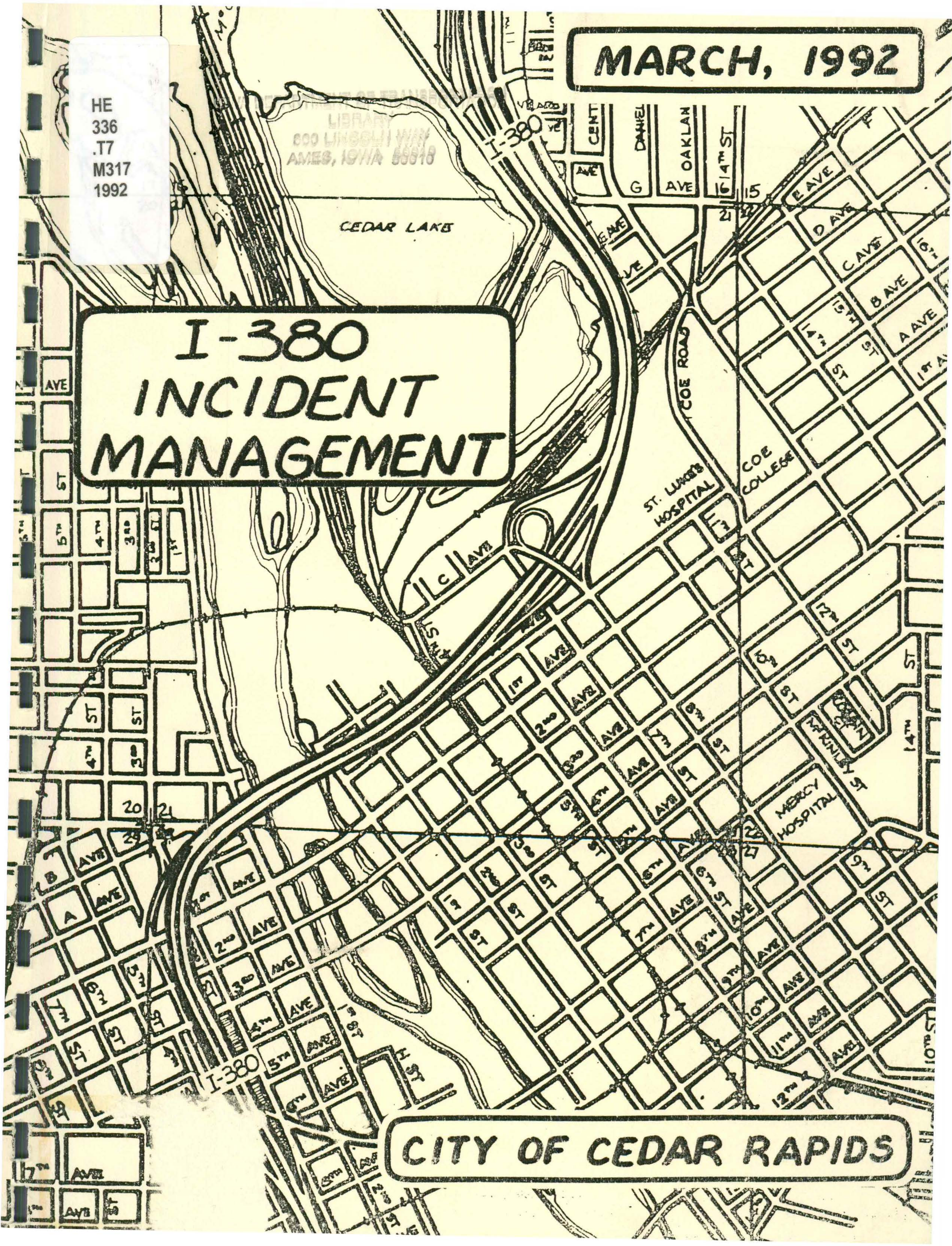
MARCH, 1992

I-380 INCIDENT MANAGEMENT



CITY OF CEDAR RAPIDS

MANAGEMENT OF URBAN FREEWAYS

A PROJECT INVOLVING

TRAFFIC FLOW & SAFETY

ON

INTERSTATE 380

WITHIN THE

CITY OF CEDAR RAPIDS, IOWA

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March 12, 1992

I-380

MANAGEMENT OF URBAN FREEWAYS

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I-380
MANAGEMENT OF URBAN FREEWAYS

INTRODUCTION

Construction of I-380 through the City of Cedar Rapids was initiated in 1969 and completed in 1982. While other corridor location alternatives were considered in the initial I-380 location study through Cedar Rapids, the final location occurred on the north edge of the central business district, located between Quaker Oats, the largest cereal mill in the world, and the downtown area. In order to accomplish the design within the restricted rights-of-way several curves were required to connect the north/south facility. The design of the center segment in the downtown area was unique in many ways. Much of this center section, which is the focus of this report, is an elevated freeway, a portion of which passes over the Cedar River which at this point provides eight lanes on the freeway, five lanes on a surface street system directly below the freeway, and a dam structure. The dam is utilized for creation of a recreational pool north of the downtown, maintaining a static head for the City's well fields, and generation of electrical power.

Immediately after opening the central section in approximately 1981 problems were experienced regarding the safety and operational aspects of this central section. These problems occurred primarily between the "H" Avenue N.E. interchange on the north and the 5th Avenue/Diagonal Drive S.W. interchange on the south. In April 1982, within a year of opening, a significant multiple vehicle accident occurred within the southbound I-380 lanes on the curve just west of the Cedar River. This multiple car accident involved 29 vehicles. Since that time, continual multiple car accidents have occurred. City and Iowa D.O.T. officials are very aware of the potential for increased accident occurrence and have jointly been involved with numerous discussions, meetings, and reports to identify the problem and potential solutions.

In April 1986 the City prepared a report titled "I-380 Traffic Flow and Safety" which provided a review of the traffic flow and safety for the previous three years and recommendations for consideration of traffic incident management strategies for this central section of I-380. Following this report an engineering psychologist human factors expert from the Federal Highway Administration in Washington, D.C. reviewed the area of concern with FHWA, D.O.T. and City officials resulting in an in-depth analysis and report of these conditions. The analysis provided by the engineering psychologist identified some specific concerns regarding this portion of the freeway with summary comments as follows.

- This section of I-380 is somewhat geometrically substandard in the vicinity of the CBD.

- Problems are primarily associated with two compound curves and restricted sight distance.

- Rapid icing occurs during adverse weather seasons.

- Icing results in a high number of ice related single and multiple vehicle accidents.

- Poor geometrics and sight distance contribute to the site's multi-vehicle collision potential.

- Poor geometrics and sight distance hamper incident detection and management activities.

- Poor geometrics and sight distance are felt to be hazardous by authorities.

- There is a need for a traffic management team approach to develop

  1) an effective plan for a fully coordinated effort of warning drivers prior to an incident
  2) a full system of incident detection, management, and control.

- The motorist information display aspect of the system must be developed and could range from fixed and portable signage to real time displays.

Various discussions and correspondence occurred in the ensuing years with a subsequent request provided to the Iowa Department of Transportation in July of 1991 for installation of temporary fold-out signs in advance of the curves to provide notification to approaching traffic of accident conditions which may exist in the area. These signs were approved by the Iowa Department of Transportation and installed in November 1991. The temporary fold-out signs were intended only as an interim solution prior to determining a long range solution which may involve incident management strategies.

This update report includes an additional five year accident history since the earlier report and provides specific recommendations as to the manner in which incident management on I-380 in this area should be addressed. The primary objective of this report and resultant project is to determine the methodology of incident management that may apply to this portion of I-380. The specific goal is to reduce multiple car involvement accidents which occur from an incident on the freeway and to improve the safety for investigating officers and those individuals who may be investigating or involved in accidents or incidents. The potential for multiple car involvement accidents in this area is high due to the design elements which preclude adequate advance visibility of the scene and location of the incident.

During the last five years of accident analysis no significant change occurred from the previous study in the types of accidents. Two hundred sixty-four accidents were recorded in the section of I-380 under study. Seventeen percent of all accidents were multi-car accidents. Twenty-nine percent of all accidents involved motorists who were out-of-town or out-of-state and were not generally familiar with the design elements of this central section of the freeway. A summary of the 5 year accident information is shown in Exhibit D. This emphasis on multi-car accidents further identifies the need to address this section of I-380, find resolutions to the problem, and implement solutions.

BACKGROUND

I-380 Traffic Flow and Safety Report (Attachment A).

The I-380 traffic flow and safety report for the City of Cedar Rapids, dated April 16, 1986, is included in its entirety as Attachment A.

This report provides the history of I-380 construction scheduling and opening, volumes of traffic and detail of accident history for the three-year period 1983, 1984, and 1985. This background information related to that portion of I-380 between 32nd Street NE and 33rd Avenue SW. More specifically, however, the report addressed that portion of I-380 between "G" Avenue N.E. on the north and 5th/8th Avenue S.W. interchange on the south. The report provides a detail of the sequence of events from opening of this section of I-380 up until a planned meeting with the Federal Highway Administration Human Factors Expert. Details are provided of the numerous meetings with law enforcement agencies, the Iowa Department of Transportation, and City officials concerned about the traffic flow and safety on this segment of the interstate system.

The report concludes with a concept of incident management identification signing for the two curves where the greatest problems have occurred. The intent of the signing concept was to provide an idea or concept of what could be done moreso than a specific proposal for installation. The report's purpose was to indicate potential measures that could be taken to (a) reduce the potential for accidents and (b) reduce the potential for multiple accidents after a single accident had occurred, concurrent with increasing the safety of investigating officers. Signing layouts were included to indicate the type of messages which could be provided to advise approaching motorists in advance so as to enable a change in operating speed or diversion to other lanes or to seek other roadway alternatives. The report references an upcoming meeting, to be attended by human factors experts of the FHWA in Washington, State and City officials which was intended to provide an analysis of the scope of the problem and the potential solutions. The objective of the 1986 City report was to provide background information which would be followed by an in-depth study, perhaps by a consultant, to identify the scope of the problem, identify the solutions following which a plan for correction could be implemented.

FHWA Field Trip Report April 16, 1986 (Attachment B).

Beginning on April 14 and extending through April 16, 1986 Harold Lunenfeld, Engineering Psychologist Traffic Engineering Applications Br. with the Federal Highway Administration in Washington, DC met with Iowa FHWA officials, Iowa Department of Transportation, and City officials to review various problem areas on the I-380 corridor in Cedar Rapids. The purpose was to identify human factors related problems and recommend improvements.

The final report specific to those portions of I-380 between 32nd Street NE and 33rd Avenue SW which is the scope of the current study is included in its entirety as Attachment B. The conclusions and recommendations of the report are as follows.

> "I-380 Northbound and Southbound (32nd Street, N.E. to 33rd Avenue, S.W.: This mainline section of Interstate 380 is somewhat geometrically substandard in the vicinity of Cedar Lakes, the Cedar River, and Cedar Rapids' CBD. The problems are primarily associated with two compound curves and restricted sight distance, which, when coupled with the rapid icing that occurs during adverse weather seasons, results in a high number of ice-related single and multiple vehicle accidents. The poor geometrics and sight distance, in addition to contributing to the site's multi-vehicle collision potential, also hamper incident detection and management activities, and are felt to be hazardous by authorities. Data are lacking to fully describe this location's problems, and to develop effective improvements. Based on a preliminary analysis, it is concluded that there is a need for a traffic management team approach to develop an effective plan for a fully coordinated effort of warning drivers prior to an incident, and a full system of incident detection, management and control. Elements of this system should include ice detection, freeway surface treatment, surveillance, diversion, and lane closure. The motorist

information display aspect of the system must be developed and could range from fixed and portable signage to real-time displays."

The specific recommendations regarding implementation were stated as follows.

"Those locations where improvements can be readily implemented should be treated in accordance with the Field Trip Report. For the sites (the urban intersection and the freeway mainline section) requiring more study, efforts should be initiated to collect the prerequisite data to develop needed improvements."

The following are excerpts and summaries from the report which is included as Attachment B. The following overview is not intended to take the place of the entire field report as the report itself best represents the total scope of the concern that has been identified.

In both the north and south directions the I-380 transitions from essentially a rural design to an urban freeway on structure with closely spaced interchanges, compound curves, and moderate traffic volumes. Drivers generally do not experience problems for most of the year, however during cold months the section of I-380 on the "Five in One" structure over the Cedar River, Cedar Rapids CBD, and Cedar Lakes tends to experience rapid icing. This environmental phenomenon coupled with poor sight distance an alignment in the vicinity of the two compound curves widely spaced bridge joints and lack of adequate shoulders on the structure results in a transitory hazardous situation. Two problem classes exist, problems associated with the hazard(s) prior to an incident and problems associated with incident management. In addition four goals have also been identified:

1) prevention of accidents during icing conditions;

2) prevention of secondary collisions and chain reaction accidents once an initial incident has occurred;

3) protection of officials investigating and managing incidents; and

4) diversion of traffic when lanes, or the road itself, have to be closed.

The geometric design, alignment and routing of this facility through the City results in problems both for the motorist and police. This is particularly the case in the segment bounded by the two compound curves on the "Five-in-One" structure and is primarily a problem under icing conditions.

Both locals and strangers are experiencing tracking and accident avoidance problems when the structure ices up. Of primary concern is preventing accidents and maintaining the safety of an officer at the scene of an incident. Major driver problems are related to excessive speed for icy road conditions, poor sight distance, and improper road geometry.

These factors contribute to a loss of control, single vehicle or multiple vehicle collisions, chain reaction accidents, and conflicts with police.

Regarding expectancy violations, several features of the mainline in the problem areas violate driver expectancies and thereby contribute to the freeway's hazardousness under icy conditions. One involves the abrupt transition from an essentially rural freeway to an essentially urban one. The road's current information system with exception of a flashing curve sign does not warn drivers of the potential problems.

A number of features in the problem segment contribute to driver task difficulty. A major contributing factor to multiple car collisions and police vulnerability at this location in addition to the icing is the lack of sight distance in the vicinity of the compound curves. This lack of sight distance at operating speeds (which have been estimated to be in excess of the posted 55 mph) results in an unsafe situation both for vehicles involved in an initial incident and for officers and safety equipment involved in incident investigation. It is probable that operating speeds particularly during icing are too high for road conditions both for locals and strangers. An aspect of this site which may indirectly contribute to its problems and which would affect the effectiveness of information related improvements are distractions off the traveled way.

In any problem situation there are hazards of nature and there are a range of counter measures which can be used singularly or in combination. In essence, they fall into three broad categories.

1. Remove the hazard(s).
2. Protect the motorist from the hazard(s).
3. Inform the motorist of the hazard(s)/provide information to enable the motorist to avoid the hazard(s).

Given the range of variables associated with this location it is not possible or desirable at the juncture to recommend a single "solution" to the site's problems. In fact, there is probably no clear cut "solution" short of major reconstruction. There are, however, a range of potential countermeasures that can be applied in both the long range and short range. More study is needed to resolve all the issues relating to what is most appropriate.

An optimum way to ameliorate problems on this segment would be through reconstruction. The freeway's geometric design is substandard particularly regarding sight distance, alignment in grade, and forgiveness. While it is probably not feasible to rebuild this freeway segment, future designs of the state should be carefully evaluated prior to construction to avoid repeating these problems.

Another set of countermeasures provide drivers with information to prevent an accident from occurring under icy conditions and/or to prevent secondary collisions once an incident has occurred. This information can be designed to achieve the following:

(a) modify driver behavior;
(b) regulate driver behavior;
(c) inform drivers of conditions and alternatives.

Once an incident has occurred timely incident management techniques are required. Given this location's characteristics protecting motorists and authorities on the structure from subsequent incidents is also required. Protection may entail routing subsequent traffic away from the crash and/or the police managing the incident and diverting traffic. This requires timely incident detection and suitable incident management. Incident detection may necessitate active surveillance either through regular patrols or TV monitoring. Incident management requires personnel on site and would involve upstream information presentation.

There are numerous kinds of driver information display methods and systems that could be used on this segment of the freeway. They range in sophistication from fixed signing through real-time devices to highway advisory radio and public information campaigns. Some rely on or complement surveillance, incident detection and management, and facility control methodology while others stand alone.

While fixed signing has proven effective in numerous situations, its effectiveness on this segment with its transitory environmental and incident hazards is problematical. A simple display such as the curve warning sign and beacon now in place has little impact on behavior.

Given that the site experiences problems of a transitory nature a more responsive information system than a fixed signing one may be appropriate. Such a system may require relatively simple seasonal adjustment such as establishing the already mentioned reduce speed and enforcement during the icing season and operating flashing beacons or displaying the lower speed limit signs accordingly. A more sophisticated system may entail a real time surveillance and control with a series of changeable message signs for speed and lane control and diversion.

Real time systems often require a coordinated effort of surveillance and control to achieve a multiplicity of purposes and the level of driver compliance that will justify its capital and operating expenses. While it would be desirable to detect ice automatically, the current state of the art of ice detection is not sufficiently reliable to rely solely on automatic needs.

A sophisticated real time information system should also have the capability to prevent multiple collisions after an incident has occurred. To achieve this goal at this site requires surveillance and monitoring of the roadway particularly in the vicinity of the curves. Once an incident has occurred it must be detected and drivers informed of its presence and/or diverted. One way to reduce or eliminate the time delay is to provide continuous around the clock surveillance. This could be achieved using television cameras monitored at a central dispatch system. Such a system could serve to detect the incident, implement the warning, and dispatch aid to the site.

The specific recommendations are:

In developing improvements of the nature covered by this field trip report, and implementing them on a freeway segment such as I-380, i.e., one with multiple jurisdictions, an approach that has proven successful is the establishment and utilization of a traffic management team to participate in all levels of decision making. The traffic management team is comprised of a multidisciplinary group of transportation professionals and enforcement officials. For this location, the City of Cedar Rapids, the Iowa Department of Transportation, the Federal Highway Administration, the Iowa State Highway Patrol, and the Linn County Sheriff Department would all participate in the team. Once established, the team would be involved in all levels of analysis, development, implementation, and review. This will assure coordination among all involved agencies and jurisdictions, and increase the chances for an effective improvement and a smooth implementation. Therefore, as a point-of-departure, it is recommended that cognizant authorities structure a traffic management team similar to the one described in Enclosure C. This team should develop an action plan for the site, emphasizing icing situations and incident detection and management. The plan should outline surveillance, control, and incident management authority. It should spell out all requirements for detecting icing and incidents, changing speeds, closing lanes, diverting traffic. etc. Ultimately, the plan will specify all efforts relating to this site and all requirements for its information system.

In addition to formulating a traffic management team and developing an action plan, it is recommended that a study be initiated to determine needs and develop measures. This study should assess all available historical data to establish accident rates, hazardous locations, environmental situations, involved motorists, etc. Before inclement weather occurs, performance data should be collected relative to speeds, paths, lane use, volume, conflicts, etc. Such information will prove useful in establishing a base-line of driver performance and an indication of accident causation mechanisms. Based on these data, a determination should be made of operational and information needs for various problem conditions such as icing, incidents, and congestion. Requisite speeds under ice conditions, effects of closure, diversion routes, response requirements, distractions, etc. should be determined, and information display techniques and messages specified. In addition, stages of implementation should be developed, along with an implementation and evaluation plan.

Since it will not be feasible to implement a full information system such as the one described by the Cedar Rapids Traffic Department in their April 16, 1986 report by the start of the 1986-87 ice season, consideration should be given to short-term improvements and staged implementation. It would be feasible for example, to fabricate and test out fold-out and/or transportable signs for use in icing and incident management situations. Various messages could be developed, formats made, procedures described, and driver compliance determined. Thus, if a reduced speed zone is a candidate measure, fixed reduced speed zone signing with flashing lights could be fabricated and displayed, and speed data collected. Similarly, diversion and lane closure compliance could be determined using portable signs.

Data collected as part of the above short-term improvement phase under ice conditions and during incidents could then be evaluated and a second level system developed, if deemed necessary. Such a second level system might consist, for example, of 1 or 2 changeable message signs in the northbound and southbound direction, upstream at points of diversion, and/or in the vicinity of the compound curves. This system should be linked to a central location for surveillance and control, and should be evaluated both for information display effectiveness and coordination and response suitability. A determination could then be made whether, and to what extent, further development and sophistication is needed. Costs, benefits, and effectiveness should form the ultimate criteria for the final system used.

CURRENT CONDITIONS - MARCH 1992

Mr. Lunenfeld's report dated May 30, 1986 addressed a myriad of problems, needs, and potential solutions to what is a serious problem for motorists, law enforcement officers and emergency services personnel. Though a number of conclusions and recommendations were included in Mr. Lunenfeld's report it was left to D.O.T. and local agencies to develop a plan of action through a traffic management team approach.

While a "traffic management team" per se has not been officially established, there has been continuing communication between governmental agencies concerning the I-380 accident/incident management concerns in Cedar Rapids. Local City and State officials have recognized the difficulty of trying to consistently and effectively warn motorists of icy conditions that may or may not occur on the elevated sections of I-380 under certain weather/temperature conditions. It has also been recognized that the restricted sight caused by the curves combined with the long bridges that confine vehicles and motorists after an accident occurs, creates special problems for investigating officers, emergency services personnel and the involved motorists.

Subsequent to Mr. Lunenfeld's report there has been improvement in the Iowa D.O.T.'s ability to respond to potentially hazardous weather related roadway conditions on I-380 in the area of the curves in downtown Cedar Rapids. Unfortunately during this same time period there has been no significant improvement with regards to safety for those motorists involved in an incident and those investigating officers who must respond to it. On May 31, 1991 a Cedar Rapids Police Department internal memorandum requested that consideration be given to implementing a plan to aid police officers and emergency personnel in coping with hazardous conditions on I-380 near the Cedar River. The memo indicated that in the three year period from 1988 through 1990 a total of 271 accidents had been reported and responded to in the area bounded by 33rd Avenue on the south and Collins Road on the north. This memo served as an impetus for additional discussion and subsequent meetings with the Iowa D.O.T. which led to the installation of fold out "Accident Ahead" signs on I-380 in advance of the curves. These fold out signs, a joint project with the Iowa D.O.T., were intended only as an interim measure until an Incident Management project which may include permanent changeable message signing and surveillance which could resolve these long standing problems.

The City Traffic Engineering Department was charged with this responsibility and fully intended to come up with a concrete proposal for an incident management project. As research began on the subject of changeable message signs and the need for reliable and accurate surveillance capabilities, it became evident the Department did not have the background experience to conclude what type of a system was required and to design, purchase and install such a system. Similar conclusion of the City's 1986 report suggested that consultant services are required to substantiate the need and provide the necessary research and implementation strategy necessary for addressing the solution.

Update Information and Accident History

The following identifies various aspects relating to this area of I-380. Figure A-1 identifies the elevated sections of I-380 and the curve sections. Referenced are potential locations for overhead changeable message signs based on the City's preliminary and elementary investigation. Figure A-2 shows the location of the existing fold out "Accident Ahead" signs installed in November of 1991. Volumes of traffic on I-380 have continued to increase.

Figure B indicates the number of accidents occurring over a five and one-half year period on I-380 from "J" Avenue N.E. to 16th Avenue S.W. The roadway was arbitrarily broken into five sections (C-1 through C-5) simply to make the accompanying collision diagrams more manageable. Figures C-1 through C-5 are the collision diagrams beginning in January of 1986 through June of 1991. Figure B-2 is a summary of the 264 accidents which occurred on the mainline of this 3 mile section. A conclusion of the analysis is that 17 percent of the accidents were multi-vehicle accidents involving more than 2 vehicles. 33 percent occurred when snow and/or ice was present on the roadway. 28 percent occurred within the 6:00 AM to 9:00 AM morning rush hours. Other information relating to the accidents is indicated on Figure B-2 Information provided on the actual accident reports was used to develop the collision diagrams and accident summary.

Figure D provides a summary of 1991 traffic flow on I-380. The current volume of has more than doubled from its 27,500 vehicles per day referenced in the earlier 1986 report.

Figure E-1 - E-3 provides background media information only for reference purposes.

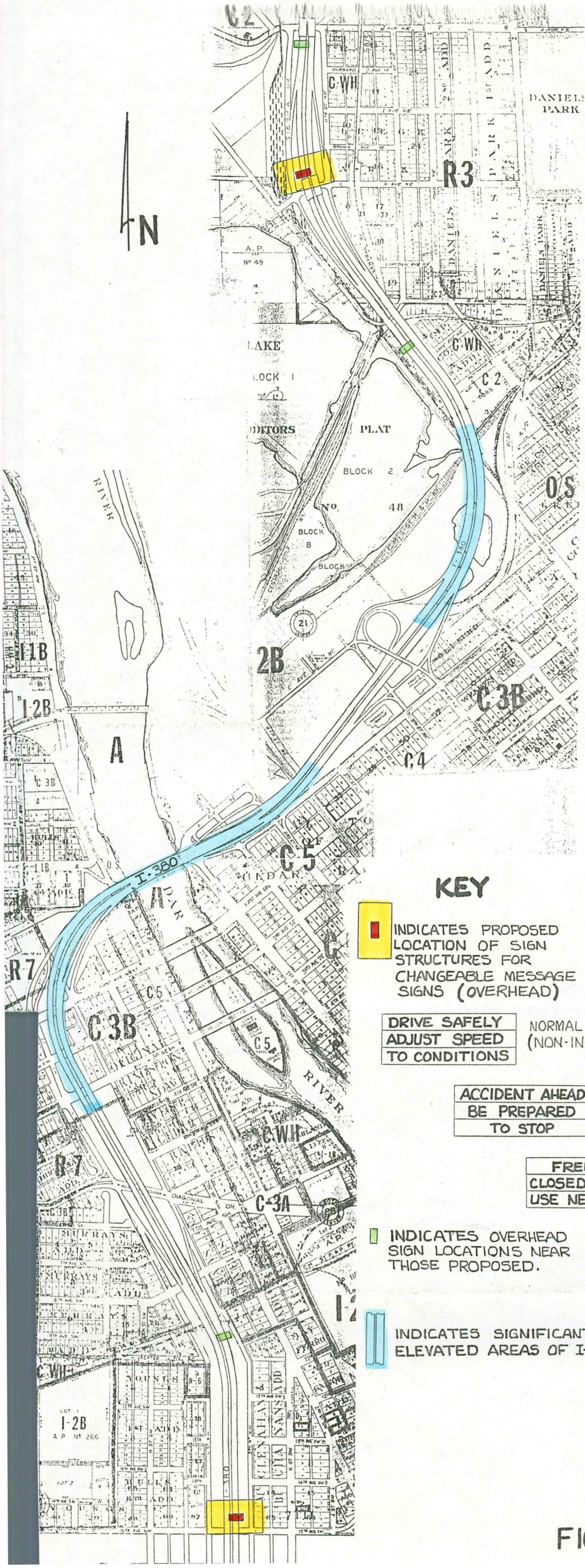
SUMMARY

Since opening of I-380 through the Central Business District many governmental bodies, agencies, and individuals have been involved in addressing the concerns of accident frequency, multiplicity of accidents, and the possible solutions as to what can be done to provide improved detection of adverse conditions, reduce the potential for multiple accidents and improve the safety of investigating officers. Since the 29 vehicle accident occurred in April of 1982, multiple accidents have continued to occur. It appears inevitable that it is only a matter of time as traffic volumes continue to increase on I-380 that the conditions will worsen unless some significant efforts are made to correct the problem or to provide some type of a management approach that will reduce the potential for on-going accidents and improve the overall safety and traffic flow on this section of I-380.

The indicated geometrically substandard design of Interstate 380 in the vicinity of the downtown combined with the contributing factor of a lack of sight distance in the vicinity of the compound curves on the elevated structure is a strong indication of need that countermeasures should be developed to address these safety and traffic flow concerns. Professionals experienced in development of incident management strategies are required to provide a thorough review of the problem, determine the solutions and to provide necessary documentation for project implementation.

RECOMMENDATIONS

While many opinions have been stated in the various reports which are attached, a general conclusion is reached that a degree of research is required to verify the extent of problems which have been identified in this report and to follow up with management strategies to address the concerns. The responsibilities for improvement to this portion of the Interstate system must rest with the Federal Highway Administration and the Iowa Department of Transportation. The City of Cedar Rapids is not exempt however from acknowledging responsibilities as I-380 is part of our urban transportation system impacting many of our citizens and enforcement officials who are involved with I-380 on a daily basis. The City recognizes the importance of safety and efficiency of traffic flow on I-380, for the benefit of the citizens of the State of Iowa, the nation and the future impact on this segment of the Avenue of the Saints. The City acknowledges participation in the project not only as an element of encouragement to pursue determination of solutions, but also in the final implementation and operation of the solutions.



KEY

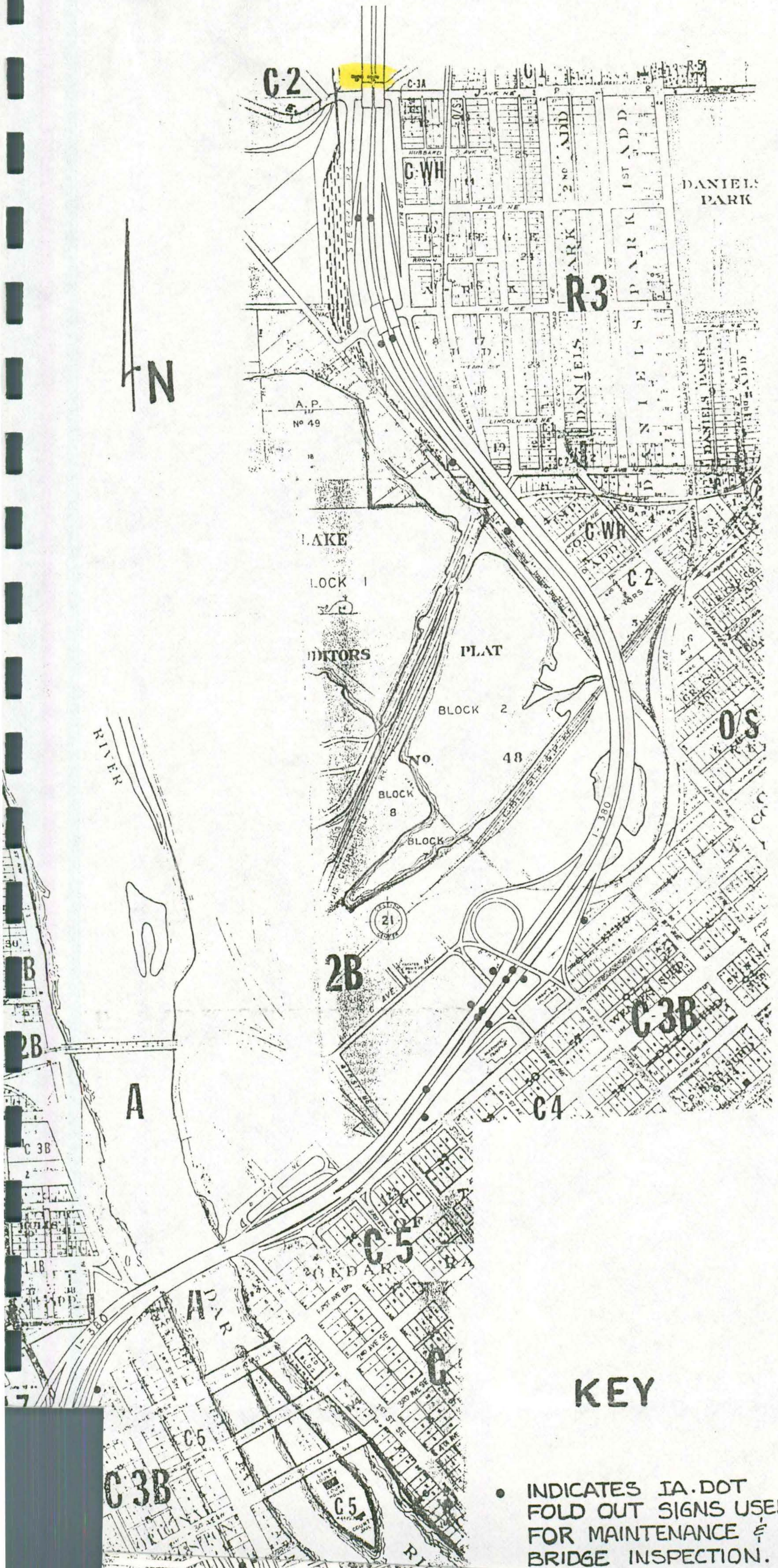
INDICATES PROPOSED LOCATION OF SIGN STRUCTURES FOR CHANGEABLE MESSAGE SIGNS (OVERHEAD)

DRIVE SAFELY ADJUST SPEED TO CONDITIONS	NORMAL LEGEND (NON-INCIDENT)
ACCIDENT AHEAD BE PREPARED TO STOP	INCIDENT LEGEND # 1
FREEWAY CLOSED AHEAD USE NEXT EXIT	INCIDENT LEGEND # 2

INDICATES OVERHEAD SIGN LOCATIONS NEAR THOSE PROPOSED.

INDICATES SIGNIFICANT ELEVATED AREAS OF I-380

FIGURE A1



KEY

• INDICATES IA. DOT FOLD OUT SIGNS USED FOR MAINTENANCE & BRIDGE INSPECTION.

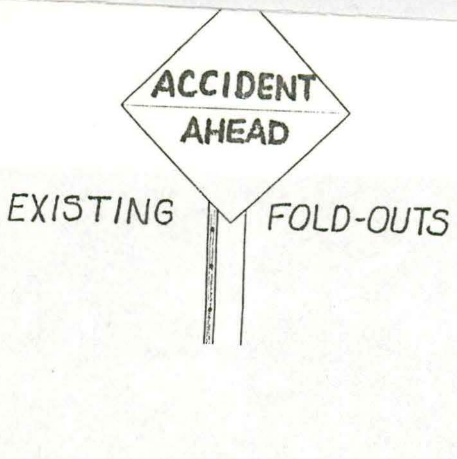


FIGURE A_2

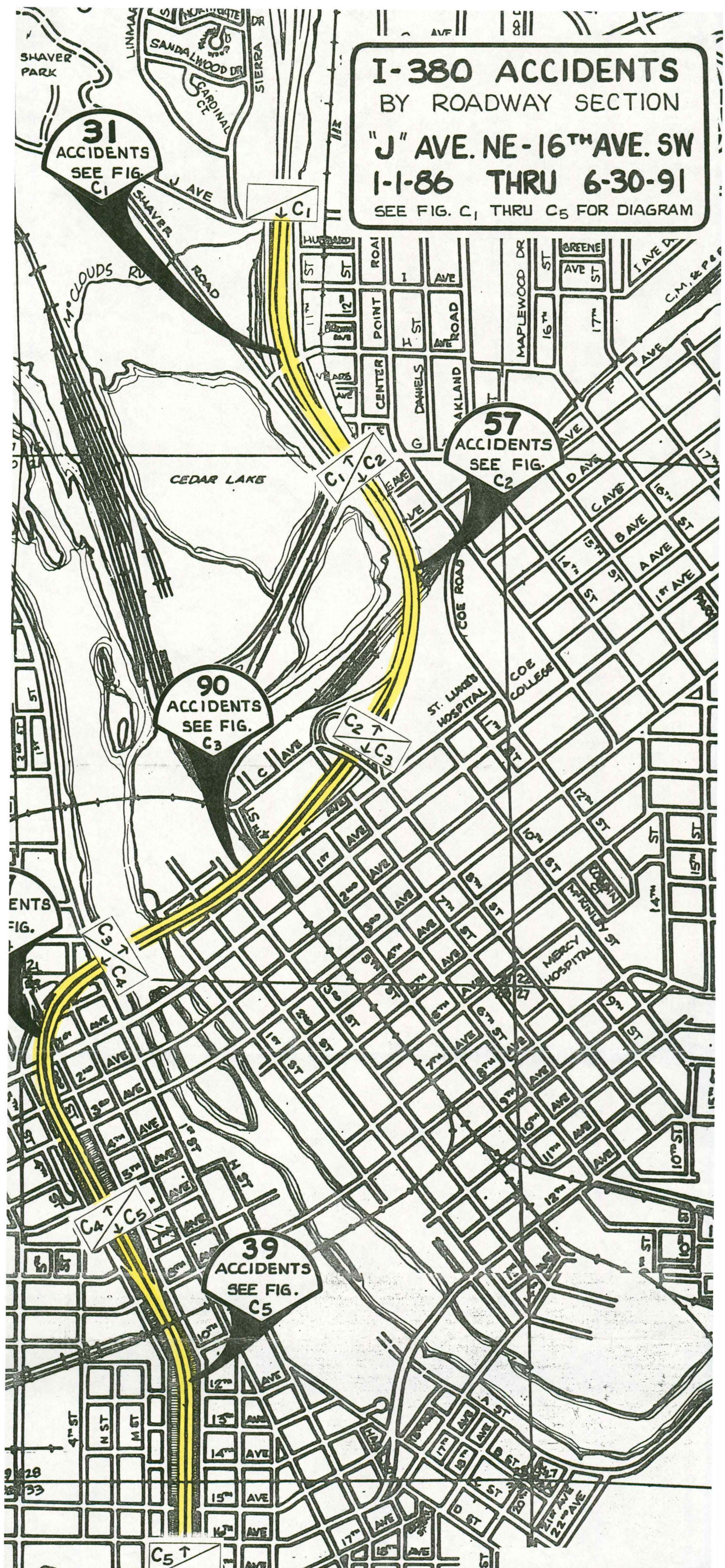

I-380 ACCIDENTS
BY ROADWAY SECTION
"J" AVE. NE - 16TH AVE. SW
1-1-86 THRU 6-30-91
SEE FIG. C1 THRU C5 FOR DIAGRAM
31 ACCIDENTS SEE FIG. C1
57 ACCIDENTS SEE FIG. C2
90 ACCIDENTS SEE FIG. C3
39 ACCIDENTS SEE FIG. C5
C1
C1 ↑ ↓ C2
C2 ↑ ↓ C3
C3 ↑ ↓ C4
C4 ↑ ↓ C5
C5 ↑
SHAVER PARK
SANDALWOOD DR
CARDINAL CT
SIERRA
J AVE
SHAVER ROAD
MCCLOUDS RUN
CEDAR LAKE
CENTER POINT ROAD
DANIELS
OAKLAND ROAD
MAPLEWOOD DR
COE ROAD
COE COLLEGE
ST. LUKE'S HOSPITAL
MERCY HOSPITAL
MCKINLEY ST
HAYES ST
19TH AVE

FIGURE B1

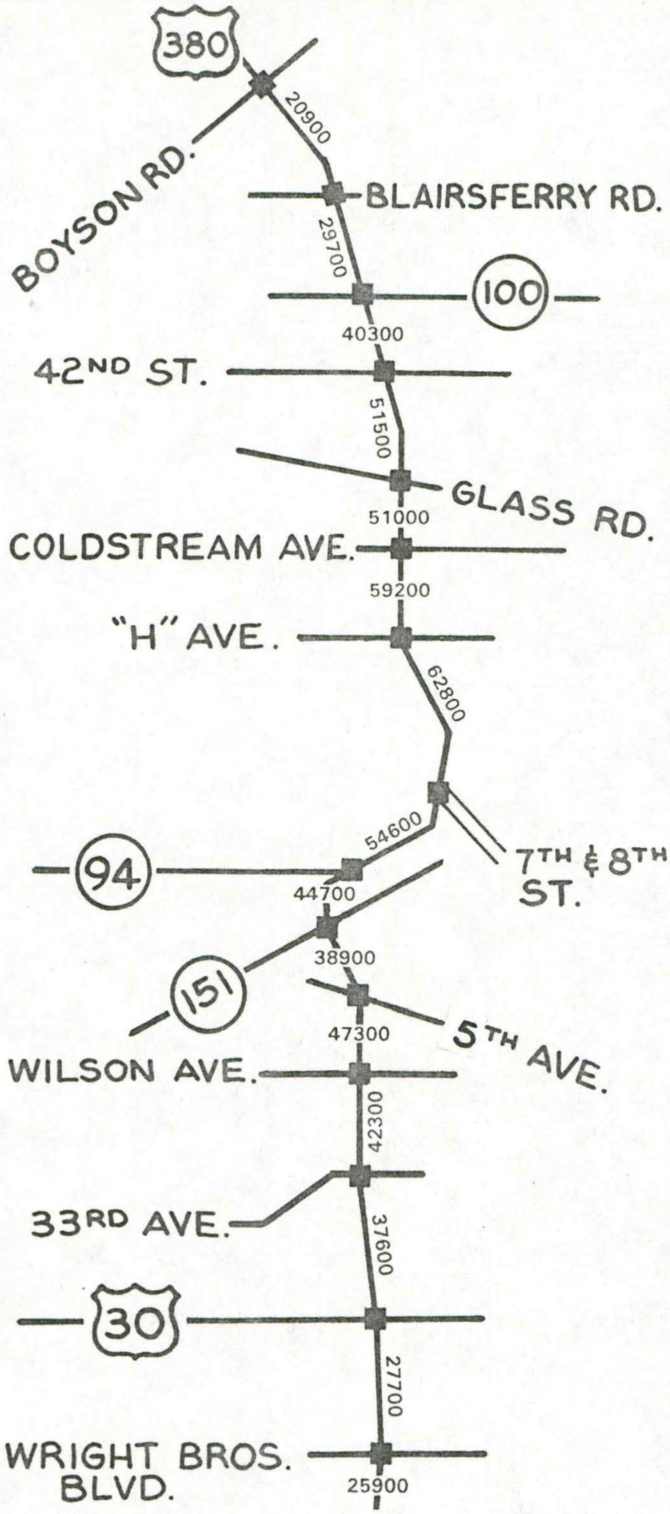
I-380 ACCIDENT SUMMARY
FOR THE PERIOD 1-1-86 THRU 6-30-91
FROM "J" AVENUE N.E. TO 16TH AVENUE S.W.

	NUMBER	PERCENT
Total Accidents	264	100%
Multiple Vehicle (3 or more vehicles)	46	17%
Police Vehicles or Personnel Involved in Accident While at Incident Scene	5	1.9%
Unfamiliar Drivers-From Outside the Metropolitan Area	77	29%
Out of State Drivers (Included Above)	11	4%
Drug or Alcohol Related (Cited for OMVUI)	16	6%
Trucks-Excluding Pickups, Vans, Etc.	23	9%
Peak Hour Occurrence - 6 Hrs.	122	46%
6AM-9AM	75	28%
3PM-6PM	47	18
Road Conditions-As Stated on Reports		
Snow/Ice	86	33%
Wet	35	13%
Dry	101	38%
No Mention	42	16%

TRAFFIC ENGINEERING DEPARTMENT
CITY OF CEDAR RAPIDS

FIGURE B2

I-380 TRAFFIC VOLUMES

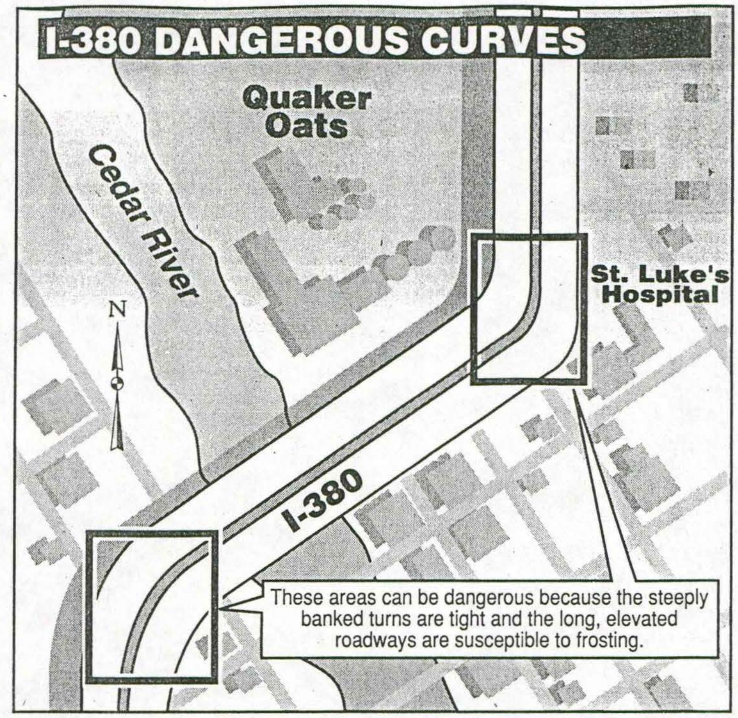


1990 IOWA D.O.T.
TRAFFIC VOLUMES

FIGURE D

Cops: 'Rather face armed robbery' than traffic control on I-380 curves

By Ed Barrett
Gazette staff writer



Gazette graphic by Greg Good

Police officer Glen Kieler was on patrol last month when he was dispatched to control traffic at a minor accident on Interstate 380 above the 5-in-1 Dam.

He was there a short time when an oncoming car went out of control on the icy road, skidding into his vehicle and sending him to the hospital.

Kieler's injuries were minor, but the incident is the latest in a series of accidents and near misses on the downtown curves of the interstate.

"Most (officers) would rather go on an armed robbery in progress than go up there and face that traffic," one officer confided, echoing a comment made more than a year ago by then-Lt. Tom Erceg after a near miss.

Because of the increased danger, department administrators issued a standing order in 1988 that provides two additional cars for traffic control and protection for officers who are working accident scenes. Several of the injured officers were in the protective or "cover" cars when their accidents occurred.

THE DESIGN of the overpasses makes the roadway exceedingly dangerous at times.

Short, highly banked turns limit the visibility of oncoming traffic; high speeds and heavy volume increase necessary stopping distance; and long, exposed bridges are more likely to freeze than normal pavement, leaving drivers unaware of hazardous conditions.

"There definitely are problems unlike any location in the United States," Traffic Engineer Mel Meyer has said.

Combined, the variables create concern: Half a dozen officers injured and at least twice that many narrowly missed in the past two years.

Publicly, officers will not comment on the situation. Privately, though, several say little has been done to deter the risk they face.

"Imagine you're at the Indy 500," one traffic veteran says. "Now, imagine that you're on the racetrack with the cars screaming past you. That's what it's like up there."

The police administration is examining "all sorts of options," Assistant Police Chief Mike Klappholz says, adding that the most likely solution would be some sort of sign to warn drivers of upcoming hazards.

It is not a new concept, having been proposed in 1984 after a 28-car pileup. Various options have been aired since then, yet each trial balloon was shot down by liability concerns or grounded by inaction.

In 1986, for example, two overhead signs with flashing lights were posted on the interstate that said, "Roadway may be icy/when flashing/reduce speed."

The "when flashing" portion was covered two months later after the Iowa Department of Transportation and the Cedar Rapids City Council could not decide who would monitor conditions, run the flasher and assume ultimate liability.

The killing stroke came when the council failed to act on a proposal that would have split liability equally.

"There was some discussion about who would be responsible for activating the signs, but it was never resolved," IDOT District Engineer Maury Burr says.

Without the flashers, Burr adds, "drivers would have probably driven by that sign a hundred times without encountering icy conditions. They just wouldn't have respected the sign."

So, in September 1987, less than a year after the signs went up, they came down at the instruction of the IDOT legal staff.

"You really can't put the fault anywhere," Police Chief William "Bud" Byrne says. "Somebody may have the ideal solution at some point. Unfortunately, I don't."

MEYER MET Feb. 11 with police officials to address the problem in the short and long term.

The preferred long-range solution, Meyer and Byrne say, may be some sort of changeable message sign.

Erecting such signs could be expensive, however. Meyer refused to estimate the cost, but prior estimates fell in the $300,000 range.

Another difficulty lingers.

"This is not just a city project," Meyer says. "It takes the cooperation of not only the IDOT, but the Federal Highway Administration. But the consensus is now that we need to take another look" at solving the problems.

Several patrol officers wonder, though, if this may be another false start. Even if a solution is found, they ask, will it come too late?

"Eventually, somebody is going to get seriously hurt or killed up there," one officer says acidly. "Everybody will be walking around with tears in their eyes saying what a tragedy it is, but nobody is willing to do anything to prevent it."

FIGURE E1

The Cedar Rapids Gazette: Wed., June 12, 1991

Gazette photo by John McIvor

I-380 jam

A Cedar Rapids police officer directs rush-hour traffic away from an accident just ahead on Interstate 380 Tuesday. The crash, which occurred on the interstate behind St. Luke's Hospital, caused no injuries, but snarled traffic from 5:20 to just before 6:15 p.m. Capt. Jim Noonan said the traffic tie-up was made worse by the heavy, after-work traffic and the fact that the middle lane of traffic had to be closed until the two vehicles could be moved.

FIGURE E2

The Cedar Rapids Gazette, Sunday October 21, 1991

New signs to warn of I-380 hazards

Compromise reached by city, state officials

By Ed Barrett
Gazette staff writer

After more than 10 years of multicar pileups, abortive warning plans and liability squabbles, city and state officials have agreed on a system to help protect motorists and police on Interstate 380's dangerous downtown curves.

"The city knows this is a problem, a hazardous area," Cedar Rapids Traffic Engineer Mel Meyer acknowledges. "This is the best (solution) we could come up with in a temporary situation."

The plan will place four fold-down signs reading "Accident Ahead" along the interstate to help prevent secondary accidents. Since the bridged area downtown was completed in the early 1980s, several factors have combined to turn otherwise minor accidents into small-scale demolition derbies as drivers whiz unaware onto accident scenes.

Short, high-banked turns limit visibility; high speeds and heavy volume increase the necessary stopping distance; and the long, exposed bridges are more likely to freeze over in the winter than the surrounding freeway, leaving drivers unaware that hazardous conditions exist.

THE CITY'S long-range plan calls for a series of signs that will flash changeable messages to motorists, but planners wanted the interim signs in place before winter blows into Iowa.

Worries about driver and, particularly, officer safety drove planners in this effort, sources say. Repeated injuries to Cedar Rapids patrol officers prompted department administrators to establish a 1988 standing order that provides extra cars for traffic control at accident sites. Despite the precautions, half a dozen officers have been injured and twice as many had near-misses when traffic blundered onto crashes at full speed and drivers were unable to stop in time.

Police Chief Bud Byrne says he anticipates that patrol officers will take a "wait-and-see" attitude before they put their faith in the new signs. He says, though, that the project should improve safety for the time being.

"We don't know whether we can predict and say, 'Yes, it's going to work,' " he said. "We would like to eventually see a (changeable message) sign . . . Until we get that done, we like having something."

Traffic officials have been trying since 1983 to come up with "something" to solve the problem. Meyer proposed putting up similar accident signs then, and the idea has been bounced from city to state officials ever since.

Three years later, two overhead signs with flashing lights were posted that read, "Roadway may be icy/when flashing/reduce speed." Disputes over who would monitor conditions, run the flasher and assume liability eventually killed the signs, which were removed in 1987 when the City Council failed to act on a proposal that would have split liability equally between the city and state.

Meyer and Iowa Department of Transportation officials worked around the liability issue in a series of meetings this summer, culminating in the Aug. 26 agreement. The four signs have been fabricated by the city at a cost of about $500 and will be given to DOT workers this week. The signs should be erected and operating by Nov. 1, Meyer says.

"We hope these fold-up signs will notify motorists," he says. "We hope they'll reduce their speed," which will reduce the chance of secondary accidents.

Patrol watch Capt. Jim Noonan calls the move a "definite step in the right direction."

"Until this, people were coming into situations unaware that there is trouble ahead," he says. "I think the long-range goal is going to be a big asset . . . but it will be a lot safer."

BOTH MEYER and IDOT district maintenence engineer Kevin Mahoney say funding will be a major obstacle to installing the changeable-message signs. Meyer hopes to move the project ahead in the next two years, but obtaining the estimated $400,000 necessary for the project could be difficult in an era of tight spending.

"The department has a variety of programs available for funding, but I couldn't say whether this project would qualify," Mahoney says. "It would have to show that the benefits outweigh the cost."

Still, everbody involved in the decade-old quest to resolve the dangerous situation expresses optimism that a permanent solution is near.

"The (fold-down signs) are a little unusual, but that's OK," Mahoney says. "The alignment of the freeway there is a little unusual, too. I think we've got not *the* solution," he adds, "but a solution."

"The city knows this is a problem, a hazardous area. This is the best (solution) we could come up with in a temporary situation."

Mel Meyer

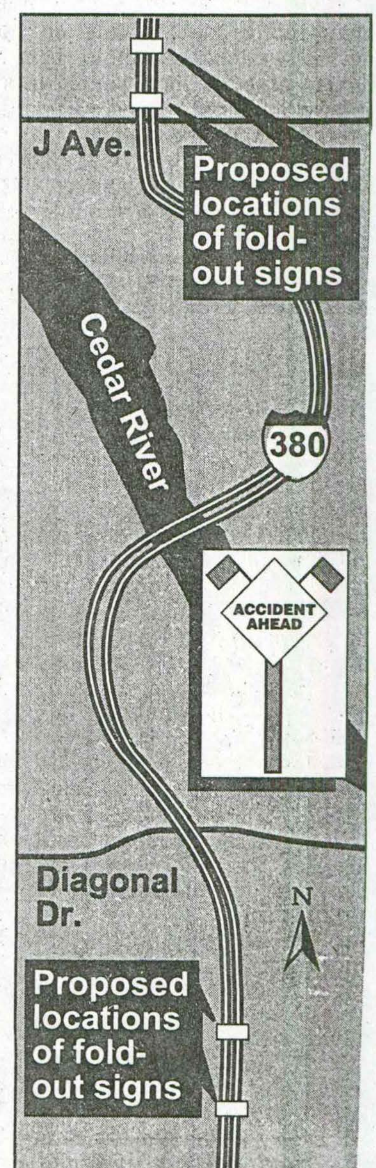
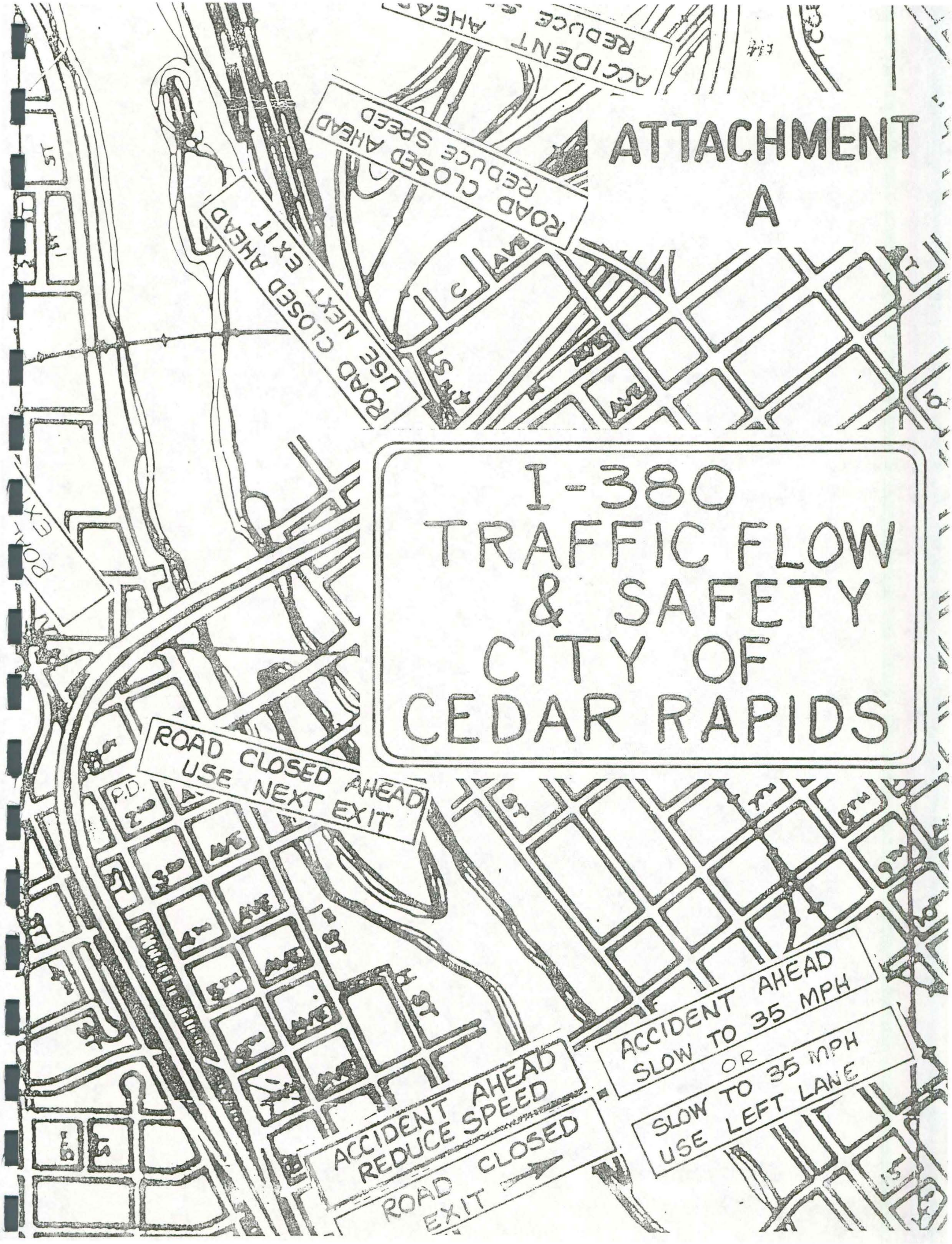


FIGURE E3

ATTACHMENT A

I-380 TRAFFIC FLOW & SAFETY CITY OF CEDAR RAPIDS



I-380

TRAFFIC FLOW AND SAFETY

CITY OF CEDAR RAPIDS

PREPARED BY

TRAFFIC ENGINEERING DEPARTMENT

M. B. MEYER, P.E., CITY TRAFFIC ENGINEER

WITH ASSISTANCE OF GERALD R. HINZMAN, CHIEF OF POLICE

IN COOPERATION WITH

DENNIS H. BLOME, LINN COUNTY SHERIFF

LT. B. D. HALL, IOWA STATE HIGHWAY PATROL

ROBERT C. HENELY, DISTRICT ENGINEER, IOWA D.O.T.

April 16, 1986

POLICE DEPARTMENT
310 Second Avenue SW
Cedar Rapids, IA 52404-2098
(319) 398-5045

CEDAR RAPIDS
CITY OF FIVE SEASONS
...time to enjoy

Gerald R Hinzman
Chief of Police

April 11, 1986

TO WHOM IT MAY CONCERN:

Reference: Computerized Signs on Interstate 380

Over the past several years, the Cedar Rapids Police Department has been aware that segments of Interstate 380 travelling through the downtown Cedar Rapids area are extremely hazardous during inclement weather.

The hazards include poor visibility, what appears to be an incorrect grade, improper speed zoning which in turn has led to a number of multi-car and serious accidents including fatalities. This situation is not only a safety problem for the general public, but it is also a problem of utmost concern to road maintenance workers and law enforcement personnel. Numerous incidents have been reported by officers of the Cedar Rapids Police Department whereby they have nearly avoided being struck by vehicles themselves while trying to assist accident victims on this stretch of highway.

More specifically, the section of road in question spans between Wilson Avenue S.W. through 42nd Street N.E. In the downtown area where the Interstate makes dramatic turns near police headquarters on the west side of the river and near St. Lukes Hospital on the east side of the river seem to be the areas of utmost concern. This is also the area which is elevated as it crosses the Cedar River/Cedar Lake area. Because of the elevation of the Interstate, combined with poor visibility and inclement weather, it makes an extremely dangerous situation. For example, officers who are working traffic accidents cannot sufficiently slow down and control traffic and have many times found themselves in one of the curves of this stretch of highway with motor vehicles sliding out of control and coming in their direction and they are left without any method of escape on this elevated section.

Our personnel are aware of the dangers and some of the construction problems inherent with this stretch of Interstate highway, and have on numerous occasions expressed their concerns both verbally and in writing to our command officers. This has created a most unsatisfactory situation both for safety reasons and for vicarious liability reasons.

Having researched this particular problem for a number of years since the

Interstate was opened, it is our recommendation that computerized message signs be installed along the Interstate route for both north- and south-bound traffic so that motorists can be warned well enough in advance of up-coming perils and can take appropriate action prior to entering a stretch of the highway where the danger exists. This is not to say that we feel that that is the only acceptible solution, however, we strongly believe that a research team or group of consultants need to examine this stretch of highway closely in an attempt to find a solution to this serious problem.

Sincerely,

Gerald R Hinzman

Gerald R. Hinzman,
Chief of Police

GRH:mcr

Office of

Linn County Sheriff

Dennis H. Blome
Sheriff

Darrell Gear
Captain

P.O. Box 4844, Cedar Rapids, IA 52407-4844

Sheriff's Office
(319) 398-3521

Correctional Center
(319) 398-3431

January 27, 1986

TO WHOM IT MAY CONCERN

RE: Safety Warnings on I-380

During the past few weeks, Linn County Law Enforcement Agencies which include the Iowa Highway Patrol, the Cedar Rapids Police, and the Linn County Sheriff's Department as well as the City of Cedar Rapids Traffic Engineering, have met with the Iowa Department of Transportation regarding the posting of safety signs on Interstate 380 for both north and southbound lanes between 33rd Avenue SW and 32nd Street NE inside of Cedar Rapids, particularly warning about the area in the S-curves as it crosses the river in Cedar Rapids.

Two sets of signs have been proposed, one warning of traffic hazards such as sharp curves or reduced speed and the second set of signs has to do with computerized notification of a motorist involving a situation on the highway ahead of the motorist.

The morning of January 27, 1986, exemplifies the need for some type of notification for motorist safety.

I had entered the southbound lane of traffic at H Avenue on I-380 and as I rounded the curve approaching the 7th Avenue exit in the southbound lane, I noticed a large amount of traffic but due in part to the amount of fog coming off the exhaust of the vehicles in the extreme cold temperatures and the amount of traffic, I was unable to determine immediately what was transpiring and subsequently found that traffic had stopped on the Interstate due to a 3-car property damage accident at the 7th Avenue exit.

From the number of people standing along the edge of the road and in the right-hand lane of the Interstate traffic, it appeared, and I found that no injuries had occurred, and at that time I called in the location of the accident on my police radio from an unmarked car.

Office of

Linn County Sheriff

Dennis H. Blome
Sheriff

Darrell Gear
Captain

P.O. Box 4844, Cedar Rapids, IA 52407-4844

Sheriff's Office
(319) 398-3521

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Subsequent to that, two more vehicles were involved with this same accident and what had originally been a property damage accident only was now a personal injury accident situation involving a total of five cars.

Had the warning signs been properly installed and in working order, the Police Department could have immediately flashed up-traffic ahead, reduce speed or whatever message they felt appropriate at that time from my observation.

I believe it is necessary that steps be taken to mark that stretch of Interstate highway, both northbound and southbound, as had previously been discussed with the Department of Transportation and the various law enforcement agencies in Linn County.

I, as Sheriff of Linn County, would strongly urge that steps be taken to enhance traffic safety and reduce the number of property damage accidents and would take steps to prevent personal injury accidents and/or deaths to the motorist.

Respectfully submitted,

Dennis H. Blome

DENNIS H. BLOME, SHERIFF
LINN COUNTY, IOWA

DHB/ph

IOWA DEPARTMENT OF **public ★ safety** DPS

TERRY E. BRANSTAD
GOVERNOR

GENE W. SHEPARD
COMMISSIONER

DIVISION OF
IOWA STATE PATROL
WALLACE STATE OFFICE BUILDING
DES MOINES, IOWA 50319
515/281-5824

April 15, 1986

Chief Gary Hinzman
Cedar Rapids Police Department
310 2nd Avenue SW
Cedar Rapids, IA 52404

Dear Chief,

I wish to recommend that something be done to alleviate the traffic problem and hazard that exits on I-380 from St. Lukes to the general vicinity of the Police Department.

As you are very well aware, this particular area constitutes a very dangerous situation to any peace officer that has to work an accident due to hazardous road conditions. If a multiple vehicle accident occurs, which is quite often the case, it is a life threatening situation due to the amount of slope, the fact that it is a bridge surface and elevated, which leaves the officers no escape from an impending accident, not to mention the danger to the motoring public.

As the District Commander for the Iowa State Patrol, I believe that a reduction of speed through proper warning signs at times of hazardous road conditions, including accident situations, would alleviate the problem.

My interest in this problem is two fold and includes peace officer and motoring public safety. Needless to say, it is just a matter of time until someone is killed in this location. It could be a State Trooper. Anything you can do will be appreciated.

Yours for a safer Iowa,

Lt. B. D. (Pete) Hall

Colonel Frank Metzger
Lieutenant B. D. Hall
District #11 Commander
Iowa State Patrol
5400 16th Avenue SW
Cedar Rapids, IA 52404

BDH/mn

I-380
TRAFFIC FLOW AND SAFETY

INTRODUCTION:

Since opening of Interstate 380 (I-380) through central Cedar Rapids in the area of the 5-In-1 structure, traffic utilizes six lanes of traffic through two curves located on either side of the Cedar River. Following opening of the central section in 1979-1981 problems began to be experienced relative to specific safety aspects of this portion of I-380. In April of 1982, with I-380 opened only to 32nd Street, a significant multiple vehicle accident occurred within the southbound I-380 lanes on the curve above 1st Avenue West. This multiple vehicle accident involved approximately 29 vehicles. At this time City officials became very much aware of the potential for further accident occurrence and began discussions with the Iowa Department of Transportation on the subject of "prevention of accidents" and "prevention of multiple accidents".

The purpose of this report is to summarize the past history of I-380 specific to traffic flow and safety with an intent to initiate further considerations by the Iowa Department of Transportation, and the Federal Highway Administration to address this specific concern. The objective of this report and any further action is to minimize the potential of injury and fatal accidents, and multiple accidents in the subject area.

BACKGROUND:

History

The original concept of an expressway through Cedar Rapids to relieve traffic on 1st Avenue began as the Cedar Valley Expressway. Portions of this original concept were incorporated into the I-380 concept through Cedar Rapids. Following is a section by section summary of the completion and costs of I-380.

Construction on I-380 began in 1969 and was completed through Cedar Rapids in 1982.

*Sept. 19, 1973, the 14.6 mile stretch from I-80 to Airport Road in Cedar Rapids opened. Cost: $16.8 million.

*June 25, 1976, the 5.7 mile stretch from Airport Road to Third Avenue S.W. opened. Cost: $42.2 million.

*June 11, 1979, the 1.4 mile stretch from Third Avenue S.W. to Eighth Street N.E., including the five-in-one bridge.) over the Cedar River opened. Cost: $41.4 million. ($10.5 million just for the five-in-one bridge.)

*Dec. 4, 1981, the 1.8 mile stretch from Eighth Street N.E. to 32nd Street N.E. opened. Cost: $26 million.

*Nov. 17, 1982, the 2.8 mile stretch from 32nd Street N.E. to Boyson Road in Hiawatha opened. Cost: $29 million.

*Aug. 14, 1984, the 18.1 mile stretch from Boyson Road to Highway 101 near Urbana opened. Cost: $36.5 million.

*Sept. 12, 1985, the 30.2 mile section from near Urbana to Waterloo opened. Cost: $100.3 million (construction cost only).

Figure A pictorially indicates the sequence of construction and cost of I-380 from Interstate 80 to Waterloo.

Traffic Volumes

Construction of Interstate 380 through Cedar Rapids changed traffic patterns on all adjacent streets. Some paralleling streets dropped 50 percent in traffic. First Avenue, which at one time carried 45,000 cars per day has dropped to 30,000 to 35,000 cars per day in various sections. Interstate 380 has already fulfilled its purpose and traffic projections by carrying in 1984 approximately 54,000 cars a day on its heaviest segment north of the 7th-8th Street Interchange. Figure B provides an overall assessment of the traffic volumes on I-380 through Cedar Rapids.

Accidents

Controlled access facilities such as I-380 have lower accident rates than facilities that are not access controlled and which are not designed for speeds indicative of freeways. Information (1984) released by the Iowa Department of Transportation indicates that Interstates within municipalities have an overall accident rate of 176 accidents per million vehicle miles. This is further defined as 58 injury accidents and 1.38 fatal accidents per 100 million vehicle miles of travel. The intent of this report and the following discussion is not to relate to the overall urban interstate accident statistics in the State to this segment of I-380 as much as it is to identify specifically within Cedar Rapids the areas on I-380 where accident problems have existed that have the potential for serious multiple car accidents.

While the specific areas of concern are the two curves basically located above First Avenue and adjacent to the ash pit behind St. Luke's Hospital, a study section was identified from the 33rd Avenue S.W. interchange north to the 32nd Street N.E. interchange. It was determined that accident information would be compiled for the three year period beginning January 1, 1983 through December 31, 1985 to quantify the accident problems in the subject section. Due to the Cedar Rapids system of accident records being more in depth, these records were used for the accident information in this report. Figure C provides a summary of all of the accidents over the three year period which were available from the Cedar Rapids Police Department files in terms of number, type and location. Following identification of the number of accidents as shown on Figure C, each of the accidents were reviewed based on the reports on official file and a collision diagram was completed and is shown as Figure D1 and Figure D2.

The accident review determined that vast majority of accidents on the curve above First Avenue West involved icy conditions. The Department has not reviewed in depth the accidents in the sense of time of day or other causes, as the intent at this time was to document the frequency with subsequent recommendations for in depth review and followup of the specific problems by an outside source.

Since January 1, 1986 through February 28, 1986, 11 additional accidents have occurred on I-380 between 8th Avenue S.W. and the ash pit curve. The attached article, Figure F, from the Cedar Rapids Gazette, reports on two multiple car accidents occurring in the curve area on February 3 and February 4, 1986 involving 5 and 9 vehicles respectively.

<u>Sequence of Events</u>

The following is a summary of events which occurred, beginning with the approximate 29 vehicle accident in 1982, leading to the proposed meeting on April 16, 1986.

April 5, 1982 - Approximate 29 vehicle accident on southbound I-380 above First Avenue West.

Nov. 17, 1982 - A meeting in Chief Baker's office, C.R. Police Department, attended by Iowa D.O.T. and Traffic Engineering Department staffs to discuss the curve and safety problems.

Dec. 1, 1982 - Letter from Traffic Engineering Department to R.C. Henely, District Engineer, Iowa D.O.T., calling attention to the area of concern and requesting appropriate actions by the Iowa D.O.T.

Dec. 2, 1982 - Received confirmation of D.O.T. approval for installation of a 48 inch curve sign and flashing beacon for southbound traffic in advance of the curve above First Avenue.

April 11, 1983 - Traffic Engineering Department letter to the Iowa Department of Transportation calling attention to the concern for prevention of accidents and multiple accidents and requesting consideration for installation of changeable message sign.

Aug. 30, 1983 - Traffic Engineering Department letter to the Iowa Department of Transportation requesting status of previous correspondence of April 11, 1983.

Sept. 6, 1983 - Letter from Iowa D.O.T. indicating no answer has yet been formulated on correspondence of April 11, 1983.

Nov. 27, 1985 - Meeting held at the C.R. Police Department Academy attended by Iowa D.O.T., Iowa Highway Patrol, Linn County Sheriff's Office, Cedar Rapids Police Department, Traffic Engineering Department. The meeting discussed the current status of the previous request and current concerns.

Jan. 31, 1986 - Traffic Engineering Department letter to Iowa D.O.T. requesting FHWA review.

April 16, 1986 - Proposed meeting scheduled for FHWA, Iowa D.O.T., all law enforcement agencies, and City of Cedar Rapids staff.

CONDITIONS:

The following is a summary of conditions as provided in correspondence to the Iowa D.O.T. in a letter dated April 11, 1983 from City Traffic Engineer M. B. Meyer to James Loy, District Local Systems Engineer.

> Over the past year numerous discussions have occurred regarding conditions surrounding the accident occurrence and accident potential on Interstate 380 specifically in the area of the curve adjacent to the Cedar Rapids Police Department. The problem which has been previously identified is that the structure has a tendency to ice creating a potential for accidents which when combined with the curvature of the roadway creates an unexpected condition

for the motorist. This condition resulted in a 29 car pile up on April 4, 1982. After the single car accident occurred, the vehicle came to rest at a location which was not adequately visible to approaching traffic, consequently when additional southbound vehicles came around the curve, also experiencing icy conditions, they were unable to stop in time resulting in the involvement of numerous vehicles. It was extremely fortunate that the situation at that time did not result in significant injuries or fatalities. While other accidents have occurred in the vicinity, the City's major concern at this time is to pursue the problem and seek resolution to reduce the potential for a repeat occurrence in the next winter season.

Based on a review of the matter before the City Council, we have been directed to officially request the D.O.T.'s readdressing this concern with specific suggestions as follows. While the Department of Transportation installed two advance curve signs with flashing lights in the subject area for both north and southbound traffic, this type of signing is quite passive and would not appear to be of any assistance to the motorist in warning them of icy conditions or of pending hazards due to an accident which may have occurred in the curve area. There are two conditions of concern. First, what can be done to prevent accidents from happening in the area, and secondly, if an accident happens, what can be done to limit the involvement with additional vehicles approaching the accident site? There is an area approximately 1200 feet in length for southbound traffic and 300 feet in length for northbound traffic which provides a marginal stopping sight distance when icy conditions exist, therefore, not providing adequate visibility to approaching motorists to stop or otherwise adjust their movement. The following suggestions are made:

1. Prevention of Accidents - In addressing the prevention of accidents in the specific area, it appears the only method of advising the motorist of the condition when it actually occurs is to install a changeable message sign that would indicate "Icy Conditions on Bridges" or a similar message when the actual conditions existed or perhaps during the entire season when the icy conditions could occur. Enclosed is a copy of current literature on one brand of ice detection equipment.

2. Prevention of Multiple Accidents - After an accident has occurred in the subject area, it is appropriate to advise approaching motorists of the condition ahead. It is suggested that a changeable message sign indicate to the motorist "Accident Ahead" or a similar appropriate message for the approaching traffic to advise them to be alert, reduce speed or expect to stop.

The proposed location of the changeable message signs is at approximate station 354+66 for southbound traffic and approximate station 290+30 for northbound traffic. You will note that each of these locations is on existing sign structures approximately one-half mile in advance of the location in question. It appears that adequate room exists on each of the existing overhead structures to install a sign as previously referenced.

While the efforts which the Department of Transportation have taken in the past providing early morning inspection of bridges and spreading of sand when necessary are commendable, they do not address the specific problem referenced.

Similar conditions have occurred in other cities and States which have been addressed with changeable message signs. The proposed method of signing has been previously used, proven successful, and is appropriate to the Cedar Rapids situation. It is in the interest of safety that this request is made for your consideration in furtherance of the project.

During the meeting on November 27, 1985 each of the law enforcement agencies, including the Iowa State Highway Patrol, the Linn County Sheriff's Office, and the Cedar Rapids Police Department expressed strong concern about the conditions which existed on both the curve previously referenced in file information, above First Avenue, and an additional curve adjacent to the Ash Pit behind St. Luke's Hospital. As a result of these discussions the Traffic Engineering Department initiated this report.

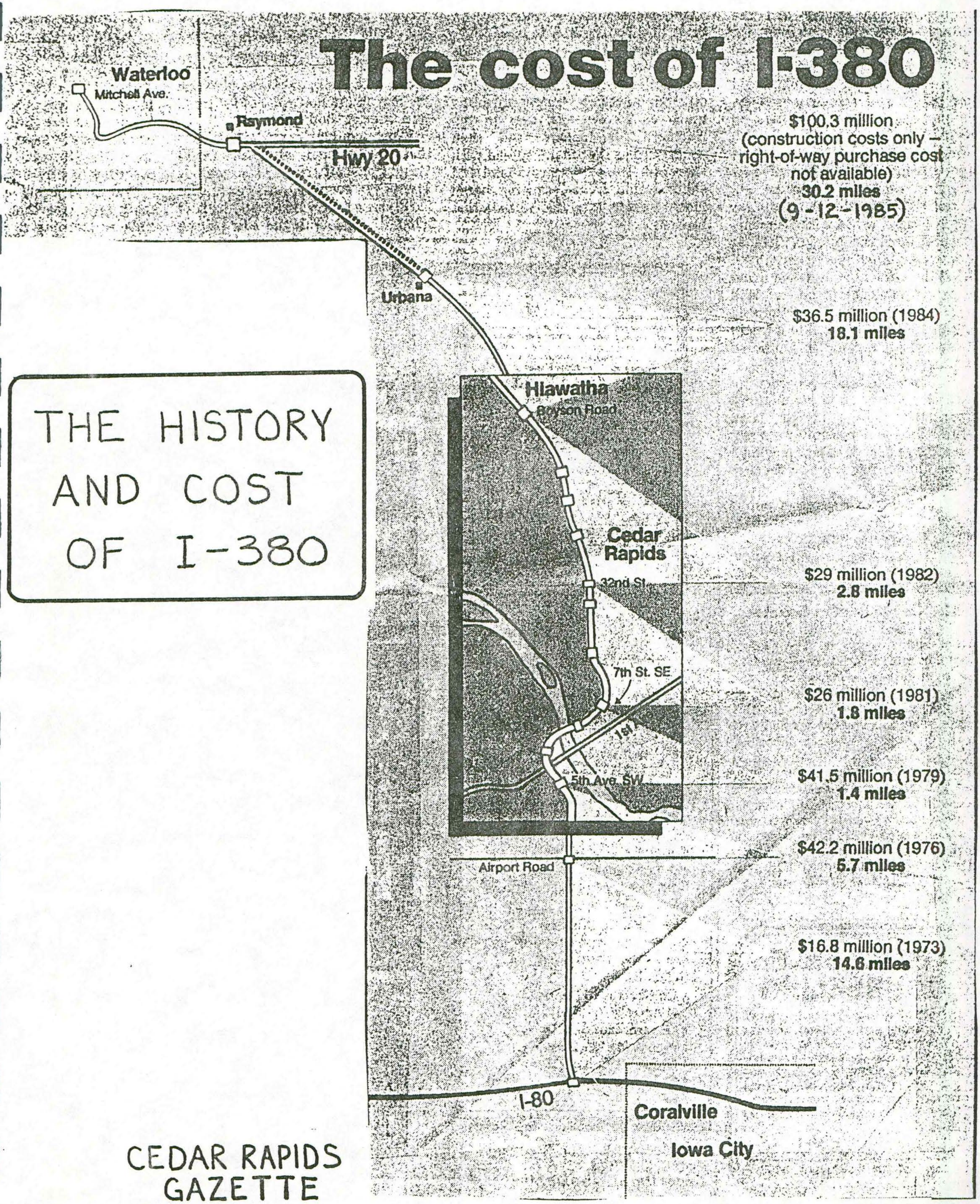
Following the meeting on November 27 the Traffic Engineering Department reviewed literature, reference material, the location in question, and identified a concept of incident notification signing for the two curves in question. The intent of this concept was to provide an idea or concept of what could be done. It was not intended to indicate a specific proposal for installation. Its purpose was to clearly indicate potential measures that could be taken to (a) reduce the potential for accidents, and, (b) to reduce the potential for multiple accidents after a single accident may have occurred. Figure E provides the concept plan for Incident Notification Signing. The specific legends should not be taken literally as they are only a concept of a multitude of various messages that could be provided to clearly indicate to the motoring public the conditions which exist in the areas of concern.

SUMMARY:

The concern for safety on Interstate 380 specific to the two curves in question has been reviewed previously by the Cedar Rapids City Council. This concern was more recently identified by a meeting of the Iowa Highway Patrol, Linn County Sheriff, Cedar Rapids Police Department, and the Cedar Rapids Traffic Engineering Department in conjunction with the Iowa Department of Transportation. All indications are that there is unanimity as to an expressed concern for safety to be maintained on the Interstate in future years. Each governmental agency and Department has a vested interest in maintaining the safety of the motoring public in addition to a responsibility to further implement those measures that can improve upon the future safety. The Iowa State Highway Patrol, Linn County Sheriff and Cedar Rapids Police Department have provided letters of concern on the safety aspects of this portion of I-380. This correspondence provides an insight into the problems associated with the curves, the investigation of accidents, and the safety of the motoring public. The importance of these views cannot be overestimated. These letters are provided in the forefront of this report immediately following the title page.

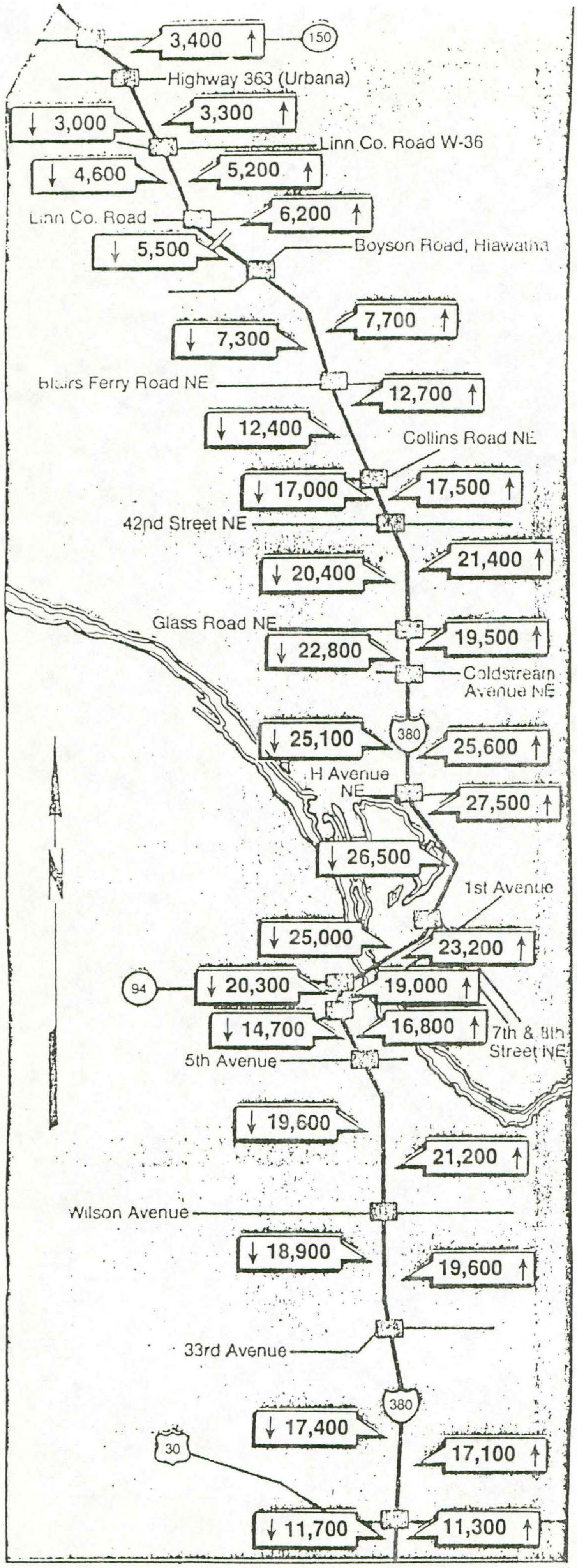
The meeting scheduled for April 16, 1986 to be attended by human factors experts of the FHWA in Washington, other FHWA representatives, Iowa Department of Transportation, Iowa State Highway Patrol, Linn County Sheriff's Office, Cedar Rapids Police Department, Traffic Engineering Department and other officials of the City and State, will bring together a clear consensus of the scope of the problem and the potential solutions to be determined. While this report did not attempt to provide specific recommendations, earlier discussions focused on the need to specifically confirm the problem followed by the initiation of an in depth study by a consultant to identify the scope of the problem and to identify the solutions, following which a plan for correction could be implemented.

THE HISTORY AND COST OF I-380



CEDAR RAPIDS GAZETTE
AUGUST 5, 1984

FIGURE A



I-380 TRAFFIC VOLUMES 1984

SOURCE: IOWA D.O.T.

FIGURE B

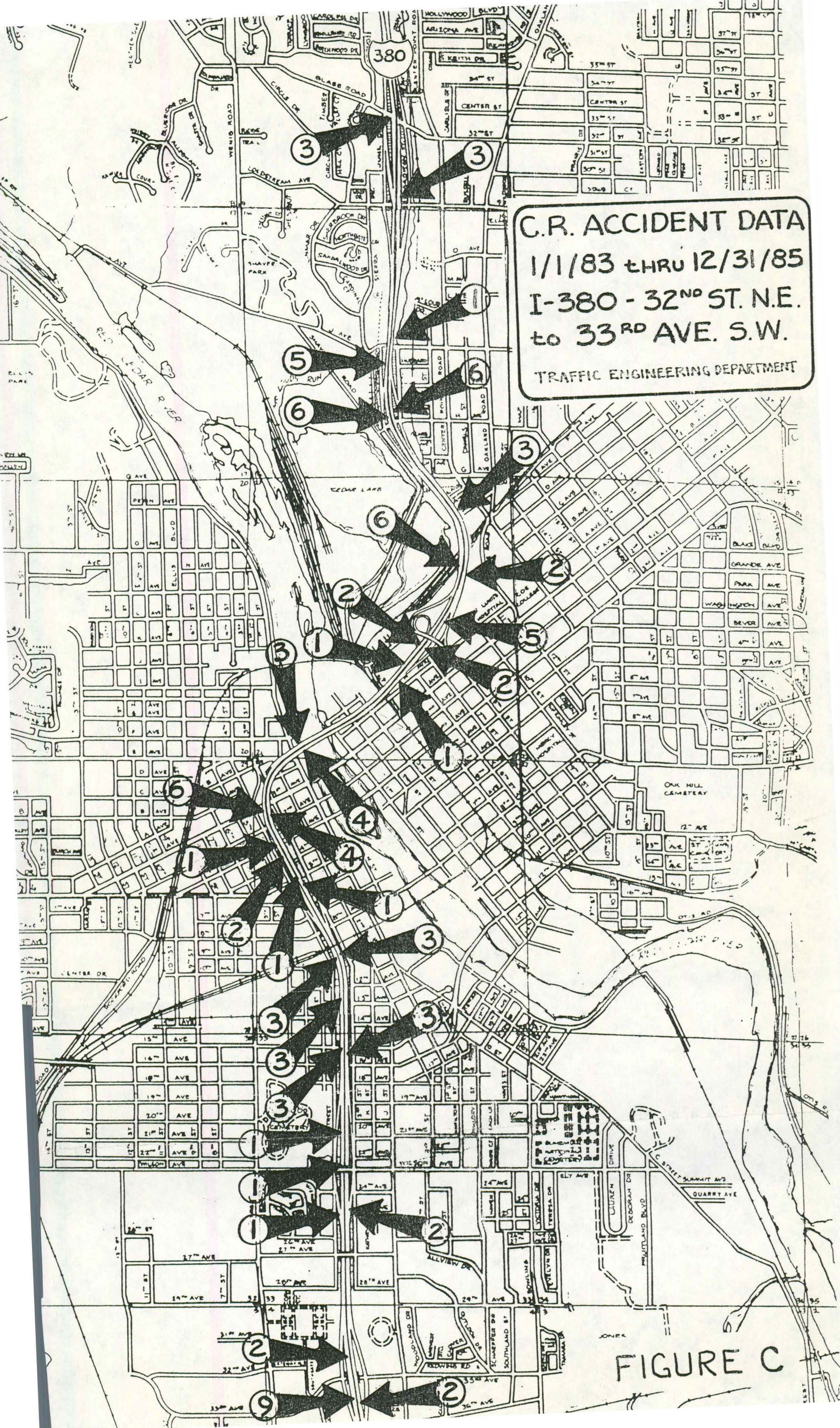

C.R. ACCIDENT DATA
1/1/83 thru 12/31/85
I-380 - 32ND ST. N.E.
to 33RD AVE. S.W.
TRAFFIC ENGINEERING DEPARTMENT
380

FIGURE C

I-380 ACCIDENT DATA
33RD AVE. S.W. TO 32ND ST. N.E.
1/1/83 THRU 12/31/86

K.O.

TRAFFIC ENGINEERING DEPARTMENT

T-163

1 OF 2

I-380 ACCIDENT DATA
33RD AVE. SW TO 32ND ST. N.E.
1/1/83 THRU 12/31/86
KO
TRAFFIC ENGINEERING DEPARTMENT
T-163

2 OF 2

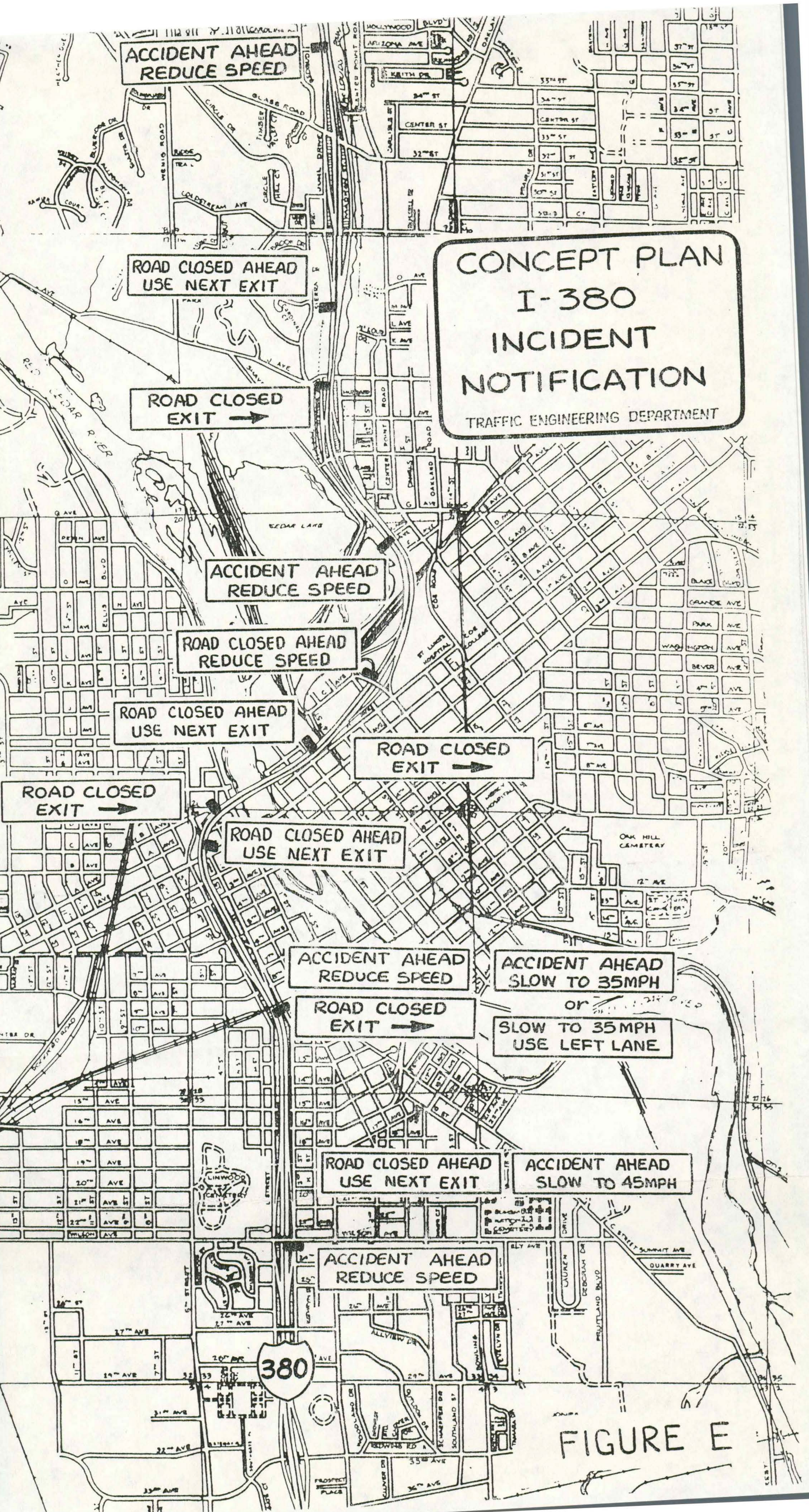

CONCEPT PLAN
I-380
INCIDENT
NOTIFICATION
TRAFFIC ENGINEERING DEPARTMENT
ACCIDENT AHEAD
REDUCE SPEED
ROAD CLOSED AHEAD
USE NEXT EXIT
ROAD CLOSED
EXIT →
ACCIDENT AHEAD
REDUCE SPEED
ROAD CLOSED AHEAD
REDUCE SPEED
ROAD CLOSED AHEAD
USE NEXT EXIT
ROAD CLOSED
EXIT →
ROAD CLOSED
EXIT →
ROAD CLOSED AHEAD
USE NEXT EXIT
ACCIDENT AHEAD
REDUCE SPEED
ACCIDENT AHEAD
SLOW TO 35MPH
or
SLOW TO 35MPH
USE LEFT LANE
ROAD CLOSED
EXIT →
ROAD CLOSED AHEAD
USE NEXT EXIT
ACCIDENT AHEAD
SLOW TO 45MPH
ACCIDENT AHEAD
REDUCE SPEED
380
RED CEDAR RIVER
OAK HILL CEMETERY
LINWOOD CEMETERY

FIGURE E

2nd I-380 pileup; electric signs proposed

By Mark Glenn
Gazette City Hall reporter

Cedar Rapids city officials believe electronic warning signs on Interstate 380 in the city could reduce the number of chain-reaction accidents like those Monday and Tuesday.

Shortly before 8 Tuesday morning, icy conditions caused a pileup involving nine vehicles on the interstate over the 5-in-1 Dam complex. Monday morning, five cars were involved in a chain-reaction accident caused when one driver stopped on the traveled part of I-380. No one was seriously injured in either accident, but in the one Tuesday, traffic was slowed for about an hour.

City officials are working with area public safety officials and the Iowa Department of Transportation on a proposal to install about a dozen message boards that would warn motorists of dangerous road conditions or accidents on two curves near the city's downtown area.

Cedar Rapids Police Chief Gary Hinzman said Tuesday that such a system could cut the number of multiple-vehicle pileups and reduce danger for motorists approaching an accident on that part of the interstate.

In addition, Hinzman said, the sign system would make the accident area safer for drivers who leave their wrecked vehicles, law officers investigating the accident and those trying to clear the roadway.

Linn County Sheriff Dennis Blome said such a system could improve "officer safety and public safety." Blome said he drove by Monday's accident and called in the three-car crash on his car radio. Soon after, it turned into a five-car accident, because two other motorists didn't know there was a wreck ahead, he said.

Floyd Bergen, Cedar Rapids city councilman, agreed that the sign system would improve safety on the interstate, especially if visibility is hampered by weather conditions. "It really is putting a lot of people's lives in jeopardy," he said.

To solve those problems, Hinzman said they are looking at a system of programmable electronic signs along the northbound lanes between 33rd Avenue SW and the bridge, and the southbound lanes between 32nd Street NE and the downtown area.

The signs, which could be controlled from one of the public safety communication centers in the city, would warn motorists of icy conditions, Hinzman said. As communications personnel receive information from officers at the scene, they could use the signs to tell drivers to slow down, move to a different lane or tell which exit to take if the interstate is blocked by an accident, he said.

A rough estimate places the cost of the system at less than $300,000, Hinzman said.

PLACING WARNING signs along the interstate is not a new idea. Several years ago, after a 28-car pileup on one of the curves in Cedar Rapids, a similar plan was proposed to IDOT, but that's as far as it went, officials said.

The idea was resurrected by Hinzman before winter began. Hinzman said several meetings among area public safety and highway officials concluded that the sign system would be the best solution to the problem.

Mel Meyer, head of the city's traffic engineering department, said a report on the accident problem should be completed within 30 days. If approved by the City Council, the report will be submitted to IDOT, then forwarded to the Federal Highway Administration, Meyer said.

The proposal asks federal officials to fund an in-depth study of the problem by a consultant, Meyer said. That study could conclude that the best way to solve the problem is the electronic signs, he said, or it could come up with another, better recommendation.

CEDAR RAPIDS GAZETTE NEWS ARTICLE

SOURCE:
CEDAR RAPIDS
GAZETTE
FEBRUARY 3, 1986

FIGURE F

ATTACHMENT B

FIELD TRIP REPORT

Federal Highway Administration
U. S. Department of Transportation

Prepared by
Harold Lunenfeld
Engineering Psychologist
Traffic Engineering Applications Branch

April 14-16, 1986

(While the above report included analysis of other portions of I-380, only that section pertaining to the area between 32nd Street NE and 33rd Avenue SW is included in its entirety as Attachment B.)

Form FHWA-121

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

FIELD TRIP REPORT

(See instructions on reverse)

DATE: May 30, 1986

TO: Sheldon G. Strickland, Chief, Traffic Engineering Div., THRU Larry W. Barnes, Chief, Traffic Engineering Applications Branch

FROM: Harold Lunenfeld
Engineering Psychologist
Traffic Engineering Applications Br.

INCLUSIVE DATES
From April 14, 1986 To April 16, 1986

ITINERARY

Washington, D.C. to Cedar Rapids, Iowa, and return.

PURPOSE

To review four problem locations in the Cedar Rapids, I-380 corridor in Iowa, identify human factors related problems, and recommend improvements.

PRINCIPAL CONTACTS

Jack Latterell, James Hogan, and Bruce Baldwin, FHWA Iowa Division; Dwight Stevens, Harold Shiel, and James Loy, Iowa DOT; Melvin Meyers, city of Cedar Rapids, Iowa.

ACCOMPLISHMENTS OR RESULTS

The problem sites, two interchanges, an urban intersection, and a mainline section of I-380 were reviewed, problems identified, and suggested improvements identified. A field trip report was generated covering all aspects of the field review and in-house analysis.

SUBSEQUENT ACTIONS TAKEN

The field trip report was reviewed in-house and by FHWA Iowa Division personnel.

Copies of the field trip report will be sent to the Region and Division for implementation.

RECOMMENDATIONS

Those locations where improvements can be readily implemented should be treated in accordance with the findings of the field trip report. For the sites (the urban intersection and the freeway mainline section) requiring more study, efforts should be initiated to collect the requisite data to develop needed improvements.

OTHER PERTINENT ITEMS

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Replaces Form PR-13 (R 2-63) which is obsolete.

FIELD TRIP REPORT

A HUMAN FACTORS EVALUATION OF FOUR LOCATIONS ON INTERSTATE 380 IN CEDAR RAPIDS, IOWA

- I-380 SOUTH/US-30, US-218
- 1ST STREET/ E & F AVENUES
- I-380/IOWA-100, COLLINS ROAD
- I-380 NORTHBOUND & SOUTHBOUND- (32ND STREET, N.E. TO 33RD AVENUE, S.W.)

HAROLD LUNENFELD
ENGINEERING PSYCHOLOGIST
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS
WASHINGTON, D.C. 20590

MAY 30, 1986

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A HUMAN FACTORS EVALUATION OF FOUR LOCATIONS ON INTERSTATE 380 IN CEDAR RAPIDS, IOWA

Introduction

On April 14, 1986, an informal drive-through of Interstate 380 in the Cedar Rapids area was conducted by Harold Lunenfeld of the Federal Highway Administration (FHWA). This activity assessed the driving task and potential problems on I-380 north and southbound between 32nd Street, N.E. and 33rd Avenue, S.W., the interchange of I-380 southbound and US-30, US-218, and the interchange of I-380 and Iowa-100, Collins Road.

On April 15, 1986, a field review was conducted by Harold Lunenfeld of FHWA Headquarters; Messrs. Jack Latterell, James Hogan, Bruce Baldwin and Dominic Hoang of the FHWA Iowa Division; Messrs. Dwight Stevens and Harold Schiel of the Iowa Department of Transportation; Mr. James Loy of District 6 of the Iowa DOT; and Mr. Melvin Meyer, the City Traffic Engineer for the city of Cedar Rapids, Iowa. This field review assessed the aforementioned locations, and a fourth one, the intersection of 1st Street and E & F Avenues at the foot of the exit ramp of 1st Street from I-380 northbound. In the course of this field review, and a subsequent meeting at the Iowa DOT District Office, reasons for driver problems were discussed, and potential measures to improve the safety and operations of the four locations were identified.

On April 16, 1986, a second meeting took place, at which time the group that participated in the field reviews and meeting of April 15 was joined by Chief Hinzman and Lt. Benners of the Cedar Rapids Police Department, Sheriff Bloom of Linn County, Iowa, and Lt. Hall of the Iowa State Highway Patrol. At this meeting, concerns were expressed by the various law enforcement officers relative to incident management problems on the five-in-one structure of I-380 over the Cedar River, Cedar Lakes, and the Cedar Rapids Central Business District (CBD).

Background

Accident plots, site plans, memoranda and a report outlining a preliminary system of changeable message signs were submitted several weeks prior to the field review by the FHWA Iowa Division and the IOWA DOT for the I-380 mainline problem location. This material, augmented by verbal discussions and reports submitted by the Cedar Rapids Traffic Engineering Department, all indicated a high potential for roadway icing at two compound curves on I-380. This segment has a substandard geometric design, inadequate sight distance, and a high accident frequency, and has experienced several chain reaction collisions since it was opened. Incident detection and management was also identified as a major area of concern by enforcement authorities.

Information was also provided for the three other sites covered by this report. The I-380 South/US-30, US-218 interchange was identified as causing lane positioning difficulty due to unusual geometrics and poor visibility; the intersection of 1st Street and E & F Avenues was identified as having visual clutter, poor sight distance, and a high accident frequency; and, it was indicated that the Interchange of I-380 and IA-100 had unusual geometrics, partially obscurred sight distance, and signal operations questions.

Human Factors Field Review

All sites were assessed in the field. In the course of these reviews, drive-throughs were conducted using commentary driving, and traffic operations were observed. It was determined that each site had varying degrees of driver perception and task performance problems.

This report sets forth the results of the field reviews, meetings, and a human factors analysis of each of the four sites, and presents suggestions and recommendations. The location of prime concern to the State of Iowa, the city of Cedar Rapids, and the law enforcement agencies, is the mainline segment of I-380, north and southbound from 32nd Street, N.E. to 33rd Avenue, S.W.

The analyses, conclusions and recommendations in this report are preliminary in nature, as it was not feasible to conduct a comprehensive site survey and operations review or collect performance data relative to speeds or paths. In addition, since problems on the I-380 mainline section are keyed to adverse environmental conditions and incidents, data could not be collected under icing or accident situations. Such data, along with data collected during optimum environmental conditions to serve as a baseline for comparison, will be needed to design improvements and evaluate their effectiveness.

Conclusions and Recommendations

The sites for which the human factors analysis, field reviews, and technical discussions were conducted all are determined to have design and/or operational deficiencies that have contributed to driver problems. The following is a summary of conclusions and recommendations for each site. Individual detailed discussions are presented in separate sections of this report.

- I-380/US-30, US-218 Interchange: This interchange is functionally an optional lane split with restricted sight distance. However, it is signed as an interchange lane drop, causing problems with lane assignment at its gore, and on its two-lane exit ramp. Based on an analysis of this location, it is concluded that a standard "Two-Lane Exit with Optional Lane" diagrammataic treatment, in accordance with the MUTCD, should alleviate this site's lane assignment problems.

- 1st Street/E & F Avenues Intersection: This intersection is located at the end of the I-380 northbound "1st Street-Downtown" off-ramp. It is situated in a visually cluttered environment, with poor sight distance caused by I-380's structure overhead. It experiences a high frequency of collisions, primarily right-angle and (illegal) left-turns. More data are needed to pin-point exact problems and develop specific improvements. However, a preliminary analysis points to the conclusions that (1) The Site's safety could be enhanced by reducing clutter; (2) The target value of important traffic control devices needs to be increased; (3) Verbal educational plates on symbolic turn restriction signs could increase their comprehension; (4) Adding safety shapes at the intersection could further prohibit the illegal left turn; and (5) Changes in the intersection's traffic operations may reduce some of the site's problems.

- I-380/Iowa-100, Collins Road Interchange: This site is a three-level diamond interchange with full signalization in the mid-level platform. It has some sight distance restrictions in two of the platform's quadrants. An analysis and observation of this interchange yields the conclusions that while its design is unusual, the low traffic volume and current traffic operations are such that the interchange does not now appear to be a problem. This is born out by the site's accident experience. It is concluded that the site's markings need to be improved, and that full signal actuation is required.

- I-380 Northbound and Southbound (32nd Street, N.E. to 33rd Avenue, S.W.: This mainline section of Interstate 380 is somewhat geometrically substandard in the vicinity of Cedar Lakes, the Cedar River, and Cedar Rapid's CBD. The problems are primarily associated with two compound curves and restricted sight distance, which, when coupled with the rapid icing that occurs during adverse weather seasons, result in a high number of ice-related single and multiple vehicle accidents. The poor geometrics and sight distance, in addition to contributing to the site's multi-vehicle collision potential, also hamper incident detection and management activities, and are felt to be hazardous by authorities. Data are lacking to fully describe this location's problems, and to develop effective improvements. Based on a preliminary analysis, it is concluded that there is a need for a traffic management team approach to develop an effective plan for a fully coordinated effort of warning to drivers prior to an incident, and a full system of incident detection, management and control. Elements of this system should include ice detection, freeway surface treatment, surveillance, diversion, and lane closure. The motorist information display aspect of the system must be developed and could range from fixed and portable signage to real-time displays.

In conclusion, two of the four sites require more study to define problems and develop cost-effective improvements. The Office of Traffic Operations, FHWA, would be pleased to participate in those efforts. It is recommended that any improvements developed should be evaluated for effectiveness, particularly if improvements are implemented in stages.

I-380 NORTHBOUND AND SOUTHBOUND FROM 32ND STREET, N.E., TO 33RD AVENUE, S.W.

Problem Description

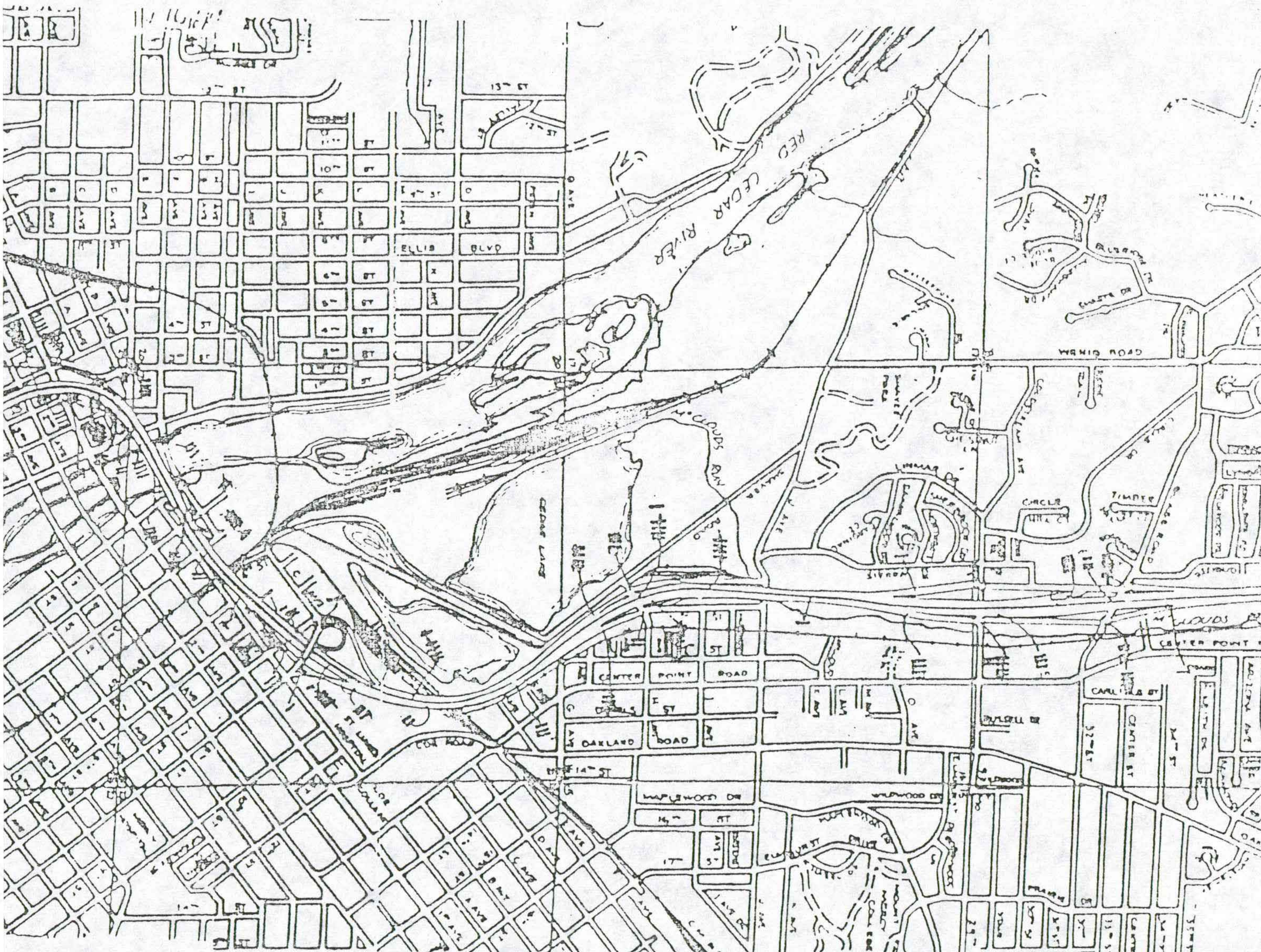
Problems for both northbound and southbound I-380 in the segment from 32nd Street, N.E., to 33rd Avenue, S.W., are similar in nature. In both directions, the road transitions from an essentially rural design to an urban freeway on structure, with closely spaced interchanges, compound curves, and moderate traffic volume. The facility is relatively new and constructed to current Interstate design standards. Drivers generally do not experience problems for most of the year. However, during cold months, the section of I-380 on the "five-in-one" structure over the Cedar Rjver, Cedar Rapid's CBD, and Cedar Lakes, tends to experience rapid icing. This environmental phenomenon, coupled with poor sight distance and alignment in the vicinity of two compound curves, widly spaced bridge joints, and a lack of adequate shoulders on the structure, results in a transitory hazardous situation. When ice occurs, there are a number of loss-of-control crashes that create the potential for "chain-reaction" multi-vehicle accidents. In addition, police engaged in incident servicing feel that they are in jeopardy because of the poor sight distance and lack of refuge. Two problem classes exist, problems associated with the hazard(s) prior to an incident, and problems associated with incident management. In addition, four goals have also been identified: (1) Prevention of accidents during icing conditions; (2) Prevention of secondary collisions and chain-reaction accidents once an initial incident has occurred; (3) Protection of officials investigating and managing incidents; and (4) Diversion of traffic when lanes, or the road itself, have to be closed.

Site Description

The section of freeway between 33rd Avenue, S.W., on the south end of I-380 to 32nd Street, N.E., on the north end of I-380 has three lanes in each direction, although auxillary lanes are added and dropped in the portion of the facility that goes over Cedar Rapids. Traffic is generally free-flow. There is an AM peak in the southbound direction, and a PM peak in the northbound direction (field observations conducted during the review did not reveal such peaks). Truck traffic is light, and is estimated at 3 percent. Land-use and road design from I-80 to the U.S. 30 interchange at the southern end of I-380; and beyond the Iowa-100 interchange on the northern end to the city of Waterloo is essentially rural, with rolling terrain and good sight distance. I-380 transitions from a rural to an urban facility between 33rd Avenue, S.W., and 32nd Street, N.E. In this section I-380 is on structure through central Cedar Rapids. In a distance of approximately 5 miles, there are 7 interchanges: 33rd Avenue; Wilson Avenue, Seventh Avenue, First Street-Downtown; H-J Avenue; Coldstream Avenue; and 32nd Street-Glass Road, as shown in Figure 4-1.

While the entire section of I-380 bounded by the 33rd Avenue, S.W., and 32nd Street, N.E. interchanges is included in the discussion, the primary problem site is the "five-in-one" structure over the Cedar River, Cedar Rapid's CBD, and Cedar Lakes. In this segment, there are two separate compound curves with restricted sight distance. One is located above First Avenue on the southern end; the other curve is adjacent to the "ash pit" in the vicinity of St. Lukes Hospital on the northern end. Traveling on I-380 from south to north, the road curves to the right over First Avenue. A police station and roadside furniture blocks sight distance downstream of this curve. Further north, there is the potential for distraction caused by a view of downtown Cedar Rapids. In the vicinity of St. Lukes Hospital, the second compound curve is located. Billboards and a large changeable message sign serve as distractions here. Throughout the segment, there are conventional overhead freeway advance and exit direction guide signs for each interchange. There is also one curve warning sign with a single beacon that flashes during winter months.

Traveling from north to south on I-380, the road curves right in the vicinity of the "ash pit." In this direction, Cedar Lake is visible. The road downstream of this curve is somewhat obscured by the off-ramp



RED CEDAR RIVER
ELLIS BLVD
13TH ST
10TH ST
WENIG ROAD
CENTER POINT ROAD
OAKLAND ROAD
CEDAR LAKE
MAPLEWOOD DR
CARLISLE ST
CENTER ST
TIMBER
CIRCLE

structure of H-J Street. While the off road environment in the southbound direction in not as distracting as it is in the northbound direction, Quaker Oats silos are visible downstream, close to the roadway. They may serve as a distraction and also block the road's view. Beyond the silos and the H-J Street on-ramp, there is a curve warning sign and beacon of the same design as that used on the northbound lanes. Downstream, the road curves down and to the left (the First Avenue curve). Visiblity is restricted by the road's alignment and grade, and by the northbound lanes of I-380 which are at a higher level

Throughout the section, guide signing, markings, and delineation are standard and in compliance with the MUTCD. Interchange design and geometry is "tight", and there are a series of auxilliary lanes between on and off ramps. All interchanges are on the right, and some drivers appear to use this segment as a local feeder to downtown destinations. Through drivers would probably be in the left lanes, and locals would probably use the right lanes. Some drivers were traveling at high speeds, and considerable speed differentials were noted during the field review.

Problem Analysis

The geometric design, alignment, and routing of this facility over the city of Cedar Rapids results in problems, both for motorists and police. This is particularly the case in the segment bounded by the two compound curves on the "five-in-one" structure, and is primarily a problem under icing conditions. Both locals and strangers are experiencing tracking and accident avoidance problems when the structure ices up. Of primary concern is preventing accidents and maintaining the safety of an officer at the scene of an incident. There is no evidence to indicate that drivers are experiencing direction finding problems, or that there are major difficulties with the various interchanges.

Major driver problems are related to excessive speed for icy road conditions, poor sight distance, and improper road geometry. These factors contribute to a loss of control, single vehicle or multiple vehicle collisions, chain-reaction accidents, and conflicts with police. Human factors considerations contributing to these problems are discussed below.

- <u>Expectancy Violations</u> - Several features of the mainline in the problem areas violate driver expectancies and thereby contribute to the freeway's hazardousness under icy conditions. One involves the abrupt transition from an essentially rural freeway to an essentially urban one. Although the view of the change in land use, particularly in the northbound direction (i.e., where Cedar Rapid's skyline is visible) may prepare some drivers for the rural-to-urban change, many drivers would not expect, nor be prepared for the increased demands in task performance caused by the changes in design, geometrics, and traffic operations. That is, traffic volume increases substantially, interchanges (including auxilliary lanes) are more complex, road alignment changes occur, and sight distance becomes restricted. Such changes, occurring as abruptly as they do in this segment of roadway have the potential of violating the expectancies of strangers, particularly those who are not used to urban driving. A more critical expectancy violation involves the nature of the icing that occurs on the "five-in-one" structure. Icing occurs rapidly, without warning, and affects this structure before, and often without occurring on, other bridges in the area. Thus, many drivers using I-380 would not expect the "five-in-one" structure to be icy. In addition, the road's current information system, with the exception of the flashing curve sign, does not warn drivers of potential problems. Thus, drivers probably are unprepared for ice, a difficult driving task, and the need for increased vigilance.

Few drivers would expect a relatively new Interstate facility to have sight distance restrictions, a difficult alignment, and bridge joints that affect their task performance. It is doubtful that any driver would even understand the ramifications of these elements. Taken together, all of the many expectancy violations of this segment contribute to the apparent lack of caution and vigilance of some drivers during icing conditions. In fact some drivers may expect that the Interstate's high level design enables them to drive at a high rate of speed under adverse weather conditions.

- Task Difficulty/Overload - A number of features in the problem segment contribute to driver task difficulty. These include alignment changes, difficult interchange designs, close interchange spacing and auxilliary lanes, moderate traffic volumes, speed differentials, poor sight distance, and bridge joints which causing some vehicles to "fishtail" at high speeds. Adverse environmental conditions such as wind, snow, and ice add to the driver's task difficulty. There is also a potential for overload. While the processing of the site's route guidance information would not, in and of itself, overload the driver, motorists are also affected by the site's short interchange spacing and exiting and entering vehicles. In addition, the driving task difficulty takes up most of the driver's processing capacity. This leaves little space capacity to respond to additional information such as incidents or emergency displays.

- Sight Distance/Visibility - A major contributory factory to multiple collisions and police vulnurability at this location, in addition to the icing, is the lack of sight distance in the vicinity of the compound curves. This lack of sight distance at operating speeds (which have been estimated to be in excess of the posted 55 mph) results in an unsafe situation, both for vehicles involved in an initial incident, and for officers and safety equipment involved in incident management.

- Traffic Operations - Speed and path data are lacking for the problem segment of I-380. However, based on observatioans and police reports, it is probable that the operating speeds, particularly during icing, are too high for road conditions, both for locals and strangers. While traffic volumes and truck traffic is not excessive, an increase in either or both would greatly exacerbate the site's accident problems. Another important aspect of the location's traffic operations for which data are lacking is whether drivers would divert, and whether there are routes for them to use. There is evidence that most drivers "wait out" a delay rather than diverting on to an unknown secondary route. This is a major consideration in any diversion strategy that may be employed in the event of ice, accidents, or back-ups.

- Distractions - An aspect of this site which may indirectly contribute to its problems, and which would affect the effectiveness of information-related improvements, are distractions off-the-traveled-way. In addition to Cedar Rapid's skyline, there are numerous billboards and several changeable message advertising signs in the area. The police station in the northbound direction, and the Quaker Oats buildings in the southbound direction, may be sources of driver distraction. These distractions take a driver's attention away from more important information processing tasks, and could lessen the effectiveness of real-time information displays.

Discussion of Countermeasures

In any problem situation, where there are hazards of the nature described herein, there are a range of countermeasures that can be used singularly or in combination. In essence, they fall into three broad categories:

1) Remove the Hazard(s).

2) Protect the Motorist from the Hazard(s).

3) Inform the Motorist of the Hazard(s)/Provide Information to Enable the Motorist to Avoid the Hazard(s).

Given the range of variables associated with this location, it is not possible nor desirable, at this juncture, to recommend a single "solution" to this site's problems. In fact, there is probably no clear-cut "solution" short of major reconstruction. There are, however, a range of potential countermeasures that can be applied in both the short and long term. More study is needed to resolve all the issues relating to what is most appropriate. In the course of such studies, consideration should be given to specific problem identification in terms of scope and magnitude, and detailed improvement development in terms of anticipated effectiveness. This will enable a determination to be made of costs and potential benefits for various levels of improvements. Only then can meaningful decisions be made as to what is appropriate for this site. It should be understood, however, that measures ultimately selected which rely on motorist response to information may not be fully successful, given the fact that many locals, who should know about the structure's icing problems, are not now changing their driving behavior in adverse weather. Systems requiring motorist response are only as good as the level of compliance achieved by the system's users.

o <u>Reconstruction:</u> An optimum way to ameliorate problems on this segment would be through reconstruction. The freeway's geometric design is substandard, particularly regarding sight distance, alignment and grade, and forgiveness. While it is probably not feasible to rebuild this freeway segment, future designs in the State should be carefully evaluated prior to construction to avoid repeating these problems. Computer graphics and model construction are useful tools to aid in design evaluation. It may be possible, however, to apply some short-term reconstruction to ameliorate part of the site's problems. It may be feasible, for example, to remove some of the sight distance obstructions, such as fences, rails, or even the police station.

- o Ice Prevention and Removal: Countermeasures can be used to prevent, eliminate, and/or remove, in so far as practicable, ice from the structure. It should be possible to predict when conditions are right for ice to form and position salt trucks on the freeway that could immediately treat the roadway. This would be in addition to the sanding operations employed after ice has occurred. A range of technologies including computer prediction, surveillance, and ice detectors (see below) could aid in this activity.

- o Driver Information: Another set of countermeasures provide drivers with information to prevent an accident from occurring under icy conditions, and/or to prevent secondary collisions once an incident has occurred. This information can be designed to achieve the following:

  (a) Modify Driver Behavior - To slow down drivers before the icy conditions are reached, and to warm them of the icing. In addition, this information should take the driver through the hazardous location, and inform him/her when "normal" driving is safe.

  (b) Regulate Driver Behavior - To require drivers to slow, change lanes, and/or divert once an incident has occurred, thereby avoiding chain-reaction collisions and protecting officers. (See incident management below.)

  (c) Inform Drivers of Conditions and Alternatives - To tell drivers what is happening and why, thereby increasing compliance and increasing diversion and vigilance.

- Incident Management: Once an incident has occurred, timely incident management techniques are required. Given this location's characteristics, protecting motorists and authorities on the structure from subsequent incidents is also required. Protection may entail routing subsequent traffic away from the crash and/or the police managing the incident, and diverting traffic. This requires timely (in some cases instantaneous) incident detection, and suitable incident management. Incident detection may necessitate active surveillance, either through regular patrols or TV monitoring. Incident management requires personnel on-site and would involve upstream information presentation.

- Operational Changes: Operational changes, such as lowering the "five-in-one" structure's speed limit year round, or in the event of potential icing, or closing the road when conditions warrant, could ameliorate the site's problems. It would require additional information display and increased enforcement to achieve changes in behavior.

Driver Information Systems

There are numerous kinds of driver information display methods and systems that could be used on this segment of freeway. They range in sophistication from fixed signing through real-time devices to Highway Advisory Radio and public information campaigns. Some rely on or complement surveillance, incident detection and management, and facility control methodology, while others stand alone.

- Fixed Signing: One method would entail the development and display of one or more fixed signs to warn motorists of potential icing on the structure. Similar fixed signs could be used to slow drivers down, to regulate reduced speed limits on the segment and/or to encourage diversion. Even with fixed signing, there is a range of display techniques and formats that could be used. These include size, shape, color, message, mounting location, etc. In addition, attention gaining techniques such as flashing beacons could be used for added emphasis. While fixed signing has proven effective in numerous situations, its effectiveness on this segment, with its transitory environmental and incident hazards, is problematical. Such fixed signing displays would require drivers to modify their behavior without appreciating the reasons for the changes, and/or would require drivers to make complex decisions under time pressures. The problem analysis has shown this location to be one that violates expectancies, and one that has the potential for overload. A simple display, such as the curve warning sign and beacon now in place, has little impact on behavior. However, installing a complex array of fixed messages could lead to confusion or distraction, and probably not result in much diversion or prevent many accidents. There is a system using fixed signing, however, that could help alleviate the site's problems. Such a system would be directed toward changing the site's operations and informing motorists of the change. That is, excessive speed for the road's geometrics, sight distance restrictions, and icing problems is clearly a causal factor in accidents. Reducing speeds over the structure should ameliorate some of its problems. Such a system would entail establishing a reduced speed zone, providing signing, possibly with flashing beacons, and strictly enforcing the reduced speed limit.

- Real-Time Systems: Given that the site experiences problems of a transitory nature, a more responsive information system than a fixed signing one may be appropriate. Such a system may require relatively simple seasonal adjustments, such as establishing the aforementioned reduced speed and enforcement during the icing season, and operating the flashing beacons or displaying the lower speed limit signs accordingly. A more sophisticated system may entail a real-time surveillance and control, with a series of changeable message signs for speed and lane control and diversion. As in the case of fixed signing, there are a range of methods, techniques and complexities possible for real-time systems.

Real-time systems often require a coordinated effort of surveillance and control to achieve a multiplicity of purposes and a level of driver compliance that will justify its capital and operating expenses. Assuming that a primary purpose of such a system for this site is the display of information concerning icing, there is a need to detect the presence of ice in real-time. There are several ways that ice can be detected: Automatically using ice detectors; or, by having an observer on the spot detect its presence. While it would be desirable to detect ice automatiacally, the current state-of-the-art of ice detection is not sufficiently reliable to rely solely on automatic means. Attachment A sets forth FHWA's policy regarding ice detectors, which is to have a human observer verify that ice is present. The inherent unreliability of ice detectors lead to two related real-time systems problems. (1) If ice detectors are relied on without surveillance and they fail, the motorist will not be warned of ice and will become involved in an accident; (2) Using human detectors can introduce a time delay in getting the individual to the scene (Patrol), detecting the presence of ice, conveying this information to a central authority, and warning the traffic stream. In this regard, there is a need to specify what warnings and measures are warranted. For example, should speeds be reduced and by how much? Is the conditions severe enough to close the road and divert traffic?, etc. Hence, an effectual real-time system should include a plan of action, a control authority to implement the plan, and protocalls covering all aspects and contingencies.

A sophisticated real-time information system should also have the capability to prevent multiple collisions after an incident has occurred. In this site, to achieve this goal requires surveillance and monitoring of the roadway, particularly in the vicinity of the curves. Once an incident has occurred, it must be detected, and drivers informed of its presence, and/or diverted. There will generally be a time lag between the occurrance of an incident and its detection, if the detection is by routine police patrol. Given the icing, geometry, and sight distance restrictions of this site, any time delay may be critical. One way to reduce or eliminate the time delay is to provide continuous around-the-clock surveillance.

This could be achieved using television cameras monitored at a central dispatch location. Such a system could serve to detect the incident, implement the warning, and dispatch aid to the site. Here again, there is a need for a plan, a control authority, and protocalls for action. There is also a need for coordination and personnel to operate the system.

Another real-time system performance requirement is the protection of police and maintenance personnel at the scene of an incident. In this case, on-site personnel should determine what they need in the way of protection and incident management equipment and personnel. These needs should be communicated to the central authority for implementation and information display.

Whatever system of motorist real-time information is used, it must be born in mind that its effectiveness is directly related to its credibility. That is, drivers must be informed of what to do, e.g. "slow," "stop," "divert", etc., and understand why the behavior is needed, e.g. "accident," icing." In addition, the system must be turned off and returned to "normal" after the need for the information is removed. Thus, there must also be procedures for follow-up to shut the system off. Otherwise, repeat drivers will ignore its messages in future situations.

Depending on the measures, surveillance, control and messages needed, there are a range of techniques available to achieve the system's goals. These vary from fold-out signs (fold-out signs are currently used at the site for maintenance), to fixed signs transported on vehicles which are used when dispatched by the control authority, to changeagle message signs. There are also a range of changeable message signs that can be used, including scroll signs, rotating drums, neon signs, fiber-optic signs, bulb-matrix signs, and electro-mechanical signs. In the case of lane control for freeways, lane-use control signals can also be used. Attachment B, abstracted from the Traffic Control Systems Handbook, provides information on each of these techniques. It should also be understood that any system that uses electrical or electronic displays requires power, a telecommunications link from a central dispatcher to-and-from the surveillance personnel, and in-field displays.

Other Means of Communicating with the Motorist: It is also possible to provide additional information through other media. For example, Highway Advisory Radio could be used to warn of ice on the bridge, radio and TV stations could broadcast traffic and road conditions, and public information campaigns could educate the public on operations and problems at the structure.

Recommendations

In developing improvements of the nature covered by this field trip report, and implementing them on a freeway segment such as I-380, i.e., one with multiple jurisdictions, an approach that has proven successful is the establishment and utilization of a traffic management team to participate in all levels of decisionmaking. The traffic management team is comprised of a multidisciplinary group of transportation professionals and enforcement officials. For this location, the city of Cedar Rapids, the Iowa Department of Transportation, the Federal Highway

Administration, the Iowa State Highway Administration, and the Linn County Sheriff Department would all participate in the team. Once established, the team would be involved in all levels of analysis, development, implementation, and review. This will assure coordination among all involved agencies and jurisdictions, and increase the chances for an effective improvement and a smooth implementation. Therefore, as a point-of-departure, it is recommended that cognizant authorities structure a traffic management team similar to the one described in Enclosure C. This team should develop an action plan for the site, emphasizing icing situations and incident detection and management. The plan should outline surveillance, control, and incident management authority. It should spell out all requirements for detecting icing and incidents, changing speeds, closing lanes, diverting traffic, etc. Ultimately, the plan will specify all efforts relating to this site and all requirements for its information system.

In addition to formulating a traffic management team and developing an action plan, it is recommended that a study be initiated to determine needs and develop measures. This study should assess all available historical data to establish accident reates, hazardous locations, environmental situations, involved motorists, etc. Before inclement weather occurs, performance data should be collected relative to speeds, paths, lane use, volume, conflicts, etc. Such information will prove useful in establishing a base-line of driver performance and an indication of accident causation mechanisms. Based on these data, a determination should be made of operational and information needs for various problem conditions such as icing, incidents, and congestion. Requisite speeds under ice conditions, effects of closure, diversion routes, response requirements, distractions, etc. should be determined, and information display techniques and messages specified. In addition, stages of implementation should be developed, along with an implementation and evaluation plan.

Since it will not be feasible to implement a full information system such as the one described by the Cedar Rapids Traffic Department in their April 16, 1986, report by the start of the 1986-1987 ice season, consideration should be given to short-term improvements and staged implementation. It would be feasible, for example, to fabricate and test-out fold-out and/or transportable signs for use in icing and incident management situations. Various messages could be developed, formats made, procedures described, and driver compliance determined. Thus, if a reduced speed zone is a candidate measure, fixed reduced speed zone signing with flashing lights could be fabricated and displayed, and speed data collected. Similarly, diversion and lane closure compliance could be determined using portable signs.

Data collected as part of the above short-term improvement phase under ice conditions and during incidents could then be evaluated and a second level system developed, if deemed necessary. Such a second level system might consist, for example, of 1 or 2 changeable message signs in the northbound and southbound direction, upstream at points of diversion, and/or in the vicinity of the compound curves. This system should be linked to a central location for surveillance and control, and should be evaluated both for information display effectiveness and coordination and response suitability. A determination could then be made whether, and to what extent, further development and sophistication is needed. Costs, benefits, and effectiveness should form the ultimate criteria for the final system used.

U.S. Department of Transportation
Federal Highway Administration

Memorandum

ATTACHMENT - A

Subject: Ice Detection Systems

Date: DEC 26 1984

From: Director, Office of Highway Operations
Washington, D. C. 20590

Reply to Attn of: HHO-41

To: Regional Federal Highway Administrators
Regions 1-10
Direct Federal Program Administrator
ATTN: Technology Transfer Coordinators

The FHWA has been monitoring the performance of ice detection systems on highways for over 15 years. In the last 6-8 years only one manufacturer, Surface Systems Incorporated (SSI) has actively pursued the ice detection market in the United States. Late last year we asked for reports on the performance of SSI's ice detection system from all State highway agency's (SHA) using the equipment. We received reports from 9 SHA's and one city. Attached is a brief summary of the information we received.

Early work by the FHWA and the manufacturers of ice detectors was targeted at developing a system with the reliability necessary to operate an ice warning sign system. The risks associated with this type system are so great that these efforts have largely been abandoned. The FHWA position on this issue is that ice detection systems have not, to date, demonstrated the near 100 percent reliability required to provide adequate credibility for use with active ice warning signs. Ice detection systems should, therefore, not be used as a basis to activate and deactivate ice warning signs, i.e., ICY BRIDGE AHEAD. Current efforts should be directed toward developing systems which will enable maintenance personnel to deploy snow plow and chemical deicing operations more efficiently.

During 1984 the Boschung Company Inc., introduced its ice detection system into the U. S. market. The company has headquarters in Schmitten, Switzerland with its U. S. office in South Holland, Illinois.

Although it may now be possible to obtain ice detection systems on a competitive basis, we request that projects incorporating either Surface Systems Inc., or Boschung Company Inc., systems be programmed experimental. Designating ice detection system projects experimental will enable us to receive needed performance evaluations of Boschung's equipment as well as reports on SSI's new equipment.

Thank you for your support in the technology transfer effort. We will continue to apprise you of our findings as we receive additional information on either the Boschung or SSI Systems.

David S. Gendell

Attachment

REPORT NO. FHWA—EP—85—001

U.S. Department of Transportation
Federal Highway Administration

Experimental Projects Program

SUMMARY
SURFACE SYSTEMS INCORPORATED (SSI) ICE DETECTION AND WARNING SYSTEM

Technology Transfer

OFFICE OF HIGHWAY OPERATIONS
DEMONSTRATION PROJECTS DIVISION
400 7TH STREET S.W.
WASHINGTON D.C. 20590

SUMMARY
SURFACE SYSTEMS INCORPORATED (SSI)
ICE DETECTION AND WARNING SYSTEM

Background

The Federal Highway Administration (FHWA) has been following the performance of ice detection systems on highways for over 15 years. In the early 1970's, 22 ice detectors were evaluated in a feasibility study by the FHWA for detector operational reliability. Six of the detectors were selected for field testing. All but one of the six failed before completion of the testing. In a followup study, nine available detectors were reviewed. Six of the nine were eliminated from further testing primarily for technical reasons prior to testing. The Surface Condition Analyzer (SCAN) by SSI was one of the three selected for further testing. The SSI detector was judged the better of the three, although far from being operationally reliable.

By 1977, SSI became the lone marketer of ice detection equipment in the United States. Experimental installations were encouraged by FHWA for ice detector systems that involved a new approach or were significantly improved over previously studied systems. SSI's SCAN 7000 system met the criteria and qualified for Federal-aid funding on an experimental basis.

Since 1977, SSI has progressed from the SCAN 7000 system to the SCAN 16 and the SCAN 16 EF (Extended Format) systems. The 16 series systems are microcomputer based systems with software analysis packages.

Early work by FHWA and the manufacturers of ice detectors was targeted at developing a system with the reliability necessary to operate an ice warning sign system. The risks associated with this type system are so great that these efforts have largely been abandoned. Recent efforts have been directed toward developing systems which would enable maintenance personnel to deploy snow plow and chemical deicing operations more efficiently. In 1983, FHWA asked the State highway agencies (SHA) that had used SSI equipment on Federal-aid experimental projects to provide their latest findings on the operational reliability of the equipment. The following is a brief summary of the information received.

Summary

Nine SHA's and one city that have installed SSI systems experimentally on Federal-aid projects submitted information.

The SCAN 7000 system was tested in seven of the nine states during the period of 1976 to 1981.

A. Arkansas reported 80 percent reliability and Maine reported 90 percent. Problems with the system were defined as minor in both States.

B. Illinois, Minnesota, Montana, and Nevada reported that the SCAN 7000 system failed to operate properly. Illinois, Montana, and Nevada arranged for replacement of the SCAN 7000 system with the SCAN 16 system. Minnesota elected to abandon any further use of SSI equipment.

C. Ohio, after an initial installation of a SCAN 7000 system in late 1981, replaced it with a SCAN 16 system in 1982.

The SCAN 16 system was tested in one city and five of the nine States reporting.

A. In late 1983 and early 1984 SSI refurbished and improved the original Illinois installation and re-installed the system on McClugage Bridge, Route 150, at Peoria, Illinois. Illinois reports that from January 1984 until the end of the winter season the system performed as designed. Illinois plans to continue accumulating winter performance data in an effort to determine the long term benefits of the system.

B. Montana reported that SSI upgraded the original installation in February 1984 to include newer computer hardware and software and that the performance of the new system has been satisfactory. The Department has also informed our local FHWA office that they do not intend on entering into a yearly maintenance contract with SSI for $4,000 to $7,000. Since the annual maintenance cost of the equipment exceeds the amount Montana anticipated, they have requested that they be allowed to terminate the experimental project in 1985.

C. The Nevada system was installed in a tunnel and SSI has conceded that more study of tunnel conditions is needed before their system can be made to work in that atmosphere.

D. Michigan reports that its 1983 installation is working well. They report that the system requires a minimum of operator intervention and that SSI's personnel were very helpful. They caution that maintenance personnel cannot rely solely on the system, since data presented by the system are not infallible and need interpretation. The FHWA Michigan Division office agrees that the system appears to be a very helpful tool provided it continues to operate satisfactorily.

E. A city official of Columbus, Ohio, reported the SCAN 16 system installed in the fall of 1982 to be highly accurate, although the telephone line communications are costly. Wide area snow and ice control was suggested in the Ohio report as suitable use. The FHWA Ohio Division office was not satisfied with the system's reliability or accuracy and recommended it remain experimental.

F. The SCAN 16 system in Utah had not been installed as of November 1984.

Conclusions

A. SSI has continued to improve their product for a number of years in an effort to provide a marketable service to the highway community in the area of snow and ice control.

B. The newer SCAN 16 and 16 EF systems are performing much better than the SCAN 7000 system performed.

C. Adequate data are not available to determine the long-term reliability or cost effectiveness of the "16 series" systems.

Recommendations

A. Since SSI has announced replacement of the SCAN 7000 system and is now concentrating on the SCAN 16 EF system, further evaluation of the SCAN 7000 system should be terminated.

B. The five State highway agencies having SCAN 16 or 16 EF equipment should be encouraged to evaluate the performance of each system and provide FHWA with well documented reliability studies.

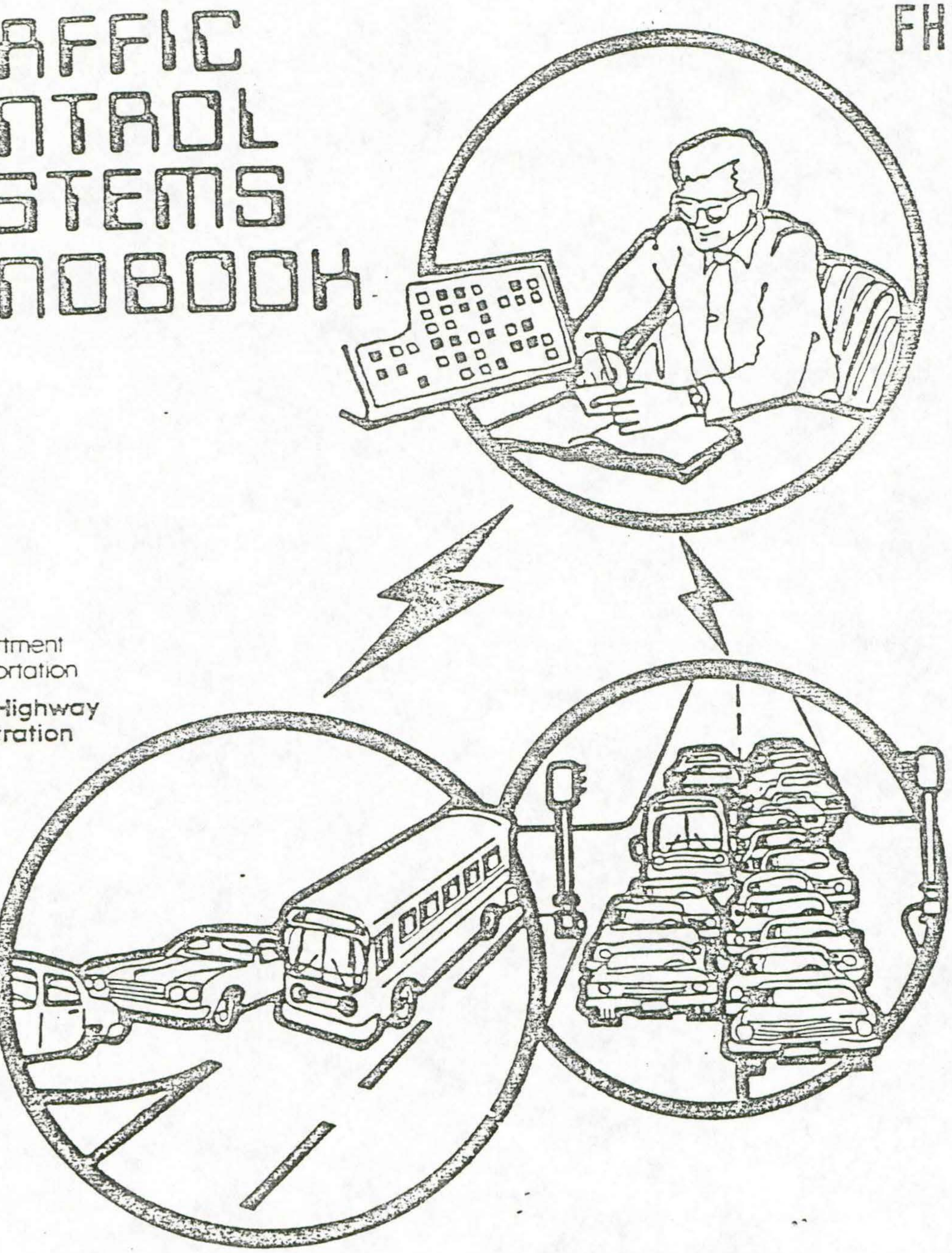
C. Future installations of SSI equipment should be classified experimental.

ATTACHMENT - B

DRIVER INFORMATION SYSTEMS

TRAFFIC CONTROL SYSTEMS HANDBOOK

FHWA-IP-85-11



U.S. Department of Transportation

Federal Highway Administration

REVISED - APRIL 1985

9. DRIVER INFORMATION SYSTEMS

9.1 INTRODUCTION

The highway transportation system involves three major elements: (1) the vehicle, (2) the roadway, and (3) the driver. The most complex of the three elements in the system is the driver, who is also the one element which is most prone to failure. A majority of these failures are due to errors in perception, or information processing, often the result of inappropriate information, lack of information, or simply overlooking available information.

To provide more adequate information and communication to the driver, concerning the roadway, the traffic engineer utilizes driver information systems such as traffic and lane control signals, traffic signs, pavement markings, delineators, telephone systems, and commercial radio.

Driver information is essential for the roadway system to operate efficiently and safely. Driver information systems have already been discussed earlier in Chapters 3 and 4 on control concepts for urban streets and freeways. In the present chapter, only a brief summary discussion will be needed to consolidate and identify types of hardware associated with driver information systems.

The major visual techniques for conveying driver information include the following:

- External
  - Signals
  - Static signs
  - Changeable message signs
  - Transportable signs
  - Pavement markings
- Internal
  - In-vehicle displays

Major audio techniques include the following:

- External
  - Warning signals
  - Public-address systems
  - Telephones
- Internal
  - Commercial radio
  - Low-power radio

Driver information systems are used in mainline control to advise motorists of freeway conditions in order that appropriate action can be taken by the driver to enhance the efficiency and safety of traffic operations. The traffic engineer's philosophy is to inform the driver of impending conditions with up-to-date information. With this information, the driver is capable of deciding what actions should be taken — i.e., whether to continue on the planned route with the knowledge of the problem ahead or to divert to an alternate route to avoid the problem.

The objective of this chapter will be to identify typical hardware associated with the various visual and audio techniques.

9.2 STATIC SIGNS

The three basic types of static signs include the following:

- Regulatory signs
- Warning signs
- Guide signs

Table 9.1 illustrates the intended use of each type and provides some examples. The *Manual on Uniform Traffic Control Devices* (MUTCD) (*2*) contains standards for the three types of static signs. This section will only describe the use of static signs to warn drivers of special freeway problems, such as a closed lane, congestion, or a particularly hazardous condition because of inclement weather.

Static signs are single-message signs, i.e., capable of conveying only one message. Single-message displays are most useful when a situation is recurrent and the same

Table 9.1. Sign types and uses

Sign Type	Intended Use	Typical Uses
Regulatory	To inform motorists of traffic laws and regulations which apply at definite locations and at specific times	• Intersection control • Definition of right-of-way • Speed limits • Turning movement control • Pedestrian control • Exclusions and prohibitions • Parking control and limits • Regulations for maintenance and construction
Warning	To warn motorists of unusual or potentially hazardous condition(s) on or adjacent to a street or highway	• Horizontal and vertical alignment • School areas • Crossings and entrances to streets, highways, and freeways • Intersection areas • Road construction and maintenance
Guide	To provide simple and specific information to aid motorists in reaching their destination	• Route markings • Destination • Information • General services • Parks and recreational information

Source: Reference (*1*)

driver response is desired each time the sign is used. Therefore, static signs can be used at locations where a hazard is well-defined and occurs periodically. However, these signs are limited in the type of information that can be displayed. For example, static signs cannot display distances susceptible to change (accident location, distance to end of queue, etc.), or times susceptible to change (delay information, travel times).

A common example of a static sign used to warn the driver of slow or stopped traffic is shown in Figure 9.1. Flashing beacons are generally mounted on each side of the sign panel and are actuated when the hazard exists. The major advantage of this type of display compared to changeable message signs is lower initial cost and the capability of agencies to fabricate this type of sign.

Transportation engineers have found it desirable to provide directional guidance to a particular road facility from other highways in the vicinity. This is accomplished by means of trailblazers erected at strategic locations, usually along major urban arterials, to indicate the direction to the nearest or most convenient point of access. The use of the word TO indicates that the road or street where the marker is posted is not a part of the indicated route, and that a driver is merely being directed progressively to the route.

9.3 DIAGRAMMATIC SIGNS

Diagrammatic signs are guide signs that depict a graphic view of the exit arrangement in relationship to the main highway. The use of such guide signs has been found to be superior to conventional guide signs for some interchangeable types.

Diagrammatic signs should be used at advance guide sign locations, for example, for splits having off-route movements to the left, optional lane splits, and exits with route discontinuity and left-exit-lane drops (see Figure 9.2). Diagrammatic signs, which may also be useful at 2-lane exits with an optional lane, should be designed in accordance with the MUTCD (*2*).

9.4 CHANGEABLE MESSAGE SIGNS (CMS)

Changeable message signs have been used in experimental and operational systems in several parts of the world during the last two decades (*3-11*). Changeable (variable) message signs (CMS) are real-time driver communication devices whereby the visual word, number, or symbolic display can be electronically or mechanically varied

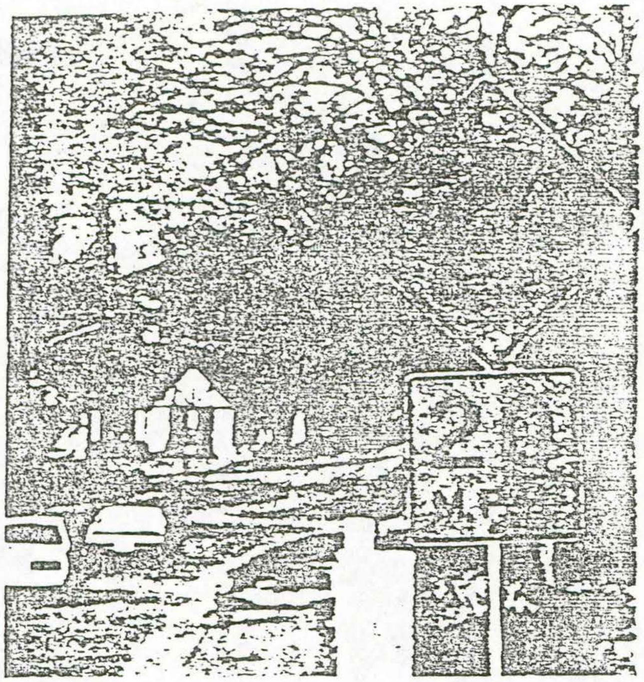


Figure 9.1. Static sign

as traffic conditions warrant. The MUTCD defines CMS as signs designed to have one or more messages that may be displayed or deleted as required (*2*). This type of sign has emerged as a valuable and important display tool for use by the traffic engineer to effectively communicate to the driver. While the conventional static sign conveys a message to the driver about a static situation, increasing hazard/incident occurrences require specific messages in the form of dynamic displays.

CMS displays can address a considerably wider range of traffic management functions. CMS signs are required when it is necessary to inform drivers of varying traffic, roadway, or environmental conditions. In addition to being effective when different types of driver actions are required, multiple-message displays can also be used to provide more specific information relative to locations, delay, etc. (*3*).

CMS systems can perform a critical role on high-speed highways by providing drivers with real-time information on a current roadway condition. However, to retain driver credibility a CMS system must supply timely, accurate, and reliable information. Once driver confidence is lost, even the most elaborate and costly system can quickly lose its effectiveness. Dudek has researched and conducted interviews with operations personnel to compile the following list of ways in which a driver's confidence can be lost (i.e., pitfalls to be avoided) (*10*):

- Displaying inaccurate or unreliable information
- Displaying information too late for drivers to make appropriate responses (untimely information)
- Displaying messages that drivers don't understand
- Displaying messages that are too long for drivers to read under prevailing highway speeds
- Not informing drivers of major incidents (adverse conditions) a large majority of the time
- Telling drivers something they already know
- Displaying information not related to environmental, roadway, or traffic conditions, or not related to routing
- Displaying garbled messages

CMS systems are becoming increasingly important in improving the safety and operation of existing highway and urban facilities. For example, CMS's will be representing the primary source of real-time motorist information in the Integrated Motorist Information System (IMIS) in the Northern Long Island Corridor (*12*). These signs, placed at key locations along the major roadways in the corridor, will indicate prevailing traffic and roadway conditions, and provide alternate routing information for the motorist where applicable. Applications of various types of driver information displays for corridor management are listed in Table 9.2.

CMS's can either be permanently installed or be transportable to serve a specific need. CMS systems range from fixed-time, onsite control to remote automatic control. Several computer-based freeway surveillance systems also utilize CMS's. Currently, however, these types of signs are most widely used to manage traffic through construction areas and maintenance zones and special events. Table 9.3 summarizes the techniques and possible traffic operations applications for CMS control.

A variety of CMS's are available to a highway agency, with each type having its own unique characteristics. while standards for CMS's have not been established and only minimum guidelines are provided in the MUTCD, a major research project, FHWA-RD-77-98 (*8*), summarizes CMS technology currently being utilized for traffic control applications and lists manufacturers for each display type.

The remaining portion of this section provides the traffic engineer with a working knowledge of the different types, features, uses, and effectiveness of CMS systems (*8,10,11*).

CMS Display Types

Of the three current types of CMS displays, the first requires a mechanical movement with appropriate electromechanical control to the sign's message. The second uses light sources arranged to form characters for varying the message. The third relies on an electrical impulse and mechanical movement to alter the display. (See Table 9.4 for a summary of these three different types of displays.)

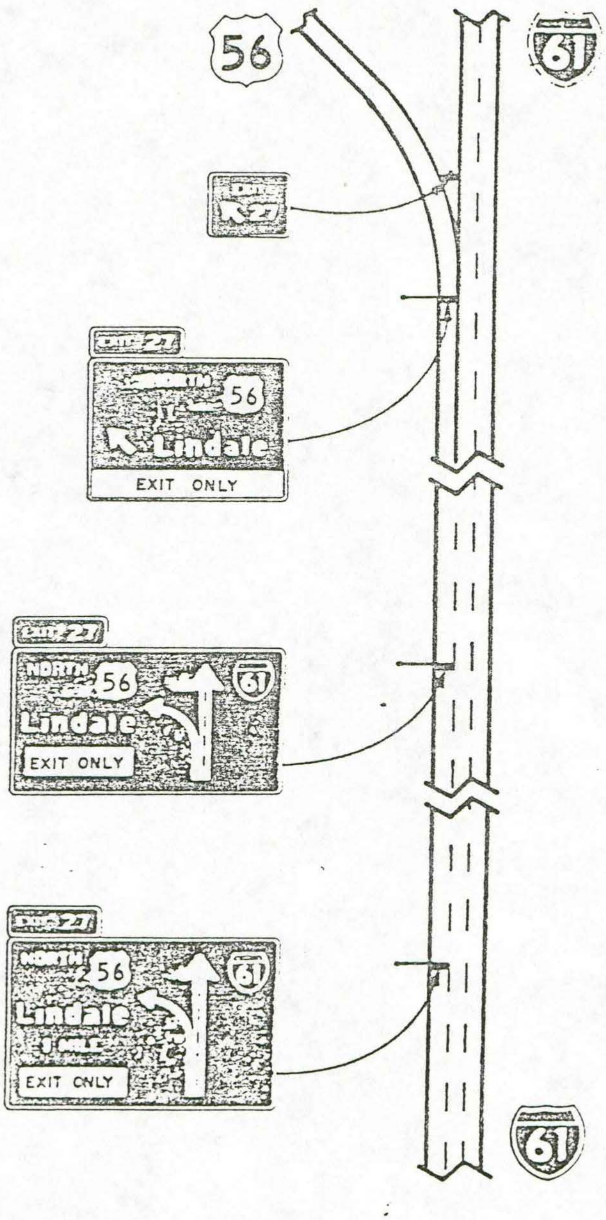


Figure 9.2. Diagrammatic sign for exit only on left-hand interchange land drop

Source: Reference (*2*)

Mechanical

Foldout Signs. The foldout sign is a relatively simple and effective 2-message sign, using a small motor to swing 2 hinged panels across the face of a standard sheet metal sign. This type of sign can display 2 separate messages or may display 1 message with the panels open (blank with the panels folded). The motor rotates these panels 180 deg to change the display.

Since foldout signs are relatively inexpensive, they have been widely used for a variety of information situations throughout the United States (i.e., school zone control, lane control, turn movements, high-water warning, and weigh stations). The major problems with these signs are

Table 9.2. Applications of changeable message and other types of real-time displays

Traffic management and diversion

- Freeway traffic advisory and incident management
- Freeway-to-freeway diversion
- Special events
- Adverse road and weather conditions
- Speed control

Warning of adverse conditions

- Adverse weather and environmental conditions (fog, smog, snow, rain, dust, wind, etc.)
- Adverse road conditions (ice, snow, slippery pavement, high water, etc.)
- High truck loads

Control at crossings

- Bridge control
- Tunnel control
- Mountain pass control
- Weigh station control
- Toll station control

Control during construction and maintenance

- Warnings
- Speed control
- Path control

Special-use lane and roadway control

- Reversible lanes
- Exclusive lanes
- Contraflow lanes
- Restricted roadways

Source: Reference (*10*)

a result of the highway environment and mechanical failures, such as the panels jamming due to severe ice or snow conditions. (See Figure 9.3 for an illustration of a foldout sign.)

Scroll Signs. The predominant face of the scroll sign containing several stored messages, is formed as a continuous belt of flexible material (plastic film), which is mounted on rollers at the sign's ends. The tape or film is then rotated until the desired message is properly positioned in the display window. The signs are designed with belts rotating either vertically or horizontally.

A desirable feature of this sign is that the enclosure is environmentally sealed and protected, plus some models have a standby power source and are manufactured for transportable operation. Two unfavorable characteristics are the limited number of maximum messages (typically 8 to 12) and the amount of time required to change messages which, if excessive, could cause driver confusion.

Rotating Drum Signs. Rotating drum signs generally contain 1 to 4 multifaced rotating drums, with each drum containing 2 to 6 message faces. Each face of a drum has one line of a fixed message formed to the panel. The drums are pivoted on the ends and rotated with a mechanical assembly to change the display. (For examples of this type of CMS installed in Dutch-John, Utah, and Duluth, Minnesota, see Figure 9.4.)

The drum sign's favorable characteristics include simple operation, good visibility, and the ability to operate from a 12-v power source or hand crank. Some unfavorable characteristics include the lack of environmental sealing. limit size on large characters, and on the number of faces on a drum, plus the necessity of replacing the entire fixed message panel to change a line of copy. In addition, mechanical failures can cause the drums to misregister when the limit switches are defective, which sometimes results in misleading information. Recently manufactured drum signs, however, have resolved the environmental problem by enclosing the face with a polycarbonate sheet.

Light Source

Neon Signs. The neon or inert gas sign uses neon tubing to form the legend characters. For variable-message applications, its use is limited to displaying 2 or more messages within the same sign space. Designs can be varied by stacking the neon tubing for each message or by separating each message on the sign face. For a large number of messages, however, the display has numerous layers of tubing which causes the light to reflect through the outermost tubes, thus making messages illegible or significantly enlarging the surface display area. Also, while experience with neon signs has shown that green neon is not acceptable for the highway environment, the New Jersey Turnpike Authority has had considerable success with red neon during all types of weather conditions. Currently, since neon signs have limited message variability, most highway applications of this sign type are customized.

Fiber-Optic Signs. A fiber-optic display disperses light energy from a point light source through fiber bundles that form messages on the sign's face. Signs capable of displaying up to 14 messages have been developed in Europe. Although this type of display has been used predominantly for lane and pedestrian control, some fiber-optic displays have been developed for variable speed limits, weigh stations, inclement weather, and alternate routing applications.

Another example of fiber optics in traffic control is dual-color signal indications for left-turn lane control. Dallas, Texas, has over 100 intersections using fiber optics for this application. This allows a vertical stack of four 12-in. signal heads for overhead installations, with the bottom section providing both a green arrow and a yellow arrow during the change interval.

Lamp Matrix Signs. The display face of the lamp matrix display is formed by an array of incandescent lamps for each message line. Selectively illuminating the lamps in a character module permits the display of various characters. By utilizing a number of adjacent character modules, it is possible to construct various messages. Since each character module can display all letters of the alphabet and digits from 0 to 9, almost any message can be displayed if enough character modules are available. The number of messages available varies with system design. Early highway displays had only a limited number of hardwired messages. Newer display systems, however, which are used with computer equipment, provide considerable message flexibility.

Messages on lamp matrix displays can be shown statically or flashed on and off. Some systems can sequence message phrases and display messages in a run-on manner. The desired contrast of the sign display with ambient lighting is achieved by continuous variable photocell control of the power supply to the lamps. Messages will change almost instantaneously when a new message is selected.

This type of CMS has the advantages of a relatively simple operating principle, high target value, and message flexibility. It has also been environmentally tested with many operational systems. The lamp matrix sign does have several disadvantages in that the display requires continuous power to the sign, has high operating

Table 9.3. Sign control and operation techniques

CMS Sign Installation	Type of CMS Operation	Description	Possible Applications
Permanent	Remote automatic control	Sign messages are displayed and changed automatically by a remote control system when varying adverse environmental roadway or traffic conditions are sensed by detectors; manual-override capability is normally provided.	(a)
	Onsite automatic control	Sign messages are displayed and changed automatically by an onsite control system when varying adverse environmental roadway or traffic conditions are sensed by detectors.	(b)
	Remote manual control	Sign messages, based on varying environmental roadway or traffic conditions, are displayed and changed by sign operators from remote central office location.	(c)
	Onsite manual control	Sign messages, based on varying environmental roadway or traffic conditions, are displayed and changed by an operator using a control panel located at the sign site; in the case of a manually operated foldout sign, the sign is opened to display a message; and in both cases, personnel must travel to the sign site after the need for a message has been determined.	(d)
	Fixed-time automatic control	Sign messages are displayed and changed automatically at preselected times of the day.	(e)
	Fixed-time remote manual control	Sign messages are displayed and changed at preselected times by operators from a remote location.	(f)
	Fixed-time onsite manual control	Sign messages are displayed and changed at preselected times by operators at the sign site.	(f)
Transportable	Changeable message onsite control for unpredictable event	Sign is moved into place when an unpredictable event occurs (e.g., major accident); sign messages are displayed and changed onsite based on varying traffic conditions.	(g)
	Changeable message onsite control for predictable event	Sign is moved into place for a predictable event (e.g., special event, parade, holiday traffic congestion at a tunnel, bridge, etc.); sign messages are displayed and changed onsite, based on varying traffic conditions.	(h)
	Fixed message for unpredictable event	Signs is moved into place when an unpredictable event occurs; only one message is displayed.	(i)
	Fixed message for predictable event	Sign is moved into place for a predictable event; only one message is displayed.	(j)

[a] Traffic management and diversion (traffic advisory and incident management, freeway-to-freeway diversion, special events, adverse road and weather conditions, speed control); warning of adverse conditions (weather, environmental, road); control at crossings (bridge, tunnel, mountain pass); special roadway control (restricted roadways)

[b] Traffic advisory (warning of slow traffic, speed control); warning of adverse conditions (weather, environmental, road, high truck loads); control at crossings (bridge, tunnel, mountain pass); control during construction and maintenance; special roadway control (restricted roadways)

[c] Same as for remote automatic control; also, control at weigh stations and toll stations; control during construction and maintenance

[d] Same as for remote manual control; because of the delays in traveling to the CMS site(s), messages generally are not as timely in comparison with remote control operation

[e] Special-use land and roadway control (reversible, exclusive, and contraflow lanes and restricted roadways)

[f] Same as for fixed-time automatic control

[g] Traffic management and diversion (traffic advisory and incident management, freeway-to-freeway diversion, adverse road and weather conditions)

[h] Traffic management and diversion (special events); control at crossings (bridge, tunnel, mountain pass); control during construction and maintenance

[i] Same as for changeable message onsite control for unpredictable event; displays and messages are not changed to respond to varying traffic conditions

[j] Same as for changeable message onsite control for predictable event; displays and messages are not changed to respond to varying traffic conditions

Source: Reference (*10*)

Table 9.4 Types of changeable-message sign displays

Category	Type
Mechanical	Foldout Scroll Rotating drum
Light source	Neon Fiber optics Lamp matrix
Electromechanical	Electromagnetic disc matrix Electromechanical flap matrix Electrostatic vane matrix

Source: Reference (5)

and maintenance costs, has many auxiliary control systems that require trained personnel, and experiences lamp failures which can make characters or messages confusing.

There are a relatively large number of lamp displays installed throughout the United States. Many of these are used for weigh station, variable speed limit, and lane control applications. The larger, more complex traffic management and information lamp projects include the following locations: Jones Falls Expressway — Baltimore, Maryland; Eisenhower Memorial Tunnel (I-70) — Colorado; I-75 — Cincinnati, Ohio; and Santa Monica Freeway (I-10) — Los Angeles, California. (See Figure 9.5 for an illustration.)

The Los Angeles Area Freeway Surveillance and Control System, in the early 1970s, installed 35 lamp CMS's on a 12-mi stretch of the Santa Monica Freeway between Los Angeles and Santa Monica. Currently, over half of these original signs have been relocated to other freeways at points of major decision, usually in advance of freeway-to-freeway ramps. The initial half-mile spacing of these signs was determined to be too close for effective motorist information. There are approximately 50 permanent CMS's in the greater Los Angeles area including both lamp and disc matrix signs.

Electromechanical

Electromagnetic Disc Matrix Signs. Disc matrix signs are similar to the lamp matrix with the exception that reflective discs rather than incandescent lamps are used to form the legend characters. This type of CMS has recently received widespread use in many highway CMS projects because of its projected lower operating and maintenance costs.

Most disc matrix signs utilize a 2-position, flip-disc technique. Usually the message lines consist of 20 variable-matrix modules, each with 35 individual flip discs that have a reflective yellow coating on one side and a flat black coating on the other side. Illumination of the sign face is provided by exterior lighting. A close-up of this module and the discs is shown in Figure 9.6.

Some new signs of this type utilize a 3-position, flip-disc technology to display messages with or without available sunlight. The reflective discs which are made of mylar plastic, have a small permanent magnet affixed to one side. Images and characters are formed on the display by rotating designated discs to the appropriate position. One side of the disc has a flat-black finish to blend with the background of the display face. If this side is revealed, the disc is not visible at normal viewing distances. The opposite side of the disc, however, is a bright fluorescent yellow. When this side of the disc is exposed to sunlight, it is highly visible and becomes an element of the character being formed. During nighttime and other low-light periods, the discs are rotated to a third, horizontal position. When in this horizontal position, the light from a common source located behind the disc modules passes through the display face to form the light points.

The disc matrix sign has the advantages of total message or display flexibility, low power consumption, and low

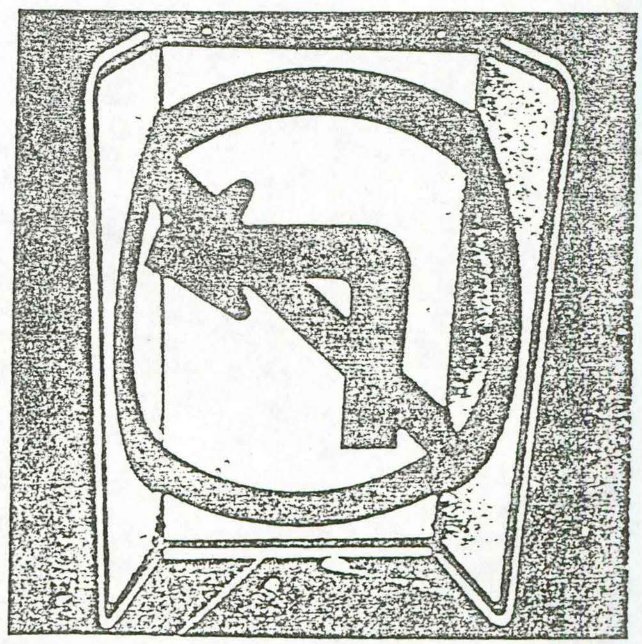
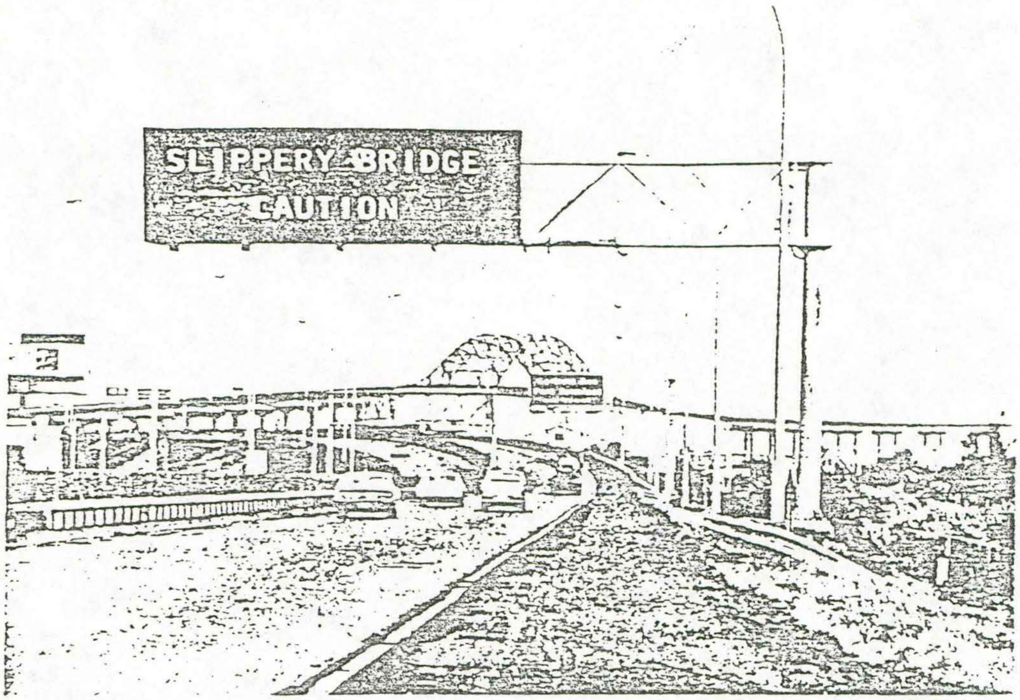


Figure 9.3. Foldout sign

Source: Reference (23)



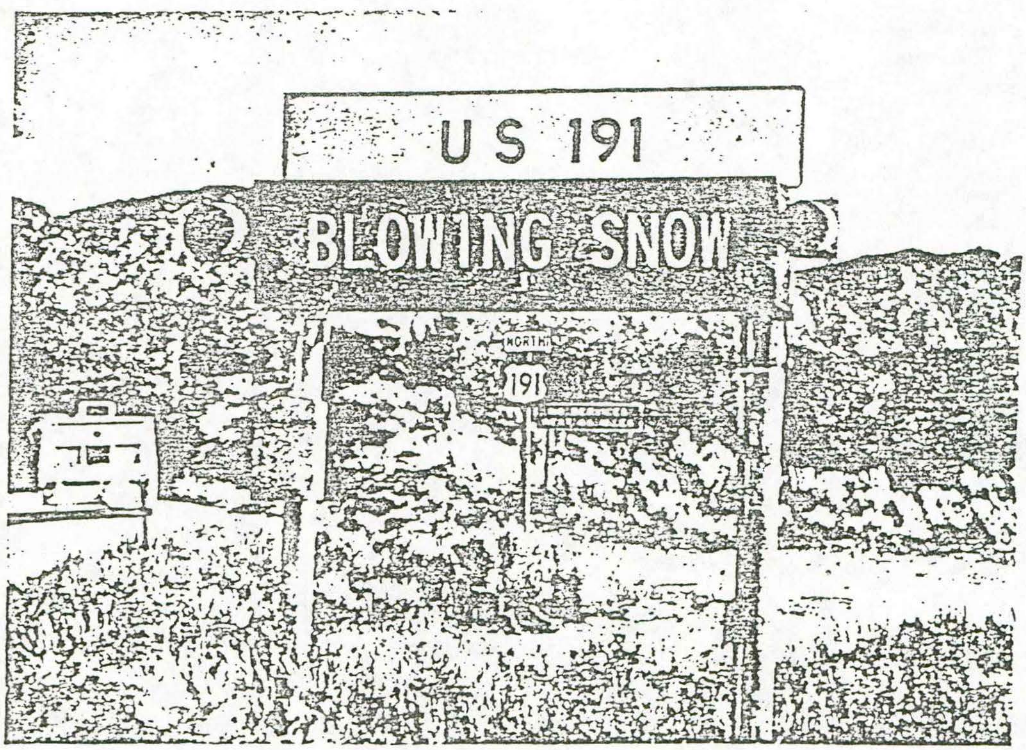


Figure 9.4. Examples of rotating drum signs. Duluth (Minnesota), top; Dutch-John (Utah), bottom

maintenance, while a sealed enclosure provides environmental protection. Favorable user comments cite the advantages of good message clarity under most light conditions, including no washout problem during intense sunlight. Disc signs, however, must be illuminated for nighttime use. This type of CMS also has reduced legibility distance, and loses visual impact on cloudy or overcast days. This method of message writing also could be considered a disadvantage compared with the lamp matrix's instantaneous message change capability. Since portions of the new and old messages are displayed concurrently while the new message is written, some confusion can occur. Even though messages cannot be flashed, some pictorial animation or simulated flashing is possible.

Several documented highway applications using disc signs include the following: Grand Rapids, Michigan; Tampa, Florida; Washington; Denver, Colorado; and Baltimore, Maryland. The Integrated Motorist Information System (IMIS) covering three major expressways in Long Island, New York, plans to install 74 signs of this type for advisory and diversionary information to motorists in order to minimize congestion and offer alternative routes. (For an example of a disc matrix sign, see Figure 9.7.)

Electromechanical Flap Matrix Signs. The message portion of the flap matrix sign is formed by an array of electromechanically actuated flaps, arranged on 5-in. by 7-in. matrix modules spaced a fixed distance apart. Typically, one side of each flap is black to match the sign background, with the other side usually white to display a white-on-black color combination. A reversible motor rotates the flaps 180 deg to form the legend characters. Exact shape presentation or display of lower case lettering types is not possible.

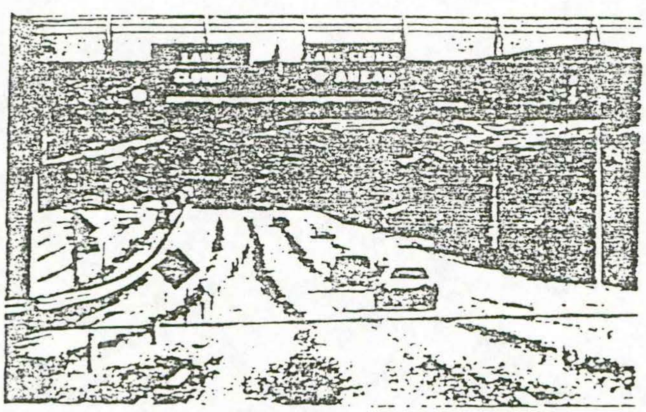


Figure 9.5. Lamp matrix sign

Source: Reference (25)

Messages are changed by inscribing the new message from left to right on each line in sequence. During a message change, parts of the new and old messages are visible since at least 2 sec are required to change one line of average length on a sign. Up to 10 sec are required to change the entire message.

Since surveys (*8*) have been reported on only one known highway installation on King Avenue Overpass in Baltimore, Maryland, it appears that only limited experience has been gained in using the electromechanical flap matrix sign.

Tri-Color Signs. The viewing face is formed by a matrix of 2½-in. square rotating 3-sided elements. The elements reveal one of 3 colors (e.g., white, black, and fluorescent yellow); thus, several color combinations of letters and backgrounds can be displayed. The element itself is electromagnetic. Surrounding the armature contained in the element is a cylindrical 3-pole permanent magnet which rotates to orient to an armature coil. When energized, it is magnetically detented after the power is removed. A typical freeway overhead sign may contain 2,430 elements. See Figure 9.8 for an example of a Tri-Color sign element.

Currently, this type of sign is the only CMS manufactured that can display both regulatory and warning messages with the proper color combination. Messages on this sign are normally statically displayed. Font size can be changed to range from 4-in. to 6-in. wide and 5-in. to 9-in. high. External lighting is required for night visibility.

9.5 TRANSPORTABLE SIGNS

In some situations, when permanent CMS's are not available on the highway to be controlled, it may be desirable to use transportable signs to display real-time information. Transportable capabilities allow the highway agency to move the CMS into place prior to predictable events (e.g., special events), or to manage traffic when unpredictable major incidents occur. It should be

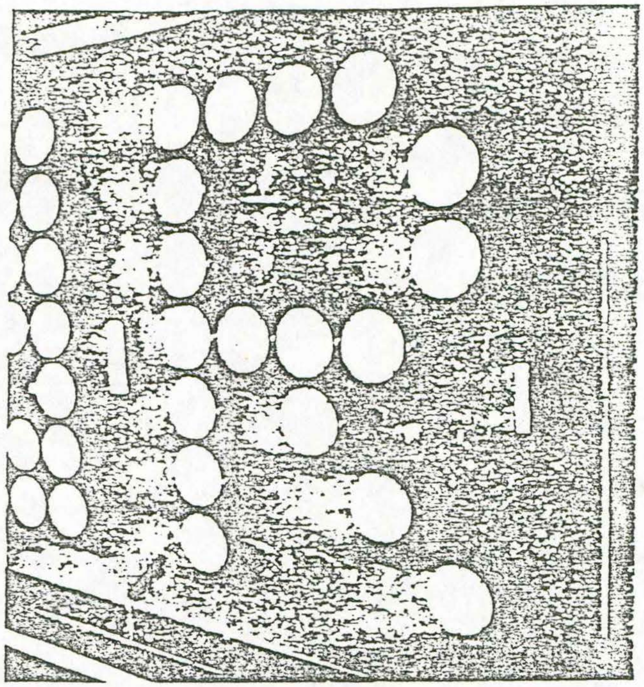


Figure 9.6. Closeup of 2-position disc matrix sign module

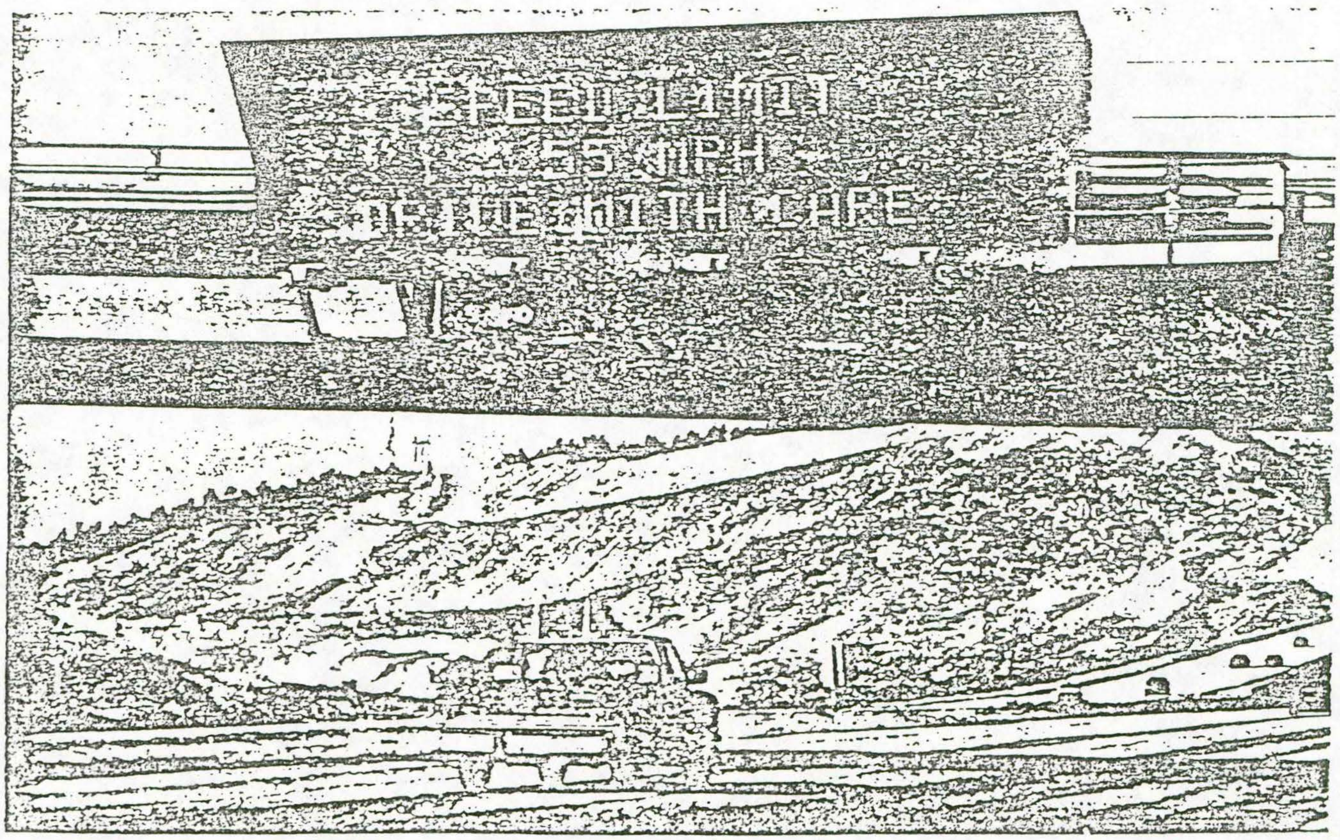


Figure 9.7. Disc matrix sign, I-70 West, Denver (Colorado)

recognized that, in the latter case, the delay in displaying a message following an accident may at times be considerable because of the travel time to the site needed by service personnel.

Transportable signs include the following three types:

- Truck- or trailer-mounted signs
- Pickup signs (leg-supported signs that can be placed in a truck or trailer, hauled to a site, and set out on the roadside)
- Ground-mounted, with removable, transportable message panels

Examples of the truck-mounted signs used in response to major incidents are the Caltrans major incident response units shown in Figure 9.9. The message inserts are signs mounted on a rigid-frame support. A library of message inserts is stored on each truck, and messages are displayed in various combinations as directed by the situation. Lamp-matrix CMS's mounted on the back of pickup trucks are also used by the response team to manage traffic during incident or special events conditions. This sign has the same capabilities as a permanent lamp sign and can be moved to any location. This type

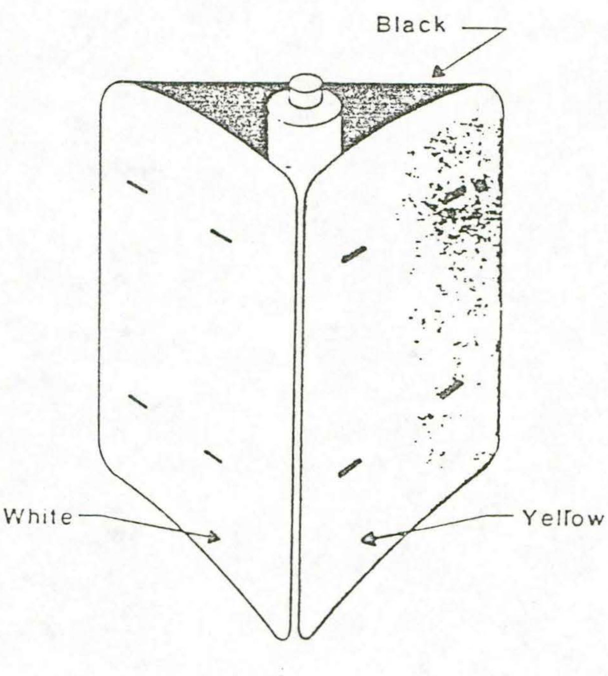


Figure 9.8. Tri-Color sign element

Source: Reference (23)

of truck or trailer-mounted sign may have limitations with respect to response time, size, and power requirements; it is best suited to predictable events. The Caltrans response team is on call at all times, thus reducing response time to a minimum. Transportable CMS's have proven superior to fixed CMS locations for end of queue management because of mobility (*18*).

9.6 HIGHWAY ADVISORY RADIO (HAR)

The Highway Advisory Radio (HAR) is a means of providing highway and traffic-related messages to the driver using his existing AM radio receiver. Typically, the service is provided at either end (i.e., 530 and 1610 kHz) of the AM band. HAR locations are restricted because either commercial stations broadcasting on frequencies too close to HAR's, or the Travelers Information Station broadcasters (National Park Service, Forest Service, Airports, Coast Guard, etc.) who use the same HAR frequencies are nearby. Use of these frequencies can be authorized by the Federal Communication Commission (FCC) on a developmental license or under FCC Rules and Regulations, Part 15, without a license which permits low power communication devices. At best, however, Part 15 systems provide marginal coverage and are not likely to prove satisfactory for most traffic control and advisory applications (*19*).

A HAR broadcast system consists of a low-powered AM transmitter which is matched to either an induction cable antenna or vertical monopole antenna (see Figure 9.10) and is modulated with a solid state voice storage unit. Typically, the AM transmitter is connected to the voice storage unit via leased telephone lines. Generally, the monopole antenna has been used in most existing installations. The cable antenna has been rarely used because of the high cost of installation.

Vertical Antenna HAR Systems

A single whip antenna may be used or several antennas can be spaced along the highway and electronically interconnected. Each antenna radiates a signal in all directions, thus forming a circular transmission zone. Some of the primary advantages and disadvantages of the whip antenna are as follows (*7*):

- It is physically small and can be installed in a relatively small space.
- It is relatively easy to install. It can be installed in a short time in various environments over earth or pavement, on a building tower, etc.

- It can be easily relocated.
- It will usually be visible, but can be partially camouflaged.
- It can be placed several hundred feet from the highway.
- It is subject to damage by weather, accident, or vandalism.
- It requires a matching network (or series inductance) that is efficient, stable, reliable, and easily tunable.
- It provides a circular zone of coverage that may interfere with other coverage zones on adjacent highways.
- It will usually be less costly to purchase and install than a cable antenna.

Induction Cable Antenna HAR Systems

The second method of broadcast utilizes a roadside cable instead of conventional vertical antennas. The radio signals are "narrow cast" by directional induction radio transmission and can thus be confined to the width of a multilaned highway.

One of the characteristics of the cable antenna is that a strong, but highly localized induction-type radio signal can be produced within a short lateral distance of 100 to 150 ft from the cable. This is sufficient to produce a good signal for the width of a multilane highway while restricting the field. At a distance of several hundred ft from the cable, the field is below the effective response value of typical automobile receivers. This results in a relatively high degree of efficiency in the use of the radio spectrum for roadway communications, as the same carrier frequency may be utilized without interference on several highways in one area. Another feature is that the system can be designed such that different messages can be broadcast over two separate frequencies on the same cable. Thus, messages could be individualized by direction of travel.

Several advantages and disadvantages relative to the use of cable antennas are as follows:

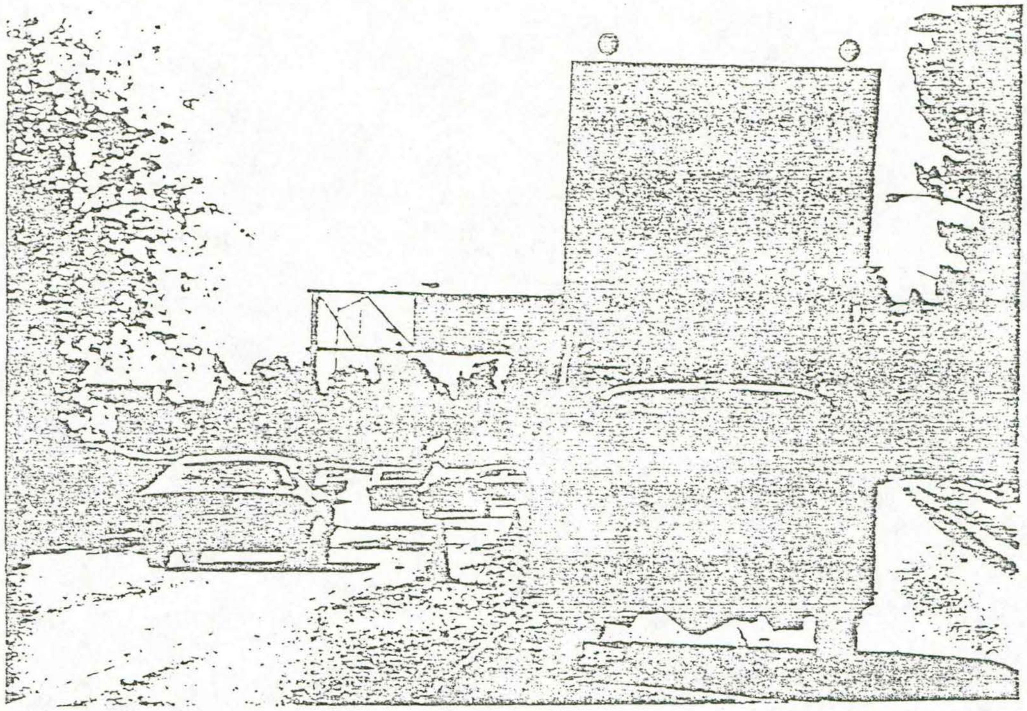
- It must physically extend the full length of the coverage zone.
- It can provide continuous coverage through tunnels, in buildings, under overpasses, etc.
- It may be placed above or below ground.
- If installed below ground, it is not subject to damage by weather or vandalism.
- If buried, it is more costly to purchase, install, and relocate; however, it can be made virtually invisible.
- It is not easily installed in some areas already built up with concrete pavement and highway structures, such as through a highway interchange or intersection.
- The cable antenna is easily connected electrically and requires no matching network or tuning adjustment.
- The radiation zone is confined to within 100 ft or less from the cable, and thus minimizes interference with nearby coverage zones.
- It must be placed close to the highway.
- The radiation is stable with temperature and weather and is relatively unaffected by the type of soil if buried.

HAR Experience

Certain shortcomings exist with the present HAR system. In developing a system which utilizes AM receivers, various compromises have had to be accepted. For example, the motorist is required to tune to the HAR broadcast manually, and the reception zone of the broadcast is directly related to the out-of-band tuning of the receiver. In addition, the broadcast is not received by all AM receivers. However, the benefits outweigh some of these problems since HAR can be used effectively to provide real-time traffic information relative to traffic congestion, construction, and maintenance operations, as well as information on specific highway environmental conditions.

Outlined below are some of the experiences obtained from HAR users as presented by Mammano in a report by the California Institute of Transportation Studies (*11*):

- Over 75 percent of the commercially available AM automotive radios will tune to 530 kHz; only 50 percent will tune to 1610 kHz.
- Many local authorities do not provide adequate documentation in applying to the FCC for Travelers Information System (TIS) authorizations. Hence, some licenses are granted in 2 months while others take over 6 months.
- One of the accepted types of transmitters requires an in-line amplifier to fully modulate the AM carrier from the leased telephone line.
- Most vertical monopole antennas require an RF impedance bridge for optimal tuning.
- One of the advance visual signs for an HAR system should indicate if the system is in operation (ON/OFF).



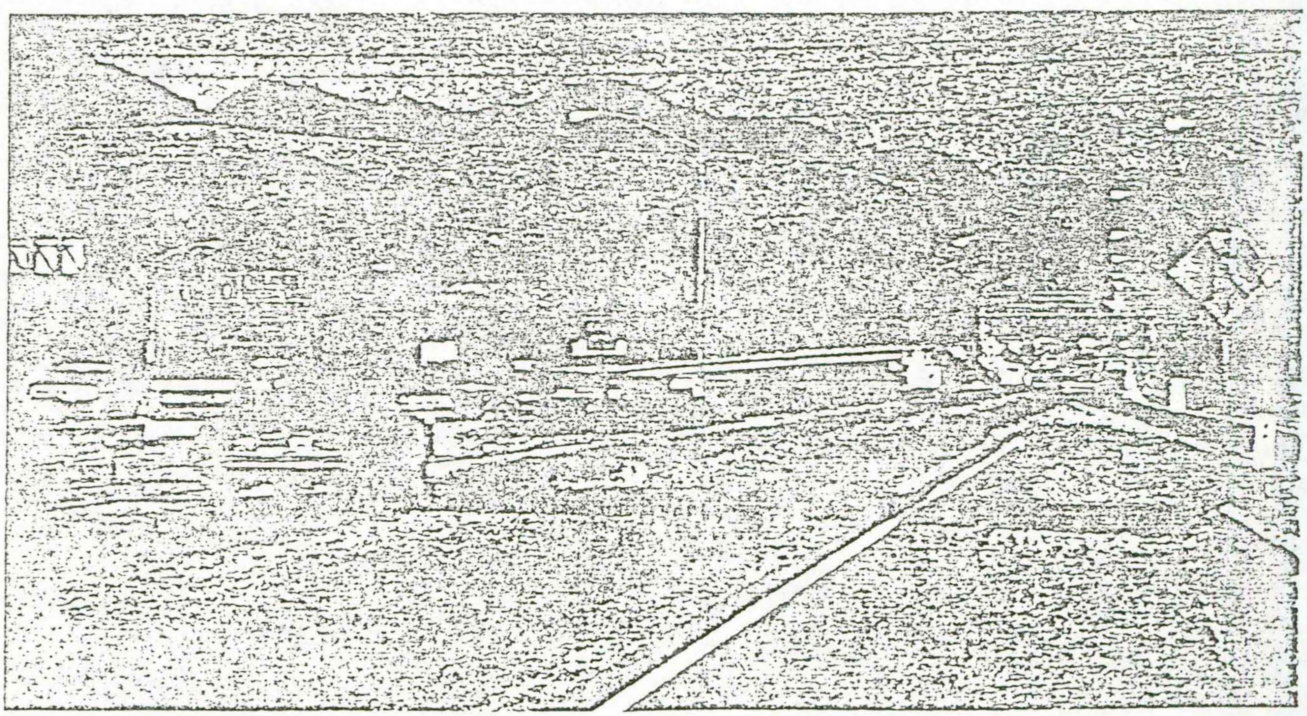
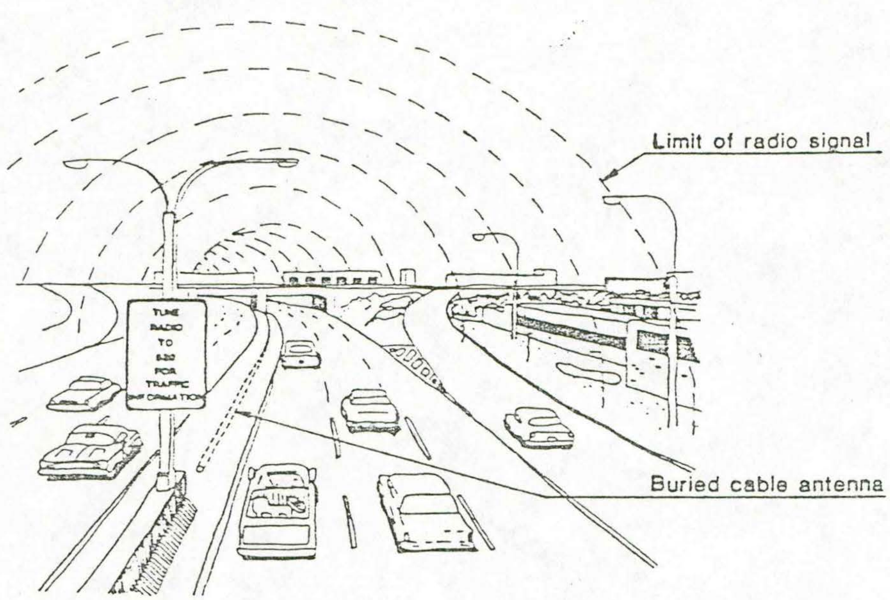
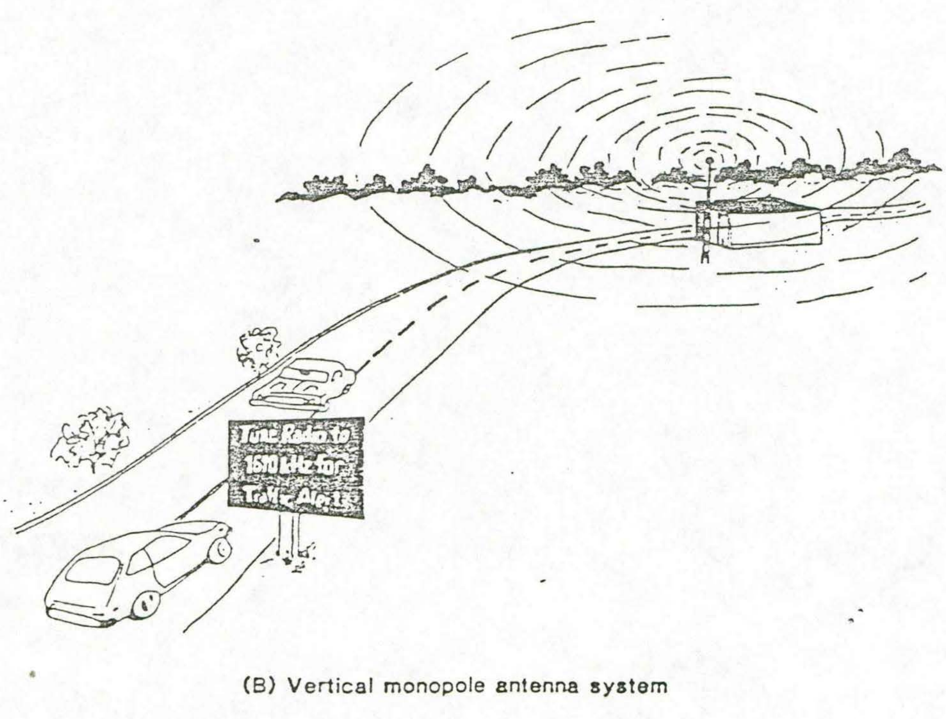


Figure 9.9. Examples of transportable CMS's used for major incident response



(A) Cable antenna system



(B) Vertical monopole antenna system

Figure 9.10. Typical highway advisory radio (HAR) antennas

Source: Reference (*11*)

- HAR systems should use either two pairs of leased lines (one to modulate the transmitter and the other to monitor the broadcast), or a sensitive receiver to monitor the roadway's broadcast.
- Sufficient roadway surveillance is required to assure that timely and credible information is being broadcast.

Examples of Existing Systems. Operational or experimental audio systems have been installed at the following locations:

- Los Angeles International Airport
- Houston Intercontinental Airport
- Colorado (Colorado Division of Highways, District 1)
- Philadelphia (Delaware Valley Regional Planning Commission)
- Minneapolis (Minnesota Department of Highways)
- Beaumont (Texas Department of Highways and Public Transportation)
- Wyoming (Wyoming State Highway Department)
- Washington (Washington Department of Transportation)
- Chicago (Illinois Department of Transportation — 5 systems)
- Yellowstone National Park
- Disneyworld

The remainder of this section describes some of the above systems to illustrate the practice in some states. A list of HAR users as of 1980 can be found in Reference (*20*).

A good example of a low-power radio broadcasting system utilized to provide driver information is that owned by the Los Angeles Airport Authority. This system consists of a buried-cable AM radio system with broadcasts transmitted via 530 kHz. Signs on I-405 in advance of airport exits advise motorists to tune to the station for airport information. The objective of the system is to minimize the number of circuitous trips around the terminal loop, a situation which creates severe traffic congestion. Basic messages guide motorists to terminal parking and to specific terminals. Over a mile is buried under Century Avenue, another mile is buried along Sepulveda Boulevard, and over 2 mi are buried along I-405 on the approaches to the terminal loop road. Prerecorded tapes are selected and played depending upon roadway and parking conditions. Information to the central control room is supplied by a closed circuit television camera and parking lot attendants. The messages range in length from 20 to 120 sec.

Another functional system is employed at the Houston Intercontinental Airport to provide information concerning parking conditions. The system output is low-power and uses tape cartridge broadcasts. Depending upon various parking conditions, designated tapes are initiated. Transmission is made using single-dipole, circular radiation antennas. Two antennas are used in the system to provide a broadcast zone of approximately 6.0 mi with the present configuration. The transmitter and antennas are connected in circuit using existing phone line. With the low-power output, broadcasts may be conducted on any frequency between 530 and 1610 kHz. However, broadcasts are made on 1100 kHz without interference from local commercial broadcasts.

In Colorado, motorists approaching the Eisenhower Tunnel on I-70 may tune their radios to 1610 kHz and receive advisory information concerning tunnel conditions, road surface conditions (approaching the tunnel and at Loveland and Berthoud Pass), traffic conditions and alternate routing if necessary. The information is gathered at the tunnel control center and appropriate messages are taped and played back over telephone lines to transmitters located at Dumont on the east and Dillon on the west side. These HAR systems operate with an FCC experimental radio license. Both transmitters broadcast on 1610 kHz with up to 10 watts of RF power into above ground monopole antennas.

In 1975, the Delaware Valley Regional Planning Commission (DVRPC) started operating a HAR system on the Walt Whitman Bridge in Philadelphia. The system informs inbound motorists from 6:30 a.m. to 9:00 a.m. of free parking to encourage the use of mass transit, reduced toll rates for carpools, and traffic conditions on the Schuykill Expressway (I-676), the main arterial to the CBD. This HAR system contains 6,000 ft of cable antenna that was suspended on the bridge, a 10-w AM transmitter, and a telephone-line interconnected tape deck. It operates on 530 kHz with an FCC experimental radio station license. Five additional HAR systems were installed in July, 1976. Each operates at 530 kHz within FCC Rules and Regulations, Part 15. Each system contains a low-power AM Transmitter and 9,000 ft of buried cable antenna.

The Minnesota Department of Highways installed a HAR system on I-35W in Minneapolis as part of an extensive surveillance and control system. The system contains 1 mi of cable antenna, a 10-watt AM transmitter, and a tape deck with a telephone interconnect. The transmitter operates at 530 kHz with an FCC experimental radio station license.

From the experience gained from existing HAR installations the FHWA has developed guidelines for the use of this system (i.e., User's Guide, Design Guidelines, and Executive Summary). Also a *Highway Advisory Radio Message Development Guide* has been recently developed to help station operators prepare HAR messages.

Automatic Highway Advisory Radio (AHAR)

A prototype of an Automatic Highway Advisory Radio (AHAR) has been developed for testing and evaluation. The AHAR system uses roadside transmitters and in-vehicle receivers to provide motorists automatically with noncommercial information pertaining to traffic, road and weather conditions, travel advisories, and general tourist information. The motorist can preselect the class of information to be received (i.e., traffic advisory or trip information). The AHAR system also has an overriding emergency information feature. This new technique should improve the motorists' attention to the driving process and, thus, improve safety by relieving them from having to search for the message they need. In addition, not having to listen to a number of irrelevant messages should assist in message retention.

The concept of AHAR is illustrated in Figure 9.11 (*21*). Figure 9.11(a) shows the basic components that make up the system. Figure 9.11(b) shows the arrangement of the system along a highway. A vehicle moving from right to left first enters the enable receive zone. This transmitter continuously transmits an enable code consisting of a single dual-tone multiple-frequency (CTMF) digit. The scan zone represents a time allowance for a scanning receiver to locate the frequency. The width of the enable receiver zone need only be sufficient for the receiver, after locking on, to receive the enabling code. Once enabled, the vehicular receive stops scanning and waits for the message. The message is received after the vehicle enters the message receive zone. Width of the message receive zone should be about 3 mi for the real-time analog approach. This will permit a vehicle moving at 60 mph to receive an uninterrupted 60-sec message at least twice from beginning to end.

A pilot demonstration of a AHAR system has been completed in Tampa/St. Petersburg, Florida. The AHAR transmitter provided messages of traffic conditions on the Howard Frankland Bridge, giving the participating motorist the alternative of using a diversion route when traffic conditions warranted. Conclusions from the demonstration project include the following (*21*):

- The AHAR concept has merit. Timely traffic information provided at locations where motorists are able to make a choice of alternate routes can influence their decision-making process. Participants indicated that about 42 percent of the messages received influenced their choices of routes.
- Unless the cost of a mass produced in-vehicle receiver can be reduced to $100 or less (1983 prices), or incorporated into a standard automobile broadcast receiver at a reasonable cost, widespread acceptance by motorists is not likely.

9.7 MOTORIST AID SYSTEMS

Motorist aid systems can be classified as follows:

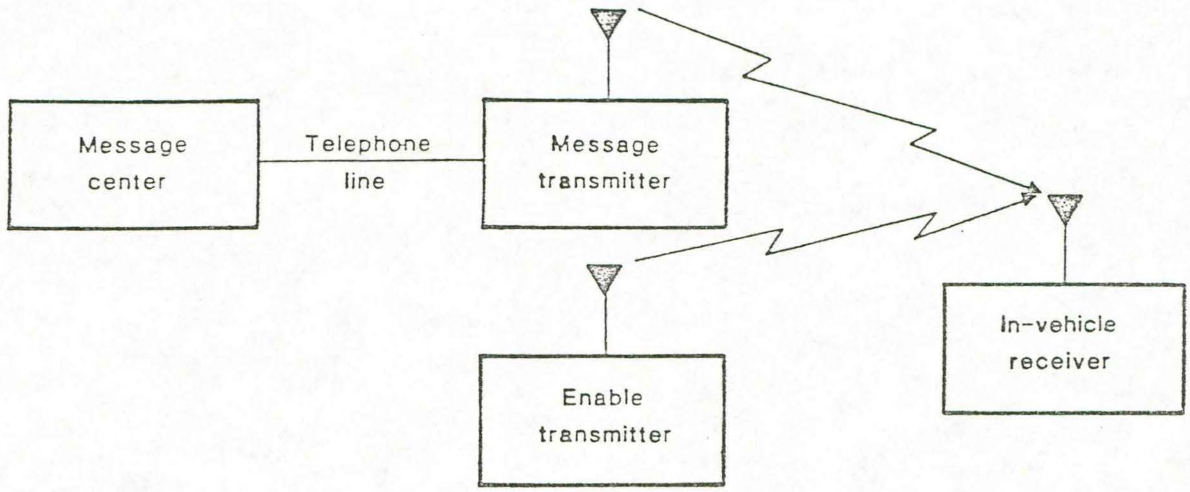
- Call box and emergency telephones
  - Coded pushbutton call-box
  - Two-way voice
  - Commercial telephone
- In-vehicle communications
  - CB radio
  - Commercial automobile telephone
- Patrols
  - Police/highway
  - Courtesy (private or public)

Call Box and Emergency Telephone Systems

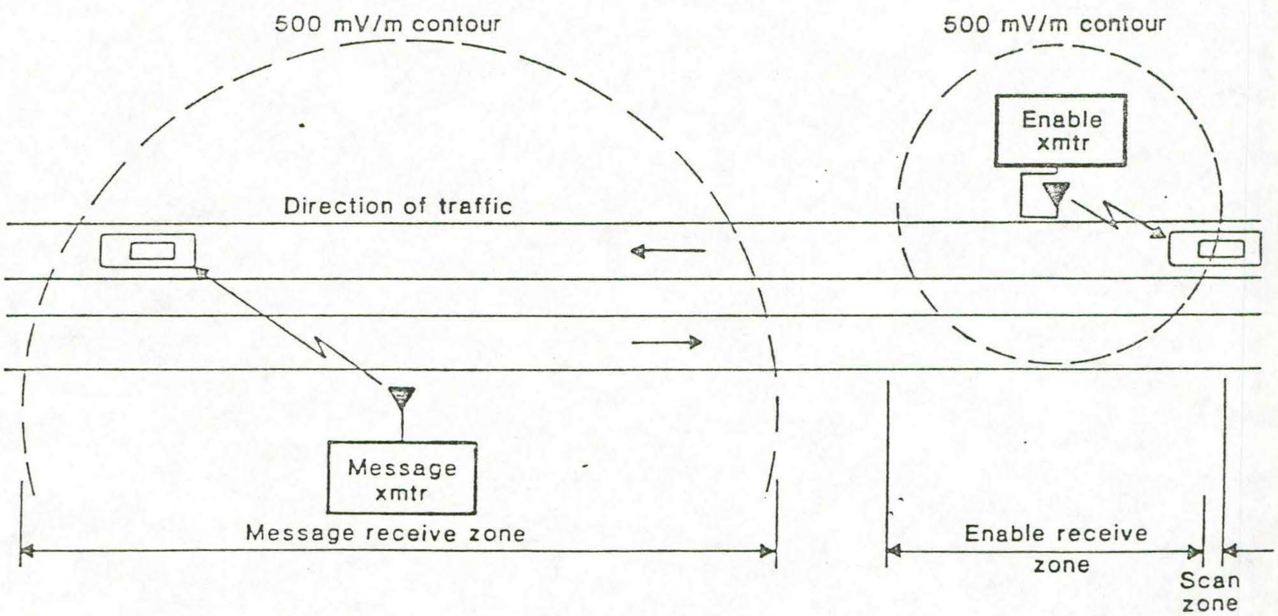
One of the earliest incident-detection systems used motorist call boxes or emergency telephones. The approximately 50 emergency telephone systems which have been installed in the United States to provide the motorist with a means of summoning aid have been shown to be valuable. Motorists experiencing, or witnessing, an incident have used the nearest call box or telephone to inform the operating agency of the nature of the incident. Telephones are generally preferred because voice communication gives the motorist an opportunity to explain exactly what services are required. However, the call box with coded message buttons is less costly (20 to 25 percent) than a telephone requiring voice transmission.

The major advantage of a motorist call system is that it is an efficient system for signaling a motorist's need for service. A major disadvantage is the delay associated with the motorist determining that an incident has occurred, recognizing that the proper action involves using the call box, locating the nearest call box, and then proceeding safely to the call box to inform the operating agency. Two disadvantages are that delay can be quite significant, and, also, that these systems are susceptible to vandalism and false alarms.

Mammano (*17*) conducted a survey of call boxes and emergency telephones in 1982, and identified 34 operating systems of this type. The 34 operating systems were found in 20 states and represented a reduction of 15 systems since 1976. The principal reasons for reduction are vandalism and high operating and maintenance costs. Five states — Florida, Rhode Island, Michigan,



(A) AHAR system components



(B) Transmitter placement

Figure 9.11. Automatic highway advisory radio (AHAR)

Source: Reference (*11*)

Connecticut, and Louisiana — have installed systems in the last 6 years.

However, some freeway operating agencies indicate that this type of motorist aid system is the best public relations device in the system. An example is in Detroit, Michigan, where the Surveillance Control and Driver Information (SCANDI) has been installed. (For some illustrations of emergency call boxes and telephones, see Figures 4.25 and 4.26.)

9.8 CITIZEN BAND (CB) RADIO

The need for a positive response that is less expensive and safer than the telephone system has led the FHWA to research in-vehicular, 2-way motorist-aid systems. These systems would allow motorists to remain in their vehicles and use their citizen band (CB) radios to render aid.

Requests for assistance are broadcast over Channel 9, which was designated as an official emergency channel by the FCC in 1970. Since then, several national volunteer citizen groups (i.e., REACT and ALERT) have been organized to provide motorist assistance by monitoring at mobile and fixed stations that interface with public safety agencies dispatching the service required. Depending on the geographic characteristics of the area, calls transmitted on this band may be effective for distances up to 20 mi (*11*).

The National Highway Traffic Safety Administration sponsors the National Emergency Aid Radio (NEAR) to develop CB system improvements and promote the use of CB radio in emergency situations. This national organization has over 30 states actively participating in the NEAR program. The evaluation of this program clearly indicates the value of a 2-way, in-vehicular radio and the need for a fully organized, well-structured communication system for this method of motorist aid to be successful. State and private organizations are attempting to provide the systems, while the NEAR program provides the structure required.

Some state agencies and private groups are actively pursuing CB motorist-aid programs by the following methods:

- Organizing volunteer groups to monitor more stations to provide an intense local area coverage
- Using the CB as an input for a wide-area motorist information system
- Involving state law enforcement agencies
- Extending the effective transmission range of CB through equipment enhancement (i.e., BEAR and CB/Aids systems)

(See Table 9.5 for a summary of the characteristics of CB motorist-aid applications.)

Broad Emergency Assistance Radio (BEAR) System

The Michigan Broad Emergency Assistance Radio (BEAR) system, developed by the state, uses the CB radio to assist motorists. The system consists of 10 remote (relay) stations along a 139-mi section of I-96 between Detroit and Grand Rapids, Michigan. (See Figure 4.27) The unattended remote stations are linked by dedicated leased telephone lines to the Michigan State Police in East Lansing.

Following a shutdown of the system in 1982 because of a lack of operating funds, the state police initiated a program to have volunteers operate the system from the state police barracks in East Lansing. Volunteers are made up of senior citizens, criminology students from the University of Michigan, welfare personnel, and other volunteers.

The BEAR system requires that the dispatcher (volunteer) monitor a display board to which all 10 remote stations are connected. The remote stations have a tone-squelching technique, allowing the motorist with the strongest signal to access the system. Once the motorist has made contact with the police monitor, the monitor advises the motorist to stand by while the monitor turns to Channel 19 to listen and then call to verify that a motorist needs assistance. Upon confirming the distress call, the monitor returns to Channel 9 and talks with the distressed motorist or acknowledges the contribution of the good samaritan caller — the motorist who reported a vehicle needing assistance. Once verified, assistance instructions are then sent from the dispatcher to 1 in 5 individual state police posts by means of police radio, telephone, or teletype.

The system operates 24 hr/day, 7 days/week. All calls received over the system have to be monitored, which places a burden on the operating staff for this coverage. At present, volunteer groups handle approximately 30 percent of the calls on the system. This cooperation with the State Police has worked quite well. Based on an expected 10-yr system life, the cost per call is currently $27.37 (*15*).

Citizen Band Automatic Interconnect Digital System (CB/Aids)

The FHWA has initiated a study to determine the technical feasibility of an automatic telephone interconnect device which could be used with a CB radio link for motorist emergencies and assistance. A pilot program has been established in DeKalb County, Georgia, approximately 10 mi northeast of Atlanta.

The basic concept of this system (see Figure 9.12) is that motorists can establish communications from their vehicles to a monitoring system through an automatic radio-to-telephone connection. To make a connection, the motorist would use a digital adapter attached to the CB radio (see Figure 9.13). Two pushbuttons on the digital adapter make it possible to select either an "emergency" (E) or "assistance" (A) monitor. By pressing the appropriate button and then keying the microphone, the motorist transmits a short burst of data, including the motorist's identification number and the E or A call identification. The decoding circuitry on a CB-base-station transceiver, at an unattended remote station, receives and stores the data. After verifying the data, the circuitry then automatically dials either the emergency monitoring telephone number or the assistance-monitoring telephone number. The audible telephone touch tone codes are then transmitted to let the motorist know that the call is being placed. The remote station monitor communicates directly with the motorist using standard radio procedure. After determining the response required and ensuring that the request is processed, the monitor terminates the call. The system automatically resets to receive the next call. One feature to reduce emergency-response time allows volunteer groups to answer assistance calls, thus freeing the police to respond only to emergency calls.

An example of an automatic CB system is the Chicago Area Surveillance Project (CASP). In the CASP system, CB radios are used as an adjunct to their automatic incident detection capability. When an incident alarm is generated by the automatic system, the nearest roadside CB unit is selected and monitored by the system operation to determine the extent of the incident. There are 5 CB units on the Eisenhower Expressway. The System covers approximately 15 mi. The CB units are spaced approximately 3 mi apart. Although there are no formal evaluation data available, system personnel indicate a very positive attitude on the usefulness of CB monitoring.Plans to expand the coverage for approximately 100 mi of the freeway system are under way.

New York is planning to install a CB system similar to the one in Chicago. This CB system will be a part of the

Table 9.5. Characteristics of various citizenband (CB) radio motorist aid applications

CB Motorist Aid Applications	Communications 1-way	Communications 2-way	Coverage Time (Hr)	Coverage Area	Response Time	False Alarm Rate	Communication Coordination	Motorist Confidence	Special Features
Volunteer monitoring		X	24	Limited	Fair	Average	Limited	Fair	Good samaritan, mobile, and/or base operation
Control center operations[b]	X	X	24	Broad	Good	Low	Excellent	Good	Radio station broadcasting, CCTV, speed-call telephone, UHF-FM
Police monitoring		X	24	Broad	Excellent	Low	Excellent	Excellent	Security, assurance, good samaritan
BEAR	X	X[c]	24	Broad	Good	Low	Excellent	Good	Extended geographical coverage, good samaritan
CB Aid System	X	X	24	Broad	Excellent	Very Low	Excellent	Excellent	Automatic identification, extended geographical coverage, digital signaling, priority messaging, good samaritan

[a]Ratings are relative to each other.
[b]These could include listening post systems
[c]The distressed motorist may not have 2-way communication if a good samaritan places the call

Source: Reference (*14*)

IMIS for the Long Island Expressway and Grand Central/Northern State Parkway, totaling 75 mi with about 25 roadside CB station units, spaced at 3-mi intervals. Communications requirements are 2 wire pairs for each unit. One pair for addressing the roadside units and the other for returning the voice transmission. A remote power turn-on capability can be incorporated without any additional pairs. On-duty IMIS operators will also be assigned to monitor the CB system.

9.9 COMMERCIAL RADIOS

Commercial radio has significant potential for becoming an important element of a driver information system. It has wide-area coverage and the opportunity of reaching a large segment of the motoring public. Major disadvantages of commercial radio include delayed and inaccurate messages to the motorists. Dudek and Carvell (*16*) have indicated the following 6 typical sources of information on traffic conditions that are utilized by commercial radio stations:

- Police hot-line — News information service is made available to radio stations by police departments.
- Police radio — Many stations monitor police radio frequencies to obtain news information.
- Mobile news vehicle — Radio stations may have mobile news vehicles with two-way radios.
- Traffic spotters — Broadcasters are located on top of a tall building from which several major routes can be observed.
- Aerial observer — Airborne observer also has broadcast ability.
- Police officer in studio — Off-duty police officer in the station utilizes his experience and police information service.

All of the previously mentioned techniques for obtaining traffic information could be improved. It is obvious that if commercial radio is to be an effective driver information tool, then considerable cooperation between commercial stations and operating agencies is necessary.

Two successful generations utilizing several of the above information sources are the Michigan Emergency Patrol (MEP) in Detroit, Michigan, and the SHADOW Network, Inc., in Chicago, New York, and Philadelphia. The SHADOW Network, Inc., a private organization, uses airplanes, helicopters, radio-equipped mobile units, high-powered telescopes, and "SHADOW boxes" (CB receivers at listening posts) to report traffic conditions. The information goes directly to a SHADOW studio. Direct voice reports from the drivers and pilots are available to subscriber radio stations. This information can be provided on a teleprinter, and then be broadcast at regular intervals on various radio stations, or be broadcast live in an emergency. The reports are transmitted at times specified by the subscriber stations and, according to the contract, information must be aired within 4 min.

The MEP is a volunteer organization that operates a base station from a building in central Detroit and communicates with CB mobiles throughout most of the Detroit metropolitan area. Support is provided by several local broadcast stations. In return, the MEP provides traffic bulletins to the commercial radio stations.

Another method for providing information to motorists is rebroadcasting to override the AM band in tunnels when traffic advisory information is required. Systems of this type operate in various tunnels in Fort Lauderdale, Florida, and Maryland (Harbor Tunnel). A prototype system which has been operating in New York (Holland Tunnel) is being enhanced with this override capability.

9.10 CELLULAR MOBILE PHONE SYSTEM

This is another system with potential use for driver information. If a transportation management center is available, then the public can be given a phone number to call if they desire information or to report on traffic conditions. With this approach, the mobile phone serves as a pretrip or alternate route planning device.

Many companies and organizations have developed and are now implementing this high-capacity mobile phone system. The system utilizes a dialed connection between mobile units and the national telephone network to provide a full-service telephone within the vehicle. The service areas are divided into an array of small cells with a radius from one to several miles. Each cell serves a limited number of users on the assigned frequency. By using low-power equipment, the small cell design allows the radio frequency used within one cell to be reused in other cells within the same city, provided the calls are far enough apart to avoid interfering with each other. As the number of users and calls increase, the cells are split into smaller cells to increase system capacity. The system operates in the 800 MHz spectrum, and typical mobile transmitter power is 12 watts.

A key feature is the switching and control function which is performed via a mobile switching office. Through the national telephone network electronic switching systems, the mobile switching offices process and coordinate calls almost instantly, automatically switching individual calls from one cell to the next as the caller drives across service areas.

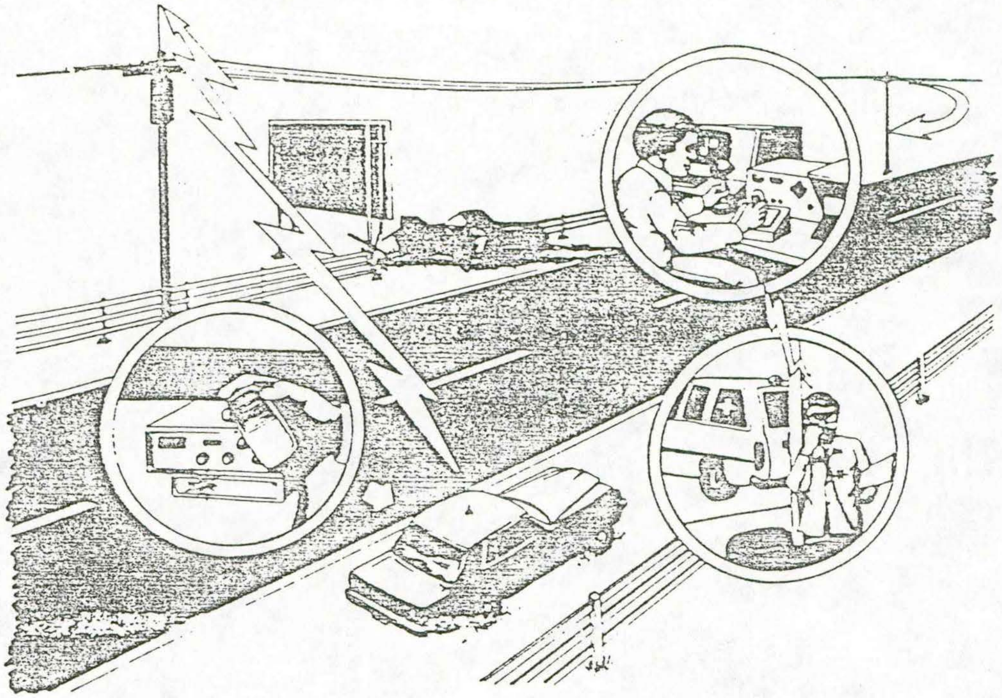


Figure 9.12. CB/Aids basic concept

Source: Reference (17)

9.11 DESIGN GUIDE

The U.S. Department of Transportation, FHWA, has conducted a major research project, *Human Factors Requirements for Real-Time Motorist Information Displays* (3), to provide the traffic engineer with practical guidelines for the development, design and operation of driver information needs, both visual and auditory, for freeway traffic management.

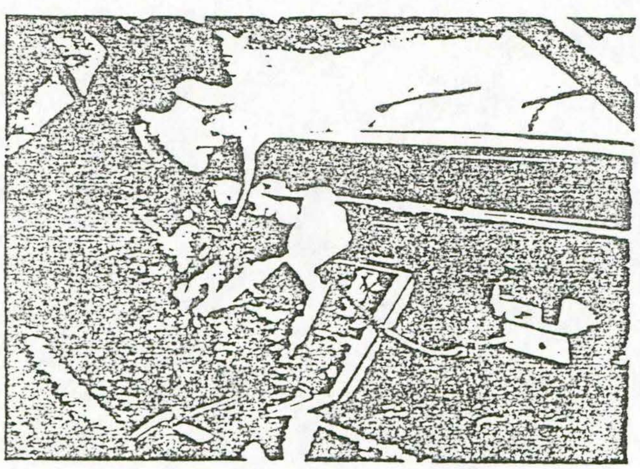


Figure 9.13. CB digital adapter

Source: Reference (11)

This project emphasizes several points, including (1) the recommended message composition which is to be displayed in various traffic situations, (2) the manner in which such messages are to be displayed (such as formatting, coding, style, length, load, redundancy, and number of repetitions), and (3) where CMS's should be placed to be most effective with respect to different situations.

This design guide has recently been condensed to a *Manual on Real-Time Motorist Information Displays* (22).

9.12 TRANSPORTATION MANAGEMENT CENTER

A centrally organized operation can provide excellent coordination and communication with the law enforcement agencies, emergency services, and broadcast media. Thus, a transportation management center is a key requirement for a successful driver information system. In order to be able to transmit timely, accurate, and useful

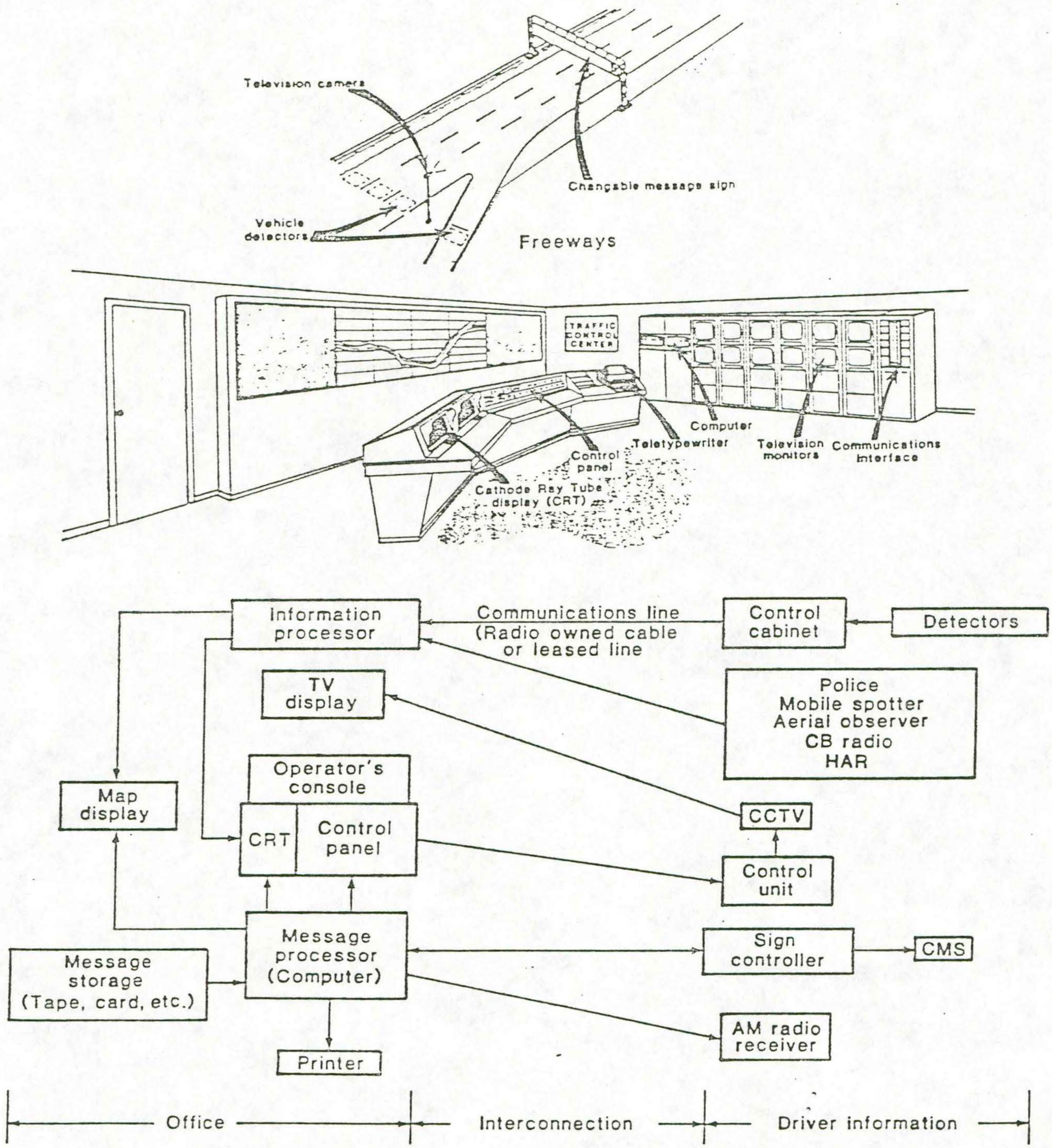


Figure 9.14. Relationship of the components of a driver information system

Source: Reference (27)

information to drivers, it is necessary to have a system for collecting, analyzing, and displaying information on traffic flow conditions.

Freeway traffic advisory and incident management CMS systems with permanently mounted signs and transportable truck- or trailer-mounted signs are computer-based systems integrated with electronic surveillance. Central computers serve several functions, including processing data from field sensors, displaying traffic characteristic information to operators, storing CMS messages, scanning the status of the CMS's and other system hardware, and in some installations, automatically changing messages on the CMS's. (For the typical components of a driver information system, see Figure 9.14.)

Agencies designing new second-generation CMS systems are now considering the feasibility of placing microcomputers at each sign site in order to have more intelligence in the field. This approach may save considerable transmission costs, particularly when the system extends for several miles.

9.13 LANE-USE CONTROL SIGNALS

According to the MUTCD (*2*). "Lane-use control signals are special overhead signals having indications used to permit or prohibit the use of specific lanes of a street or highway or to indicate the impending prohibitions of use." Installations are distinguished by the placement of these special signals over a certain lane or lanes of the roadway and by their distinctive shapes and symbols. Supplementary signs are often used to explain their meaning and intent.

Lane-use control signals are most commonly used for reversible-lane control. They may also be used to accomplish the following:

- Clear a freeway lane(s) at any time this is deemed necessary
- Indicate the termination of a freeway lane
- Indicate blockage of a lane ahead by an accident or a hazard
- Permanently operate a 2-way street with an unequal lane distribution
- Operate a 2-way street in a 1-way mode during peak periods

Such signals consist of a red X on an opaque background or a green arrow on an opaque background, with the arrowhead pointing downward. In addition to these two symbols, a yellow X may be used. Only a single indication is displayed at a time for each lane in either direction.

An example of lane-use control signals for reversible-lane control is shown in Figure 9.15. Lane-use control signals are not mandatory for reversible lanes or for their other purposes. Signing has often been used for these purposes. However, properly designed and operated lane-use control signals are generally more effective than signing and for this reason their use is steadily increasing.

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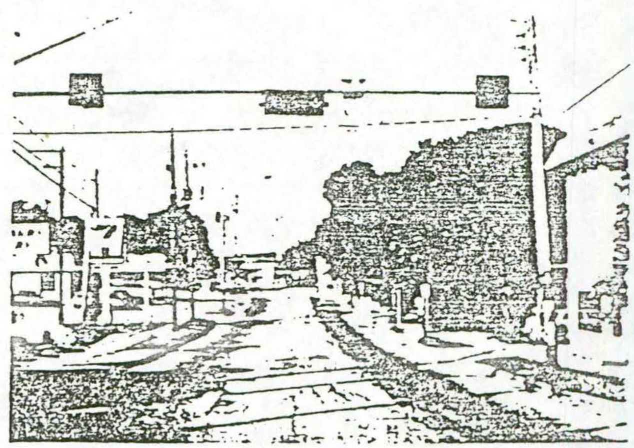

Figure 9.15. Lane-use control signals

Source: Reference (*25*)

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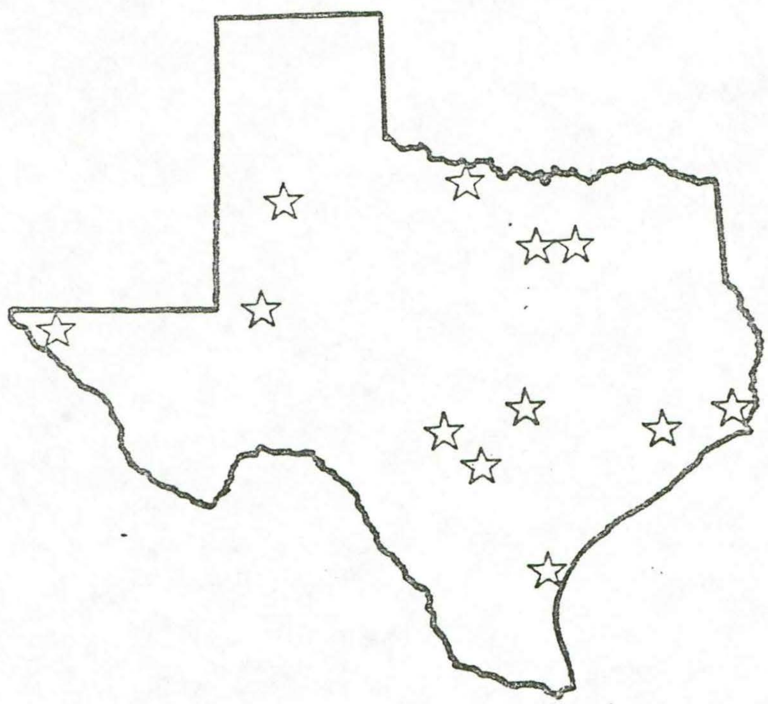
ATTACHMENT C

TRAFFIC MANAGEMENT TEAMS IN TEXAS



STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

DIVISION OF SAFETY AND MAINTENANCE OPERATIONS

February 1986

The first Traffic Management Team in Texas was officially formed in 1975. By 1980, there were five teams and there are currently 12 operating in the state. These teams cover the seven largest metropolitan areas and the nine largest cities as well as other smaller areas. The rapid spread of the team concept and the wide acceptance among the large cities in Texas lead us to believe that it is a very beneficial organization.

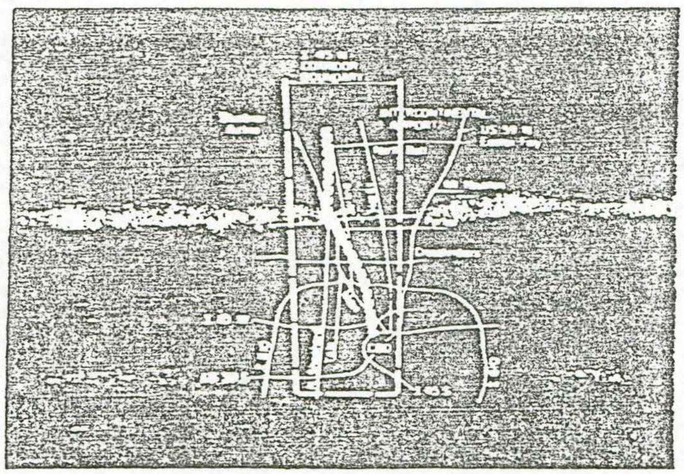
The team brings together professionals from the various traffic-related agencies in the area and helps them to work together to solve the area's traffic problems. Essential to the team's successful operation is the communication, coordination and cooperation which can be realized through working side by side on the team.

We hope this booklet will help to introduce you to how the Traffic Management Teams operate in Texas but if you would like further information or have any questions, please write to:

State Department of Highways &
Public Transportation
Safety & Maintenance Operations
Division
11th & Brazos
Austin, TX 78701

What does a Traffic Management Team do?

A Traffic Management Team improves the overall traffic operation and safety in an urban area's corridors by coordinating the activities of the principal operational agencies in the area.



What is a corridor?

A corridor is a system of roadways which interact and serve as alternate routes to each other. Corridors can consist of two or more parallel streets or a freeway with parallel streets. All cities have several different corridors serving different origins and destinations which intertwine and change in size depending on the time of day and day of week. Any change made to the capacity of one element of the corridor affects the others by shifting the demand from one roadway to another; therefore, alterations must be coordinated between the various elements for the traffic to move in an efficient manner. The different elements of the corridor, though, are quite often controlled by different agencies and communication and coordination between them is sometimes weak.

How can the operation of the corridor be improved?

There are basically three ways to improve the operation of a corridor. The first is to make the corridor safer. Much of the work done by the teams in Texas is directly related to safety and it is always a consideration in any other action. Some common safety improvements are adjusting the clearance intervals at signals, restriping faded lane lines, increasing enforcement of speed limits and improving confusing signing.

The corridor's operation can also be improved by increasing its passenger capacity. This includes adding lanes, providing good signal progression, eliminating geometric bottlenecks and providing mass transit facilities. Without good coordination, each agency will build those improvements specific to their needs, but may find that the new facility doesn't work as well as it could. For example, the state highway department and the local transit authority must work together closely in designing a separate priority entry ramp onto a freeway for high-occupancy vehicles. Other agencies can also, however, contribute to the design. The police department can suggest ways to make the ramp restrictions easier to enforce and less likely to be violated. The city traffic department can alter the geometry or signal operation of nearby intersections to make the ramp easier to access.

Recently, a very busy urban arterial highway in Houston, Texas with an average daily traffic of 80,000 vehicles, was converted from three 12-foot lanes to four 9-foot lanes in each direction. This was a temporary modification until the right-of-way could be obtained for additional lanes. In this case, the capacity of the corridor was increased at the risk of decreasing safety. The team was, of course, very concerned about the safety and discussed the project thoroughly while it was still in the early design stage. Because of this, all of the agencies involved knew exactly what was planned and a positive, cohesive front was presented to the media and the public. To date, there has not been a significant increase in accidents and the public has accepted the narrow lanes very well.

The third basic way to improve the operation of a corridor is to decrease the vehicular demand. This is more difficult to do since it requires convincing the driver to change his/her normal route. Some suggestions are to encourage use of mass transit, less traveled alternate routes and variable work hours. A temporary decrease can be obtained by the use of media releases explaining the need for diversion. Installing entrance ramp meter control may cause a more permanent shift in driver behavior.

TABLE 1

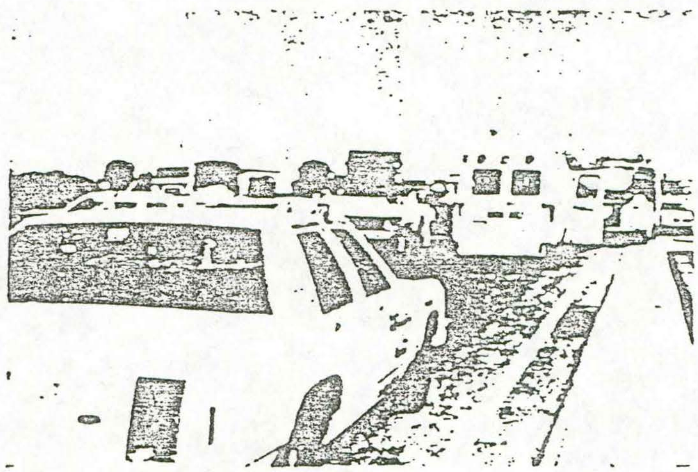
AGENCIES REPRESENTED ON TEAMS IN TEXAS

Agency	Beaumont	Corpus Christi	Fort Worth	San Antonio	Houston
City					
Traffic	X	X	X	X	X
Police	X	X	X	X	X
Fire	X				X
Transit				X	X
State					
Traffic	X	X	X	X	X
Design			X		X
Maintenance		X	X		
Highway Patrol	X	X			X
County					
Engineer		X		X	X
Sheriff				X	X
Other					
Naval Air Station		X			
Traffic Safety Assoc.					X
Railroad Assoc.					X

What different agencies should be represented?

Different cities have different situations, so it is difficult to say which agencies should be represented, but some agencies are almost always included on the team. These include the city and state traffic engineering offices, city and state law enforcement agencies, and the local transit authority. Other agencies and divisions should be included if they are significantly involved in the operation of the corridor. Possibilities include maintenance, design and public works sections; the fire department; railroads and the port authority. It is important, however, to keep the team as small as possible to minimize red tape. Table 1 shows the agencies represented on teams in five various-sized cities in Texas.

When discussing a topic which affects an agency not represented on the team, that agency should be invited to attend that meeting. For instance, several teams have met with local ambulance services to discuss ways of clearing accidents off of a freeway with as little disturbance to traffic as possible. While most teams invite a representative from a satellite city to attend a meeting at which a subject affecting his/her city will be discussed, one team includes representatives from two satellite cities as permanent members of the team.

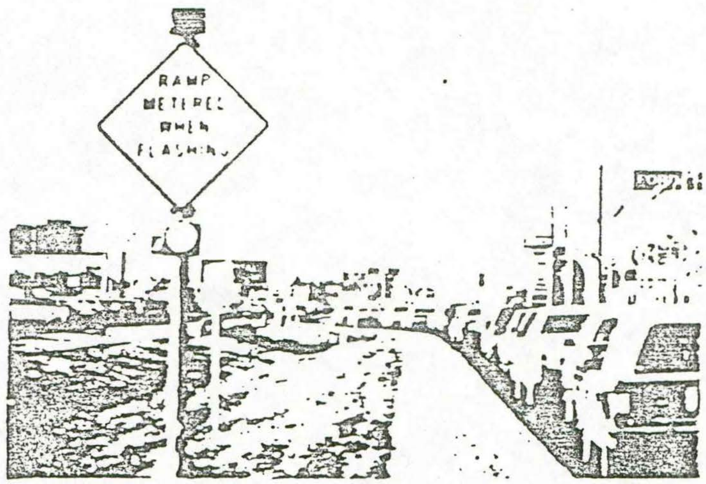


What actions need to be coordinated?

Virtually all work done in the corridor can be coordinated between the agencies of the team to the benefit of traffic operations and safety. Listed below are a few common examples.

1. Work Zone Traffic
   Operations Severe congestion often accompanies maintenance operations and new construction causing traffic to divert to alternate routes. If maintenance is also being performed on that alternate route, the entire corridor can break down. Therefore, traffic control which affects the capacity of a route should be brought to the attention of the team to prevent any conflicts. In severe cases, such as where an entire freeway is closed, the entire team should be

involved in planning and implementing the closure. The police department can direct traffic and enforce special signing while the city traffic office adjusts the coordination of the signals on the alternate route to provide an efficient operation. The highway department and city can provide signs warning of the closure and identifying the alternate route while the transit authority modifies its routes, if possible. The team as a whole can prepare media releases to warn drivers of the closure and recommend an alternate route. By coordinating the plan within the team, most problems can be worked out beforehand and the traffic control can be jointly carried out to provide a safe and efficient operation.

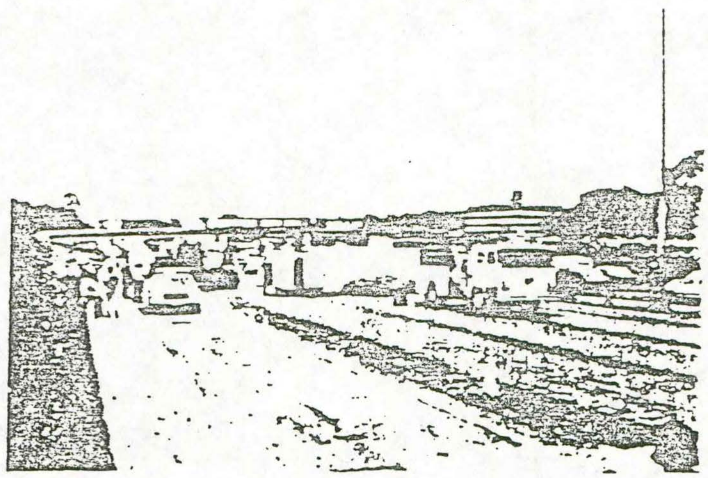


2. **Route Improvements**

Permanent modifications to any roadway in the corridor will affect the other elements, and for maximum efficiency, the corridor should be analyzed to prevent a bottleneck. Controlling entrance ramp volumes through a ramp meter, for example, can improve freeway operation in terms of total volume, but it can also cause congestion on city streets which must be taken into account. The team is well equipped to analyze the effects of new construction and to prepare for the changes in traffic flow.

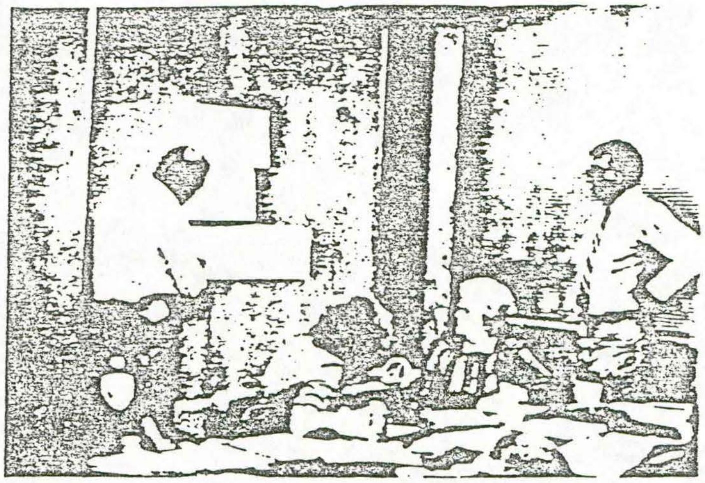
3. Normal Operations
In their day-to-day work, police officers often notice locations where there is a violation or accident problem. The team provides a ready line of communications to the traffic engineering agencies who can act to correct the problem.

A change in operation can also be important to the team because of the interaction between the elements of the corridor. For example, banning left turns at an intersection during peak hours will force traffic to use another cross street. This information is vital to the transit authority which might need to alter its routes. The traffic might also start using a different on-ramp to the freeway causing a weaving problem or a need to change ramp meter timings.



4. **Emergency Planning**
In case of severe weather such as flooding or freezing, it is very helpful to have a plan delineating each agency's responsibilities to prevent delay and possible omission of those jobs which must be done to insure the safety of the driving public. The same type planning can also be used for major incidents, such as truck accidents which close an entire freeway. Once again, the advance planning fosters quick response and action.

5. Special Event Traffic Handling
The team can often quickly and efficiently design, analyze and operate a traffic routing plan for a special event such as a parade or fair. The transit authority can provide express bus service to the event while the highway department and city provide signs telling the driver how to get to the bus service and the event. The police department can direct the traffic around the event.



What is a Team Meeting like?

The team should be a group of transportation professionals with mutual respect and confidence. Below are a few guidelines which might help in setting up and running team meetings. Each team is different though, and this is reflected in the way the team operates.

1. Most teams in Texas hold monthly meetings but some only hold them every other month. It is important to schedule the meeting well beforehand so that all the members will have ample time to arrange their calendars. This can be easily done by setting a standing meeting date, such as the second Tuesday of each month at 2:30 in the afternoon.

2. The same people must attend the meeting each time rather than send an alternate. This helps to create a spirit of cooperation and respect among the team members, and also helps to create a more comfortable situation as time goes by since everyone will know each other, having worked with them before.

3. The meetings should be informal. A chairperson helps in coordinating the discussion but with such a small body, formal rules are not needed and tend to stifle the interaction of the team. Most teams use a short prepared agenda of three or four items submitted by the team members and leave time for impromptu items. One type of problem should not be allowed to dominate the meeting; rather, a mixture of subjects keeps everyone interested and involved.

4. After discussion, the team reaches a verbal consensus on the solution to a problem. The responsible agency or agencies will then take steps to implement the plan. The team members must be able to make decisions about committing their agency's resources to a team project and also be close enough to the operation to be able to effectively discuss the issues.

How is the team and its projects funded?

Generally, in Texas, the teams have not had dedicated funding sources. Rather, each agency funds its own improvements with its normal budget.

Is this approach suitable for my city?

There are currently twelve Traffic Management Teams operating in Texas in areas ranging in population from 15,000 to 3,000,000 with seven of the cities over 300,000 population. We feel that this concept is very advantageous for cities over 300,000 population. Cities smaller than this quite often do not have a traffic engineering staff and this cuts off a valuable contact in the team. Our experience has shown that the team helps considerably in improving relationships between the various agencies and helps to unite the agencies in their common goal of improving traffic conditions.

How much time does this take?

Attending team meetings does take time away from a busy schedule, but most team members feel that this time is more than compensated for by the reduction in time wasted because of misunderstandings, redesigns and letter writing. The team gets problems out in the open early and everyone benefits from the improved communication, coordination and cooperation.