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HUMAN FACTORS REQUIREMENTS FOR REAL-TIME MOTORIST INFORMATION DISPLAYS

VOL. 7 ANALYSIS OF DRIVER REQUIREMENTS FOR INTERCITY TRIPS

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16. Abstract

The primary objective of this report is to document a systems analysis conducted to determine driver information requirements for intercity trips in freeway corridors when incidents occur on the freeway. The analysis was conducted using a driver task analysis approach that was supplemented with an analysis of information needs during a 1,500-mile trip through six states including travel through eight large cities.

Several driver information design issues for real-time visual, audio, and mixed modal displays were identified based on the results of the analysis, a thorough state-of-the-art review, and a questionnaire survey conducted by the Texas Transportation Institute.

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PREFACE

This document is part of a seventeen-volume report entitled, Human Factors Requirements For Real-Time Motorist Information Displays. Titles of all volumes are shown below.

Volume	FHWA-RD Number	Title
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2	78-6	State of the Art: Messages and Displays in Freeway Corridors
3	78-7	Summary of Systems in the United States
4	78-8	Bibliography and Selected Annotations: Visual Systems
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EXECUTIVE SUMMARY

A systems analysis was conducted to determine driver information requirements for intercity trips in freeway corridors when incidents occur on the freeway. The analysis was conducted using a driver task analysis approach that was supplemented with an analysis of information needs of a 1,500 mile trip through six states including travel through eight large cities.

The results of the analysis indicated that driver familiarity with routes, time considerations of the driver, and his destination relative to the city affect his decisions and actions during incidents. These results suggest factors that must be considered in driver information systems design. In addition to the above, driver assessment of the incident and alternate routes also influences his decisions concerning rerouting.

Route selection and alternate route evaluation criteria that drivers use to assess and decide on a course of action when confronted with freeway incidents were identified. These criteria, which also suggest information needs, are as follows:

- Severity of problem
- Location of problem
- Type, distance, and location of alternate route and its return point to the primary
- Weather and pavement conditions
- Ease of negotiating alternate route
- Expected guidance
- Required services and conveniences
- Types of areas alternate route passes through
- Benefits (time saved, speed, delay, etc.)

The exact decisions drivers make during freeway incidents are complex and cannot be easily catalogued. The complexity is manifested in the diverse value systems of the freeway driving population. Thus, although general route selection and alternate route evaluation criteria were identified, the parameters for these criteria are not easily identifiable.

There is a spectrum of route familiarity within the freeway driving population ranging from familiarity with the freeways and surrounding street system to total unfamiliarity. The study points out that although commuters may be very familiar with the freeway route they drive to work, they may not be familiar with the surrounding street system along the entire freeway route, nor are they necessarily familiar with other freeway routes.

Intercity trips can be conveniently divided into trip components for analysis purposes. The components relevant to this study are 1) pretrip planning, 2) travel enroute to the primary facility, 3) travel on the primary facility enroute to and approaching a city, and 4) travel on the primary facility within a city. There are a number of decisions a driver must make during each trip component. These decisions are listed in a form of questions shown in the top of Figure S-1. The remaining questions outlined in Figure S-1 apply to the driver's knowledge of unusual freeway conditions and his assessment of the incident and alternative routes. These latter questions indicate the type of information required by the driver in order to make decisions about his actions on the freeway and about rerouting.

Two additional criteria that are important to the success of traffic management using real-time information displays are the confidence drivers have in the signing system and the credibility of the information displayed. These criteria are influenced by the manner in which the system is operated

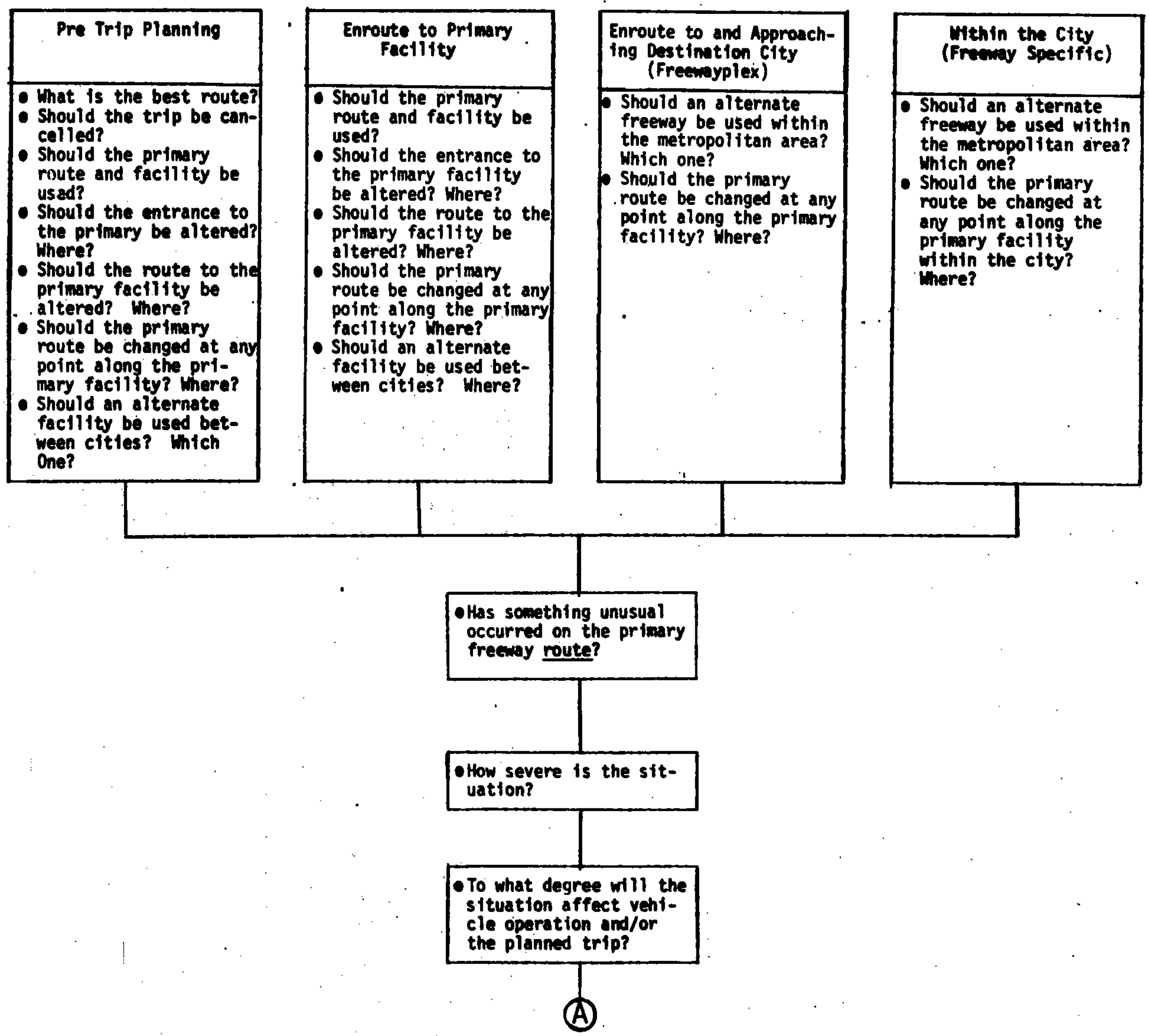

Figure S-1 - Summary of Driver Decisions and Information Needs When Confronted with Freeway Incidents

A

Pre Trip Planning

- Where is problem area in relation to
  1) origin and destination?
  2) planned exit from the primary facility?
  3) entrance to the primary facility?
  4) major trip interchange points?
  5) major freeway interchanges?
  6) primary alternate routes?

Enroute to Primary Facility

- Where is the problem area in relation to
  1) entrance to the primary facility?
  2) planned exit from the primary facility?
  3) major trip interchange points?
  4) major freeway interchanges?
  5) primary alternate routes?

Enroute to and Approaching Destination City (Freewayplex)

- Will sudden braking be required? Where?
- What lane should be used?
- Where is the problem area in relation to
  1) present freeway location?
  2) planned exit from the primary facility?
  3) major trip interchange points?
  4) major freeway interchanges?
  5) primary alternate routes?

Within the City (Freeway Specific)

- Will sudden braking be required? Where?
- What lane should be used?
- Where is the problem area in relation to
  1) present freeway location?
  2) planned exit from the primary?
  3) major freeway interchanges?
  4) primary alternate routes?

- Is an alternate route available?
- Has an alternate route or course of action been recommended?

If an alternate route is available

- What type of facilities are involved?
- What is its location relative to the primary facility and/or destination?
- What areas does it pass through?
- Can sufficient guidance be expected?
- What distance is involved?
- How difficult will it be to negotiate the alternate route?
- What are the benefits to taking the alternate rather than the primary?
- What are the traffic and pavement conditions on the alternate route?
- Are needed services and conveniences available?

Figure S-1 (Cont.) - Summary of Driver Decisions and Information Needs When Confronted with Freeway Incidents by the agency. Drivers must be confident that the operating agency has full knowledge of the operating conditions on the primary and alternate routes and is recommending the best course of action. Displaying timely, accurate, and reliable information at all times when information is needed by the driver will enhance credibility. Inaccurate information can very quickly result in driver loss of confidence in the system. When this occurs, the best designed information displays will not achieve the desired driver response for effective traffic management.

Driver expectancies of navigational information in route following are important to successful route diversion. Violations of these expectancies can result in system failures. An illustrative example is the expectancy of route changes after leaving a freeway to bypass an incident. If the alternate route is not a frontage road, the driver has expectations of a basic combination of turning movements in order to return to the freeway (i.e. right, left, and left). Any violation of these expectations can result in driver uncertainty, apprehension, and confusion.

The analysis also indicated some evidence that unfamiliar drivers may not always need information about incidents. One hypothesis proposed is that since unfamiliar drivers appear to be destination oriented while in transit, effective destination signing at major diversion points as the driver approaches a city may be sufficient to induce unfamiliar drivers to select the alternate route through the city. Another concept proposed is to concentrate the design and operation of information toward the commuters during the peak periods since they constitute the large majority of the driving population. Also unfamiliar drivers may be more reluctant to leave the freeway during these time periods. These two concepts are both discussed in this report.

Several driver information design issues for real-time visual, audio, and mixed modal displays were identified based on the results of the systems analysis, a thorough state-of-the-art review, and a questionnaire survey conducted by TTI. These issues, presented in the final chapter of this report, need to be addressed in detail through laboratory and field experimentations and evaluations of real-time messages and displays.

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INTRODUCTION

Problem Statement

While public attention is focused on the energy crisis and the environmental impact of highway construction, highway departments are taking a closer look at operations to make better use of existing facilities. Urban transportation is so complex that it defies meaningful definition. In the broadest sense, urban transportation is the movement of persons, goods, and services within, into and out of the urban area. Any system that provides adequate mobility for the high concentration of persons and goods within a relatively small area will necessarily be extremely complex.

In most urban areas, the capacity of the transportation system would be adequate to accommodate all movements required within the urban corridors if the use of space were distributed over time. If the traffic load could be spread out throughout the day, better use of time and space on the streets and highways would be achieved. Most movement is concentrated during the daylight hours and coincides with the starting and ending times of workers. Peaking of transportation demand is a characteristic problem for all modes of transportation.

Most intercity traffic is carried through corridors in which multilane freeways serve as the major traffic carrier. The definition of a freeway corridor is different to different people, depending on their perspective. In many metropolitan areas, sub-urban cities have developed adjacent to a major city, thus creating corridors of traffic patterns. In other locations, there is a close proximity of metropolitan areas where the freeway serves as the major traffic carrier although alternate routes are available.

Peak-period congestion occurs daily and thus is quite predictable in both effect and duration. Freeway ramp control systems have proved their effectiveness in reducing recurrent congestion and, consequently, have improved the level of service afforded the motorist. Freeway corridor control systems are under development and are expected to further improve operations.

The occurrence of an accident or other lane-blocking incident on the freeway reduces the capacity of the freeway section significantly. Freeway incidents occur randomly and result in nonrecurrent congestion. Other events such as maintenance and construction, debris spills, adverse weather or pavement conditions, and natural disasters also result in reduced capacity. When a major incident causes a bottleneck, significant freeway congestion results even though unused capacity may exist on parallel routes within the freeway corridor. Not all incidents result in significant delay; however, each creates queuing on the freeway, which is a serious traffic hazard to uninformed motorists. Maintenance and construction activities, adverse weather conditions, and natural disasters reduce capacity as well as create safety hazards for uninformed motorists and, in some cases, may warrant complete closure of the freeway.

From a control systems viewpoint, what is needed to optimize flow within freeway corridors is to redistribute demand. When a major incident occurs on the freeway, it is important to intercept the demand before it reaches the reduced capacity location and to redirect the demand into areas of the freeway corridor where excess capacity exists. In addition, advanced information becomes vital to those motorists who are on the freeway approaching the queue area caused by the incident. A primary reason diversion of demand does not presently occur and a safety problem exists after an incident is the lack of reliable, meaningful, and timely information available to the motorist. To obtain a desired redistribution in traffic demand and improvement in safety within freeway corridors, a corridor surveillance, information, and control system will be required.

The surveillance function is required to detect and evaluate the nature of the operating characteristics, to detect any unusual conditions, and to determine the appropriate operational control strategy. The control function is desired so that the traffic controllers located at freeway ramps and at intersections along the alternate or diversion routes where increased traffic is expected can be adjusted to accommodate the short term changes in traffic patterns and demands. Driver information systems perform a critical role in the successful operation of real-time freeway corridor control systems. The real-time information system will provide information to motorists that will enable them to intelligently select and follow the best alternate course of action, whether it be from the standpoint of safety, rerouting through the corridor, or diverting to another major alternate facility.

Traffic engineers, who generally have the responsibility to design and implement real-time driver information systems, lack adequate design guidelines. Human factors considerations are central to the efficacy of any driver information system. In order to achieve effective driver communication and optimum inducement of driver response, appropriate messages must be presented to the motorist by means of information displays that are properly designed and deployed. There is a need for human performance information relative to certain design parameters so that the engineer can design equipment compatible with the needs of the driver. In order to establish these parameters, one must first determine what real-time information is needed by the motorist, and when and where he needs it.

Objectives

The primary objective of this report is to document a systems analysis conducted to determine driver information requirements in freeway corridors when incidents occur on the freeway. The systems analysis will focus on intercity trips and will include the following activities:

1. Develop generalized chart of driver decisions and actions during the course of a trip.
2. Develop a catalogue of corridor traffic situations that affect trips in freeway corridors.
3. Identify basic factors that affect driver decisions and actions while making a trip.
4. Develop a task summary of driver activities to summarize the various driver activities when incidents occur on the freeway.
5. Identify driver information requirements when freeway incidents occur through the development of driver decision-action diagrams.

This analysis coupled with a thorough state-of-the-art review will result in a set of design issues that will be used as hypotheses in developing experimental designs for Task B laboratory studies. The experimental questions regarding visual and audio messages will be evaluated relative to content, format, placement, quantity, and redundancy.

Task Analysis Approach

A driver task analysis was the analytical method used to determine driver information requirements. Task analysis methods have been used extensively in military applications and have recently been successfully applied in driver-related research. The reader is referred to reports by King and Lunenfeld (1) and Allen, et al. (2).

The analysis reported herein was at a more macroscopic level than that reported in the above references since the information requirements during incident conditions constitutes only a portion of the total driver information needs. The emphasis in this analysis was on dynamic signing for traffic management as applied during unusual traffic conditions resulting from freeway incidents. The emphasis is on advisories and route guidance rather than the microscopic aspects of vehicle control.

After a basic set of variables that might affect a driver's decisions and actions were identified, analyses were conducted by categorizing trip missions with simulated freeway incidents and then developing driver task descriptions of each trip. The decisions and actions of the driver (driver activities) during each trip resulted in an identification of information required by the driver to accomplish the trip mission. This approach was supplemented by recording and analyzing information needs during a 1,500 mile trip through six states including travel through eight large cities.

Definitions

Throughout this report several terms are used that may require defining.

Primary Facility - The major road(s) the driver selects between any two points along his trip. In this analysis the primary facility is always assumed to be a freeway. The driver may use one freeway or his trip may require travel on several freeways.

Primary Route - The route the driver selects for his trip from origin to destination. This not only includes the primary facility, but also the streets and highways a driver uses to travel to and from the primary facility.

Familiar Driver - A familiar driver is one having an intimate association with specific routes. Familiar drivers fall into several categories varying from familiarity of only one specific freeway route and unfamiliar with the surrounding major street system to those familiar with all freeways and surrounding major street system in an area. A driver might be familiar in one freeway corridor and unfamiliar in another corridor. He may also be familiar with the freeway system in a large metropolitan area and unfamiliar with the surrounding major street systems.

Commuter - These are persons driving back and forth to work regularly. A freeway commuter generally is familiar with the freeway route he uses. He may not necessarily be familiar with surrounding major city streets throughout the freeway corridor. Also, he may not be familiar with other freeways in the metropolitan area.

SOME CONSIDERATIONS FOR DRIVER INFORMATION SYSTEMS

Driving Tasks

Based on driver analysis, Allen, et al. (2) concluded that driving subtasks followed a hierarchical scale. Vehicle control subtasks such as steering and speed control were placed at the highest level and were identified as control (micro-performance). At an intermediate level, subtasks associated with the response to road and traffic situations were identified as guidance (situational performance). The lowest level subtasks, including trip planning, preparation, and route finding, were identified as navigational (macro-performance). The researchers concluded that there is a primacy of information requirements beginning with control. Control and situational (guidance) level failures increase the probability of accidents (catastrophic system failures), whereas navigational level failures lead to delay, confusion, and other inefficiencies (non catastrophic failures). Consequently, the researchers contend that control information is more important than navigational information. These concepts are further developed by Alexander and Lunenfeld (3) in their study of positive guidance information.

Although the concept of primacy is based on the severity of system failures, it is not clear whether the driver's attention is devoted to the driving task in the order suggested above. For example, the most important information to a driver traveling through a major interchange may be destination information. If the information he personally needs within that short time span he has for decision-making is not available, or is lost in a maze of competing but non-relevant (to him) signing information, he might neglect other driving tasks that could lead to a system failure. Therefore, perhaps a more positive approach to signing would be to fully satisfy the driver's needs at the lower level (navigational) of the hierarchy so that more of his attention can be devoted to situational and control needs. A good signing system allows a driver to spend as much time as needed to situational and control information in order to avoid catastrophic failures without adversely affecting his total information needs.

Micro-performance (control) needs take primacy only when the driver is faced with a last second choice between following a correct route or wrecking his vehicle while attempting to do so. By and large, micro-performance is an overlearned skill requiring less attention while situational and navigational performance vary with the trip and, hence, require greater attention. Therefore, it is in these latter two areas that information needs are primary and where research is of greater necessity.

Driver Expectancy

Expectancy is one of the general concepts used by behavioral scientists to explain the activity of people. The concept of driver expectancy has been recently advanced by King and Lunenfeld (1), Woods, et al. (4) and Ellis (5) as a means of establishing design guides for highway information and features that are essential to accomplishing the driving task. Driver expectancy can be defined as an observable, measurable change in the driving environment which increases a driver's readiness to perform a driving task in a particular manner and, in addition, causes him to persist in this behavior until it is completed or interrupted by other environmental circumstances or changes (5).

Specific information required to increase the driver's readiness may or may not actually exist in the environment, and the corresponding response may or may not be appropriate to the situation. This can have serious implications because it is important that one's behavior be appropriate to his situation. One way to insure appropriateness is to insure compatibility between what the driver expects of his environment and what actually exists.

Unless a driver is startled by some unexpected event, a background of information and activities always accompanies his perception of the immediate situation. The background includes the driver's past experiences and present objective, previous training, the driving task and environment, and the immediate sequence of past events in which he has been a participant. The general factors then establish the relevance or irrelevance of what he is about to perceive which in turn provides a basis for what he will do.

The driver expectancy is a learned response based upon his total driving experiences. A problem exists in traffic operations when the design of the highway environment (including signing messages) violates what the driver expects to find on the highway ahead. This creates a conflict situation and the sign may be actually disobeyed. Also, in the absence of information, the driver will follow his expectancies and could possibly become lost.

Ellis (5) offers general statements of material from which the highway engineer can develop a general design philosophy for driver expectancy. These statements can be grouped into the following main generalizations:

1. The driver generally feels that the roadway will not mislead or confuse him. This positive attitude shall be confirmed by design.
2. A driver generally expects in-trip cues and services to guide and assist him in reaching his destination.

3. The driver generally expects roadway information permitting him to determine where he is and where he is going at any one point in time.

4. If there are in-trip requirements for course adjustments, the driver feels that he will be told or his ability to get this information through normal processes will not be restricted.

The concept of driver expectancy is a rational approach that can be also applied to the design of real-time information systems.

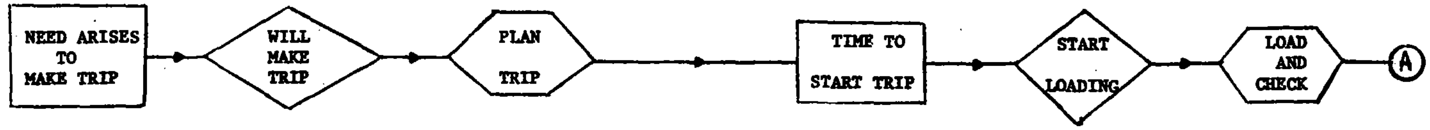
BASIC TRIP STRUCTURE

A generalized flow chart of basic driver activities during the course of a trip was developed and is presented in Figure 1. Once a need to make a trip arises, based on one or more of the factors listed in Figure 1, and a decision made to make the trip, the driver plans his trip accordingly. It could be a routine trip to work or it could involve traveling to some unfamiliar place for a vacation. Several factors will influence the amount of planning necessary.

One important factor is the time frame for the trip -- it can be fixed or variable. For example, if a person must arrive at his destination by a certain time in order to keep an appointment, the driver's arrival time would be fixed. Time will then be a critical factor in the trip and it may influence his decisions and actions when he encounters unusual traffic conditions. If the arrival time is variable, then time will not necessarily be critical.

Pre-trip planning also includes selecting a primary route with a primary facility. The degree of commitment to the primary route and facility will probably have some bearing on the effectiveness of real-time information displays for rerouting or diversion.

Once enroute to his destination several things could happen at any given point in the trip that will affect the driver's decisions and actions. The driver could normally drive through his trip as planned with perhaps only minor adjustments necessary. His trip could be interrupted, however, by unplanned stops, minor incidents, and maintenance and construction activities. These interrupters may cause the motorist some delay to "service"



A. Origination
   1. Required
   2. Requested
   3. Desired

B. Purpose
   1. Work
   2. Business
   3. Shopping
   4. Social
   5. School
   6. Vacation
   7. Home
   8. Commercial
   9. Etc.

C. Effects
   1. Driver
   2. Vehicle
   3. Road

D. Characteristics

A. Trip Satisfaction Requirements Identified
   1. Destination
   2. Loading
   3. Time Frame
      a. Arrival Fixed
      b. Arrival Variable

B. Delivery System Selected
   1. Vehicle
      a. Availability
      b. Capability
      c. Service
      d. Costs
   2. Occupants
   3. Origin of Trip

C. Trip Planning
   1. Identify Trip Length
   2. Identify Intermediate Stops
   3. Identify Services Required
      a. Vehicle
      b. Occupants
      c. Cargo
   4. Identify Facility Requirements
   5. Select Route
   6. Select Waypoints
      a. Stops
      b. Junctions to possible alternatives
      c. Landmarks
      d. Mileposts
   7. Determine departure time

A. Load
   1. Fuel
   2. Occupants
   3. Cargo

B. Check
   1. Vehicle
   2. Occupants
   3. Route

Figure 1 - Basic Driver Activities During the Course of a Trip

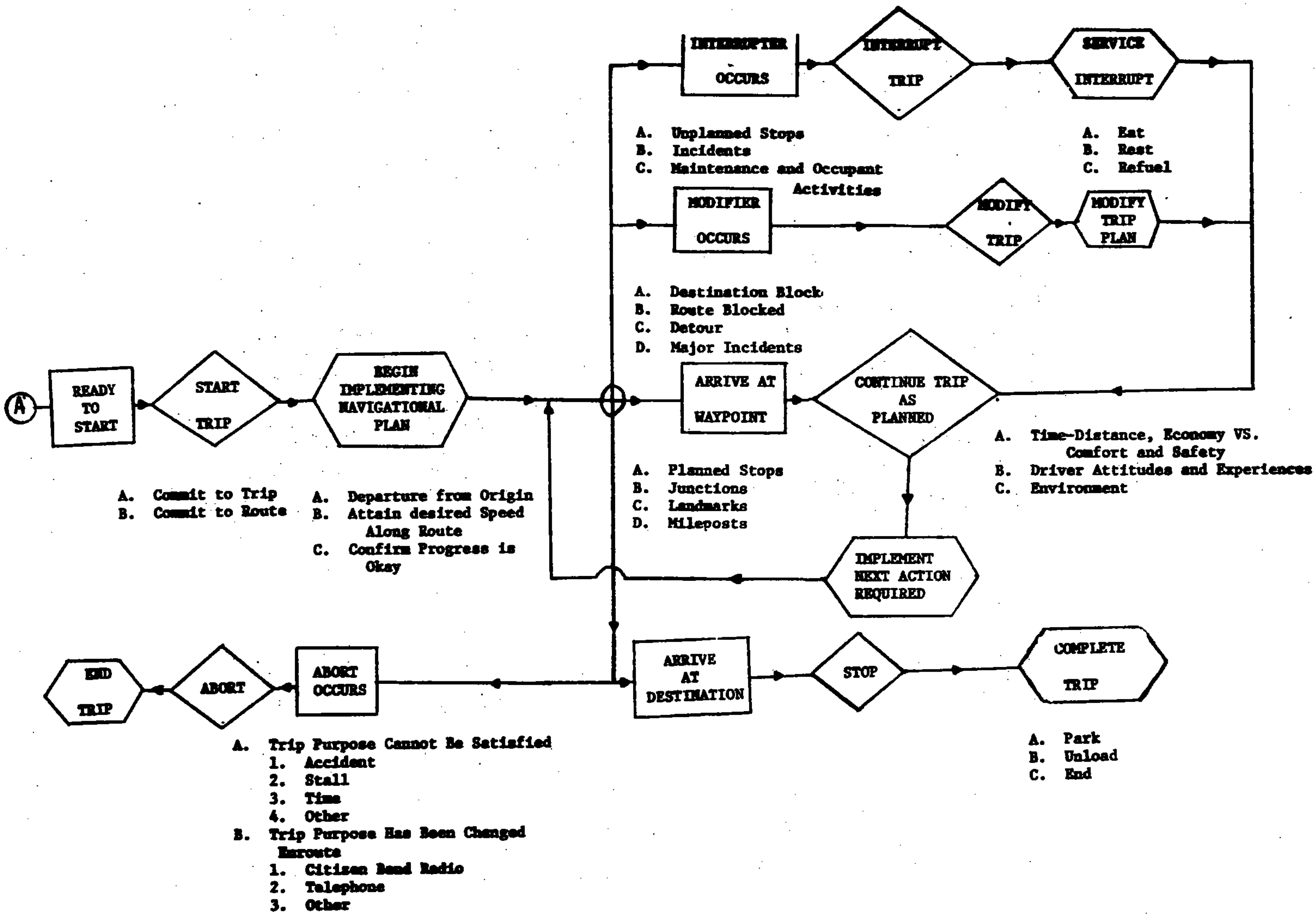


Figure 1 (Cont.) - Basic Driver Activities During the Course of a Trip

the interrupt. That is, he must fulfill some need or requirement so that he can resume normal travel. Other situations could arise during the trip such that may require the driver to modify his trip plan. "Modifiers" during a trip could arise when the primary route is blocked or a major incident causes undue delay.

Interrupters, modifiers, and waypoints are continuously evaluated throughout the trip. Unless the driver aborts his trip, he will eventually arrive at his destination, either by following his original primary route and navigational plan, or by some modification to his trip plan (alternate route, change in destination, etc.).

TRIP MODIFIERS AND INTERRUPTERS

During the course of a trip in a freeway corridor, contingencies will arise that will call for decisions to be made and actions to be taken by the driver (Figure 1). In making these decisions, the driver must have certain information available to him. As a prelude to defining driver informational requirements, an examination was made of the types of situations influencing rerouting or diversion. A listing of incidents gives some insight to the types of decisions and actions required. These incidents can be broken down and grouped as to their effect on traffic operations. Examples of incidents are listed and classified in Table 1. These incidents can be grouped according to whether or not they block one or more lanes of traffic.

For a given freeway traffic demand, incidents that result in physical lane blockages are more severe in terms of their effect on operations than the other listed incidents. Incidents blocking two lanes on a three-lane freeway section (one direction) will reduce the capacity of the freeway 80 percent; one-lane blockages will reduce the capacity of the freeway 50 percent. An incident on the shoulder of the roadway will reduce the capacity approximately 25 percent (6). With such reductions in the capacity of a freeway, some degree of delay will occur. When the motorist is confronted with such contingencies, he must decide on the most appropriate course of action. Normally, the driver has little information on which to base such decisions.

TABLE 1

EXAMPLES OF FREEWAY INCIDENTS

Lane or Freeway Blockages	No Lane Blockage But Slowdowns
Stalled Vehicles	Accident Vehicles on Shoulder
Mechanical Breakdowns	(Any) Vehicle on Shoulder
Accidents	Normal Geometric Bottlenecks
Truck(s) Jackknifed or Overturned	Emergency Vehicles on Shoulder
Construction	Vehicle on Shoulder with Lights Flashing
Maintenance	Accident in Opposing Direction
Emergency Vehicles	Bumps or Holes in the Road
Spilled Loads (Objects in Roadway)	Smoke
Animals on the Road	Ice or Snow
Ruptured Pavement	Rain, Fog, Heavy Snow
Excessive Water	Funerals
Ice or Snow	Trucks with Heavy and/or Wide Loads
Bridge Out	Slow Moving Vehicles
Freeway Closures due to Weather	Blocked Freeway Exits
Special Events	Grass Fires
	Debris on Road
	Military Convoys
	Pedestrians on Side of Roadway
	Large Animals on Side of Roadway

PRELIMINARY FACTORS AFFECTING DECISIONS AND ACTIONS

Initial identification and classification of major factors affecting the driver's decisions and actions in all phases of a trip from pre-trip planning to final destination were developed and are presented in Table 2. Twenty-six major variables are listed each with several subvariables. An analysis that considers each subvariable independently would require an untractable number of sample trip analyses. Further analysis of the variables indicated that they could be classified into three major groups: driver factors, corridor factors, and condition factors.

The driver factors include the type of driver, the attitudes of the driver and passengers, and the purpose of the trip. The corridor factors include the type of the route, the quality of the route, the type and quality of the available alternate routes, and the destination. Included in condition factors are the environmental conditions, the physical condition of the roadway, and the traffic conditions. These factors are summarized in Table 3 and are further described in the following sections.

Driver Factors

The first major area to be considered is the driver factors. The type of driver, his attitude, and how this relates to the type of the trip that he is involved in appear to have a bearing on the willingness of the driver to divert to an alternate route.

TABLE 2

INITIAL LISTING OF MAJOR FACTORS AFFECTING A DRIVER'S DECISIONS AND ACTIONS

(1) TRIP PURPOSE	(2) ORIGIN ROUTES	(3) DESTINATION ROUTES	(4) DESTINATION/ MAJOR CITY	(5) TIME	(6) TEMPERATURE	(7) WEATHER	(8) PAVEMENT	(9) WEATHER & PAVEMENT	(10) TRIP LENGTH TOTAL	(11) TRIP LENGTH THIS DAY	(12) TRIP LENGTH REMAINING THIS DAY	(13) TIME OF DAY DRIVE INTO OR PASS THRU CITY
Work/Home	Familiar	Familiar	Near Side	Critical	Hot	Clear	Dry	Local	<20 miles	<20 miles	<10 miles	7 am - 9 am
Business	Unfamiliar with Alternates	Unfamiliar with Alternates	Outskirts	Semi-Critical	Moderate	Partly Cloudy	Wet	Widespread	20 - 50	20 - 50	10 - 20	9 am - 3 pm
Social	Unfamiliar	Unfamiliar	Inside	Not Critical	Cold	Cloudy	Very Wet		50 - 200	50 - 200	20 - 50	3 pm - 7 pm
Vacation			Far Side		Very Cold	Showers or Mist	Partly Icy (Bridges)		200 - 500	200 - 500	50 - 200	7 pm - 7 am
Recreation			Thru			Rain	Icy		>500	>500	200 - 500	
School/Church						Heavy Rain	Light Snow					
Shopping						Snow Flurries	Mod. Snow					
						Snow	Heavy Snow					
						Snow Storm						
						Fog in Spots						
						Heavy Fog						
						Smoke						

(14) PRIMARY FACILITY CLASSIFICATION	(15) PRIMARY FACILITY WIDTH	(16) PRIMARY FACILITY ROUTING	(17) ALTERNATE FACILITY CLASSIFICATION	(18) ALTERNATE FACILITY WIDTH	(19) ALTERNATE FACILITY ROUTING	(20) ALTERNATE FACILITY WIDTH/CHAR.	(21) PRIMARY FACILITY CONDITION	(22) INCIDENT LOCATION	(23) QUEUE BUILDUP LOCATION	(24) QUEUE BUILDUP DISTANCE	(25) INCIDENT STATUS	(26) NUMBER LANES BLOCKED
Interstate	≥ 8 lanes	Radial	Interstate	> 8 lanes	Radial	Divided	OK	None	None	0 Miles	Mainlanes	None
State Freeway	6 lanes	Loop	State Freeway	6 lanes	Loop	Undivided One-Way	Slow	Downstream of Destination	Downstream of Destination	1 Mile	Shoulder	1 Lane
	4 lanes		Frontage Rd.	4 lanes		Undivided Two-Way	Minor Incident	Upstream of Destination	Upstream of Destination	2 Miles	Off Freeway	2 Lanes
			US Hwy.	3 lanes			Major Incident	Downstream of Alt. Route	Downstream of Alt. Route	X-Miles		All Lanes
			State Hwy.	2 lanes				Upstream of Alt. Route	Upstream of Alt. Route			
			County									
			City									

TABLE 3

PRELIMINARY FACTORS AFFECTING
DRIVER'S DECISIONS AND ACTIONS
IN FREEWAY CORRIDORS

Driver Factors			Corridor Factors		Condition Factors*	
Driver Classification	Trip Purpose	Time	Primary Facility	Destination	Environment and Pavement	Traffic
Familiar	Business	Critical	Freeway	Within City	(Variable)	(Variable)
Semi-Familiar	Work/Home	Not Critical	Expressway	Through City		
Unfamiliar	Shopping		Arterial			
	Recreation		Collector			
	Social		Local			
	Pleasure					
	Vacation					
	School/Church					

*Contingencies confronted by drivers in a freeway corridor.

Driver Classification - Reference to the type of driver, in this instance, refers to his familiarity with the routes in the corridor. This can range from totally familiar with all routes in the corridor to complete unfamiliarity. This range is continuous throughout the driver population, but is assumed to be three discrete classifications for the purpose of this analysis. In addition to the two extreme cases, a semi-familiar driver is designated as one who is somewhat familiar with the basic characteristics of the primary freeway but is unfamiliar with the surrounding street system.

The familiar driver by definition has a tremendous storage of a priori knowledge concerning the corridor. He may be able to navigate the alternate routes with a minimum of assistance and may be more willing to "chance" a diversion in the absence of information. The unfamiliar driver, on the other hand, does not have this knowledge base on which to evaluate the conditions and his information requirements may differ.

Attitude of Driver and Passengers - The attitudes of the driver and his passengers may influence a driver's decisions and actions. One important factor is patience. A patient driver may be willing to travel at a stop-and-go pace through an incident area whereas an impatient driver may feel that he has to move faster and searches for better alternatives. The effects of anger, happiness, or other emotions can also influence a driver's actions.

The attitudes of passengers may also have an influence on the driver. An impatient passenger could create a situation where he would influence the driver to take action he would not normally take if he were alone.

Because of the complexity and lack of complete understanding of the effects of driver attitudes and emotions on driving habits, it is impossible to study these factors in detail as part of the systems analysis. However, one factor that can affect driver attitudes and emotions and consequently decisions and actions is time constraint. Time, as far as a driver is concerned, can either be critical or not critical. The expected reactions by each class of drivers may vary when confronted with freeway incident situations.

Trip Purpose - Another method of classifying drivers is by trip objectives or trip purpose. It was initially rationalized that a driver's decisions and actions might be influenced based on trip purpose. For example, of the population of drivers traveling between two large cities, some may be commuters going to work, some may be vacationing, others may be shopping, etc.

Corridor Factors

Corridor factors include type of routes in the corridor (both primary and alternates) and the relative location of the driver's destination. While corridor factors may be conceptualized as separate from driver factors, their effects on decision-making are again based upon the driver's attitudes and expectations (e.g. his willingness to divert may be based upon his expectations of the type of alternate route facility, and his distance from his destination may be a factor in accepting or rejecting a route diversion advisory).

Primary Facility - The facilities available in most corridors run the gamut from interstate freeway down through a local street. These facilities can best be described by their geometric design standards and their expected operational features. Driver decisions and actions then may very well be influenced by the type of facility he is traveling on.

Destination - The driver's destination may be highly important to his selection of the primary route and facility. He will most likely select a major facility that will place him near his destination and minimize the amount of travel on interconnecting streets and highways of lower geometric design standards. It also seems reasonable to assume that a driver's willingness to reroute or divert will be influenced by his destination and its relationship and distance to the driver's current location. A driver having a destination in the center of a city, for example, may not be as receptive to divert around the city as those drivers traveling through the city.

Condition Factors

Condition factors are the trip modifiers and interrupters and include environmental and traffic contingencies encountered during a trip. Again, these factors will influence driver decisions based upon his anticipation of their effects on his driving performance (e.g. he may reject low quality facilities which are more hazardous under inclement weather and may reject routes through known areas of severe congestion at a particular time of day).

Environment - Environmental or weather conditions along the primary and alternate routes will have an affect on route choice. Adverse weather, for example, may affect the driver's decision concerning alternate routes if these routes are of lower design standards in comparison to the primary facility. Freeways have snow removal priorities and would thus be more desirable than arterials during very heavy snowfalls.

Traffic Conditions - Traffic conditions encountered enroute, even though no accident or incident is involved, could have an impact on the driver's decisions and actions. For instance, a driver traveling a long distance probably would not desire to travel through a metropolitan area during the peak period. When an incident does occur, the driver's ability to analyze the traffic conditions will influence his decisions about route choice.

PRELIMINARY DRIVER TASK ANALYSIS

Trip Missions

An initial driver task analysis was conducted to further screen the factors affecting driver decisions and actions during intercity trips and to identify some general driver information needs. Simulated trips were made for several combinations of driver and corridor factors listed in Table 3. For example, a typical mission for a driver familiar with the freeway system was to travel from one major city through the next major city to keep a business appointment.

Trip Components

An intercity trip can be conveniently divided into trip components for analysis purposes as shown in Table 4. These components range from pretrip planning to travel on the connecting roads or streets to the final destination.

In this analysis the destination city represents the next major city along the trip. It may be an intermediate city along the trip or may indeed be the final destination. For example, a trip may require a driver to travel through several large cities. Each large city following the origin is considered for analysis purposes to be one of the several destination cities. Driver information requirements should not change as he travels through these cities. The only influencing factor would appear to be whether his final destination lies within the city.

TABLE 4

INTERCITY TRIP COMPONENTS

- Pretrip planning
- Enroute to Primary Facility
- Travel on Primary Facility
    - Within Origin City
    - Enroute to Destination City
    - Approaching Destination City
    - Within Destination City
- Travel on Connecting Roads To Final Destination

Results of Preliminary Driver Task Analysis

Familiarity - Familiarity emerged as a very critical factor in driver decision-actions. Although the driver classification of commuter or non-commuter has implications of familiarity, it is the degree of familiarity that is most relevant.

At any given section, the freeway population composed of commuters and non-commuters might be further classified into subgroups of drivers

- Passing through the section
- Originating their trip in the section
- Having a destination in the section

Table 5 illustrates the prime informational needs for the above groups and subgroups. The non-commuter does not have total a priori knowledge to help satisfy his information needs. In addition to time-varying traffic condition information, the non-commuter passing through or with a destination in the section of freeway is concerned with knowing of his location, with in-trip cues and services to guide and assist him in reaching his destination (navigation and position), and with road conditions and regulatory information. Those drivers originating their trips in the section are also concerned with operations, navigation, regulations, and road conditions. Some motorists may indeed be familiar with the freeway section in their immediate area and, like commuters, would need only time-varying traffic operations information.

TABLE 5

FREEWAY DRIVER INFORMATION NEEDS

Classification	Thru-Drivers	Originating in Section	Destination in Section
Non-Commuter	Location Navigation Position Regulation Road Conditions Traffic Conditions	Navigation Regulation Road Conditions Traffic Conditions	Location Navigation Position Regulation Road Conditions Traffic Conditions
Commuter	Traffic Conditions	Traffic Conditions	Traffic Conditions

The commuter driver, because of his familiarity with the freeway section and his pre-conditioning to the geometrics, ramp locations, landmarks, etc., is basically concerned with the traffic conditions on the freeway. Although several types of information are available, his past experiences on the facility reduces the importance he places on the information; he seeks only that information he needs or thinks he needs and ignores the others. In short, the commuter knows about all fixed geometric factors (non-time varying) and is only interested in events varying with time which may be atypical such as incidents and traffic congestion.

Once an incident occurs on the freeway which requires trip adjustments, then the requirements change. The commuter, for example, may suddenly be expected to change his course onto an unfamiliar route. Although the commuter may be very familiar with the freeway route, many are not familiar with the surrounding street system. The needs and importance of information consequently change accordingly. Since the commuter is now unfamiliar, his information needs are the same as the visitor passing through or looking for a particular destination.

Purpose of Trip - The results of the preliminary analysis also indicated that although trip purpose seems to affect driver decisions and actions, it is the time constraints on the driver that are more critical. Obviously, time may be less important than scenery on a vacation trip. The opposite is probably true for a work trip. However, a driver on a vacation may very well be constrained by time commitments such as having to arrive at a motel at a certain time. His decisions and actions are influenced by the criticalness of time. Thus, regardless of the trip purpose, time seems to be the controlling factor.

More detailed analysis, discussed in the next chapter, further suggests that trip purpose can influence the type of vehicle a driver uses. This, in turn, will affect his decisions and actions.

In summary, trip purpose can be translated into other factors (such as time commitments) that are more relevant in analyzing driver decisions and actions when contingencies are encountered. Therefore, it was unnecessary to analyze all different possible purposes for taking a trip since driver information requirements would differ primarily to the degree that time was critical.

Facility Type - The premise followed throughout the analysis is that the primary facility is a freeway. Thus the primary facility type classification did not apply and was eliminated from further consideration.

DRIVER TASK ANALYSIS

The reclassification of preliminary driver and corridor factors based on the initial analysis is shown in Table 6. These factors result in a combination of 12 types of trips that were analyzed in greater detail.

Certain patterns emerged during the analysis. First of all, the detailed decision-action diagrams for each trip with different combinations of driver and corridor factors tended to be similar. The major differences were in the types of decisions and subsequent actions taken by each driver. When confronted with the same contingency in the corridor, each class of drivers placed importance on different criteria which resulted in a wide range of actions.

It was observed that driver decision-action diagrams could be made more explicit by structuring the charts according to trip components. A review of Table 4 on page 25 shows a trip divided into seven components. The analysis indicated that decision-actions of drivers while traveling on the primary facility in urban areas is essentially the same within each city, whether it is the origin or destination city (defined on page 22). Thus the *Within Origin City* and *Within Destination City* trip components shown in Table 4 can be combined into one category.

Driver actions to real-time information while enroute to the destination city is influenced in part by the distance between the cities. If the distance between the cities is large, it is doubtful whether a driver will react to incident type information in the destination city since many miles of good travel is still available on the primary facility before he will encounter the incident. Also, driver decisions while enroute to the

TABLE 6

PRELIMINARY FACTORS AFFECTING
DRIVER'S DECISIONS AND ACTIONS
IN FREEWAY CORRIDORS (REVISED)

Driver Factors		Corridor Factors	Condition Factors*	
Driver Classification	Time	Destination	Environment and Pavement	Traffic
Familiar	Critical	Within City	(Variable)	(Variable)
Semi-familiar	Not Critical			
Unfamiliar		Through City		

* Contingencies confronted by drivers in a freeway corridor.

destination city are essentially the same as those while approaching the city and can be combined into one category. Travel on the connecting roads to the final destination places a driver in a position beyond the point where freeway information can be of use. This trip component was therefore eliminated from consideration.

In summary, driver decision-actions resulting from freeway incidents can be structured into four basic trip components, namely, pretrip planning, enroute to primary facility, enroute to and approaching destination city, and within city. In many cases as the driver approaches the destination city, more than one freeway route may be available for his travel within or through the city. The freeway system configuration in the metropolitan area may be simple or it may inolve several radial and loop freeways.

DRIVER INFORMATION REQUIREMENTS

The results of the systems analysis strongly suggest that driver decisions and actions when incidents occur in a freeway corridor are influenced by the interrelationships between the following factors:

- familiarity
- time considerations
- destination
- assessment of incident and alternative routes

The first three factors are driver and trip related, and are not affected by driver information systems. The last factor is information related since the driver's ability to assess the incident and alternatives is affected by available information. The study results indicate that this factor is central to driver decisions and actions throughout a trip.

Figure 2, a summary of the systems analysis, outlines basic questions that a driver may have when freeway incidents occur. The questions outlined in the upper portion of Figure 2 for each trip component indicate the type of decisions confronted by a driver. The remaining questions apply to the driver's assessment of the incident and alternative routes and indicate the type of information required by the driver in order to make decisions about vehicle operation while on the freeway and about rerouting.

One of the driver's primary concerns while traveling on the freeway at high speeds is to be warned of unexpected stoppages or slow moving traffic. If a driver encounters congestion and decides to remain on the

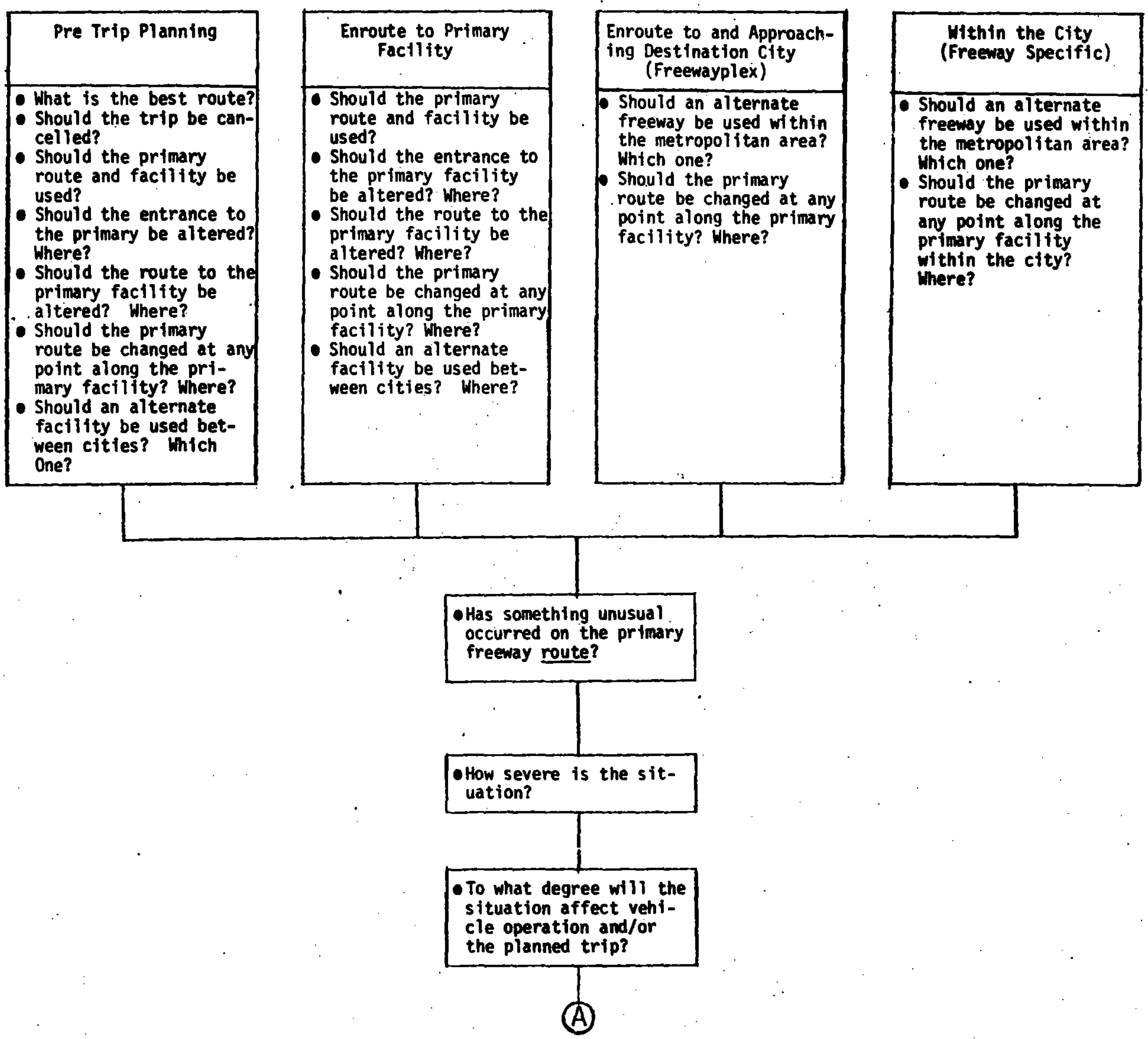


Figure 2 - Summary of Driver Decisions and Information Needs When Confronted with Freeway Incidents

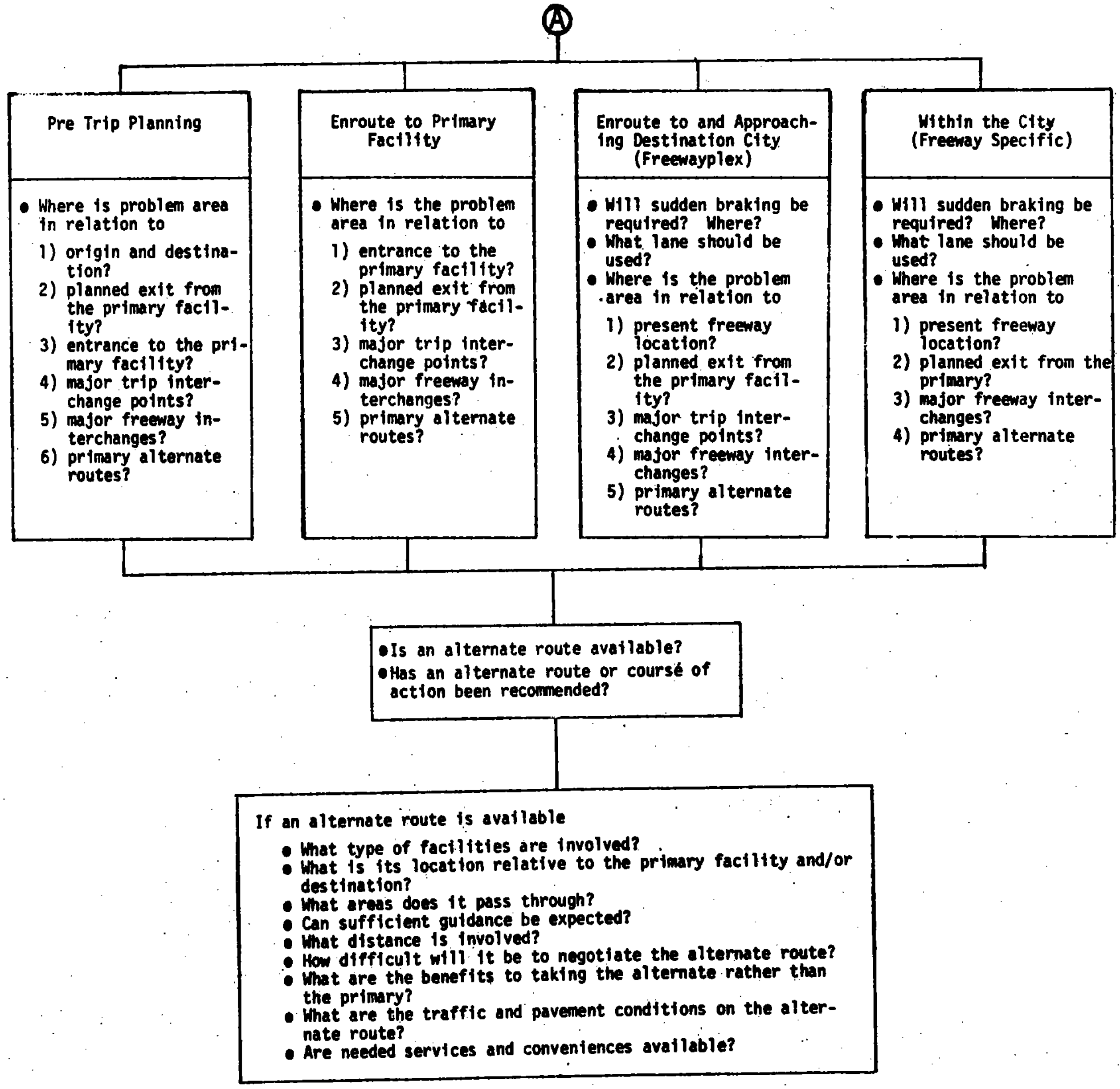


Figure 2 (Cont.) - Summary of Driver Decisions and Information Needs When Confronted with Freeway Incidents

freeway, it would be of some value to know what lanes are available so that he can change lanes, if necessary, far in advance of an obstruction.

When an incident occurs, the driver must decide on a course of action. His response will be influenced by his assessment of the severity of the problem, the location of the problem, availability of alternate routes, and the quality of the alternate route. In addition, recommendations via radio or signing advising to take an alternate route indicates that the severity of the problem warrants rerouting and may tend to influence driver decisions. Driver assessment of the alternate route and his subsequent decision are influenced by certain evaluation criteria that are discussed below.

Route Selection and Alternate Route Evaluation Criteria

Table 7 is a listing of route selection and alternate route evaluation criteria that evolved from the systems analysis. It identifies the types of things a driver considers in deciding whether or not to take an alternate route. The exact decisions drivers make during incident conditions are very complex and are not easily structured in a flow chart. The complexity is manifested in the diverse value systems of the freeway driving population. Drivers may place emphasis on different criteria. Thus, although general route selection criteria were synthesized, the parameters for these criteria are not easily identifiable.

The criteria listed in Table 7 suggest information required by drivers to assess and decide on a course of action when confronted with freeway incidents. Although many of the criteria are interrelated, each will be briefly discussed in the following sections.

TABLE 7

ROUTE SELECTION AND ALTERNATE ROUTE EVALUATION CRITERIA

- Severity of Problem
- Location of problem
- Type, distance, and location of alternate route, and its return point to the primary
- Weather and pavement conditions
- Ease of negotiating alternate route
- Expected guidance
- Required services and conveniences
- Types of areas alternate route passes through
- Benefits (time saved, speed, delay, etc.)

Severity of Problem - The degree the incident affects a driver's trip is a primary criterion in route choice. Drivers, as a rule, encounter many freeway incidents in their driving experiences and have developed expectations concerning their effects. In many cases, drivers have passed incidents such as accidents that did not seriously affect the overall trip. In other cases, the problems were severe and the consequences horrendous. Unfortunately, drivers in most cases are not aware of the degree of the problem resulting from an incident, and thus may not be in a position to make the proper decision. In other words, they do not know which incidents they encounter are severe enough to warrant rerouting.

From a technical standpoint, the effects of an incident are related to the number of freeway lanes, the width of freeway blocked by the incident, the length of time the incident blocks the lanes, and the vehicular demand. The effects are translated into delay, stop-and-go traffic, annoyance, being late for work or appointments, pollution, gasoline consumption, etc., from the driver's standpoint.

Research (7) has indicated that drivers are less reluctant to reroute after they are on the freeway. Thus if diversion from the freeway is to be effective, drivers must be convinced that the problem is severe enough to warrant rerouting.

There appears to be a critical level of congestion that drivers are willing to tolerate before other alternatives become acceptable or even considered. Each driver has his own value system; the critical level of congestion may therefore vary within the driving population. The critical level for each driver will also vary from day-to-day and from location-to-location. Although the final decision to divert will be influenced by other criteria discussed below, drivers need a clear understanding of the severity of the problem ahead and knowledge of the degree to which their trip will be affected so that alternatives can be evaluated. The more severe the problem, the less weight drivers place on the "inconveniences" of other routes. Unknown is whether the driver needs an exact description of the severity level to make a decision or whether a more general description is sufficient to complement an advisory to divert. In the latter instance, the driver accepts on faith that an "accident" is a "severe accident" and is sufficient to justify the indicated advise.

Location of Problem - Problem location applies to both the incident and the queue buildup. Knowledge of where the incident is and the extent of the queue will help the driver evaluate the severity of the problem. In addition, if the driver can identify the problem location relative to known alternative routes, it will aid his evaluation of alternatives and add credence to his decision. If the driver is unfamiliar with alternative routes, information severity and location information should enhance diversion recommended via signing. It is not known whether the problem location is best expressed in terms of distance or in terms of cross-streets. Indeed, the understanding of the display using either approach may vary with driver familiarity.

Type, Distance, and Location of Alternate Route and Its Return Point to the Primary - The type, location, and distance of the alternate route are interrelated criteria. Drivers select freeways as primary routes because of the higher operating speeds, directness or shortness of route, convenience and accessibility of the route, and lack of traffic control devices. They have developed expectations of conditions on other routes of lower geometric standards that will affect decisions about rerouting.

Drivers approaching a metropolitan area would generally expect to be routed around the city via another freeway and not along an arterial street. Even when circumferential freeways are available, the required travel distance on the facility will influence route choice. The shorter the distance on the loop, the more attractive it becomes. The distance drivers are willing to divert is related to the severity of the incident and the associated delays.

When the driver is traveling in the urban area, he would expect to be rerouted along the frontage road and/or arterial streets. He would not expect to travel on the alternate route for considerable distances.

Drivers tend to evaluate the location of the alternate route relative to their present positions and are concerned with the convenience (or complexity) of getting to the alternate facility. Another consideration is the location of the alternate facility relative to the destination, and the convenience of traveling from the alternate to the destination along other routes.

The location of the alternate facility interacts with the driver's desire to return to the primary facility (or arrive at his destination), his concern about getting lost, and other factors such as time. The farther away the alternate facility is from the primary, the less apt a driver would be willing to reroute.

Frontage roads offer convenient and easily accessible alternate routes when they are available. Continuous frontage roads in urban areas are an exception rather than the rule. In many cases, they are discontinuous at railroad tracks and major intersections. Frontage roads, as a rule, are not continuous through major freeway interchanges. Therefore, there may be driver uncertainty about the complexity of the alternate route along the frontage road when the driver is informed to use the route.

The geometric standards of the routes also affect the driver's ability to negotiate the route. Thus the driver has certain expectations of maneuvering problems that may be encountered when he is traveling with a trailer, camper, large truck, bus, etc. When the driver is uncertain of what to expect, he is more apt to remain on the primary facility that is of higher design standards. Ease of route negotiation is a criterion interrelated with facility type and is further discussed later.

Earthquakes, Smog Alerts

Weather and Pavement Conditions - Weather and pavement conditions play an important role in driver decisions. Inclement weather can affect the initial decision during pretrip planning as to whether the trip should be made, postponed, or aborted. During the trip, weather and pavement conditions in relation to type of facility can influence driver decisions about rerouting. Drivers' expect that the most heavily traveled routes would receive priority treatments of snow removal, salting, etc. during adverse weather conditions. The effects of large volumes of traffic also helps lessen the hazard somewhat under certain conditions. Therefore, there is a sense of security about remaining on a freeway and not deviating from the main route, particularly to facilities of lower design standards, unless there are assurances that the route is satisfactory.

Ease of Negotiating Alternate Route - Other concerns of drivers are those problems encountered in maneuvering along the alternate route. An alternate route can vary from a simple path along a frontage road to a more complex route involving several turning movements.

Drivers traveling with trailers, campers, large trucks, buses, etc. are particularly concerned about negotiating their vehicles along routes of lower geometric design standards. Some drivers would probably remain on the primary facility, except in cases of complete closure, while others may reroute if assured that there would be no problems in maneuvering. The complexity of the route a driver is willing to accept will depend a great deal on the severity of the incident and associated congestion.

Truckers with high loads generally know a priori that the primary freeway route can accommodate the high load and may not be familiar with overhead clearances on alternate freeways. Thus, even though a freeway is advised as an alternate route, truckers would need assurances of satisfactory clearances.

Expected Guidance - One of the greatest concerns of a driver is the possibility of getting lost in unfamiliar areas. The confusion and apprehension that arise from poorly signed routes has a lasting effect. The driver, therefore, tends to select the routes on which he is confident of adequate guidance that fulfills his navigational needs, and refrains from selecting those where guidance cues are inadequate.

Although there is some indication that guide signs on freeways need improvement, drivers encounter more problems in navigating urban arterials or city streets (8). The problems are compounded in the essentially non-rectangular and older city layouts. The uncertainty of direction and route guidance on the arterials or streets tends to affect the driver's decision to remain on the primary freeway during incident conditions. Since the driver has planned his trip along specific routes with a definite objective in mind of reaching a specific destination, he must be given the assurance that adequate route guidance is available on the alternate route that will guide him back to the freeway or to his destination.

Previous discussions in this report have indicated that commuters are not necessarily familiar with alternate routes along the entire freeway. Thus, their requirements for guidance (and guidance assurances before they leave the freeway) may be as great as those for the non-commuter.

Required Services and Conveniences - Services and conveniences required by a driver may also influence his decision to reroute. The driver's previous experiences have conditioned his recognition of services he will find on different types of facilities.

In many situations a driver may have already selected the location of his needed service such as motel accommodations. His commitment to a destination and route, therefore, could affect his decisions during freeway incidents.

Types of Areas Alternate Route Passes Through - Another criterion that affects a driver's decision about routes is the type of areas it passes through. There is a sense of security and perhaps pleasantness of traveling on a freeway particularly when passing through unfamiliar areas. Many drivers may be adverse to driving through areas in which these values are threatened. For example, some drivers simply detest traveling long distances on arterial streets through industrialized areas.

Benefits - Whatever the situation, the driver must perceive benefits in taking the alternate route in comparison to remaining on the primary facility.

There are many level of service variables such as relative travel times, speeds, delays, etc. that drivers use in evaluating routes. If the distances are equal on the two routes, a relative comparison can be made using one of many descriptors. However, generally the distance on the alternate route is greater than the primary route. Since the driver has no idea as to the relative distances involved, many level of service descriptors would not allow him to appraise the alternatives. For example, knowledge of the average speeds on both routes is not sufficient for a driver to assess the merits of the routes. Even if the distances were known, it is questionable whether unfamiliar drivers could complete the mental computational gymnastics to appraise the routes.

It appears that drivers evaluate travel between various key intermediate locations along the route according to estimated travel time. As long as travel time is provided to known intermediate destination points, drivers may be able to assess the relative merits of the routes by comparing the travel times. However, they must have some notion as to the distance involved to the intermediate point along the primary route. For example, a difference in travel time of 10 minutes is more appealing if the intermediate point is 1 mile away in comparison to 30 miles away.

If a comparison of travel times is an acceptable criterion to the drivers, another possible approach to signing is to give the driver information about the amount of time he can save by taking the alternate route. This concept eliminates the need for the driver to perform any arithmetic computations. One limitation of travel time and time saved is that they must be referenced to clearly specified beginning and end points.

Travel time or time saved descriptors may be practical while the driver is traveling on the freeway but may not apply during pretrip planning or while the driver is enroute to the primary facility. In these latter two cases, drivers are widely scattered and it would not be possible to provide correct travel time information for each driver. In these cases, it may be necessary to utilize another type of descriptor such as the delay he would encounter after he enters the freeway.

There appears to be a critical level of travel time, time saved, delay, etc. that makes an alternate route attractive. The critical level may vary for each driver. It will also vary according to the driver's appraisal of the type, distance, and location of the alternate route, weather and pavement conditions, expected guidance, ease of negotiating the route, required services and conveniences, the types of areas the alternate route passes through, and his time commitments, destination, and familiarity. Since each driver possesses a unique value system, the parameters of each criteria will differ among the driving population.

Pretrip Planning

Once a need for a trip arises, there are two major decisions: 1) whether to make the trip, and 2) selection of the primary route and facility. A driver familiar with the routes may merely rely on his past experiences for route selection, whereas, an unfamiliar driver would probably study maps and/or consult with other individuals. Route selection criteria that were discussed in the previous section also apply to driver decisions during pretrip planning.

The decisions and actions, and consequently the information needs of drivers planning intercity trips, appear to be related to the distance between the cities. Regardless of distance, information about conditions in the origin city are important. If the cities are relatively close (e.g. Baltimore-Washington, D.C. and Dallas-Fort Worth), knowledge of incidents on the primary facility in the destination city may affect a driver's route choice between cities. The influence of incidents in the destination city on driver decisions and actions during pretrip planning reduces as the distance between cities increases. Ordinarily, there is only one "acceptable" facility between cities spaced far apart. Normally, this is the shortest route of Interstate quality. Knowledge of incidents in the destination city would not appear to affect a driver's route choice between cities but would tend more to influence his anticipated choice of routes through the destination city. This is particularly true if the activity happens to be maintenance or construction of major proportion, or if the incident is expected to last for a prolonged period and involves freeway closure.

As discussed above, the location of the problem will affect driver decisions and actions, particularly in routing through a city. He must be able to associate incident location to his planned route and other alternative routes.

More alternative routes are generally available to a driver when cities are closely spaced. When certain types of incidents occur on the freeway, major arterials and other freeways in many cases offer acceptable alternatives. In other cases, the geometric design and operational features are less acceptable. All other things being equal, the greater the distance between cities, the less attractive a nonexpressway alternate facility becomes. The driver would be less likely to divert to a two-lane, two-way route if his destination were far away, but would more likely select a longer Interstate facility in the origin city.

Selecting an alternate intercity facility may require the driver to also change routes in both the origin and destination cities. The types of facilities the driver must travel on to reach or when leaving the alternate also affect his decisions.

If the cities are far apart, and thus the primary facility is predominantly in a rural environment, the primary facility is generally the "best" route when incidents occur or construction or maintenance activities are taking place, with the exception of times following natural disasters such as earthquakes. The driver's major decision will be whether the trip should be made or aborted. This decision will largely be influenced by weather conditions and how it affects travel on the primary facility. All things being equal, the driver expects that if the primary facility (freeway) is closed due to inclement weather, other alternative routes will also be closed.

In contemplating alternate routes during pretrip planning, drivers continuously seek to optimize their trips by taking the "fastest" route. They tend to evaluate not only the distance on the alternate facility, but also the required travel distance on streets with lower geometric standards leading to and away from the facility.

Enroute to the Primary Facility

As the driver approaches the primary facility, generally the number of alternatives reduces and he becomes more committed to the primary. The unfamiliar driver would tend to be more reluctant to deviate from the planned route to the primary facility unless he was attracted by specific directional signs or trailblazers. The familiar driver, however, may be receptive to selecting alternate paths to the freeway if his analysis of the problem on the freeway justified such action. As a rule, the familiar driver does not concentrate on directional signs or trailblazers that are paramount to route following for the unfamiliar driver. It must be emphasized that commuters are not necessarily familiar with the surrounding street system along their entire route, but it is probably safe to assume that they are familiar with alternative facilities enroute to the primary. They may not, however, be aware of the "best" route to the primary and would need advice as to what action should be taken.

Enroute to and Approaching Destination City (Freewayplex)

Prior to approaching a large city the driver evaluates alternate routes and selects the freeway route that best serves his needs. In some cases there is only one available freeway route through the city. In other instances more than one alternative are available. Loop freeways that offer a viable alternative to the driver are now completed in many cities.

Most unfamiliar drivers with destinations in the central city would probably elect to remain on the primary freeway rather than routing along the loop when an incident occurs. Their unfamiliarity with the freeway system coupled with the expectancy that positive destination guidance would not be available to direct them along the other freeways are strong motivating factors. Drivers familiar with the freeway system may elect to reroute to other freeways based on their understanding of the severity and location of the problem. Their decision would also be influenced by other route selection criteria previously discussed, with the exception that weather and expected guidance would not be as critical since routing is along familiar freeway routes.

Drivers passing through the city would be more receptive to rerouting along an alternate freeway route. They need assurance that the alternate freeway route will take then back to the primary facility that they intend to take out of the city.

In large metropolitan areas, the freeway system can be very complex in the minds of unfamiliar drivers. They are aware that the route they are on will get them through the city. All they have to do is follow the route markers and follow the route as they had planned. They are confident that they will be able to route through the city to their destination. Unfamiliar drivers generally evaluate freeway routes prior to driving through the city and place more emphasis to studying their route choice. It would be expected that drivers would tend to forget the routing and directions of other city freeways while in transit. Driver concern about getting "lost" in an urban area with the possibility of traveling several miles out of the way is crucial in rerouting. Any suggestion to the driver to take another freeway route must be accompanied with complete assurance that positive guidance to his destination will be provided along the alternate freeway route. Route markers are not sufficient; destination names become paramount.

Familiar drivers can navigate using route markers since they are familiar with the freeway system. It must be reemphasized, that although commuters are familiar with their primary freeway route, not all are familiar with the total freeway system. Information to this segment of the population must include positive destination guidance signing.

During the peak periods in large cities, the freeway driving population consists primarily of commuters most of whom are familiar with alternate freeway routes to their destinations. Consequently real-time signing during the peak periods should be directed to this large segment of the population. This approach not only assures that a large percentage of the drivers can understand and use the messages, it also minimizes the number of signs required by reducing the need for specific destination information.

The above discussion concentrated on freeway systems that might involve "complex" routing by the driver. Many cities have completed loop freeways that offer excellent alternatives for drivers traveling through the city. The major interchange upstream of the city is sometimes referred to as a major diversion point. If an unfamiliar driver studies a map and is aware of the existence of the loop freeway as an alternative, he may be more receptive to diverting. His knowledge of an eventual return to the primary facility and his evaluation of the severity and location of the incident versus his expectations of the conditions, distance, etc. of loop freeways would probably enhance diversion. (Some drivers select the loop as the primary facility to avoid the downtown area of the city particularly when traveling through the city during or immediately prior to or after the peak period.) When an incident occurs on the primary, drivers would need the assurance that the loop freeway is the best route, and reassurance that it will take them along a freeway route around the city and back to their primary facility.

Within the City (Freeway Specific)

This category includes those trip components in which, the driver is traveling on the primary freeway in the city, either origin or destination city. These two trip components were combined in Figure 2 because of the similarity of questions addressed by the driver. The difference lies in driver response to incidents with respect to route choice and thus the relevancy of certain types of information for decision making. For example, the farther apart the cities are, the less value a driver places on information concerning the destination city while traveling in the city of origin. His primary concerns are routing through the city he is in and avoidance of conflicts.

The driver is less willing to reroute in urban areas after he enters the freeway (7). This driver attitude is due to several factors related to the driver's value system associated with route selection criteria previously discussed. The driver has a greater commitment to a route, particularly if he is traveling through the city. In addition, the "security" of the primary freeway requires greater challenges in "convincing" a driver to leave the freeway and reroute. The situation is amplified during the peak period when even the commuter may suddenly find himself unfamiliar with the surrounding street system and its associated conditions.

The effects of weather and pavement conditions were previously discussed and they certainly influence the driver's decision. But even under ideal weather and pavement conditions, other route criteria are important. Type of alternate facility, its location relative to the primary facility and/or destination, its distance, ease of negotiation, types of areas it passes through, and expected guidance are considered with respect to the benefits of either taking the alternate facility or remaining on the freeway.

Not all incidents result in significant delay to warrant rerouting. However, each results in some degree of queueing which is a hazard to uninformed drivers. In addition, environmental conditions at times create hazards. Drivers must be made aware of unexpected braking maneuvers required to avoid collisions when an incident occurs. They also need lane assignment information to guide them through the affected area.

SYSTEM CONFIDENCE AND INFORMATION CREDIBILITY

The preceding chapter focuses on driver information requirements and identifies criteria that should be considered in the design of real-time driver information displays. Route selection and alternate route evaluation criteria drivers use in deciding upon rerouting when contingencies occur on the freeway were also identified. These criteria are important in developing candidate sign messages.

Two additional criteria that are important to the success of traffic management using real-time information displays are the confidence drivers have in the signing system and the credibility of the information displayed. These criteria are influenced by the manner in which the system is operated by the agency. Drivers must be confident that the operating agency has full knowledge of the operating conditions on the primary and alternate routes and is recommending the best course of action. Displaying timely, accurate, and reliable information at all times when information is needed by the driver will enhance credibility. Inaccurate information can very quickly result in driver loss of confidence in the system. When this occurs, the best designed information displays will not achieve the desired driver response for effective traffic management.

A CONCEPT OF INFORMATION NEEDS FOR THE UNFAMILIAR DRIVER WITHIN THE CITY (FREEWAY SPECIFIC)

There is some question whether an unfamiliar driver would be willing to divert once he is on his primary facility within a city, particularly during peak periods. This is due to his concern about getting lost or trapped in traffic on unfamiliar city streets. It appears that the incident would have to be of major proportion before an unfamiliar driver would forego the "security" of the primary facility.

The systems analysis indicates that unfamiliar drivers tend to plan their trips to avoid large cities during peak periods. Thus, the peak period freeway traffic population would be composed primarily of commuters who are familiar with the freeway system. Consequently, real-time information on a freeway within a city should probably be directed toward the commuter during peak periods. However, there are basic information needs of both familiar and unfamiliar drivers during peak periods that were identified in the analysis and would have to be considered. These were:

- Warnings of unexpected braking due to stopped or slow vehicles or other hazards.
- Lane assignment during incidents.

A CONCEPT OF INFORMATION NEEDS OF DRIVERS APPROACHING A CITY (FREEWAYPLEX)

The primary concern of an unfamiliar driver passing through a large city is finding the "best" route through the city. As a rule, he identifies the most appropriate freeway route during pretrip activities. If only one freeway route is available, the decision is simple. The decision becomes somewhat more involved if more than one alternative freeway route is available. Several factors will influence the driver's decision. However, while driving, he searches for information that will guide him through the city toward his destination.

Unfamiliar drivers appear to be basically route oriented during pre-trip planning activities and tend to identify interstate route numbers between major intermediate points along their routes. This fact is supported by questionnaire studies conducted by King (8) and by McNees and Huchingson (9). The systems analysis, however, strongly suggests that while in transit the driver is greatly influenced by destination names particularly at major freeway interchanges. Signing containing the name of an intermediate destination would tend to enhance driver decision-making at a complex interchange, particularly since the decision must be made within a few short seconds. Drivers tend to believe that the destination name on a sign is suggesting the "best" freeway route through the city, and that they will be continuously guided along this route. The interstate shields and the cardinal direction reinforces the destination name and thus the decision. The positive attraction and influence of the destination name at major interchanges have been indicated in recent single point diversion studies by Sperry Rand (10).

The familiar driver, on the other hand, generally ignores guide signs and bases his decisions on his previous experience and current knowledge of the routes and site identification. His primary information requirement therefore is concerning traffic and incident conditions on the primary and alternate freeway routes. He will make a freeway route choice based on his evaluation of the relative qualities of each alternative freeway route, or in the absence of such information will rely on the sign system guidance for route choice.

Based on the concepts discussed above, several hypotheses are proposed for further laboratory and field evaluations. These are listed in Table 8.

TABLE 8

MAJOR POINT DIVERSION (FREEWAYPLEX)
HYPOTHESES FOR FURTHER TESTING

1. The unfamiliar driver searches for and is guided by destination information to the next major city as he is approaching and driving through a large city. For example, a driver traveling to Florida from New York through Baltimore and Washington, D.C., will seek guidance to Washington, D.C. as he is approaching and passing through Baltimore.

2. The unfamiliar driver expects that the highway department will guide him to his destination via the "best" freeway route through the city.

3. As long as an unfamiliar driver will follow destination information along the "best" freeway route, there is no reason to inform him of traffic conditions on the initial primary route.

4. An unfamiliar driver should never be given more than one choice of routes by using destination names on signs at a major diversion point.

5. An interstate decal and cardinal direction in addition to the destination name will enhance the driver's decision to route along the freeway suggested by the signs. If the suggested routing is via an arterial, the driver will become confused and remain on the route he is on.

6. Drivers expect confirmation that the route they are on will take them to their destination.

7. A familiar driver does not require detailed guidance through the city.

8. All that a familiar driver needs to know when an incident occurs on his primary freeway route is the location of the affected area resulting from the incident and the degree of the problem. He can select alternate freeway routes on his own. However, he would need to know if any incidents are on his alternate freeway route.

9. Once a familiar driver diverts to an alternate freeway route, he will need destination oriented information at major decision points for confirmation that he is heading in the right direction.

EXPECTATIONS ALONG ALTERNATE ROUTES

Since route diversion and incident management require routing drivers along alternate routes that in many cases are unfamiliar, certain driver requirements must be fulfilled. Table 6 (page 31) identified a basic set of driver information requirements. In addition to this set, drivers require confirmation via signing that they made the proper choice. This can be accomplished by signing compatability between the static and dynamic information on the primary facility and alternate route (e.g. use of the same words or symbols). Fulfillment of the driver's navigational requirements that he is on the correct route will be a key to satisfying the driver's need for assurance. It must be remembered that the driver has spent considerable time in route following prior to leaving the primary facility and has conditioned himself to certain navigational expectations. Violations to these expectations can result in system failures.

Another principle that must be considered is driver orientation to his primary route. Drivers are direction oriented relative to their primary facility. After leaving the freeway to an alternate route other than a frontage road, he has expectation of the basic turning movements to return to the freeway (i.e. right, left and left). Any violation to these expectancies can result in driver uncertainty, apprehension, and confusion. For example, a driver does not expect to make two successive right turns after leaving the freeway, placing him in a direction opposite to his destination.

Something could also be said about the driver's expectancy to remain to the right side of the primary freeway. An alternate route that requires a driver to cross over the freeway may be in violation to his expectancies. A right-turn direction would be expected if there is an obvious alternate route in that direction. If there is open country or a physical barrier on the right, a left turn would not be unexpected.

REWARD AND PUNISHMENT

Route diversion and incident management using driver information displays encourage drivers to travel on alternate routes when incidents occur on the primary facility. This requires a major decision by the driver, particularly when he is asked to route away from the freeway along arterial streets and pass through several signalized intersections. When he does accept the messages and reroutes, generally he is not sure whether he made the right choice or whether he will in fact be "punished" for following the sign's advice by taking the poorer route. If he questions the credibility of the advisory this may indeed affect his decisions later when he encounters similar situations and messages.

One approach to increasing his confidence is to reward him for making the proper choice. This may be accomplished by somehow informing him of benefits such as the amount of time he saved by selecting the alternate route. The messages would provide reassurance that he made the proper choice. The signing should be dynamic for credibility. Also, the benefits of taking the alternate route should be displayed on the freeway upstream of the exit as an incentive for him to get off.

DRIVER INFORMATION DESIGN ISSUES

The preceding discussion of the systems analysis has identified several driver information needs. A study of these needs and a thorough review of the state-of-the-art of real-time motorist information displays (11,12) and a questionnaire survey conducted by TTI (9) resulted in several design questions that require further analysis. These design issues are discussed in the following sections.

Warning Information On Freeways

One relevant item of information that a freeway driver needs is that concerning unexpected stoppages particularly at locations having restricted sight distances. In Houston, a black on yellow sign mounted to the side of the freeway and having a message: "CAUTION/SLOW TRAFFIC/When Flashing" is used. Flashing beacons are mounted on each side of the sign. This system is traffic responsive. A similar system is used north of Louisville. The sign is black on yellow with the following message: CONGESTION AHEAD/WHEN FLASHING. This system works on a fixed time basis. That is, it operates at all times each day during the peak periods, whether or not there is a stoppage on the far side of the grade. Several questions arise:

1. What is the best message?
2. What color should the sign be?
3. What is the effect of not having the sign operating in a traffic responsive mode (credibility issue)?
4. Would a matrix, rotating drum, or other type of changeable message sign be more effective than the static sign and beacon?

5. Would the sign and message be more effective if it were overhead?
6. Would the system be as effective if the sign was removed (use flashing beacons only)?
7. If a changeable message sign is normally used for giving freeway condition information, can it be used effectively for stoppage warning? (Can a sign serve two functions: display of information and advance warning?) If so, how do you make it effective?

Lane Availability

What is the best way of telling a freeway driver which lanes are blocked (or open to traffic)? On a three lane freeway section, the solution might be relatively simple, for one might use: LEFT LANE CLOSED, RIGHT LANE CLOSED, MIDDLE LANE CLOSED, or something similar. When there are more than three lanes the problem becomes more complex, and all the above messages may not do the job. For example, one might ask: "Which middle lane?"

Overhead red "X's" and green arrows have been used effectively to indicate lane availability. Some systems are currently using matrix signs with word messages. The issue of lane availability requires attention in Task B. Several questions need to be addressed.

1. If the X's and arrows were displayed on a sign to the side of the freeway, would the message be understood, or must the X's and arrows be directly over the affected lane for the correct association?
2. Can one use existing matrix signs to display lane availability information?
3. Are there alternative means of providing lane availability information?

4. If the answer to 3 is yes, then how can it be displayed? Can one use matrix signs, rotating drums, etc., or are the line spacings too far apart?
5. Are there better symbolic codes than X's and arrows that can be used?
6. How important is color coding?
7. What is the relationship between color and symbolic code for lane availability information?

Describing Freeway Conditions

One of the major issues that must be addressed is determining the most effective way to describe the freeway condition to a motorist so that he can evaluate the situation and make decisions about routes. The problem of course is that there is a continuum of conditions that can arise on the freeway ranging from zero vehicles to a situation where a bridge has collapsed. Considering more common incidents, an accident during the peak period will have a more pronounced impact than one having similar characteristics such as severity, number of lanes blocked, duration, etc. occuring during the off-peak. Compounding the communcation problem is that other incidents such as stalled vehicles, debris spills, etc., can have as much effect on operations as accidents.

1. How many levels of traffic state can a motorist distinguish between? Stated otherwise, how many states would he behave differently to--by diverting or by slowing down? (There is no need to display five or more states if the driver can distinguish or react to only a few.)

2. What is the better wording to convey an extremely high state of congestion, but without actual stoppage. Candidates might be:

   (a) CONGESTED TRAFFIC
   (b) HEAVY TRAFFIC
   (c) SLOW TRAFFIC
   (d) STOP-AND-GO TRAFFIC
   (e) DELAY AHEAD
   (f) Other

3. Is there an advantage to coding the major traffic states either in conjunction with or in lieu of the verbal message? Color coding, letter coding, number of lights, or combinations of the above are possibilities. Response time, target value, and visibility distances under adverse ambient conditions should be considered.

4. Again, how should the message be worded to convey no unusual traffic problem?

   (a) FREE FLOWING TRAFFIC
   (b) TRAFFIC - OK
   (c) TRAFFIC NORMAL
   (d) FREEWAY CONDITION - A
   (e) Three dots ...
   (f) Blank sign

5. Would it be better to inform motorists that the traffic is typical for that time of day (although not optimal); or to try to describe the actual level of traffic by some absolute density reference system?

6. To what distance regime should the traffic state information apply? If it applies to the traffic in which the motorist is driving, the information is obvious, so it should be understood to apply to "some" distance ahead. Should the message state "ahead," some specific distance, or is "ahead" implied.

7. From the standpoint of motorist needs and acceptance, should the "ahead" distance reference be to the <u>onset</u> of the congestion backup or to the

cause of the congestion? While the answer may be obvious here, it is less so in reference to messages such as stalled vehicle, accident, construction, etc.

8. How should the location be expressed: in miles or in cross-street name descriptors?

9. The literature (7, 11, 12) suggests that motorists want qualitative information on traffic state and information on the cause of the congestion, particularly if a lane is blocked. Research (10, 15) suggests they are less likely to divert when information concerning moderate or mild congestion is displayed. Under these traffic states, should they be advised to an alternate route when previous research suggests they are less likely to accept this advisory? Or should they be given a different advisory - to slow down? Or should they be given the information with no advisory at all when the situation is less than severe? Or should the information not be displayed?

10. At what level of the continuum would a motorist be willing to divert (a) from one freeway to another, (b) from the freeway to frontage road (or arterial) back to the freeway, (c) from the freeway to an arterial to his destination?

11. What is the better way to display temporal information - in terms of delay, in terms of comparable travel time on the primary and alternate routes, or in terms of time saved by taking the alternate?

12. How many levels of delay information should be displayed? How much delay in minutes is sufficient to result in motorist diversion? What meaning do motorists ascribe to "delay"?

13. Does the type of incident displayed imply its severity? Would drivers react differently to various types of incidents in terms of diversion? How specific does a message need to be in terms of the type of incident? Will general incident categories be sufficient?

Minimum Information Needs For Traffic Descriptors

Most of the studies reported in the literature polled drivers as to priorities of information. The results have shown rather consistent results in priorities. For example, distance or location, degree of incident, lanes blocked, etc., have generally been rated high. Travel time and delay have generally been rated low. These studies have indicated priorities, but do not give any clue as to the minimum amount of information the driver needs to make a decision. The important issue is: if the display gives distance or location, severity or type of incident, and lanes blocked, is this sufficient information that would allow the driver to decide whether or not to divert? If not, what other descriptors must be added?

1. What is the minimum number of descriptors needed by the driver to make decisions about diverting from
   a) freeway to freeway
   b) the freeway to arterial streets around the incident
   c) the freeway to arterial streets to final destination.
2. How should the severity of the problem be presented to the driver in order for him to evaluate the extent of the congestion? Will it suffice to only describe the nature of the problem such as ACCIDENT, STALLED CAR, TRUCK OVERTURNED, MAJOR ACCIDENT, MAINTENANCE, CONSTRUCTION, INJURY ACCIDENT, 1 OF 4 LANES BLOCKED, 3 OF 4 LANES

BLOCKED, ALL LANES BLOCKED? Is it necessary to include other descriptors such as delay, speed, or travel time? Is the duration of an incident a good descriptor? Should the distance of the congested area be used?

Incident Bypass

Rerouting freeway motorists around an incident or to their destinations via the frontage road and arterial streets will be one of the more complex tasks. Studies have shown that motorists are less apt to divert once they are on the freeway. It appears that the key to success lies in our ability to convince him that he should leave the freeway, that he will be guided either back to the freeway or to his destination, and guided along a "better" route.

The problem of rerouting traffic around an incident is compounded due to the existence of static signs at intersections along these routes which point to the freeway (Interstate decal is one example). Therefore, the routing and guidance technique must overcome the potential impact that the existing signing has on the motorist.

1. What is the shortest and simplest message which will induce a significant percentage of the motorist to divert from a freeway?
   - (a) Should the type of facility he is being diverted to be given in code on the sign? Should the code also imply that it is an alternate route which will return to the primary route?
   - (b) Is the minimum information for the familiar motorist the following:
     - Problem (accident)
     - Location (X miles ahead)

- Advisory (use incident bypass route - the latter shown only by a symbol)

(c) Is the word, "use," preferable to "take," "follow," "exit to," or any other director verb.

(d) Is the congestion on the bypass route assumed to be less than on the primary route and, therefore, unnecessary for display on an advisory sign?

(e) Is it necessary to tell the motorist in some manner the distance he will travel on the bypass route or at what point (city or street) it will return to the primary route? If so, how could this be shown?

2. What words or symbolic messages should be used?
3. In route following, how often must the word or symbolic message, on which the driver is keying, be repeated for motorist reassurance?
4. How is guidance along the bypass route accomplished in lieu of possible conflicting messages from existing static signs?
5. What is the maximum number of destination codes that should be used for route following on the bypass routes? How should they be designed (color, shape, etc.)? What codes and colors should be avoided.
6. What words do drivers use to describe various types of alternate routes?

Major Route Diversion (Single Point Diversion)

1. What is the shortest and simplest message which will induce a significant percentage of the motorists to divert from a freeway?

(a) Should the unfamiliar motorist be advised to divert without explanation? Need he know there is a reason for his being sent that way?

(b) Should the type of facility he is being diverted to be given in code on the sign? Should the code also imply that it is an alternate route which will return to the primary route?

(c) Is the minimum information for the familiar motorist the following:

- Problem (accident)
- Location (X miles ahead)
- Advisory (use incident bypass route - the latter shown only by a symbol)

(d) Is the word, "use," preferable to "take," "follow," "exit to," or any other director verb?

(e) Is the congestion on the bypass route assumed to be less than on the primary route and, therefore, unnecessary for display on an advisory sign? Should a motorist be given a difficult decision task at a choice point?

(f) Is it necessary to in some manner tell the motorist the distance he will travel on the bypass route or at what point (city or street) it will return to the primary route? If so, how could this be shown?

(g) Is it necessary to quantify the conditions on both the primary and alternate route? If so, what descriptors should be used? Possible approaches are to display speed on both routes, travel times on both routes, delay on both routes, and time saved by taking the alternate route.

2. Should a sign at a particular location (e.g., intercity point diversion

location) be addressed only to the type of motorist who will most likely read it (the unfamiliar motorist) or should it be addressed to both familiar and unfamiliar motorists?

3. Should a sign for unfamiliar motorists direct traffic to a particular route when the state of traffic is equally good or equally poor on either route? What would be the effect on motorists believing the sign if the indicated direction was later found to be no better and perhaps believed to be poorer than the other direction?

4. Will a motorist divert more quickly and/or more consistently to a sign with the name of a major city (which is his destination or is before his destination) than he will divert to a route number?

   (a) How important is the interstate shield in either instance?

   (b) Does the name of a minor city, which is in a compass direction 90 degrees from the major city, reduce the effectiveness of the sign when it appears with the major city name?

   (c) Does including a cardinal direction on a bypass route sign confuse the motorist, when this direction is known to be 90 degrees from the direction he was headed on the primary route and, also, perpendicular to his destination? Should it be deleted when the major city is shown on a changeable message bypass sign?

5. In route following, how often must the word, or symbolic message on which the driver is keying, be repeated for motorist reassurance?

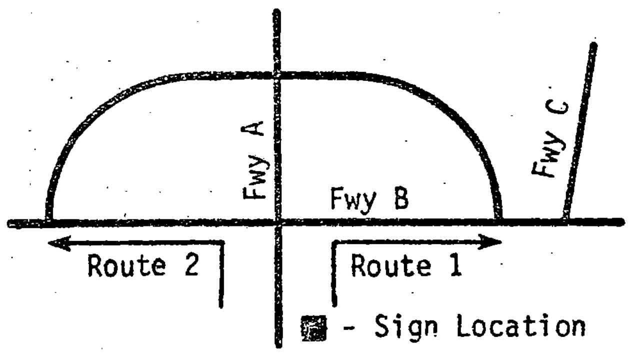
6. What message should be displayed to the motorist who has failed to follow the bypass route correctly?

7. Is there a way that signing of a bypass route can deal with the

situation in which the motorist is diverted to bypass which takes him back to the primary route at a point <u>downstream</u> of the location he would normally exit to a particular suburb city? He would be looking for guidance information on where to get off the bypass to get to an arterial to his city. How should this signing be handled?

8. What message elements should be used on an advanced warning sign upstream of advisory changeable message signs for major route diversion?

Information About Intersecting Freeways



When the driver's primary freeway route involves more than one freeway, he not only is interested in conditions on the freeway he is currently on, but desires similar information on the freeway he will connect with.

1. Should information about the Freeway B be placed on the same sign as information about Freeway A?
2. Should information about Route 1 be placed on the same sign as Route 2?
3. Should the information about Freeway B be less detailed than information about Freeway A?

4. Should the information about Freeway B be less detailed than information about Freeway A?
5. Should information about Freeway B be displayed when an incident has occurred, but Freeway B is still the "best" routing to the destination?
6. At what location(s) on Freeway A should information about Freeway B be displayed?
7. If the motorist's route involves Freeways A, B, and C, should information about Freeway C by displayed to the motorist while he is on Freeway A?

Displays During Off-Peak

There is some question as to whether or not information should be displayed during the off-peak periods. CALTRANS has decided not to display messages, as has Dallas. A Houston questionnaire survey indicates that motorists would like to know if everything is O.K. during the off-peak periods. This is contrasting to the results in L.A.

1. Should messages be displayed on CMSs during off-peak periods?
2. If so, what are the best messages?
3. If not, what display design should be used to make the motorists aware that the system is operational, but the freeway is O.K.?

Matrix Displays

Signs such as those employing matrix lamps or discs provide considerable flexibility in message selection. There are several issues that need to be addressed concerning the design of the signs, the amount and types of information that should be displayed, and the manner of sign operation.

1. How much information can a driver retain when reading a sign? What is the maximum amount of information that should be displayed?
2. How many lines should be used on the sign?
3. How should the sign be operated? Should messages be sequenced on the sign? Should a moving message be used?
4. What type of symbols can be used with respect to route guidance? What symbols on a matrix sign are easily recognized and translatable to other types of signs that might be used for route guidance?
5. How is message readability affected by various amounts of bulb loss?

Audio and Mixed Modal Displays

Commercial radio has long been used for traffic advisories, but the recent expanded uses of localized radio broadcasting suggests that an investigation is needed of the same design issues for the audio domain as for the visual domain. These issues involve the content, format, length, and repetition of the messages and their "placement" relative to driver. Much research has already been conducted on speech intellegibility and voice characteristics. But an important new area is the ways in which visual signing and the radio will work together to facilitate the drivers task in route diversion and incident management situations. Among the important design questions are the following:

1. What should be the content of radio messages which would advise freeway motorists to divert? What are the minimum types of information which should be included?

2. What should be the format or ordering of the message elements?
3. Could a motorist effectively select and retain a set of pertinent audio information when this information is embedded in various positions in a set of irrelevant audio information similar in content?
4. What type of language style should be used - conversational, staccato or sign language, or something in between, but with complete sentences and verbs?
5. Is it feasible to give radio route guidance information, which must be retained over a period of time? Will drivers forget the names of streets, routes, turn directions, etc before he encounters guidance signs along the alternate route?
6. What are the limits of this application? What is the minimum number of units of information (load) which can be retained from route guidance messages when the message is given only once? What effect does driver familiarity with the area have on ability to negotiate a route of varying levels of complexity?
7. How often must an audio message be repeated as a function of the messages loading of information?
8. What should be the content of audio messages which provide route guidance information? (a) What effect does providing a diversion course which is logical (in terms of diversion away from and then back to the freeway) have on the driver's ability to negotiate routes of greater complexity such as eight, ten, or twelve units of information? (b) What is the typical way people in our society describe routes? What language is used to describe turns, distances, and

en route confirmatory information? How important are cardinal directions, turns, street names, traffic lights, and landmarks to route descriptions in terms of success in route negotiation?

9. Given that one of the key elements of a route description is names of the streets or routes comprising the legs, should these names be repeated within the message itself (internal redundancy) or should the entire message be repeated (successive redundancy)?
10. What should be the content of the highway sign messages which direct motorists to turn their radio dials to a particular station to receive important traffic or route information?
11. Where should this sign be placed on the highway? How far upstream of the broadcast area should it be located based upon typical driver dial turning response times? Should there be two signs - the second a reminder the driver is within the broadcast area?
12. How may visual and audio information be used to complement one another in the route diversion situation? Should a radio system describe the problem and direct the driver to follow trailblazer-type route guidance signs or should the trailblazer signs be in addition to an audio guidance message? Are such visual signs necessary and to what degree does it depend on the complexity of the route?
13. Which type of information -- visual or audio -- is relied upon with greater confidence in situations where the two may present conflicting information?

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