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16. Abstract

Studies were conducted at a major maintenance work zone on a rural Interstate highway in Texas to evaluate the use of Highway Advisory Radio (HAR) for work zone traffic management. The studies consisted of lane distribution, volume and vehicle classification counts (conducted before and during operation of the HAR), and a questionnaire survey administered to motorists traveling through the work zone.

The studies revealed that the HAR had little or no impact on work zone traffic operations 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. Almost 45 percent of the motorists entering the work zone reported that they did not even see the signing.

Even though the HAR system did not significantly affect work zone traffic operations, the studies indicated that HAR may have good potential for work zone traffic management in certain applications. The HAR hardware performed adequately. Motorists, generally speaking, were satisfied with the quality of the broadcasts and supportive of this innovative approach to work zone traffic management.

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TRAFFIC CONTROL AT THE I-10 RECONSTRUCTION WORK ZONE IN CHAMBERS COUNTY, TEXAS

by

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Research Report 263-4

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

August 1981

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is also acknowledged for their guidance and assistance during the study.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

BACKGROUND

Highway Advisory Radio (HAR) is a means of providing motorists with pertinent traffic and travel-related information over their standard AM car radios. It is intended to supplement visual signing (e.g. conventional highway signs, changeable message signs, etc.) in those situations where signing alone is inadequate, inappropriate, or inefficient. The concept and technical approach to HAR are fairly straightforward. Motorists traveling down a freeway are instructed by signs to tune their car radios to a specially designated frequency (by law: 530 kHz or 1610 kHz). Upon tuning to the frequency, they hear a live or pre-recorded message broadcasted from a field transmitter.

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 (1).

USE OF HAR AT WORK ZONES

In 1978, the FCC amended its regulations pertaining to HAR to permit greater areas of use. There have also been advancements in hardware and operational technology in recent years (2, 3). These developments prompted the Federal Highway Administration in September 1978 to encourage the use of Highway Advisory Radio systems where appropriate, and for the first time, to encourage states to use HAR on a temporary basis at construction work zones

where:

1. traffic control is critical;
2. traffic movements change frequently; and/or
3. the traveling public will be inconvenienced for a substantial period of time.

HAR appears to have great potential as a traffic management tool at some types of work zones; however, there has been very limited experience with the use of HAR at work zones. This report documents the performance of one of the first HAR work zone installations in the United States. This HAR system, on I-10 midway between Houston and Beaumont, Texas, was used to divert traffic around a rural freeway resurfacing worksite. District 20 of the Texas State Department of Highways and Public Transportations installed and operated the HAR system.

STUDY SITE

RESURFACING ACTIVITY

A contract was let in early 1979 to resurface the mainlanes of a 14-mile rural section of I-10 in Chambers County midway between Houston and Beaumont, Texas. The resurfacing work involved milling the existing pavement and placing additional base material and an asphaltic concrete overlay on all the travel lanes. The work required approximately six months to complete.

ROADWAY CHARACTERISTICS

In the area of the work I-10 has four 12-foot travel lanes (two lanes per direction), with 10-foot outside and 4-foot inside shoulders in both directions of travel. A 32-foot ditch median separates opposing traffic. The section has continuous frontage roads which normally operate as two-way roadways.

The section has an ADT (Average Daily Traffic) of 20,000 vehicles per day. Approximately 20 percent of this traffic is truck traffic and a large percentage is commuter traffic. The normal posted speed limit on the mainlanes and frontage roads is 55 miles per hour.

TRAFFIC CONTROL

The resurfacing work was performed utilizing four construction phases. Each phase required 1-2 months to complete. During each phase, the mainlanes in one travel direction (eastbound or westbound) were completely closed to traffic for a 7-mile length or approximately one-half the total project

length. While a particular section of roadway was closed, all work required on that section was completed.

Figure 1 shows the innovative traffic control strategy used to divert traffic around the portion of the work area closed to traffic. 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.

From Figure 1, all trucks and buses were required to use the open mainlane section to travel through the work area. This open side was temporarily converted to a two-lane, two-way roadway to accommodate both eastbound and westbound truck and bus traffic. Passing was prohibited for the entire length (approximately 7 miles) 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. For the duration of the work activity, the two-way frontage roads were converted to one-way operation, with the north frontage road carrying westbound traffic and south frontage road carrying eastbound tarffic. The posted speed limit on the frontage roads was reduced to 50 miles per hour.

To inform motorists of the special traffic conditons and diversion routes at the work zones, an elaborate system of signs and channeling devices was installed at the worksite. Some of the ground mounted and overhead diversion signs installed at the worksite are shown in Figure 2. A combination of channelization devices, including barrels, vertical panels, and paint markings, were installed at the diversion points on both ends of the work area.

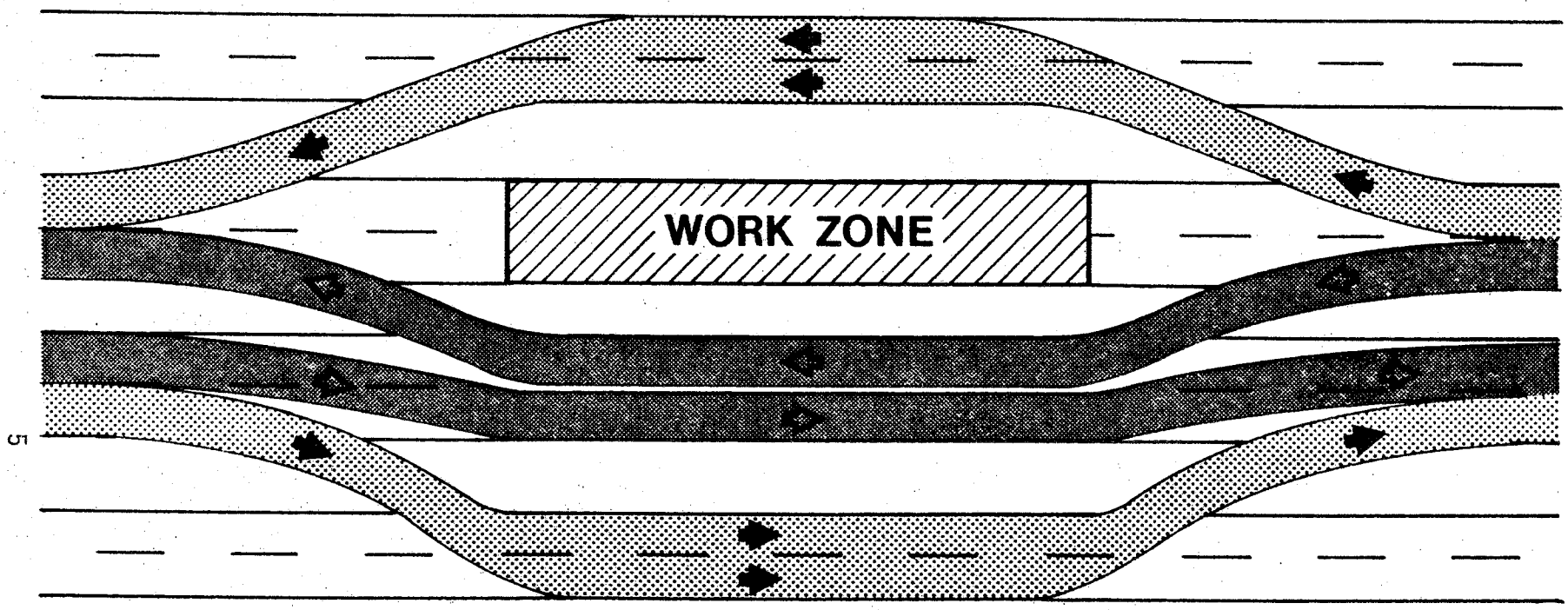


Figure 1. Work Zone Traffic Control Strategy

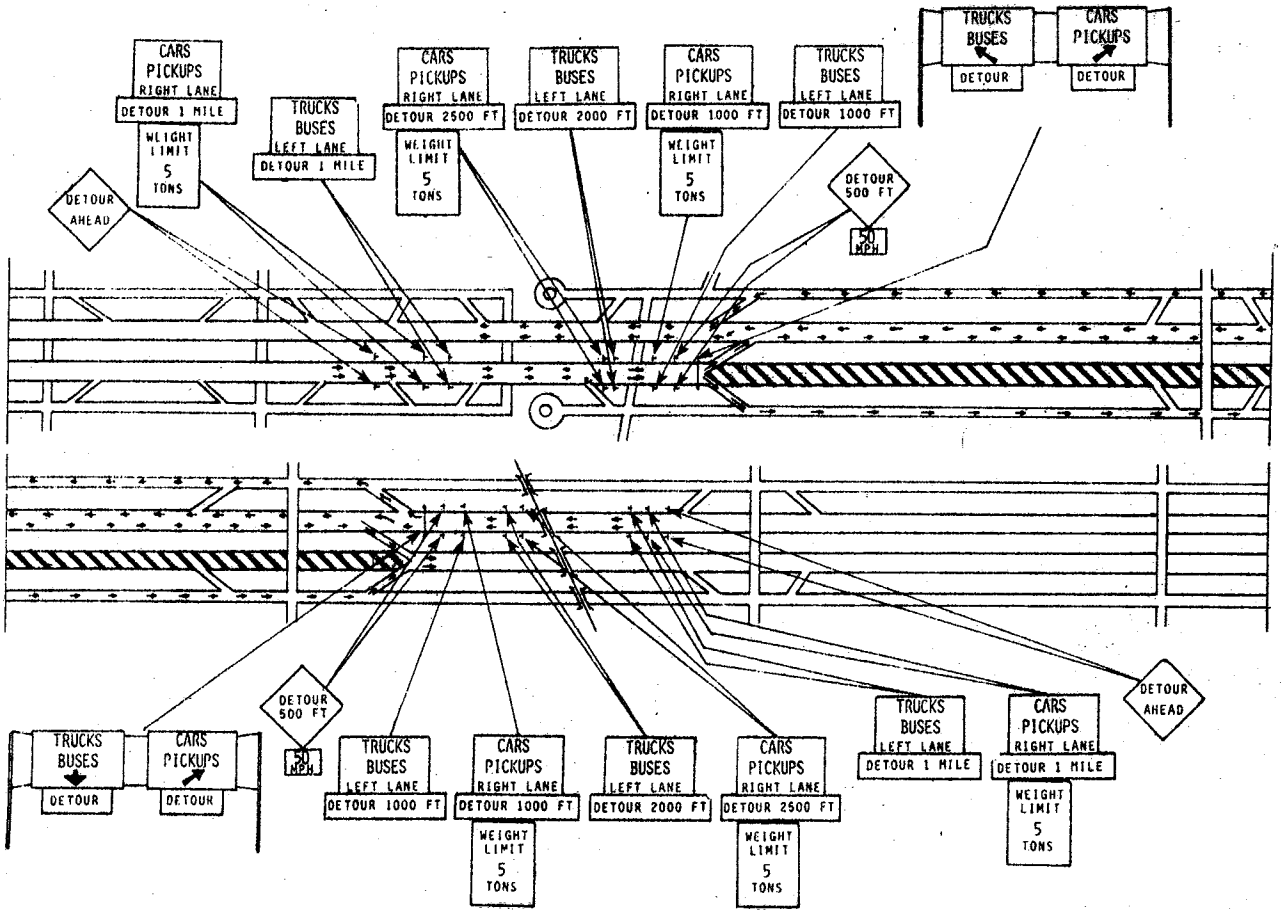


Figure 2. Work Zone Signing Layout

HIGHWAY ADVISORY RADIO

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 traveling through the work zone. Although every effort was made to effectively sign and channelize the work area, there was still 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 visual traffic control devices.

The decision to use HAR came after the project Traffic Control Plan had been approved. Therefore, a field change was necessary to install the HAR system. By the time the field change had been reviewed and approved, the HAR equipment had been ordered and installed, and the system licensed, most of the road work had been completed. The HAR system was in operation for less than one month at the worksite.

HAR Equipment

Two 10-watt field transmitters were installed at the work zone, one on each end of the project. The transmitters broadcasted independently and the broadcast signals were projected by vertical monopole antennas tuned to 1610 KHz. A single antenna was used for each transmitter. The radio messages were recorded and continuously played on a heavy duty 8-track cartridge recorder/player. The detailed specifications for the HAR equipment, as prepared by the Department, are shown in Appendix A.

HAR Licensing

The work zone HAR system was operated on a temporary broadcasting license. Temporary licensing of the system 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.

Radio Messages

The below message was broadcasted continuously to both east and westbound traffic at the worksite:

> 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.
>
> (Between each repetition of the message there was a 3-4 second silent pause.)

Two versions of the message were evaluated during the study. In one version, the message was read alternately by a man and a woman who were employees of the District 20 Office of the Texas SDHPT. These individuals had no experience in public announcing and both of them recited the message 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.

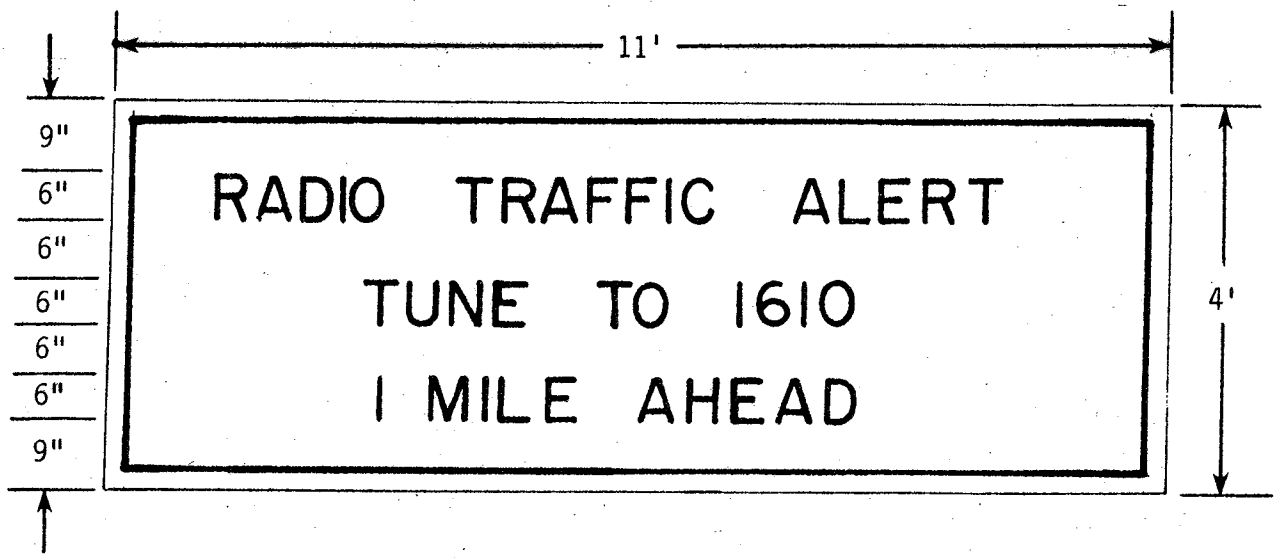
Broadcast Distance

The transmitters, which were located approximately 14 miles from each other, 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. Also, in the middle of the work zone (midway between the two transmitters), the messages broadcasted independently from the two transmitters on the same frequency were received simultaneously, resulting in an echo effect. (In other words, both transmissions could be heard but the messages were not sycronized.)

HAR Signing

Motorists approaching the work zone were informed of the HAR broadcasts by a series of three signs shown in Figure 3. All the signs had black 6-inch lettering on an orange background and were mounted just off the right shoulder of the main lanes.

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



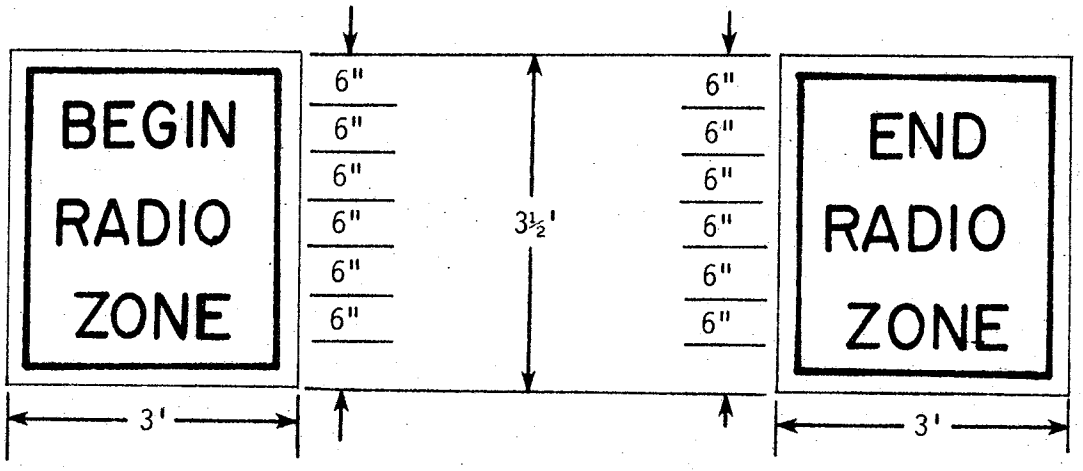


Figure 3. Advance Signing for HAR

FIELD EVALUATION AND MOTORIST SURVEY

STUDY DESCRIPTION

Field studies were conducted to evaluate the effectiveness of the innovative traffic control strategy and, in particular, the HAR system in warning motorists of conditions at the work zone. The studies, conducted on several days in November 1979, included speed studies, lane distribution and volume counts, and vehicle classification counts on the mainlanes and frontage roads. In addition, a motorist questionnaire survey was administered to 53 motorists who had an opportunity to hear the HAR broadcasts. The questionnaire is shown in Appendix B.

The studies were conducted the week before the HAR system was installed and the week after the system had been in operation for a few days, providing data for a "before and during" evaluation of the HAR system. It should be emphasized that during the "before" period there was an elaborate system of overhead and ground-mounted signs and various channelizing devices at the work zone. In the "during" period, the HAR system was used to supplement these signs and channelizing devices.

FIELD STUDY RESULTS

The results of the field studies revealed that the innovative traffic control strategy used at the work zone was very successful, both with and without the HAR. In fact, the effectiveness of the innovative strategy with only 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, provided insight into driver reaction to the HAR signing and messages. The survey results also suggested some apparent deficiencies in the HAR system. These will be discussed in detail in a later section.

Effectiveness of Innovative Traffic Control Strategy

The innovative traffic control strategy used at the work zone involved diverting all cars, pick-ups and vans to the frontage roads. Trucks and buses were encouraged to use one side of the mainlanes which was operated as a two-lane, two-way roadway (see Figure 1).

Field crews were deployed at approximately 20 locations in advance of and at the work zone to determine motorists reaction to the innovative strategy. The field crews made lane distribution and diversion traffic counts by vehicle type. They collected data for several hours one week before the HAR was installed and again, after it was installed. The "before" studies evaluated the effectiveness of the strategy with the conventional signing system in place (see Figure 2). The "during" studies evaluated the strategy with both signs and HAR in use.

The field studies revealed that the conventional signs and channelizing devices 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. Thus, it may be concluded that the innovative strategy was successful in accomplishing its main purpose.

It should also be noted that during the field studies no major traffic operational problems were observed at the work zone. However, one minor problem was noticed which deserves mention. There was a problem with recreational vehicles (i.e., campers) using the mainlanes. These vehicles, generally speaking, traveled very slowly and inconvenienced faster truck traffic. In fact, some truckers passed these slower vehicles illegally in the work zone. It was the District's intent for recreational vehicles to use the frontage roads.

Work Zone Accidents

A limited study of accidents occurring at the work zone was conducted. The study found that the number of accidents actually decreased during the time period when the work activity occupied the roadway. For example, accidents in one section decreased in number from 14 to 9. These figures are for comparable 6-month periods during and before the work.

Speed Studies

Spot speed studies were conducted by District 20 personnel at several locations within the work zone. The speeds of several hundred vehicles on both the mainlanes and frontage roads were measured by radar. The speed data were collected during periods before and after implementation of the HAR system.

The speed studies revealed that the 85th percentile speeds of trucks (on the mainlanes) and cars (on the frontage roads) were above 60 mph. As noted earlier, the posted speed limit on the frontage roads and mainlanes was 50 mph in the work zone. The studies also indicated that the HAR broadcasts had no measurable effect on 85th percentile speeds.

MOTORIST SURVEY

A questionnaire survey (see Appendix B) was administered to 53 work zone motorists (passenger car drivers only). The survey was intended to evaluate the percentage of motorists having an operative AM radio, driver familiarity with the work zone, motorist opinion of the HAR signing and 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.

HAR Use

Table 1 shows the number and percentage of survey participants who attempted to tune to the HAR broadcasts. From the table, only 30 percent of the participants reported that they tried to tune to the HAR station.

Table 2 summarizes the reasons cited by the 37 drivers who did not attempt to tune to the HAR station. Almost one-half of these drivers (49%) said they did not attempt to tune because they did not see the advance signing for the HAR. Apparently, the HAR signs were too small and lacked target value. In fact, many of the motorists that 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.

From Table 2, 19% of the motorists surveyed said that they were very familiar with the work zone and simply did not desire to tune to the HAR broadcasts. This finding suggests that HAR may not be effective in presenting information to commuting drivers, especially if the HAR is operated continuously.

Four drivers (11%) did not use the HAR because they did not understand the advance sign messages. Some of these drivers thought that the signing applied only to CB radio operators.

Driver Familiarity

The survey revealed that familiar drivers were more likely to tune to the HAR broadcast compared to the unfamiliar drivers. Also a larger percentage of familiar drivers saw the HAR advance signing (35% versus 9%). Apparently, while some drivers may not pay attention to work zone signing, the familiar drivers appear most likely to detect changes in the signing or new information. The fact that few unfamiliar drivers did not see the HAR advance signing and there were few changes in traffic control for the familiar driver may have influenced the performance of the HAR installation on the heavy I-10 commuter route.

TABLE 1. FREQUENCY OF HAR USE BY MOTORISTS

Direction of Travel	Motorists Sampled	Number Attempting to Use HAR	Percent Attempting to Use HAR
Eastbound	25	8	32
Westbound	28	8	29
East and Westbound	53	16	30

TABLE 2. REASONS CITED BY MOTORISTS FOR NOT ATTEMPTING TO USE THE HAR

Reasons for Not Using HAR	Number of Motorists	Percent of Non-Users
Motorist failed to see advance signing for HAR.	18	49
Motorist was familiar with the work area and did not desire HAR information.	7	19
Motorist saw the HAR advance signing but did not understand the sign message.	4	11
Motorist's vehicle was not equipped with an operable AM radio.	3	8
Motorist had heard the HAR message on a previous trip and did not wish to hear it again.	2	5
Motorist was listening to commercial AM radio broadcast and did not want to interrupt the broadcast.	2	5
No response.	1	3
Totals	*37*	*100*

Radio Equipment

Table 3 shows a summary of the radio equipment in the vehicles of the 53 survey participants. Only one of the participants did not have an AM radio in his/her vehicle. The data in the table also suggest that the drivers who had several radio components (e.g., C. B. radio, FM radio, etc.) in their vehicles were more likely to tune to the HAR broadcast. This apparent finding is interesting but no definite conclusions can be made because of the small sample sizes.

The survey also considered the effect of antenna-type (pole versus windshield) on reception of the HAR broadcasts. Based on the limited data from this study, there were no differences found in reception ability for the two basic types of car antennae.

Advance Signing Improvements

As noted earlier, the advance signing for the HAR system was apparently inadequate. During the survey, motorists were asked how this signing might be improved. Their suggestions are summarized in Table 4. From the table, 50 percent of the 18 motorists who responded to the question suggested larger, more conspicuous signing.

Broadcast Reception

Although less than one-third of the survey participants attempted to tune to the HAR broadcasts, those who did tune in were generally pleased with the broadcast quality and content. Most of the drivers rated the broadcasts as equal to or better than commercial AM broadcasts. All of the drivers who heard the HAR message said that it was helpful to them and/or other drivers.

TABLE 3. MOTORIST USE OF HAR BY TYPE OF VEHICLE RADIO EQUIPMENT

Radio Equipment in Vehicle	Number of Motorists	Percent of Motorists Attempting to Tune
AM Radio	10	20
AM Radio and Other (No CB Radio)	26	31
AM Radio and CB Radio	3	100
AM Radio, CB Radio, and Other	13	23
No AM Radio	1	--
Totals	*53*	*30*

TABLE 4. IMPROVEMENTS TO HAR SIGNING REQUESTED BY MOTORISTS

Signing Improvements	Number of Motorists Responding	Percent of Motorists Responding
Use larger or more conspicuous signs.	9	50
Use overhead signing.	4	22
Use two advance signs.	3	17
Improve the advance sign message.	2	11
Totals	*18*	100

Message Performance

As mentioned earlier, two versions of the HAR message were evaluated during the studies. In the first version, the message was given alternately by a male and female employee of District 20. In the second version, a professional male radio announcer gave the message. The study results revealed no significant differences in driver response to or preference for either message.

CONCLUSIONS AND DISCUSSION

INNOVATIVE TRAFFIC CONTROL STRATEGY

The innovative work zone traffic control strategy (see Figure 1) was apparently very effective and safe. Thus, the strategy may be considered as a practical alternative for handling traffic at work zones with characteristics similar to those at the I-10 reconstruction work zone in Chambers County. The strategy may be best suited for long term work projects, since commuting drivers will become familiar with the unusual traffic flow patterns. It is recommended that if the strategy is used, a well-planned system of traffic control devices (signs, channelizing devices, etc.) be installed and maintained for the duration of the project. The traffic control system used by District 20 (see Figure 2) is a good example.

HIGHWAY ADVISORY RADIO

Even though the HAR did not improve traffic operations at the I-10 work zone, the studies indicated that HAR 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. If a HAR system is to be effective however, the advance signing must be adequate. It is therefore recommended that the advance signing for a work zone HAR system on an Interstate highway of urban freeway be designed to at least the same standards as Interstate guide signing (e.g., same sign size, letter size, letter series, etc.).

In addition, guidelines need to be developed for the use and operation of HAR in work zones. 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.

There is also 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 is to be used effectively and regularly at work zones. The application for a license of HAR transmitters should be made during the preparation of the Traffic Control Plan. This would eliminate the delay previously experienced.

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2. Dorsey, Warren F., "Highway Advisory Radio Potential Site Survey and Broadcast Equipment Guide", Systems Development and Technology Group Traffic Systems Division Office of Research and Development Federal Highway Administration April 1979

3. Carlson, G. C., Dahl, R. D., and Lari, A. Z. "Evaluation of Highway Advisory Radio in the I-35N Traffic Management Network" Minnesota Department of Transportation March 1979

APPENDIX A

DETAILED SPECIFICATION FOR HIGHWAY ADVISORY RADIO SYSTEM

1.0 Two transmitters, FCC Type Accepted, to operate on frequency 1610 kHz, with power from one to ten watts, tunable, shall be supplied.

2.0 Two crystals on frequency 530 kHz with a TTL network shall be supplied to convert the transmitters to 530 kHz.

3.0 Four monopole vertical antennas tuned to 1610 kHz with loading coils shall be supplied.

4.0 Two monopole vertical antennas tuned to 530 kHz with loading coils shall be supplied.

5.0 One heavy duty recorder repeater, which includes a microphone, to use on 8-track magnetic tape cartridge for a continuous loop message shall be supplied. The unit shall operate at 117 VAC.

6.0 Two heavy duty cartridge players (repeaters) which have an audio output compatible to the input of the transmitter shall be supplied.

7.0 One 100% solid state voice storage unit shall be supplied with the following features:

- 7.1 Voice storage time: 20 seconds minimum.
- 7.2 One controlled reluctance microphone.
- 7.3 Record input impedance of at least 10,000 ohms.
- 7.4 One battery to retain stored message during power failure.
- 7.5 Audio output impedance shall be matched to the radio input impedance.
- 7.6 Unit shall come equipped with all necessary cabling and connectors to interface with transmitter.

8.0 Fifty 5-minute continuous loop 8-track tape cartridges shall be supplied.

9.0 Two lockable, environmentally sound, metal security boxes shall be supplied. Each security box shall be large enough to have one radio transmitter, one power control assembly, and one tape playback unit. The security box shall also be large enough to substitute the solid state voice storage unit for the tape playback unit.

10.0 Maintenance manuals, detailed schematics, and other technical information shall be supplied such that the State Department of Highways and Public Transportation shall be able to maintain, troubleshoot, modify, and repair equipment.

11.0 All accessories that are required for a complete and operating installation of the Highway Advisory Radio System shall be furnished.

12.0 After delivery, but prior to acceptance, the System shall undergo a two week test period on a freeway site. The test period shall be used by the Department to determine whether the minimum specifications have been met. The testing shall consist of functional testing and qualitative evaluation of the system to determine whether the broadcast signal is of a quality acceptable for operational use. The Department shall complete such testing within thirty calendar days after receipt of the System and support materials.

13.0 After acceptance, the Contractor shall unconditionally guarantee all workmanship and parts furnished by the Contractor for a period of one year, and shall supply the Department with such parts and materials which fail or otherwise become defective through normal use within the guarantee period.

14.0 The above equipment shall be bid as a compatible system.

15.0 Due to the duration of this project, delivery shall be required within thirty days after award of contract. The Contractor shall be responsible for all shipping charges. Delivery shall be made to: State Department of Highways and Public Transportation, General Warehouse, Camp Hubbard, Attention: D-18 Radio Shop, West 35th and Jackson Streets, Austin, Texas 78705.

We request a copy of these specifications be sent to: Audio-Sine, Inc., 3415 Forty-eighth Avenue North, Minneapolis, Minnesota 55429.

APPENDIX B
HAR QUESTIONNAIRE SURVEY

1. On November 13, 1979, you were observed driving westbound through a construction site on I-10 in Chambers County between Houston and Beaumont. What radio equipment was in the vehicle that you were driving?
(Check all that apply)

☐ AM Radio ☐ Tape Deck ☐ CB Radio
☐ AM/FM Radio ☐ Radio/Tape Comb. ☐ Radio Telephone
☐ Other (Specify: _____)

2. Did the vehicle have a wire antenna built into the windshield?

☐ Yes ☐ No

3. How many times had you traveled through the I-10 construction site prior to the trip you made on November 13, 1979?

☐ None ☐ 2-5 Times
☐ 1 Time ☐ More than 5 Times

4a. As you approached the I-10 construction site, did you see the signs instructing motorists to tune their car radios to 1610?

☐ Yes ☐ No

b. Did you see the signs which marked the beginning and end of the radio broadcast zone?

☐ Yes ☐ No

c. What could be done, if anything, to improve the signs referred to in 4a and b?

_____

_____

_____

5a. As you approached the I-10 construction site, did you attempt to tune your car radio to 1610?

☐ Yes ☐ No

b. If no, explain: _____

_____

_____

6. How well could you hear the special workzone radio broadcast?

- ☐ Better than most commercial AM radio broadcasts
- ☐ About the same as most commercial AM radio broadcasts
- ☐ Not as well as most commercial AM radio broadcasts, but I could hear the message
- ☐ It was difficult to hear all or part of the message
- ☐ It was impossible to hear <u>any</u> of the message
- ☐ I did not attempt to tune to 1610

7. How did the radio message influence your driving?

- ☐ It helped me to travel with greater safety and/or convenience through the construction site.
- ☐ It did not help me, but may have helped other drivers
- ☐ It did not help me and probably did not help other drivers
- ☐ It made my driving more hazardous because it was confusing, misleading, and/or distracting
- ☐ I did not hear the message

8. How could the radio message be improved?

_____

_____

_____

_____

Thank you for your help. Please feel free to write additional comments in the space below.

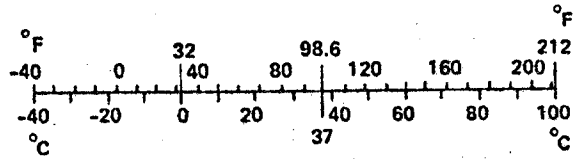
APPENDIX C
METRIC CONVERSION FACTORS

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

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



*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.