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16. Abstract

Expectancy relates to a driver's readiness to respond to situations, events, and information in predictable and successful ways. It influences the speed and accuracy of information handling, and affects all aspects of highway design and operations, and information presentation.Aspects of the highway situation that are in accordance with prevalent expectancies aid the driving task, while expectancies thac are violated lead to longer reaction time, confusion and driver error. Two classes of driver expectancy are operative throughout the driving task. The first are a priori expectancies that most drivers form through habit and experience, and that are brought into the task. The second are ad hoc ones that drivers form in transit based on the road and its environment. Each class of expectancy must be considered in the design and operation of the road and its information system. This report describes the concept of driver expectancy in the context of the driving task, and provides examples of expectancy and expectancy violations. It includes a procedure for identifying general and specific expectancy violations to enable engineers to develop remedial treatments to deal with expectancy problems.

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DRIVER EXPECTANCY in HIGHWAY
DESIGN and TRAFFIC OPERATIONS

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SCOPE

The concept of expectancy is presented within the context of the driving task and the reception and use of information by drivers. The discussion centers on driver expectancy and the way it affects and is affected by the presentation of information.

It describes the ways in which expectancy and expectancy violations influence driving task performance. It includes an historical development of the expectancy concept and its application to highway design and traffic engineering. It describes various highway and traffic situations where expectancy impacts on driver behavior.

Finally, it presents a procedure for the application of the expectancy concept in the analysis of problem locations and the development of information system improvements.

INTRODUCTION

Driver expectancy is a key factor in driving task performance. It affects all aspects of driving, including pre-trip planning, hazard avoidance, lateral placement, speed control, road following, route following, and direction finding. It affects how drivers react to and handle information, how they make decisions, and how they translate their decisions into control actions and driving strategies.

It affects the safety and efficiency of driving task performance, and ultimately, the effectiveness and suitability of highway design and traffic operations (30). Accordingly, the focus of this report is on expectancies, what they are, how they are structured, reinforced, and/or violated, and how engineers and designers can use them in the design and operation of highways.

Ultimately, the success or failure of any design or operational strategy rests in its ability to be used safe and efficiently by drivers. Therefore, since expectancy is so basic to driving task performance and information handling, it should be considered in all driver-related aspects of highway design and traffic engineering.

The material on the driving task, information reception and use, and expectancy is derived from several primary references. These include an article by the authors (5), NCHRP Report No. 123 (30), The 2nd Edition of the Users' Guide to Positive Guidance (32), and SAE Report SP 279 (37). The reader is referred to these references for detailed discussions of specific factors.

POSITIVE GUIDANCE

BACKGROUND

The highway system consists of a complex array of elements: drivers; in vehicles; on roads; in traffic; in an environment. It is dynamic, with diverse subsystems (e.g., information displays, Interstate roads, urban arterials, city streets, police, traffic platoons) and interactions, often of a transitory nature.

As a principal controlling element, drivers are primary determining factors in the system's successful operation. Skillful driving task performance, maintenance of vehicle control, safe and efficient guidance through roads and traffic, and proper navigation using an optimum mix of routes, represent ways in which driver performance enhances system operations and safety.

Highway and traffic engineers are also major determiners of the success of the highway system. Their production of designs that match the capabilities of drivers, that take human limitations in account, and that, through the highway information system, convey the operating conditions of the highway and its environment to the driver, enhance optimum driving task performance.

Since the safety and operational efficiency of the highway system depends, in great measure, on a driver's ability to perform in a proper, error-free manner, an appreciation of human factors is essential to highway design and traffic control.

While engineers have considerable knowledge about vehicle characteristics, load factors, environmental effects on pavement, etc. (1) (14), they often have only a rudimentary understanding of the motorist. They fail to account for driver error, the consequence of designs that are beyond driver capabilities, maneuvers that are unusual or unexpected, decisions that are overly complex, or information displays that are confusing or ambiguous.

Driver error is one of the leading contributors to accidents and inefficient traffic operations, and must be minimized for the highway system to perform its intended function, the safe and efficient movement of people and goods.

Driver Error

Driver errors occur for a variety of reasons. A leading cause, beyond the scope of this report, is that drivers are unable to perform due to drugs, alcohol, fatigue, etc.

Causes within the scope include the following:

- expectancy violations;
- situations that place too much demand on drivers, causing overload;
- situations that put too little demand on drivers; causing lack of vigilance;
- information displays that are deficient, ambiguous, or missing content;
- misplaced information;
- blocked or obscured information;
- information that does not possess sufficient size, contrast, or target value (29) (34) (35) (42).

These deficiencies cause drivers to miss or be unable to process traffic control information.

In cases where errors are committed due to the nature of the task, the demands of the situation, the inability of drivers to handle information, the inadequacy of the information being presented, or the violation of expectancies, it is the responsibility of designers and engineers to reduce the sources of error.

Positive Guidance, a procedure that identifies information system deficiencies and provides suitable, expected information, when needed, where required, and in a form best suited for its intended purpose, achieves this goal (4).

The premise of **Positive Guidance** is that competent drivers, using properly designed roads with appropriate traffic control devices, will drive safely and efficiently. Conversely if designs are incompatible with driver attributes, or if the information displays are ambiguous or erroneous, or if expectancies are violated, drivers will commit errors, and the system will fail.

Armed with the proper information, designers and traffic engineers can provide roads and information displays matched to highway users and their expectancies.

The Driving Task

In order to understand expectancies, it is necessary to understand what drivers do, and how they receive and use information to perform the driving task. The basic driving task consists of three performance levels - control, guidance, and navigation (3) (see Figure 1). These levels, and their associated activities and subtasks, can be described according to scales of complexity and priority (primacy). The scale of complexity increases from control through guidance to navigation; priority (primacy) decreases in the same direction.

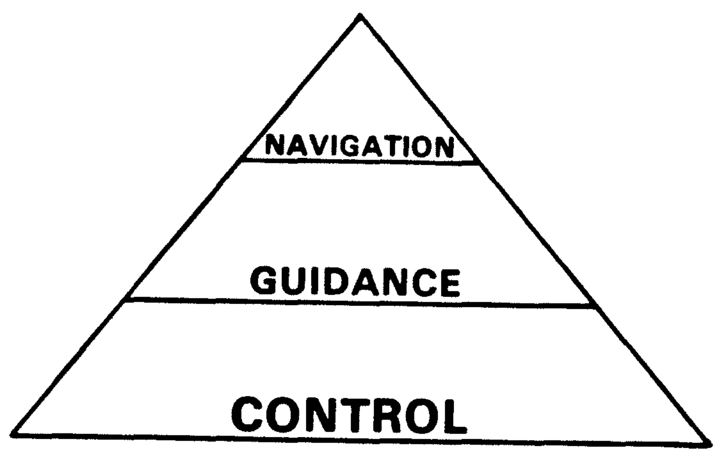

Figure 1. Levels of the Driving Test

Control: Control refers to a driver's interaction with the vehicle. The vehicle is controlled in terms of speed and direction. Passenger vehicle drivers exercise control through three or four mechanisms- steering wheel, accelerator, brake, and gear shift. Information about how well or poorly the driver has controlled the vehicle comes primarily from the vehicle and its displays. Drivers receive continual feedback through vehicle response to various control manipulations.

Guidance: Guidance refers to a driver's maintenance of a safe speed and path. Control subtasks require action by the driver. Guidance requires decisions involving judgment, estimation, and prediction. The driver must evaluate the immediate environment and translate changes into control actions needed to maintain a safe speed and path in the traffic stream. Information at this level comes from the highway-alinement, geometry, hazards, shoulders, etc.; from traffic-speed, relative position, gaps, headway, etc.; and from traffic control devices-regulatory and warning signs, traffic signals, and marking.

Navigation: Navigation refers to the activities involved in planning and executing a trip from origin to destination. Navigation information comes from maps, verbal directions, guide signs, and landmarks.

The three levels-control, guidance, and navigation-form a hierarchy of information handling complexity. At the control level, performance is relatively simple and so completely overlearned by most drivers that it is performed almost by rote. At the guidance and navigation levels, information handling is increasingly complex, and drivers need more processing time to make decisions and respond to information inputs.

The key to successful driving task performance is efficient information handling. However, the total driving task does not consist of independent activities performed independently. At any given point in time, drivers are faced with a multitude of information, transmitted from a variety of sources, and received through a number of sensory channels. They may be required to sift through this information, determine its relative importance, make proper interpretations, decide on courses of action, and take those actions in a limited time period.

When drivers are required to sift through a mass of information, both relevant and extraneous, under time pressures, they need to assign a relative priority to the competing sources, and therefore require a criterion upon which to base their decisions. Similarly, engineers need a basis for deciding what information to give the driver. The concept of primacy has been developed to deal with this problem.

Primacy

Primacy refers to the relative importance of each level of the driving task and of the information associated with a particular activity. The major criterion upon which primacy is assessed is the consequence of driver error on system performance. Since control and guidance level errors often result in crashes, these levels assume a higher primacy than do errors at the navigation level, where the consequences of error are likely to be lost or confused drivers.

There are, in addition, primacy gradients within a given performance level. At the control level, going into a skid is more serious than stripping a gear. At the guidance level, failure to avoid an immediate hazard is worse than driving too fast. Although failures at the navigation level assume a lower primacy, they can and do have an effect on system operations and safety. Erratic maneuvers and traffic conflicts are two common indicators of navigation level uncertainty, and often cause problems for the traffic stream. In an event, primacy is an important consideration when information needs compete. Higher primacy needs should be satisfied, and lower primacy information deferred.

Information Handling

Drivers use most of their sensory input channels to gather information. They hear horns, radio broadcasts, and engine noise; they feel road surface texture and raised pavement markers through the vehicle; they smell burning insulation wires; they sense changes in acceleration, pitch and yaw through the "seat of their pants"; and they see road alinement, traffic, signs, signals, and markings. Although most senses are used to gather information, drivers receive more than 90 percent of all information visually.

While driving, motorists do many things either at the same time or very nearly so. They look at traffic, follow the road, read signs, listen to the radio, and steer their vehicles. To accomplish this, they gather information from many diverse information sources, both informal (e.g., the road, its alinement) and formal (e.g., signs, signals, markings); make many decisions (e.g., take a particular exit, brake for a road hazard, speed up to avoid a signal change); and perform continuous control actions (e.g., steering, speed control, gear shifting).

At any point in time, drivers may have several overlapping information needs associated with each individual activity for each driving task level. To fulfill these needs, drivers must search the environment, detect information, and use it in a safe and efficient manner. Thus, information must be available when needed, where required, and in a form best suited for its intended purpose.

An important consideration in the reception and use of visually displayed information is that drivers can only attend to and process one source of visual information at a time. Drivers are "serial", rather than "parallel" processors of visual information. Since the driving task often requires motorists to perform more than one activity at a time, or in very close temporal proximity, and since drivers can not parallel process information, they have developed a way to cope with competing visual information through an information-handling "juggling act."

Drivers integrate various subtasks and maintain an overall appreciation of a dynamic, ever changing environment by sampling information in short glances, and shifting attention from one source to another. They make some decisions and delay others, depending on the primacy of the need. They rely on judgment, estimation, and prediction to fill in gaps. Such task-sharing behavior enables drivers to use their limited attention span and information processing capabilities (17).

Drivers receive and handle information using a signal search, detection, recognition, and use process. In the search and detection modes, a driver scans the environment and samples available information in short glances until a potentially needed source is detected. Once detected, the source is attended to, either continuously or intermittently, until recognized. The driver then determines whether the information is needed. If the information is needed, it is read (if verbal or symbolic), or otherwise perceived, and used in a feedback process to make decisions and perform control actions.

In situations where information needs compete, unneeded and low primacy information is (or should be) shed. Relevant information that is not immediately used is stored in short-term memory for rapid access and retrieval. If this stored information is not quickly used, reinforced, or repeated, it is usually forgotten. On the other hand, if information in short-term storage is reinforced or repeated, it is transferred to long-term memory for future use. This process structures expectancies. If other sources of information interpose before information in the short-term memory is used, the new information often extinguishes the information in storage.

Relevant information immediately needed is attended to, processed by comparison with **a priori** knowledge and expectancies in long-term storage, decisions made, and control actions taken (including no change in speed, path, or direction, if applicable). Once used, the driver then gathers and uses information from other sources. This process is repeated continually throughout the driving task (7).

Reaction Time

The time it takes drivers to process information and respond is their reaction time. Reaction time, like visual acuity, color vision, and eye height, varies from individual to individual. Reaction time also varies with decision complexity, information content, and expectancy. The more complex the decision, the more information required to make the decision, the longer the reaction time, and the greater the chance for error (39).

The relationship between information content and reaction time is based on the amount of information needed to resolve uncertainty. The information needed to make a decision can be broken down into binary units called "bits", where a bit is the smallest amount of information required to decide between two alternatives. Since a bit is a binary unit, the relationship between information content and decision complexity is 2^n, where n = number of alternatives to make a decision (7). Thus, a "zero" bit decision has only one response, a "one" bit decision has 2, a "two" bit decision 4, etc. This is an exponential relationship where a complex decision (4 bits or more) often exceeds a driver's capacity to respond, and either a very long reaction time, or confusion, occurs. Hence, several simple decisions are usually preferable to a single complex one.

Whether or not a decision is expected also affects reaction time. Researchers (18) measured brake-reaction time for expected and unexpected signals. When information was expected, reaction time was, on average, 2/3 sec (ranging from less than 0.2 sec to greater than 2.0 sec). When the signal was unexpected, reaction time approached 1 second, with some drivers taking over 2.7 sec to respond.

In addition, a complex, unexpected, multi-alternative decision has a considerably longer reaction time than a simple, expected one (see Figure 2). Long reaction time decreases a driver's time to sample information and leaves less time to attend to other important sources of information. This, in turn, increases the chances for missing information and committing errors.

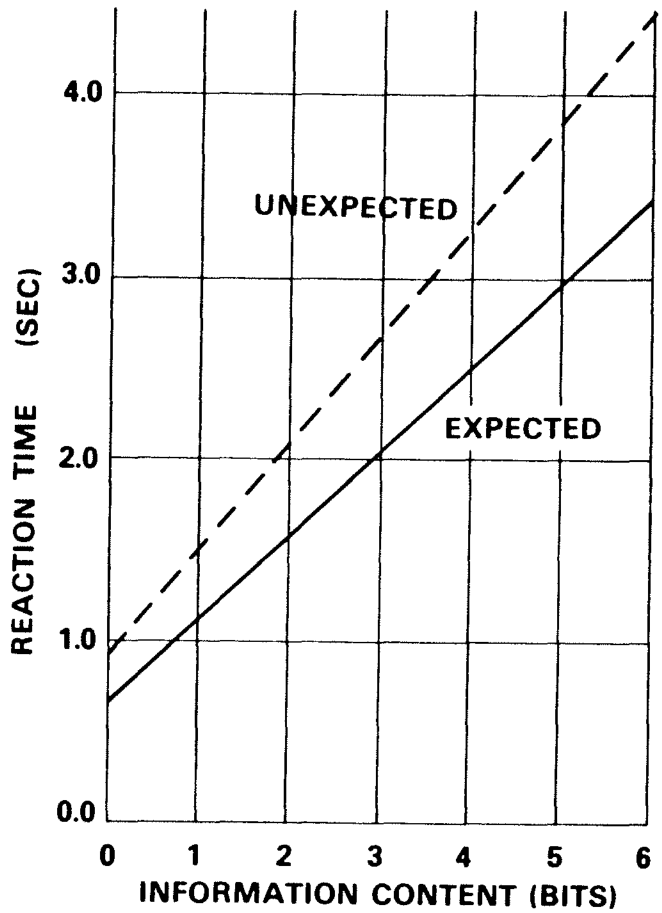

Figure 2. Median Driver Reaction Time

Thus, the nature of the driving task and the process of information handling, from the detection of information through its use in making decisions, can contribute to driver error. Information may be missing or ambiguous. It may not be visible, legible, or conspicuous enough and may be missed. Drivers may not have sufficient time to handle it, or its content may require overly long reaction time, or lead to confusion.

In addition, there may be too few or too many sources to handle and a driver may become inattentive or overloaded. In each of these conditions, reinforced driver expectancies regarding the presence, form or location of information play a key role in rapid, error free information handling and task performance. Conversely, violated expectancies worsen the situation and result in slower, less appropriate responses.

THE EXPECTANCY CONCEPT

The nature of the driving task and the driver's information handling characteristics point to the importance of expectancies. For example, a driver's reaction time to an unexpected situation or source of information is longer than when the situation or information is expected. Conversely, drivers are less likely to become confused or commit errors when their expectancies are reinforced. Since the key to safe and efficient driving task performance is rapid, error-free information handling, what a driver expects and does not expect has a major impact on task performance, particularly under time pressures and/or high information loading.

Because the expectancy concept is such an important consideration in driver task performance and information processing, it is one that engineers, designers, and operations personnel should understand and use. Expectancies affect all levels of the driving task, and should be accounted for in highway design, traffic operations, and traffic control device applications.

The expectancy concept was first identified by psychologists (19) (41) over 50 years ago. It was not until the 1960's, however, that the concept found its way into highway applications (27) (38). Since then, a number of highway researchers and practitioners have recognized the importance of expectancy, and used it in diagnostic and design activities (2) (8) (9) (10) (11) (13) (15) (25) (28) (36) (40).

The landmark work in expectancy was accomplished by NCHRP Project 3-12 (30) and refined by the Federal Highway Administration (FHWA) (5). Since then, the expectancy concept was further developed and applied in a number of additional FHWA efforts (20) (21) (22). Its use and application in highway design and traffic control culminated in the development of **Positive Guidance** (4) (32) (33) and its demonstration in FHWA Demonstration Project No. 48 (6) (23) (31).

Definitions

Expectancy relates to a driver's readiness to respond to situations, events, and information in predictable and successful ways. It influences the speed and accuracy of driver information processing and is one of the most important considerations in the design and operation of highways and the presentation of information.

Configurations, geometrics, traffic operations, and traffic control devices that are in accordance with and/or that reinforce expectancies, aid drivers and help them respond quickly, efficiently, and without error. On the other hand, configurations, geometrics, traffic operations, and traffic control devices that are counter to and/or violate expectancies, lead to longer reaction time, confusion, inappropriate response, and driver error.

Expectancies operate at all levels of the driving task. At the control level, expectancies relate to vehicle handling characteristics, the placement of controls and displays, and vehicle response to control manipulations. At the guidance level, expectancies relate to highway design and traffic operations. They affect how a driver negotiates the road, responds to traffic, selects a safe path, perceives hazards and avoids them.

At the navigation level, expectancies relate to drivers' trip plans, their use of route markers and guide signs, their selection of exits at interchanges and streets at intersections, how they locate destinations, and how they use services. They affect route choice and in-trip route diversion, and ultimately, whether or not motorists arrive at their destinations with a minimum of inefficiency and confusion.

There are two types of driver expectancies. The first are long term, **a priori** ones that drivers bring to the task, based on past experience, upbringing, culture, and learning. The second are short term, **ad hoc** ones that drivers forumulate from site-specific practices and situations encountered in-transit. Both types affect driving task performance and should be accounted for in highway design and traffic control.

A Priori Expectancies: Because things are designed to operate in standard, consistent ways, and are applied nationwide, certain expectancies are structured over a lifetime. Whether it's the typewriter keyboard, the direction of movement of a clock's hand, or the placement of HOT and COLD shower knobs, the intent of consistent, standard design is to foster rapid, error-free operation. Red is used to signify danger ("STOP") and green to signify safety ("GO") in a similar manner.

Thus, people expect things to operate predictably. For example, when entering a room all light switches are expected to be toggles, and are expected to operate UP for ON and DOWN for OFF. It is also expected that there will be no difference between wall switches in Minot, North Dakota, and Selma, Alabama. As a result, if these expectancies are fulfilled, user performance is rapid and error free.

If a light switch is not placed on the wall adjacent to the door, but is on a wall behing the door; and if instead of a toggle, is a push button or a toggle installed upside-down; then these expectancies are violated. The results of these "surprises," or expectancy violations range from taking longer to figure out how to turn on the light, to frustration, anger, inappropriate action, and the increased possibility of accident involvement.

In designing highways and traffic control devices, it is necessary to understand the nature of **a priori** expectancies. For example, because most freeway exits are on the right, drivers expect ALL exits to be on the right. Unexpected left exits often have serious consequences. However, not all **a priori** expectancies are held by the entire driving population. There are regional and local differences. Thus, if most interchanges in a given area contain left exits, then drivers in that area would expect to exit on the left, rather than the right. This expectancy aids performance in the area a driver is familiar with, where interchanges are as expected. However, outside the area, the same driver's response would be inappropriate. In a similar manner, if most signalized intersections in a central business district use an all-red phase for pedestrian movements, pedestrians will come to expect this treatment to be used elsewhere-sometimes with disastrous results.

Ad Hoc Expectancies: In designing and operating highways, it is as important to recognize and understand the nature of short term, **ad hoc** expectancies structured in response to in-transit, site-specific situations. Drivers form initial expectancies from their trip plan and experience. At the guidance level, these relate to what roads and traffic will be like. At the navigation level, initial expectancies relate to information (e.g., freeway guide signs, route markings, destinations signed for) service availability, land use, etc.

As drivers traverse an unfamiliar area, the geometry of the routes, the traffic control devices, and the traffic patterns structure **ad hoc**, site-specific expectancies. For example, when driving on a rural road, if several relatively sharp curves are preceded by curve warning signs, an **ad hoc** expectancy is structured that similar curves will be similarly signed. If a sharp downstream curve is not preceded by a curve warning sign, thereby violating the **ad hoc** expectancy, drivers may not respond properly. Unfamiliar drivers may misinterpret the sharpness of the curve, take it too fast, and run off the road.

In a similar manner, if the upstream road geometry provides a 70 MPH design speed with clear sight lines and adequate stopping sight distances, then strangers will expect these design standards to continue, and if services and rest areas are readily available, motorists will expect services and rest areas to continue to be available, etc.

Thus, not only does a driver bring a set of previously held **a priori expectancies** into the driving task, but he or she is constantly formulating new **ad hoc** expectancies based on what is encountered in transit. The engineers and designer must understand both type of expectancies and account for each.

EXPECTANCIES AT WORK/VIOLATIONS

Since expectancies affect all aspects of the reception and use of information by drivers, this section presents and discusses examples of expectancies and expectancy violations to illustrate how they are structured, how they are violated, and how they can be restructured to aid driver task performance. The material is based on a series of lectures and training courses on driver expectancy presented by the authors to engineers and technicians at the Federal, State, and local levels throughout the United States (Human Factors Symposium, 1973-1974; Positive Guidance in Traffic Control, 1977-1979; Seminar on the New Positive Guidance Procedure, 1985-1986).

General Expectancies

The first group of expectancies are general in nature, and are taken from everday experience. They are designed to illustrate how expectancies are formed, what they are like, and what occurs when they are violated. To gain a full appreciation of these general expectancy examples, it is recommended that the reader follow along and solve the problem or answer the questions prior to reading the explanation.

Expectancy Related to Series and Sets:

3 - 6 - 9 - ?

3 - 9 - 27 - ?

3 - 14 - 159 - ?

Figure 3. Expectancies related to Series and Sets

In Figure 3, three sets of numbers are presented. The problem is to supply the missing number signified by the question mark (?) and to identify the process by which it is derived.

Problem Solving Procedure:

- o In the first example (3 - 6 - 9 - ?), the correct answer is "12". The process is to add three to each number.
- o In the second example (3 - 9 - 27 - ?), the correct answer is "81". The process is to multiply each number by three.

In this **ad hoc expectancy** example, three sets of numbers are used. two expectancies are structured, both seemingly designed to enhance rapid problem solution. While they succeed in the first two sets, they inhibit a solution in the third. First, the number 3 seems to play a role, since there are three cases of three numbers, each beginning with the number 3. An expectancy is structured that the number 3 is somehow involved in the solution to all sets. This is not correct for the third set. Secondly, each of the first two sets is written in the form of a mathematical progression "3-6-9-?; 3-9-27-?". Because the third set is also written in the same form, the expectancy is structured that all are mathematical progressions. Again, this is not true for the third set.

In order to solve this problem, one needs to take the numbers 3, 14, and 159 out of the progression context, and write them as "314159?". Does that make it easier? Written in this form, the numbers become more recognizeable as **pi** (3.14159).

Out of over 5,000 people who have been exposed to this problem, only 3 were able to identify the third case as **pi** before any clues were given. Hence, once an expectancy is established, it is very hard, if not impossible for individuals to change their information handling behavior, even when given what should be familiar information.

The implications for design and traffic control are clear. The engineer should determine what expectancies exist and/or are being established by the road, its environment, and its complement of traffic control devices prior to presenting the driver with additional information. Further, the engineer should recognize that information being presented, while correct and accurate, may lead to an expectancy violation if the form of the information presentation is unusual or unique.

Word Expectancies:

Mac Duff

Mac Donald

Mac Hinery

Figure 4. Word Expectancies

In Figure 4, three sets of words are presented. The problem is to identify the three "MACs".

- The 1st, "MAC DUFF", is a character from Shakespeare's MacBeth.
- The 2nd, "MAC DONALD", is the farmer of note.
- The 3rd, "MAC HINERY", is actually a noun, the word "machinery."

In this example, an expectancy was structured that all three were proper names that begin with "MAC". This was violated by the third case, a noun, "machinery," rather than a name. In most instances, people have solved this correctly, particularly in light of the "Series and Set" example which structured an expectancy that there will be a "catch" in the third case. However, here again it can be seen how expectancies are structured, and how a violation can affect the way words are perceived.

Consider the use of cardinal directions on guide signs. When drivers read the message "East St. Louis", do they read the message as "EAST to St. Louis" or the city of "East St. Louis, Illinois?" Obviously, any time a potential destination has a cardinal direction associated with it, such as "West Springfield" (Massachusetts), "South Saint Paul" (Minnesota), "East Dubuque" (Illinois), and "North Little Rock" (Arkansas), there is a potential for misinterpretation.

The fact that cardinal directions on guide signs are all upper case letters, while destinations are upper and lower case, is probably not understood by most drivers. How drivers plan their trips, and what destinations they expect to see on guide signs also affect how word messages in general and cardinal directions in specific are perceived.

Spatial Expectancies:

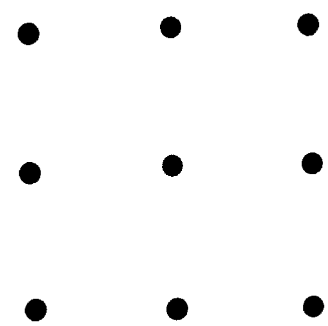

Figure 5. Spatial Expectancy

The Problem

Figure 5 presents a matrix of nine dots. The problem is to connect all dots with four straight, connected lines. Problems of spatial relationships, such as this example, are usually solved within some kind of visual framework. The framework provided here, the eight dot perimeter, is almost always seen as the limiting boundary. As in the case of the Sets and Series problem, the expectancy thus cretated inhibits correct problem solution. Remember, there is a visual frameworkm but its not the eight dot perimeter, its the whole two dimensional surface of the page. The solution can be found at the end of this report (see Figure 32, page 36).

Mechanical Expectancies: Figure 6 shows a car radio panel to illustrate a mechanical expectancy.

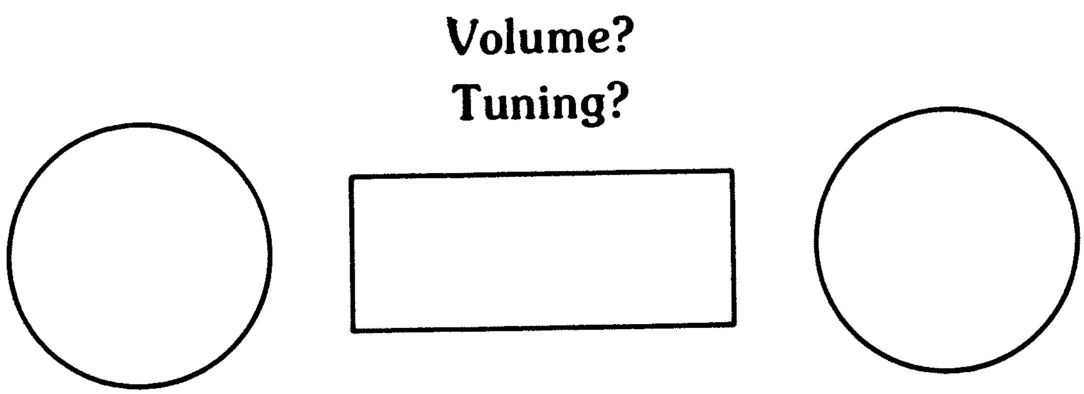

Figure 6. Mechanical Expectancy

In the case of the radio panel, the problem is determining which knob controls volume (left or right?) and which controls tuning. In the vast majority of American automobiles, the left knob is the volume control and the right knob is the tuning control. However, in Japanese and some other "foreign" vehicles, the left knob is for tuning and the right knob controls volume. Anyone who does not drive a foreign car and is not used to this configuration can attest to the difficulty in trying to change stations and or control volume. Usually, the result is very high or low volume on an unwanted station. It is very hard to break old habits.

The effects of mechanical expectancies and their violation are most applicable to vehicle design and control placement and operation. When people drive unfamiliar vehicles, finding an emergency brake, for example, that is expected to be on a console on the right, when it is on a floor panel on the left, or locating a horn on a lever rather than on the steering wheel, could be critical in an emergency. Standardization of vehicle controls and displays would help eliminate this violation. Similarly, standardization would also help eliminate many design and traffic control device expectancy violations.

On-The-Road Expectancies

The next group of expectancies and violations relate to roadway design. Some are more common than others, but all surprise motorists.

Left Exits: Because most exits are on the right, unfamiliar drivers usually expect to exit from the right hand lane of a freeway. In the absence of advance warning, unfamiliar motorists desiring to exit at a downstream interchange will move to the right lane. If the exit ramp is on the left, as shown in Figure 7, drivers in the right lane desiring to exit many either miss their exit, or perform a hazardous late lane change to get to the left lane. Such a maneuver often results in traffic conflicts or collisions.

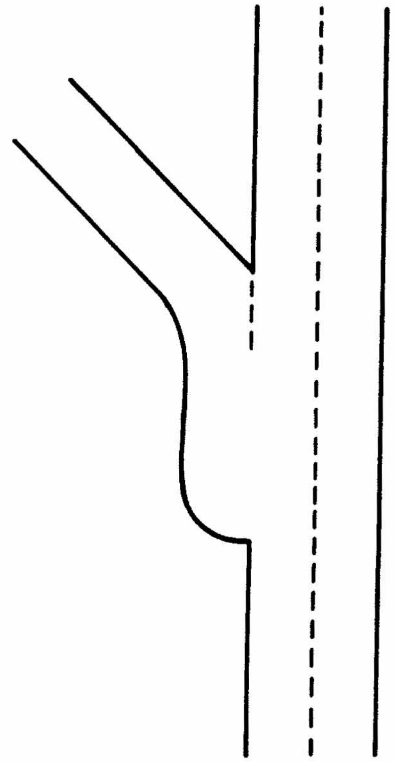

Figure 7. Left Exit

The conventional guide sign treatment applied to left exits has not proven as effective as the diagrammatic treatment contained in the Manual on Uniform Traffic Control Devices (MUTCD) (24) and shown in Figure 8. Studies (26) have shown that diagrammatics are effective in providing advance notice of an unexpected highway feature. It is important to understand, however, that diagrammatics are applicable in a limited number of cases, primarily when an off-route movement is to the left of a through-route movement.

Figure 8. Diagrammatic Treatment for Left Exit

Interchange Lane Drops: At most freeway exits, motorists must move into a deceleration lane to leave the facility. It is therefore an expectancy violation when a lane which had been a through-lane becomes a deceleration-lane and then exits the freeway (see Figure 9). Instead of having to change lanes to leave the freeway, drivers in the dropped lane have to change lanes to stay on the freeway.

The standard MUTCD device applied at interchange lane drops is the "EXIT ONLY" panel (see Figure 10). Other messages such as "MUST EXIT" and "ONLY" Have also been used, but "EXIT ONLY" has been shown to be the most effective (21). The "EXIT ONLY" panel, by virtue of its black-on-yellow color scheme, has the requisite target value, when placed on the white-on-green freeway guide sign, to gain a driver's attention. Its "EXIT ONLY" message, by virtue of its clarity and uniform application at interchange lane drops, serves to structure the appropriate expectancy.

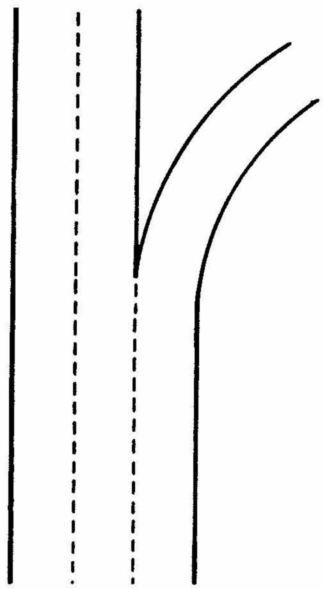

Figure 9. Interchange Lane Drop

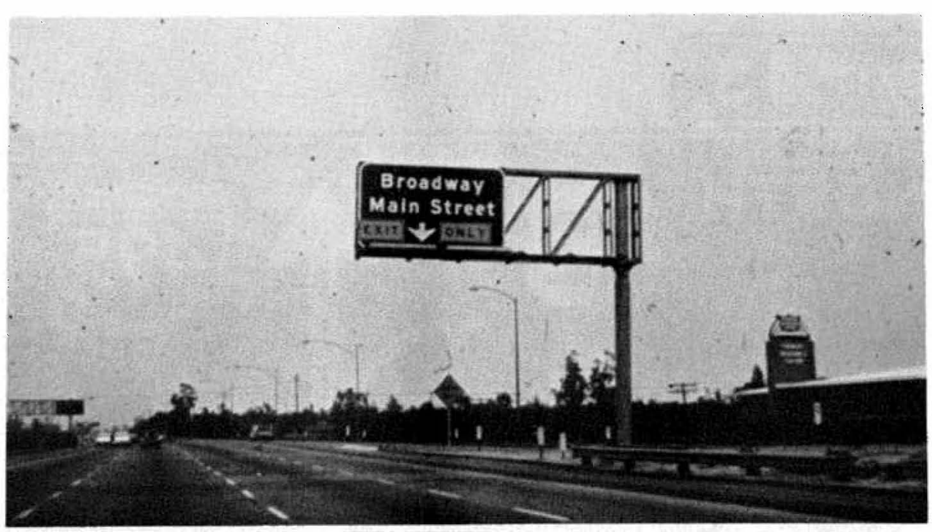

Figure 10. Interchange Lane Drop "EXIT ONLY" Treatment

Left Lane Drop: In Figure 11, a multiple expectancy violation is shown-the combination of a left exit and an exit lane drop. As might be expected, this is a far more serious problem than either of its individual components. More drivers are affected, interactions in the traffic stream are more turbulent, and the potential for confusion and accidents is substantially greater. Wherever a left-exit lane drop is located, it has been a recognized source of operational problems.

In at least one of these locations, a number of redundant information sources were used in an attempt to overcome substantial operational problems. Included were: A median mounted regulatory sign, "LEFT LANE MUST TURN LEFT," a black-on-yellow "ONLY" panel on the overhead guide sign; the word "ONLY" with an arrow painted in the dropped lane; and a different color and texture on the dropped lane. However, diagrammatic signs with a black-on-yellow EXIT ONLY panel in accordance with the MUTCD are recommended for this location (see Figure 12).

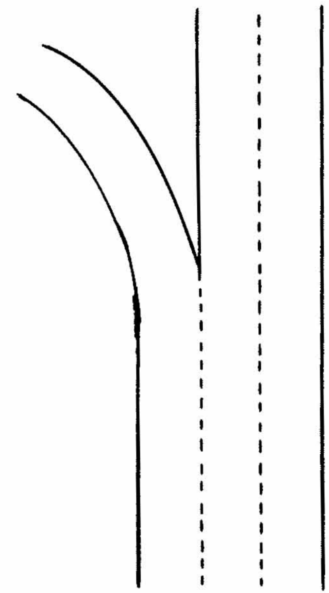

Figure 11. Left Lane Drop

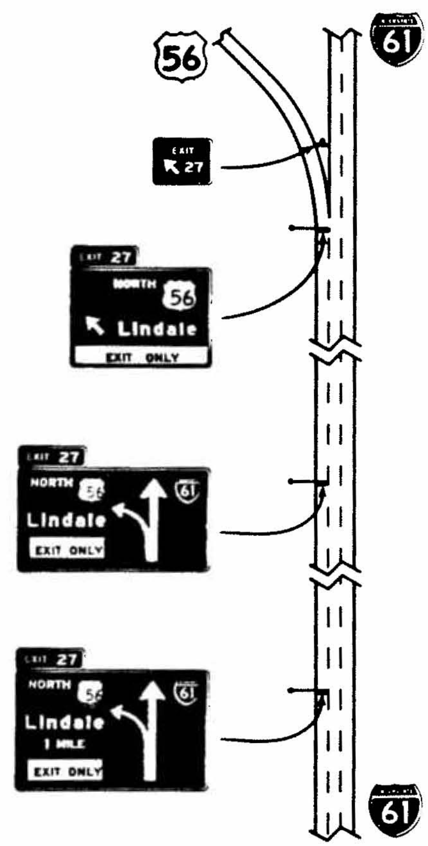

Figure 12. MUTCD Left Lane Drop Treatment

Tangential Off-Ramps: Figure 13 shows a schematic of a freeway tangential off-ramp. Unless a driver is alert, he or she could be unintentionally "pulled off" a freeway by following the heretofore straight roadway alinement on to the exit ramp. A tangential off-ramp is thus both an unexpected feature and one that creates perceptual problems. To date there is no traffic control device that can adequately warn drivers about tangential exit ramps. Solutions to this expectancy problem appear to rest in changing the geometric design itself.

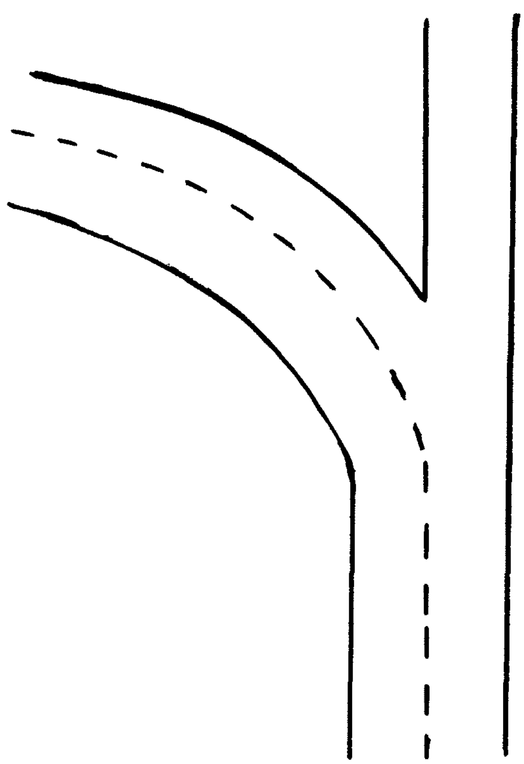

Figure 13. Tangential Off-Ramp

Tangential off-ramps are best treated by so configuring the ramp terminal that the perception of a continuous tangential movement is visually disrupted. If the ramp terminal could be located as little as 100 feet up or downstream, the desired effect would be achieved.

Parallel Roadside Features: Rural road situations similar to the freeway tangential off-ramp are: Parallel roadside features; and tangential roads intersecting at the point of curve of a turning road. A line of utlity poles, trees, or railroad tracks running parallel and adjacent to a long section of tangent, rural two-lane road, structures an expectancy for this condition to continue, with the road remaining tangent and following the off-road feature. Such situations are fairly common in States where rural two-lane roads are built on section lines. When the road curves away from the parallel feature (see Figure 14) or a tangent road begins at the point of curve (see Figure 15), an unexpected and hazardous condition is created.

The expectancies structured by the parallel roadside feature or tangential road are analogous to the freeway tangential off-ramp. In these situations, drivers may inadvertently take the tangent road, or in the case of utility poles, trees, or tracks, run off the road or cross into the path of oncoming vehicles. The best way to overcome these kinds of expectancy violations, short of removing the offending feature, is to inhibit the structuring of the expectancy by obstructing the tangential line of sight; by using landscaping that follows the curve; or by strategically placing warning signs, delineators, or markings that emphasize the true alinement.

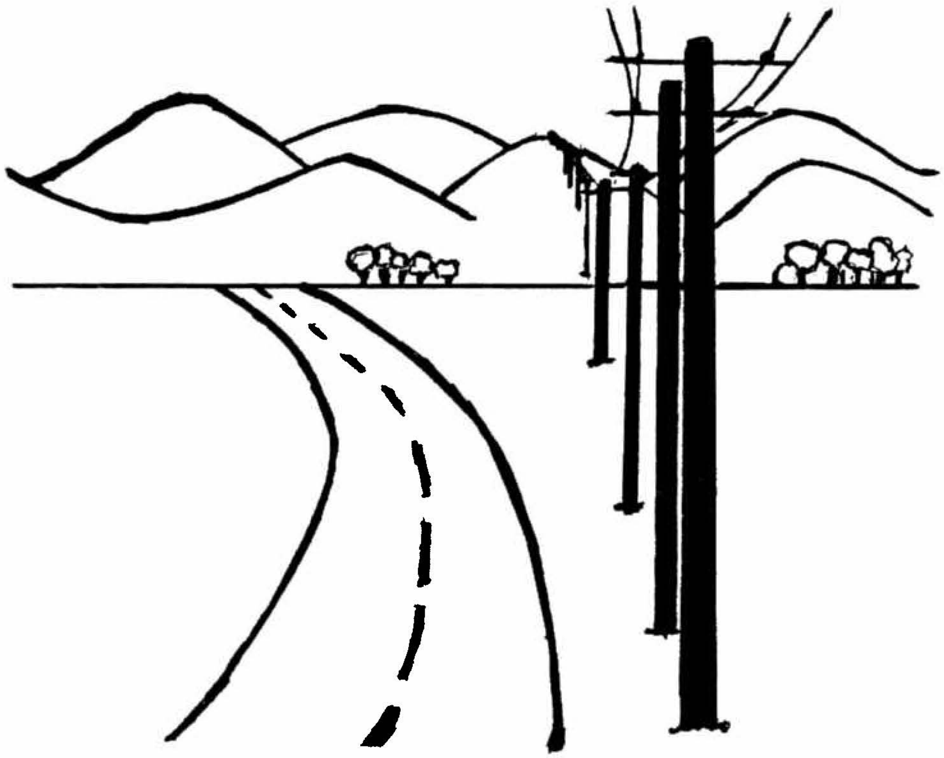

Figure 14. Parallel Roadside Features

Figure 15. Tangential Road at Point of Curve

Freeway Split: A common freeway design feature with the potential for violating expectancies is the freeway split. Several aspects of its design can lead to violations. The first is the split's geometrics, particularly when an optional lane is used (see Figure 16). The second is when the off-route movement is to the left of the through-route movement.

The optional lane design creates expectancy problems for drivers in the optional lane. They may not expect to have to make a lane or directional choice by staying in lane. This leads to a classical dilemma-the choice between two equal alternatives. If drivers have directional uncertainty-because of an imprecise trip plan or ambiguous guide signs-some will be unable to resolve the dilemma and may perform an erratic maneuver such as stopping in the gore or weaving across several lanes of traffic.

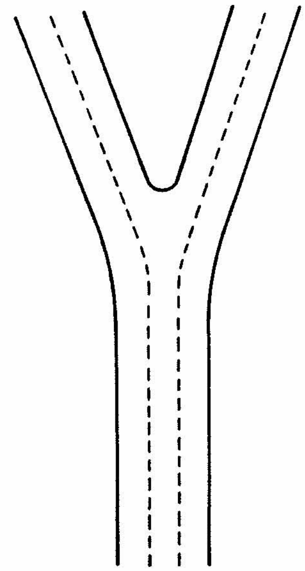

Figure 16. Optional Lane Split

An effective way to avoid the expectancy problem in optional lane splits is to eliminate the optional by adding a full lane 1/4 to 1/2-mile upstream of the gore area, and to eliminate the optional feature of the middle lane by striping.

Failing that, a diagrammatic treatment can be used. As in the case of the left exit, diagrammatic signs, in accordance with the MUTCD, are recommended for splits and two-lane exits (see Figures 17 and 18).

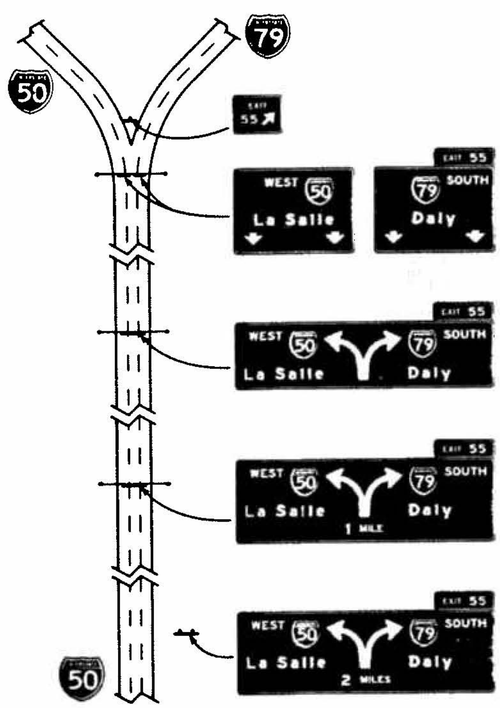

Figure 17. Optional Lane Split Treatment

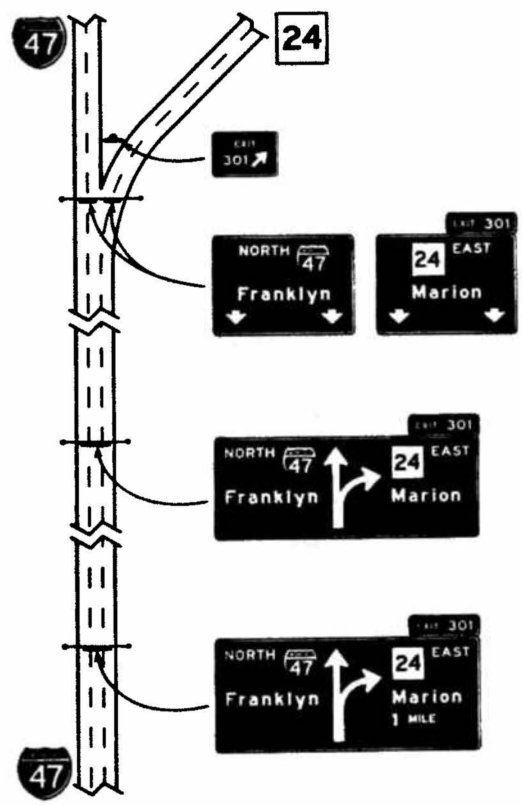

Figure 18. Two-Lane Exit Treatment

Construction Joints that Do Not Follow Lane Markings: Figure 19 shows a location where a lane is added to a two-lane facility on a curved bridge approach, with the striping reflecting the number of lanes.

As Figure 20 shows, however, the construction joints do not follow the lane markings. This is a case where a lane is added by construction on the left side while the lane is added by markings on the right. Drivers expect lane markings and construction joints to be parallel and adjacent to each other. When they aren't, drivers often have problems, particularly at night, in the rain, when painted lines are nearly invisible. In this case, drivers expecting lane markings and pavement joints to coincide, may follow the joints, often with catastrophic results. Solutions to this problem involve either making the joints and markings coincide, or making the correct lane markings visible under adverse weather.

In the latter case, raised pavement markers have proven effective. In the former case, if it is not possible to use raised pavement markers, some jurisdictions have used asphalt overlays and "artificial" joints cut into the road to make them appear to follow the markings.

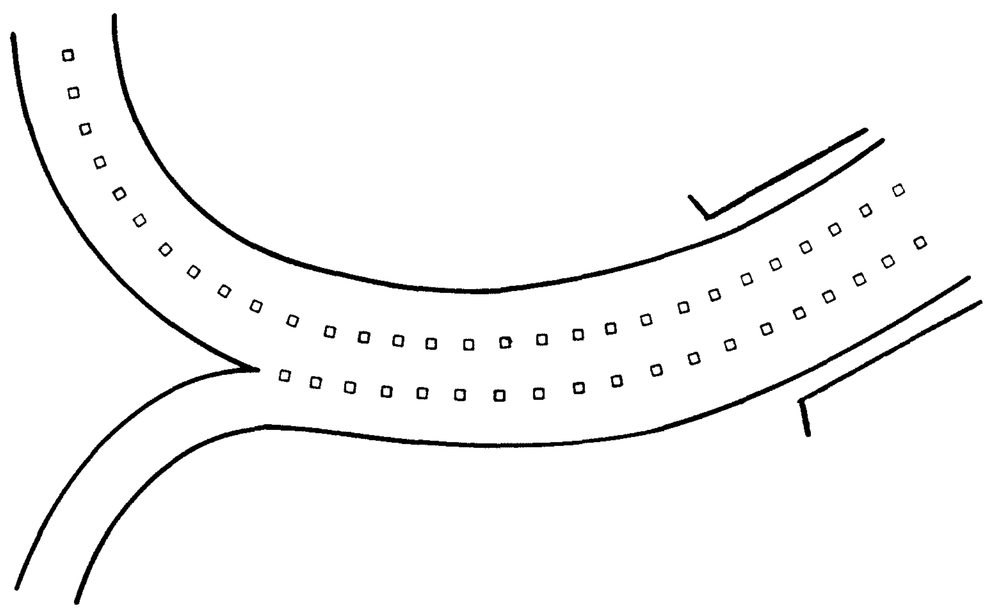

Figure 19. Lane Added by Striping

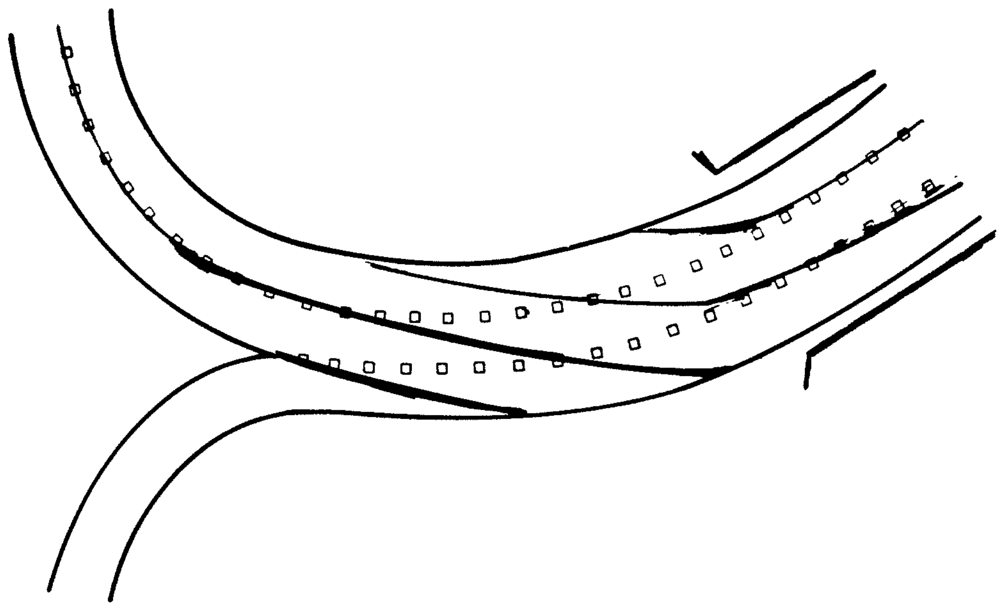

Figure 20. Lane Added by Construction Joints

Dips: Figure 21 shows a dip on a rural two-lane road. Several expectancy violations can occur at this kind of location. One concerns whether or not the road is continuous, two separate roads, or intersecting roads. Another expectancy, brought about by the broken line striping, is that the dip is too shallow to hide a car. However, with lower seated eye heights and smaller vehicles, it may be unsafe to pass.

To resolve the intersecting road violations, engineers should provide route information. No solution exits short of providing better sight distance if there are two separate roads. Finally, engineers should assure that the striping reflects the latest 3.5-foot seated eye height of the "Green Book" (1) so that no vehicle can be hidden in the dip.

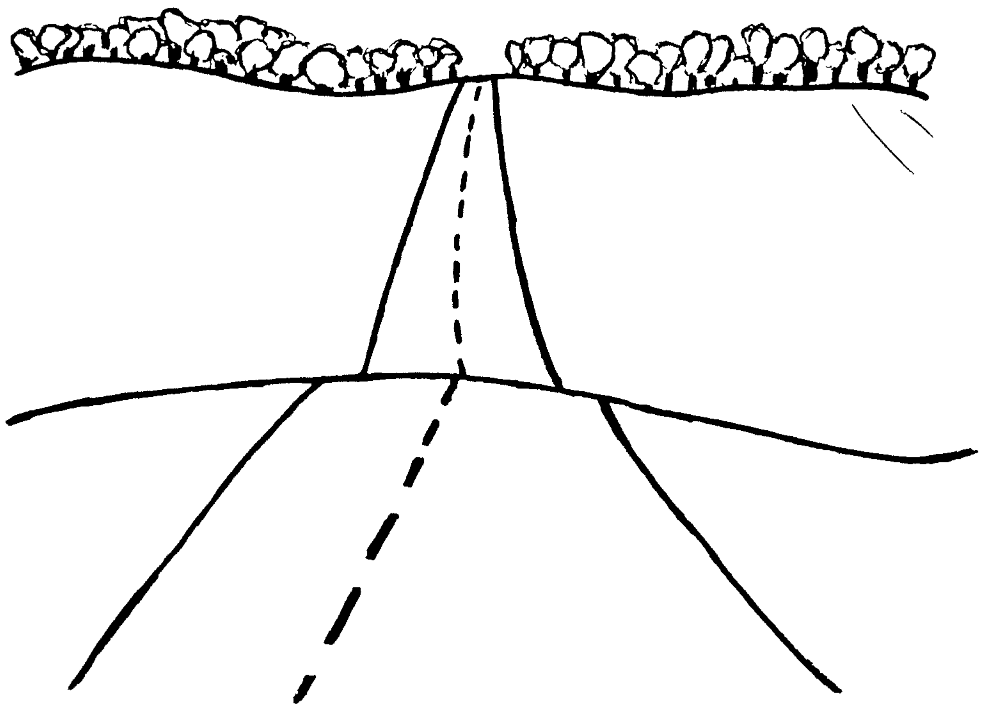

Figure 21. Dip

Narrow Bridges: Any reduction in the width of the road represents an expectancy violation and a hazard to the driver. Such situations as lane drops, construction zones, and narrow bridges are common sources of pavement width reduction. While all are expectancy violations, the narrow bridge situation is one that is particularly difficult because of the many configurations that a narrow bridge can take.

Narrow bridges come in a variety of shapes and sizes, from those that are short box culverts (Figure 22) to long bridges with trusses. "Narrowness" of narrow bridges ranges from a loss of shoulder, a situation that often occurs on freeways, to a narrowing of lane width, to a one-lane bridge.

Narrow bridges also occur on curves or dips, making them very difficult to perceive (Figure 23). Thus, not only are narrow bridges unexpected, but they may also be hard to recognize, detect, and negotiate in the presence of oncoming traffic.

Figure 22. One-Lane Bridge

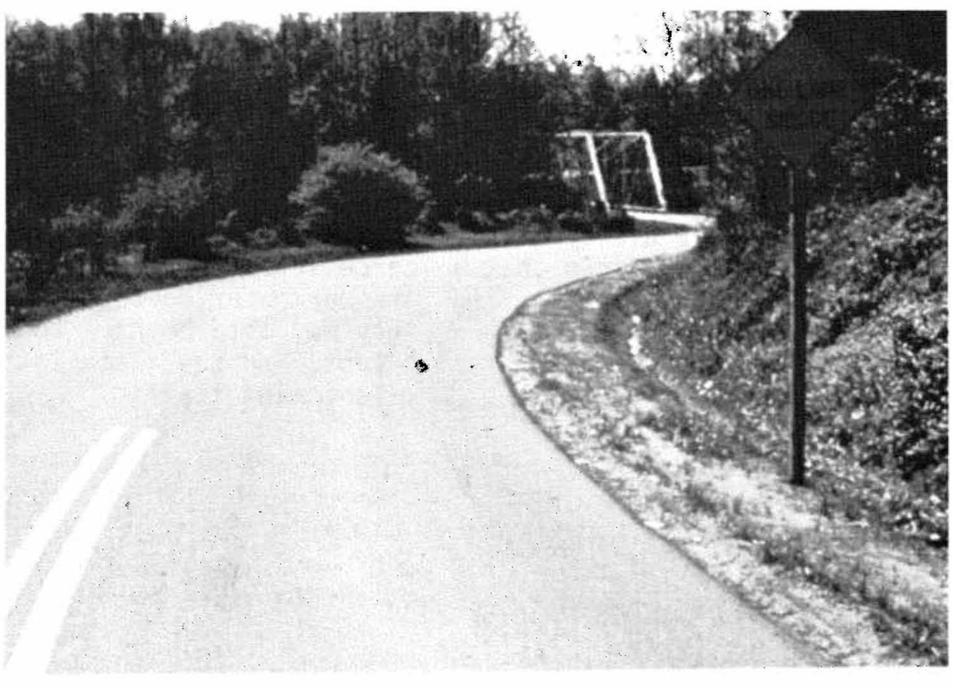

Figure 23. Narrow Bridge on Curve

Narrow bridges, depending on their configuration, require a variety of treatments, both to warn motorists of the unexpected feature or features, thereby restructuring their expectancies, and to make the bridge and its approach more visible.

In one-lane situations, a **Positive Guidance** (32) treatment may be necessary to accomplish the aforementioned goals, and to assign right-of-way on the single lane span (see the following section for a discussion of **Positive Guidance**). **Positive Guidance** treatments for a variety of narrow bridge configurations are set forth in Appendix A of the "Yellow Book" (12). Figure 24 shows a recommended treatment for a one-lane bridge on a curve with restricted sight distance.

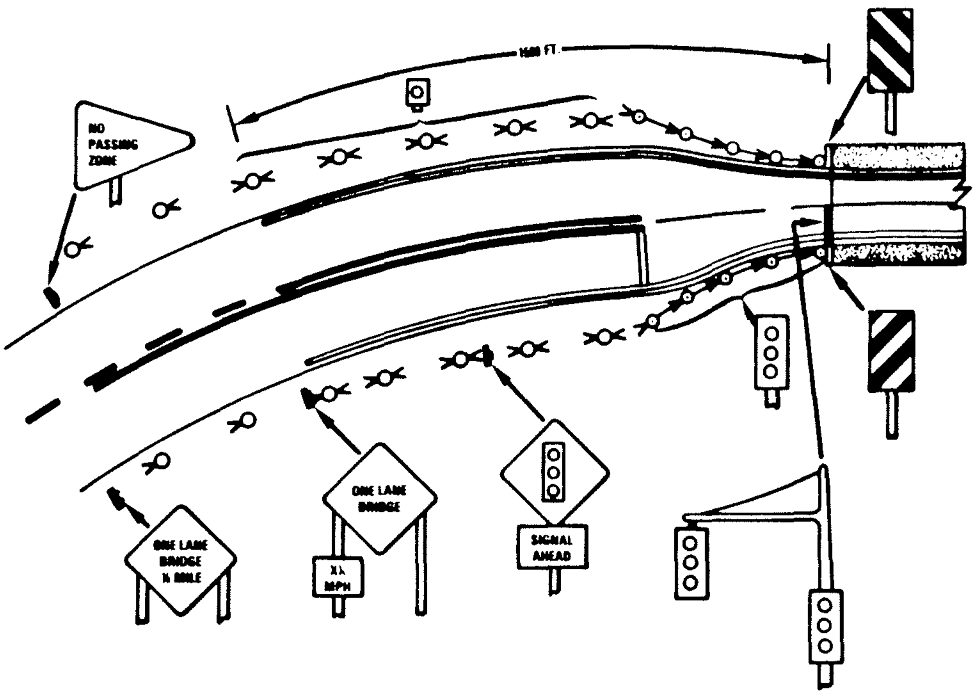

Figure 24. One-Lane Bridge Treatment

Traffic Control Devices

Traffic control devices structures expectancies about **downstream** features. They also structure expectancies concerning information treatments at similar locations. The key to effective expectancy structuring is uniformity and standardization, using standard MUTCD devices consistently applied. If devices are inconsistently applied, drivers experience problems. For example, if **upstream** curve warning signs tend to underestimate maximum safe speed, then drivers expect similar underestimations for similar curves downstream.

When a downstream curve is more realistically signed, then expectancies are violated, and drivers may be unprepared or unable to respond properly. Thus, not only do traffic control devices serve to structure expectancies, they also serve to violate expectancies when misapplied, inconsistently applied, unique to a given location, and/or ambiguous.

Traffic Signals: In Figure 25, the signal indication is changing from green-to-yellow in the cross street signal head, resulting in main street drivers expecting their signal to change from red-to-green. However, in the event of a lagging green or a protected turn phase, the signal indication in the driver's direction will not immediately turn green.

Thus drivers expecting a green signal may inadvertently enter the intersection on a red indication. One way to resolve this problem is to mask the cross street signal indication so drivers can not see it, thereby inhibiting the expectancy from being structured.

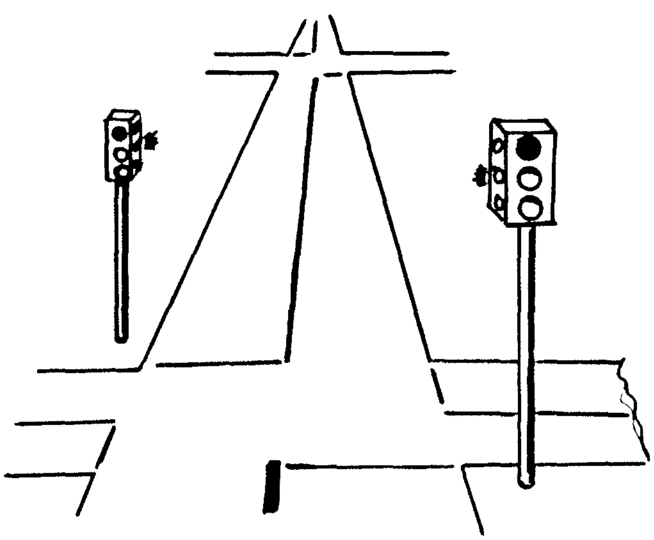

Figure 25. Cross Street Indication

Another example of an unexpected signal indication is the midblock signal shown in Figure 26. Drivers do not, in most instances, expect a signal anywhere but an an intersection. When a midblock signal is used, they may not be prepared, without advance warning, and may not react in time, or may rear-end another vehicle stopped at the crosswalk. The key in this situation is to provide conspicuous advance warning.

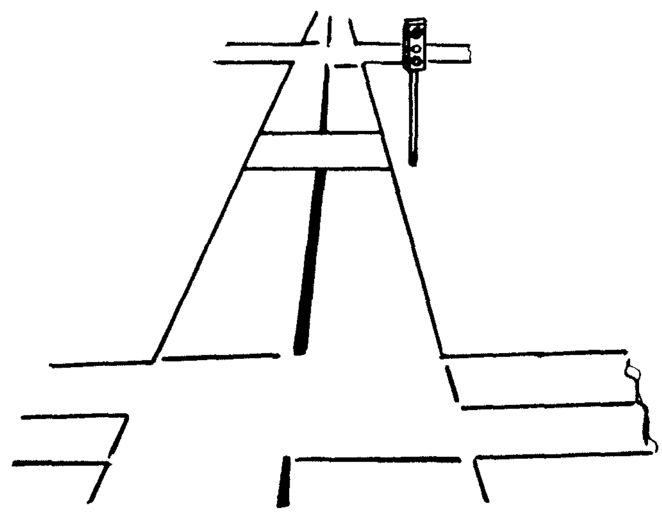

Figure 26. Midblock Signal

Signs: Signs which provide information at the guidance level (regulatory and warning signs) and at the navigation level (guide signs) also have the potential to structure or violate expectancies. With regard to guide signs, drivers, by virtue of their trip plan, formulate **a priori** expectancies relative to what route, direction, and destination information will be displayed. These are often violated in transit. There are also sign-related expectancies that are violated at the guidance level, such as the sign shown in Figure 27.

Figure 27. Curve Warning Sign

The figure shows a standard curve warning sign with a speed advisory plate.

Automobile drivers generally expect to be able to exceed the advisory speed by a substantial margin. This is based on their experience with such signs, which are often understated when it comes to a "safe" speed, at least for passenger vehicles. Truck drivers, on the other hand, may not be as likely to exceed the advisory speed, as their vehicles do not track curves as well as cars.

On wet pavement, when curve-tracking capabilities deteriorate for most vehicles, auto drivers still tend to overdrive curves. There are locations where the advisory speed must be adhered to, even in dry weather. Here, since drivers tend to exceed the advisory speed limit, a "We Really Mean It" technique is often used. Jurisdictions often employ various display treatments including oversized signs, Chevrons, and flashing beacons. An example is shown in Figure 28 (see Reference 6).

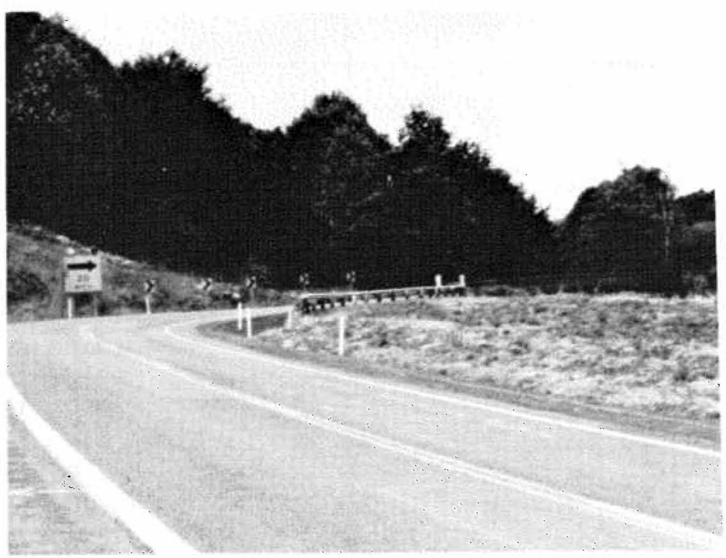

Figure 28. Curve Warning Treatment

It is difficult, at the navigation level, to anticipate exactly what drivers expect. For example, some drivers may expect their specific destination to be signed for at their exit. While this is a reasonable expectancy if the destination is a major traffic generator, there are so many potential destinations that this expectancy will be violated most of the time.

One way to overcome this problem is through education and training relative to trip planning and destination finding, thereby assuring that unreasonable expectancies are not formed. Another way to aid is to through supplemental signing of potential destinations. Various innovative aids to navigation are in the developmental stage to help in trip planning and destination finding, including highway advisory radio and in-vehicle systems.

Finally, the two common problems of freeway names versus numbers, and facility-route continuity are shown in Figure 29. Local drivers generally refer to freeways by name, while unfamiliar drivers often expect route numbers to be used. When route numbers are signed, local drivers, who often do not know them, may experience expectancy violations. The converse is true about strangers who have planned their trip using route numbers. Many jurisdictions attempt to solve this problem by displaying both the route name and number on signs.

The facility-route continuity problem is more complex, with no clear-cut way to solve it. Most drivers expect the facility they are on to carry the through-route, and to exit onto a ramp that leads to the off route. That is, people do not expect to have to "exit" to stay on their route. When this occurs, there is invariably driver uncertainty and confusion. Few "solutions," ranging from diagrammatics to different colored pavement, seem to work.

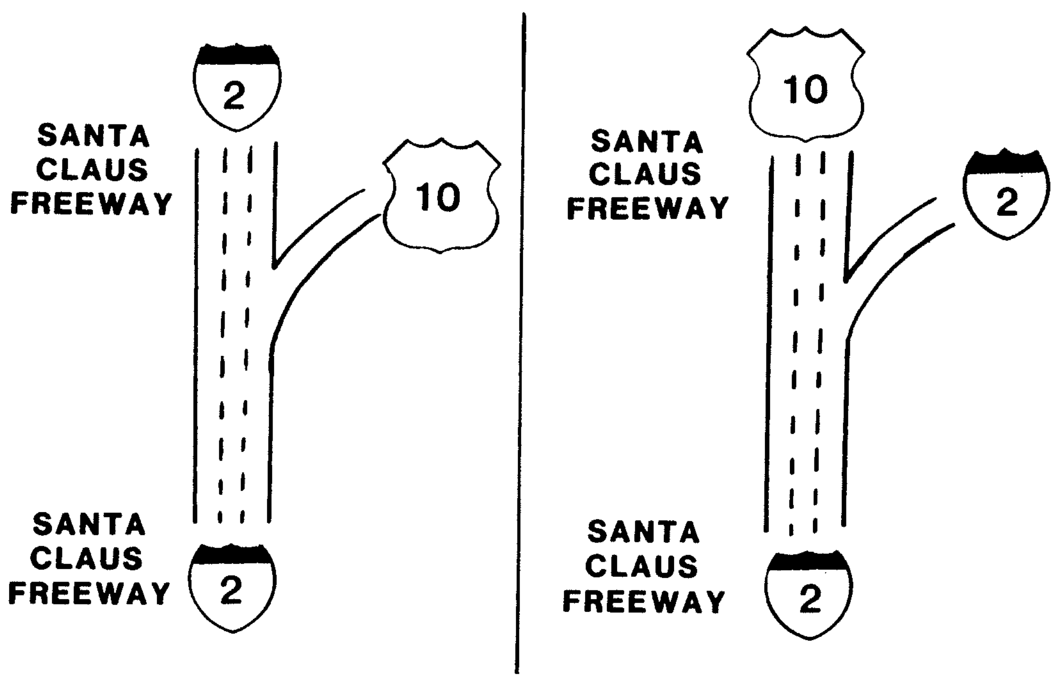

Figure 29. Route Continuity and Name vs. Number

Key Considerations

The development of appropriate designs; the display of needed information; the operation of traffic in accordance with driver expectancies; and the restructuring of expectancies that are violated through the use of standard traffic control devices, are primary ways to aid performance and enhance safety and efficiency. Unusual, ambiguous, or nonstandard designs or information displays should be avoided, and traffic control devices should be consistently applied throughout the system.

Attention should be given to assure design consistency from one segment of roadway to another. When drivers get the information they expect from the highway and its information system, driver response tends to be rapid and error free. When drivers get the information they expect from the highway and its information system, driver response tends to be rapid and error free. When drivers do not get what they expect, or get what they do not expect, then slow response, confusion, and errors occur.

Key considerations about expectancies include the following:

- o Expectancies are associated with all levels of the driving task and all phases of the driving situation.
- o Drivers experience problems and commit errors when their expectancies are violated.
- o Drivers should not be surprised.
- o Drivers tend to anticipate upcoming situations and events that are common to the route they are driving.
- o The more predictable the design, information display, or traffic operation, the less likely will be the chance for driver error.
- o Drivers, in the absence of information to the contrary, assume that they will only have to react to "standard", i.e., expected situations.
- o The roadway, the information system, and the environment upstream of a location structure expectancies of downstream conditions. Drivers experience difficulty in transition locations, and places with inconsistencies or unexpected features in design and/or traffic operations.
- o The objective in helping drivers overcome the effects of expectancy violation is to structure the appropriate expectancy through advance warning. When it is not possible to give drivers what they **do** expect, it is essential to tell them what they **should** expect.

IDENTIFYING EXPECTANCY VIOLATIONS USING POSITIVE GUIDANCE

Positive Guidance

The Expectancy Violation Analysis and Review is derived from the 2nd Edition of the User's Guide to **Positive Guidance** (32). The Users' Guide presents a conceptual development of **Positive Guidance** and contains a step-by-step description of the "Engineering and Human Factors Procedure," the heart of the process.

Positive Guidance is an approach to enhance the safety and operational efficiency of problem locations. It joins the highway engineering and human factors technologies to produce an information system matched to the characteristics of a location and the attributes of drivers. It is designed to provide high-payoff, short-range, low-cost solutions to safety and/or operational problems. It is based on the premise that a driver can be given sufficient information to avoid accidents and/or drive efficiently at problem locations.

Since few locations are identical, each is individually analyzed to develop improvements tailored to the particular site. **Positive Guidance** in general, and the Expectancy Violation Analysis and Review in particular, are tools to analyze a site, identify its problems, develop information system improvements, and determine their effectiveness. Using **Positive Guidance** procedures, a site is reviewed and analyzed in a number of ways including a drive-through from a "driver's eye" point of view, analysis of films, slides, video, and/or photologs, and the collection of performance data.

Information gained from these sources is used to perform the various steps in the Engineering and Human Factors Procedure, develop improvements, and evaluate their effectiveness. Results of various projects using **Positive Guidance** are contained in a number of reports (6) (23) (31). Since the thrust of this report is on expectancies, the Expectancy Violation Analysis Step is presented in detail.

Expectancy Violation Analysis and Review

The Expectancy Analysis and Review is designed to identify expectancy violations, pinpoint their sources, and develop information displays to restructure violated expectancies or structure appropriate ones. The Analysis and Review is initiated by first reviewing the area upstream and downstream of a problem location (if already identified) or assessing a road segment as part of general surveillance.

This general review provides an understanding of the land-use, geometric design, traffic, operational procedures, and traffic control devices which serve to structure driver expectancies. Once this understanding is obtained, and/or unidentified problems found through routine surveillance, a detailed analysis is then performed to zero in on specific expectancy violations and locate them on the road.

General Review: A general review can be performed using a variety of approaches and sources. One approach is to drive through a location and record observations in the field using audio tape or pencil and paper. Another way is to film, video, or photograph the site and analyze the data in the office. Existing photologs can also be used. Finally, a combination of approaches and sources can be employed.

In any event, the reviewer should always drive through the site and obtain a "driver's eye" view in real time. The most important activity to perform during the general review is to obtain a "feel" for the site. Hence, this part of the analysis should be fairly informal. If possible, help should be obtained from someone who is unfamiliar with the road or area, because familiarity often causes a reviewer to miss an expectancy violation that is quite apparent to a stranger.

In performing the review, it is useful to generate a list of conditions upstream of the location as well as informally locating features for further assessment during the detailed analysis. Table 1 lists factors to consider in the general review. Changes from upstream to downstream factors should also be noted.

TABLE 1

FACTORS TO CONSIDER IN THE GENERAL REVIEW

- o Land Use
- o Road Type
- o Road Surface
- o Cross-Section
- o Terrain
- o Geometry
- o Sight Distance
- o Weather
- o Lighting
- o Traffic
- o Signals
- o Markings
- o Warning & Regulatory Signs
- o Guide Signs & Route Markers
- o Missing Information

Detailed Analysis: Going from the General Review to the Detailed Analysis links expectancy violations to specific features. This is accomplished by identifying specific expectancy violation(s), their source(s), their effect(s) on driver behavior, and driver information needs brought about by the violation(s).

As in the General Review, data are obtained from an in-field drive-through and photographic sources. Since this analysis is keyed to specific site features, a schematic or plan view of the site (locating all traffic control devices and other relevant features) helps to locate source of the violation and where it operates. A checklist, such as the one shown in Figure 30, also can be used. Its input are essentially derived from the General Review, with specific details entered on the form.

Using the General Review as a point of departure, the Detailed Analysis begins by selecting a convenient starting point upstream of a problem location. This starting point should be "typical" of upstream conditions in terms of traffic, geometrics, land use, etc. since it structures a driver's **ad hoc** expectancies. Having located a starting point, the analysis proceeds toward and through the problem location. A Detailed Analysis is performed for all applicable directions. In performing the Detailed Analysis, a target population is assumed, usually unfamiliar drivers (the "stranger with a map"). There are times when locals or commuters are the target group. When this occurs, strangers should also be considered.

o **Identify Navigation Expectancies** - Assuming unfamiliar drivers as the target group, the first activity is to identify potential navigation expectancies. In doing so, the assumption is made that strangers have consulted a map and prepared a trip plan. It is likely, particularly at choice points, that strangers will be both looking for and expecting information relating to route following and direction finding. The reviewer should obtain maps of the area and identify major destinations, routes and traffic generators.

The following should be kept in mind about navigation expectancies: Drivers expect all nodes (intersections, interchanges, choice points, etc.), major routes, and cardinal directions to be identified; drivers expect their destination, if

Figure 30

DETAILED EXPECTANCY CHECKLIST

Reviewer: ______________________ Date: ______________

Location: ____

____

1. Upstream Land Use: ______________ Have Changes Occurred? _____

   Where: ______________________ What: ______________

2. Upstream Road Type: ______________ Have Changes Occurred? _____

   Where: ______________________ What: ______________

3. Upstream Road Surface: ____________ Have Changes Occurred? _____

   Where: ______________________ What: ______________

4. Upstream Cross-Section: ____________ Have Changes Occurred? _____

   Where: ______________________ What: ______________

5. Terrain: Do Terrain Features or Manmade Elements Provide False Cues? ____

   Where: ______________________ What: ______________

6. Geometry: Does Geometry or Geometric Inconsistencies Surprise Drivers? ___

   Where: ______________________ What: ______________

7. Sight Distances: Does Poor Sight Distance Cause Drivers to Miss Unexpected Features? _____

   Where: ______________________ What: ______________

8. Weather: Are Temporary Weather Features Involved? ______________

   Where: ______________________ What: ______________

9. Lighting: Does Lighting (Including Natural Light) Contribute to Expectancy Violations? ______

   Where: ______________________ What: ______________

10. Traffic: Do Any Unusual Traffic Patterns or Mixes Exist (Including Pedestrians)? __________

   Where: ______________________ What: ______________

11. Signals: Are Any Signals, Signal Configurations, and/or Signal Patterns Confusing or Unusual? _________

Where: ______________________________ What: ________________________

12. Markings: Are Any Markings (Delineation) Confusing or Unexpected? _______

Where: ______________________________ What: ________________________

13. Warning & Regulatory Signs: Are Any Warning and/or Regulatory Signs Surprising, Confusing, Obsolete and/or Nonstandard? ____________________

Where: ______________________________ What: ________________________

14. Navigation: Are Any Guide Signs, Directional Signs, and/or Route Markers Surprising, Confusing, Obsolete and/or Nonstandard? ____________________

Where: ______________________________ What: ________________________

15. Missing Information: Is Any Needed Information Missing? ________________

Where: ______________________________ What: ________________________

16. Others: Is There Anything else About the Site or Location Surprising or Confusing? _________

Where: ______________________________ What: ________________________

major, to be signed for; drivers expect well known traffic generators, such as colleges, stadia, shopping centers, etc. to be indicated; and drivers expect service availability information.

These, and other route-specific expectancies are most common in urban areas, but often are a major determinant of driver task performance in rural locations. Using maps and the drive-through, the reviewer should determine if any navigation expectancy violations occur. These are noted on Figure 30.

o **Identify Guidance Expectancy Violations** - The next activity is to identify and locate guidance expectancy violations. Using the data generated by the drive-through and photographic means, the reviewer should search for expectancy violations, note them on a plan or site diagram, and enter them on the checklist (Figure 30). Expectancy violations can be numbered for convenience. Identifying an expectancy violation may require, in addition to the criteria presented herein, considerable engineering judgment. Another aid is an accident review to see if there are location patterns.

It may also be useful to talk to maintenance personnel, police, and operational personnel. The accident review and discussions can serve to identify situational problems (e.g., at night, in rain). The basic aim is to determine whether any aspect of the site and its traffic control and operations is **surprising** to the target group(s). As an aid, particularly when a reviewer is familiar with the site, the following questions should be considered:

1. Is the Location One that Exhibits Features or Attributes that Drivers May Find Unusual or Special?

   Discussion: Table 2 presents a list of "special features" to serve as a guide. Each one is a potential expectancy violation. Since there are usually regional differences, the reviewer may have additional special features to add to this list.

2. Is the Feature a "First of a Kind"?

   Discussion: Even though a feature may not be unusual per se, it may be the first one encountered on a road. For example, if all freeway exits are cloverleafs, then the first diamond would be unexpected. If the feature is both a "special feature" and a "first of a kind," then it probably will be a major problem for an unfamiliar driver.

3. Are there Changes in Site Characteristics?

   Discussion: Drivers may be surprised by changes in geometrics, design, or operational characteristics. Changes such as different cross sections, different land use, differences in terrain, differences in road surface, closer interchange spacing, and new vehicle/pedestrian mixes may violate expectancies. It is the transition that surprises.

4. Are there Changes in Practices?

   Discussion: Operating practice changes, though often subtle, can violate expectancies. Differences in speed zoning, no passing zoning, or signal timing can vary from jurisdiction-to-jurisdiction. Sign placement and location can be different, curves that are signed in one place may not be signed in another. Once drivers get used to a specific practice, they expect it to continue. Locals

Table 2

SPECIAL FEATURES, (NCHRP 123 (30))

UNUSUAL INTERSECTIONS - Circles; squares; leading/lagging green; 4-way stops.

UNUSUAL INTERCHANGE DESIGN - EXITS: Bifurcation; double exit; exit on horiz curve; exit on vert curve; exit on combined horiz/vert curve; lane drop at exit; left exit; missing or short exit decl lane; tangent off-ramp; two (or more) lane exit; exit to collector-distributor road; unusual ramp and/or ramp terminus features. ENTRANCES: Double entrance; entrance on horiz curve; entrance on vert curve; entrance on combined horiz/vert curve; lane addition; left entrance; missing or short accel lane; two (or more) lane entrance; unusual ramp geometrics; metered ramps; extremely high volume entrances. EXITS/ENTRANCES: Multilevel exit/entrance; common accel/decel lane; inadequate weaving sect. MISC: At-grade crossing (on freeways and expressways); restricted interchanges (by type of traffic or time of day); uncontrolled access; very long/very short interchange spacing.

EXTREMES IN ROADWAY GEOMETRY - Steep hills; extreme horiz curves; combined curves; dips; bumps; improper superelevation.

UNUSUAL MANEUVERS - Weaves; stops on exit ramps; stops on entrance ramps; discontinuous route; through route on off-ramps; off route on through lanes; U turns; left turns from "Jughandle."

CHANGES - CROSS SECTION: Lane drops; lane additions; shoulders; medians; lane width. ROADWAY ENVIRONMENT: Urban-rural; rural-urban; trees, foliage, etc.; surface; elevated-depressed; freeway, arterial, two lane. LEGAL: Speed limit; lane restrictions; pedestrian zones; bicycle zones; diamond lanes; turn restrictions.

OFF-LINE RESTRICTIONS: Abutments; piers; underpasses; culverts; cuts; curbs; guardrail ends; luminares; sign supports; parked vehicles.

SIGHT-LINE RESTRICTIONS: Horizontal, vertical; combined.

ENVIRONMENTAL PROBLEMS: Freezing roadways; fog; high background lighting; sun.

TRAFFIC: Heavy traffic; congestion; large proportion of trucks, RV's etc.; bicycle traffic; pedestrians.

MISCELLANEOUS: Construction zones; maintenance zones; fallen rock zones; animal crossings; narrow bridges; tolls; railroad crossings; poor road surfaces; school zones; bus stops; billboards, tree lines and/or telephone poles that deviate from road align; pavement joints that deviate from road align; route changes; discontinuities in street grids; one-way roads; parking restrictions; hidden driveways; farm vehicles; underpasses; special use/reversible lanes.

are more affected by operations that vary from the usual such as maintenance, changes in railroad operations, and new traffic control devices.

5. Are there Sight Distance Restrictions?

   Discussion: Drivers have difficulty preparing for unexpected features that they cannot see. They must have sufficient time to see and respond. Thus, any unseen feature, be it a standard intersection beyond a crest vertical or a lane drop beyond a horizontal curve is unexpected.

6. Is it Signed For?

   Discussion: One main reason for signing is to provide advance warning of an unexpected situation or event. If an expectancy has been violated, the reviewer must ask: "Was there advance warning-was it signed for?" Even when there is advance warning, the reviewer should recognize that the sign itself could result in an expectancy violation. This is particularly true of Navigation information.

7. Is the Signing Adequate?

   Discussion: The reviewer should assess each traffic control device to determine: The expectancies the signs markings, or signals) structure; the effectiveness of the device(s) in providing advance warning; and the possibility of the device violating an expectancy.

o **Determine Affected Driver Performance** - Having identified expectancy violations and their sources and located them, the next activity is to gauge their affects on driver task performance, specifically on speed, path and/or direction. This will provide an understanding of the consequences of the expectancy violation and on the identification of an associated information need.

o **Identify Information Needs** - The reviewer should identify driver information needs associated with each expectancy violation. These represent information required to structure and/or restructure a driver expectancy at the site. Hence, these information needs are ultimately translated into traffic control device improvements.

o **Assess Safety and Operational Consequences** - If a large number of expectancy violations are identified, the review should assess each in terms of its consequences on the safety and/or operations of the location. A determination may have to be made on which violations can be restructured if a number are found. A priority estimation, based on primacy will aid in this determination.

Develop Site Improvements

Data generated by the Detailed Analysis are ultimately translated into information system improvements using the form(s) shown in Figure 31. Improvements may include removing sources of expectancy violations as well as enhancing traffic control devices at the problem location. Standard traffic control devices, applied in accordance with the MUTCD, should be used to the greatest extent practicable.

It must be born in mind that any nonstandard device or unusually application has a potential of leading to subsequent expectancy violations. Accordingly, the location should be reassessed after changes are made (particularly nonstandard ones), to assure no new expectancy violations have been structured. This assessment should be conducted upstream of the problem location as well as the hazard zone.

SITE IMPROVEMENT FORM (Use a Separate Sheet for Each Violation)

Engineer: ______________________________ Date: ____________________

Location ____

____

Expectancy Violation: ____

Expectancy Violation Source: ____________________________________

Expectancy Violation Location: __________________________________

Affected Driver Performance: Speed _________ Path ______ Direction ____

Driver Information Need(s) ______________________________________

Potential Improvement(s): Standard Device(s): ___________________

____

Non-Standard Device(s): ____

If Nonstandard Devices Are Used, Do They Result in Expectancy Violations?

____

Comments: ____

____

Sketch of Location and Change(s)

Figure 31. Site Improvement Form

SUMMARY

Expectancy relates to a driver's readiness to respond to situations, events and information in predictable and successful ways. As such, it is a key factor in driving task performance since it affects the speed and accuracy of a driver's response. Prevalent expectancies that are reinforced, aid drivers, while expectancies that are violated, increase reaction time and driver error.

Expectancy and expectancy violations operate at all levels of the driving task, from vehicle control through guidance in the traffic stream to navigation of the road network; they include **a priori** (brought by the driver as a result of culture and experience) and **ad hoc** (caused by exposure to a set of site-specific practices) aspects; and they encompass all phases of geometric design and traffic control.

Included in the design category are such features as left exits, interchange lane drops, tangential off-ramps, parallel roadside features, optional lanes, construction joints that do not follow markings, dips, and narrow bridges. Traffic control device examples include lagging green and midblock signals, curve warning signs that lack credibility, freeway names versus numbers, and route discontinuity.

Because of these considerations, engineers and designers need to maintain an appreciation of the expectancy concept, prevalent **a priori** expectancies, **ad hoc** expectancies structured in transit by a location's design and traffic control device complement, and the adverse effects of expectancy violations. They should assure that their designs, traffic operations, and traffic control devices do not violate expectancies by surprising the driver. Finally, they should rectify expectancy violations through information system improvements, including removal of the expectancy violation, based on **Positive Guidance.**

To emphasize the point, when drivers get the information they expect to from the highway and its traffic control devices, performance tends to be error free. When they don't get what they expect, or get what they don't expect, errors and system failures are the usual result.

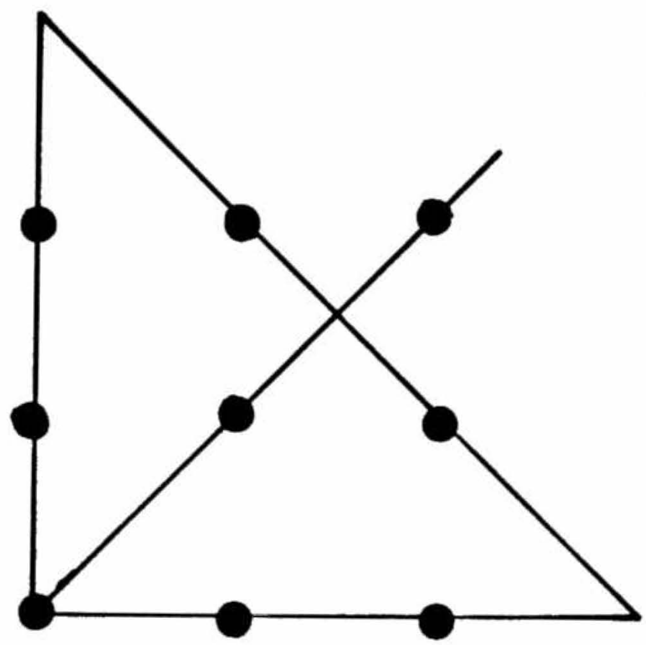

Figure 32. Solution to Spatial Expectancy Problem

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