts by three advance warning signs shown in Figure 9. The



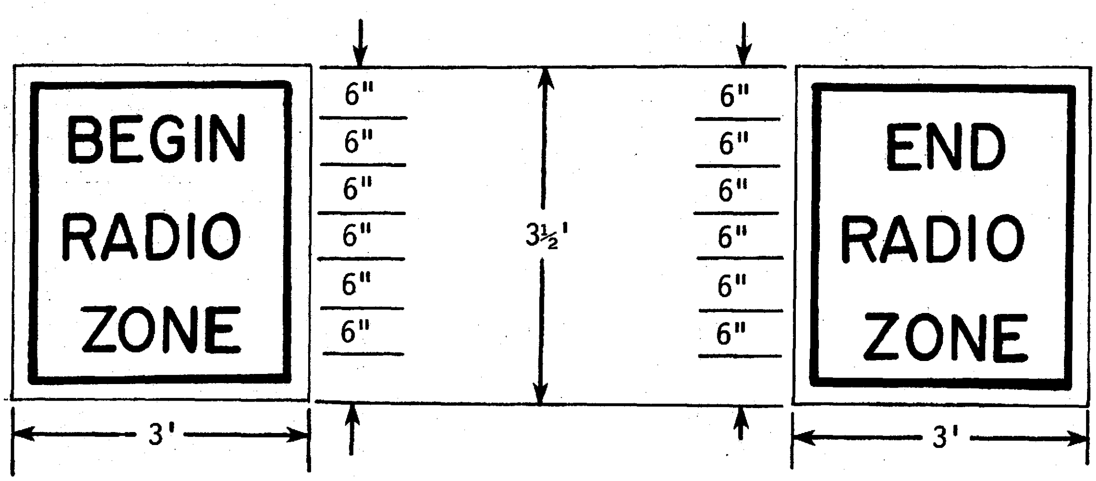


Figure 9. HAR Signing

black-on-orange signs had 6-inch letters and were mounted just off the right shoulder.

The first sign, located 1-1/2 miles upstream of the transmitter; instructed drivers to tune to 1610 one mile ahead for a radio traffic alert. The next sign was located 3/4 mile upstream of the transmitter and it designated the beginning of the radio broadcast zone. The third sign was 1-1/2 miles farther downstream and it designated the end of the radio zone.

STUDY DESCRIPTION

Field studies were conducted to evaluate the effectiveness of the HAR system in warning motorists of conditions at the work zone. The studies included lane distribution, volume and vehicle classification counts, and a motorist questionnaire survey. Studies were conducted the week before the HAR system was installed and the week after.

Questionnaire Survey

A limited questionnaire survey was developed and administered to 53 work zone motorists to evaluate: 1) the percentage of motorists having an operative AM radio, 2) driver familiarity with the work zone, 3) motorist opinion of the HAR signing, and 4) motorist opinion of the HAR messages. The questionnaire survey also was designed to estimate the percentage of motorists who saw the HAR signing and the percentage that attempted to tune to the HAR Station.

STUDY RESULTS

Lane distribution, volume, and vehicle classification counts revealed that the innovative traffic control strategy used at work zone was very successful. The conventional signs and channelizing devices used at the work zone encouraged up to 94 percent of all cars, pick-ups and vans to use the frontage roads and the same high percentage of trucks to use the mainlanes. When the HAR system was installed, these percentages rose slightly to 97 percent.

The effectiveness of the conventional signs and channelization devices made it difficult to evaluate the influence of the HAR on traffic flow patterns in the work zone. The results of the questionnaire survey, however, provide insight into driver reaction to the HAR signing and messages. The survey results also suggest some apparent deficiencies in the HAR system.

Survey Findings

Apparently, the HAR signs were too small and lacked target value. Twenty-one of the 53 motorists (40 percent) surveyed said they did not see the HAR advance signing. Many motorists who saw the signs complained that they were too small or "hidden" by larger, more conspicuous work zone and freeway guide signs. Advance signing for an HAR system must be adequate if the system is to be effective.

Only 14 of the 32 motorists (44 percent) who saw the signs attempted to tune to the HAR broadcast. The work zone was on a heavy commuter route and over half of the drivers surveyed had traveled through the work zone several times. Many of these familiar motorists said they failed to tune in because they did not desire additional information about the work zone. This finding suggests that HAR should not be used to broadcast repetitious information to familiar drivers. A few motorists who saw the signs did not tune in because their car radios were broken.

Most of the drivers who attempted to tune to the HAR broadcasts were able to hear the message and they rated the message quality as fair to good.

Generally speaking, most motorists surveyed favored the use of HAR at some work zones.

DISCUSSION

Highway Advisory Radio has potential as an effective tool for work zone traffic management. Guidelines need to be developed for the use and operation of HAR in work zones, however. These guidelines should identify conditions warranting the use of HAR at work zones. These conditions might include:

1. DELAY - Work zones where delay is excessive and more favorable alternate routes exist,
2. SIGNING EFFECTIVENESS - Work zones where normal construction warning techniques are ineffective or inappropriate,
3. ACCIDENTS - Work zones which have higher than normal accident and/or fatality rates.

In addition to the guidelines, there is a need to improve HAR licensing procedures. Obtaining a license for an HAR system currently requires up to six months. This time should be reduced if HAR and HAR guidelines are to be used effectively and regularly at work zones.

REFERENCES

1. NCHRP Synthesis of Highway Practice 61--Changeable Message Signs. Transportation Research Board, July 1979.

2. J. D. Carvell, J. M. Turner and C. L. Dudek. Human Factors Requirements for Real-Time Motorist Information Displays, Vol. 15--Freeway Incident Management Studies. Texas Transportation Institute, Report No. FHWA-RD-78-19, August 1978.

3. C. L. Dudek, G. D. Weaver, D. R. Hatcher and S. H. Richards. Field Evaluation of Messages for Real-Time Diversion of Freeway Traffic for Special Events. Transportation Research Record No. 682, 1978.

4. S. H. Richards and C. L. Dudek. Sight Distance Requirements at Lane Closure Work Zones on Urban Freeways. Texas Transportation Institute. Report No. FHWA/TX-81/28+228-7, April 1981.

5. H. W. McGee and B. G. Knapp. Visibility Requirements of Work Zone Traffic Control Devices. BioTechnology, Inc. Report No. FHWA-RD-78-143. July 1978.

6. S. H. Richards, C. L. Dudek, and J. M. Mounce. Human Factors Requirements for Real-Time Motorist Information Displays, Vol. 16--Feasibility of Audio Signing Techniques. Texas Transportation Institute, Research Report No. FHWA-RD-78-20, August 1978.

7. W. F. Dorsey. Highway Advisory Radio Potential Site Survey and Broadcast Equipment Guide. Office of Research and Development, Federal Highway Administration, April 1979.

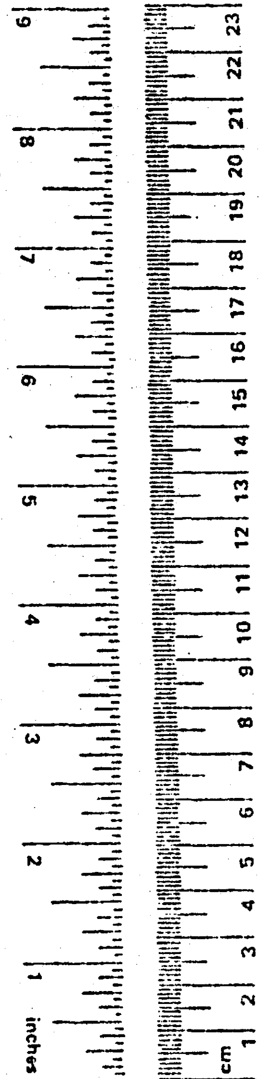
APPENDIX

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F