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DRIVER EXPECTANCY: DEFINITION FOR DESIGN

Research Report Number 606 - 5
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TEXAS TRANSPORTATION INSTITUTE

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ABSTRACT

The traffic system is a complex combination of three major subsystems - the driver, his vehicle, and the situational context of the roadway. The present paper addresses a single aspect of the driver subsystem, namely driver expectancy. The objectives were to: (1) define driver expectancy operationally; (2) delineate factors which influence driver expectancy; and (3) propose a design philosophy accompanied by an analytical technique for implementing driver expectancy criteria.

Study results led to the development of the following operational definition:

> Driver expectancy relates to the observable, measurable features of the driving environment which: (1) increase a driver's readiness to perform a driving task in a particular manner, and (2) cause the driver to continue in the task until it is completed or interrupted.

This definition suggests that driver expectancy can be defined in terms of the conditions it causes rather than the conditions that cause it. Although the factors that influence driver expectancy are primarily those same factors which the highway engineer now uses in roadway design, the approach suggested will require the designer to examine these factors from a slightly different perspective. It seemed that the most useful thing one could propose at this stage in development of the driver expectancy concept would be a general design philosophy. Such a philosophy is

proposed coupled with a flow analysis and checklist for general use in implementing driver expectancy in roadway design.

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<u>KEY WORDS</u>: Expectancy, Driver Behavior, Human Factors, Driving Task Analysis, Expectancy Checklist

1.0 INTRODUCTION

1.1 GENERAL BACKGROUND

The traffic system is a complex combination of three major subsystems - the driver, his vehicle, and the situational context which includes roadway design, legal requirements for traffic operation, and the ambient physical environment. The major subsystems interact in fairly short time continuums in which present events, influenced by previous events, have the potential to influence the occurrence of future events. It is the complexity of the individual subsystems and the manner in which they interact that makes the traffic system so difficult to understand and control.

The general approach taken to resolve this difficulty has been to examine the major subsystems individually. This procedure has proven its value in the past, and criteria have been developed to improve the efficiency and safety of traffic system operation. Probably the most significant advancements are evident in the improved design of roadways and vehicles. However, factors pertaining to the road user, or the driver of the vehicle, have received considerably less attention. Efforts to remedy this discrepancy are currently being re-doubled by state highway departments, government agencies, private industries and grant foundations. The present report is an outgrowth of some of this effort.

1.2 OBJECTIVES

The general goal of this report is to develop for the highway engineer a practical guideline for making use of a known concept of human behavior. The concept is expectancy, and the guidelines apply to design. To accomplish the general goal, three objectives have been defined. These include:

1. Development of an operational definition of driver expectancy suited to engineering design requirements;
2. Delineation of factors which influence driver expectancy are amenable to engineering design; and
3. Development of a design philosophy and analytical technique to assist the highway engineer in implementing design criteria for driver expectancy.

The balance of this report deals with these three objectives.

2.0 AN OPERATIONAL DEFINITION OF DRIVER EXPECTANCY

An operational definition is simply a basis for identifying and describing the physical factors present when expectancy is operating in driver behavior. On the basis of the material presented in Appendix A, the following operational definition is proposed.

Driver expectancy relates to the observable, measureable features of the driving environment which:

(1) Increase a driver's <u>readiness</u> to perform a driving task in a particular manner, and

(2) Cause the driver to <u>continue</u> in the task until it is completed or interrupted.

Three aspects of the above definition are worthy of additional comment. The definition is a direct attempt to remove driver expectancy from some of the physiological and psychological connotations of the general expectancy concept. Furthermore, this definition does not attempt to account for expectancy influenced by such internal factors as motivation and personality, nor by substances such as drugs or alcohol. The author recognizes the influence of such factors; however, it seems that these are direct responsibilities of the driver and only an indirect responsibility, if any, of the highway engineer. Finally, the definition represents an attempt to define driver expectancy in terms of the conditions which cause it rather than the conditions it causes. The former is a practitioner's approach and is decidedly different from the latter which represents the conventional handling of expectancy by the behavioral scientist. This departure will, in the long run, provide the greatest benefit. It is the practitioner's vantagepoint which will inherently lead to the development of roadway design criteria of value to the highway engineer.

3.0 FACTORS AFFECTING DRIVER EXPECTANCY

Unless a driver is startled by some unexpected event, a contextual background of information and activities always accompanies his perception of the immediate situation. The background includes the driver's past experience and present objective, previous training, the driving task and environment, and the immediate sequence of past events in which he has been a participant. These general factors then establish the relevance or irrelevance of what he will perceive. His perception, in turn, provides a basis for what he will do. These perceptions and corresponding anticipatory behaviors, as stressed in Appendix A, are aspects of the general expectancy concept.

The foregoing paragraph sets the stage for delineating those factors which affect driver expectancy. Although an expectancy can be initiated by the driver receiving information for any of his senses (i. e., visual, auditory, kinesthetic, etc.), subsequent paragraphs will deal only with those factors affecting an expectancy prompted through the visual channel. Important here, however, is the fact that these general phenomena can also apply to the other senses.

3.1 PERCEPTUAL FACTORS

Why do things appear as they do? Understanding of this question relates directly to understanding the perceptual factors which affect expectancy. The difficulty in resolving this question lies in the fact that to investigate it, one is "observing the process of observing" (2). If there is bias in the process, it naturally follows that the bias is also in operation when one attempts to study the process. Acknowledging this problem, however, does not obviate useful study and practical results. It merely points out that there are two general ways to analyze the physical environment: There are the physical features as they appear to a driver, there is the appearance of those same features as they exist naturally or were designed to exist. Congruence between these aspects is quite important.

To develop an approach which can provide a basis for improving congruence, one begins logically with the driver. It seems proper to examine what it is about the physical environment that the driver perceives, and then to relate these perceptual factors to those factors which the designer has at his disposal for engineering the traffic system.

There are six broad classes of perceptual phenomena (2), and a brief treatment of each as it relates to vision follows:

(1) Sensory quality and dimension - This pertains to the individual's ability to see color and differentiate between the three basic dimensions of color - hue, brightness, and saturation.

(2) Configuration - This relates to the individual's ability to perceive shape, outline, and groupings. Their appearance is especially dependent upon the position of the form (i.e., a square looks different turned up on a corner [diamond] than when resting on one of its sides). Appearance is also dependent upon the situational context. For example, a circle looks smaller when placed between parallel lines or enclosed

in an angle. Other examples could be mentioned; however, these will suffice to illustrate that this perceptual ability is perhaps most subject to the occurrence of illusions.

(3) Perceptual Constancy - This is the perceptual ability, which preserves constancy of object appearance and serves to counteract illusions. Perceptual constancy assists in the recognition of objects when they are viewed at different angles, positions and distances. Situational factors and one's past experience play an important role in this perceptual process.

(4) Subjective frame-of-reference - This pertains to an individual's capacity to make valid and reliable judgments regarding physical features of the environment. A change of a single feature of an object may or may not always be perceived by an individual. If it is not perceived, the change is said to be below his threshold of detection. It follows that if a driver is to be required to respond to environmental changes, then these changes must be above threshold.

(5) Concrete object character - This relates to the fact that an individual does not merely see lines, shapes, qualities, dimensions, etc., but sees things and events as names and concepts. For example, in viewing

a highway interchange each feature and detail is not perceived; the object whole is perceived, and it appears as a highway interchange. Names and labels of environmental objects are developed by experience and training.

(6) Prevailing set - This relates to the fact that what one sees is influenced by such things as previous familiarity and recency of last contact with the object, in addition to his attitude, personality, current needs, and future goals.

Although quite brief, the previous discussion of perceptual factors provides the engineer with a basic awareness of important considerations in analyzing the traffic system environment as it would appear to a driver. The next paragraph deals with traffic system factors which affect driver expectancy as they exist naturally or were designed by the traffic engineer.

3.2 TRAFFIC SYSTEM FACTORS

The factors associated with the driver, the environment, the driving task, and the immediate sequence of past events in which a driver has been a participant can be logically treated as general factors of the traffic system. To provide an understanding of their relationship to driver expectancy, subsequent paragraphs have been developed to define a taxonomy of roadway factors. This taxonomy will become an important source for conceptualizing flows of events in typical driving situations (Section 4.2).

Although simplifications must be made when attempting to enumerate and categorize the multiciplicity of factors operating in the traffic system, care must be exercised to avoid oversimplification. Despite the problems, there is a historical basis for such an approach (12, 13, and 14). The taxonomy summary in Table 1 was developed using some of the ideas of this earlier research as a basis.

It is suggested that the following taxonomy contains the types of factors which must be considered to structure and control driver expectancy through design. The engineer will recognize that this list also contains many common items which he uses on a daily basis in highway design. It is apparent then that a determinant of driver behavior, namely driver expectancy, can be translated into the design language of the highway engineer and integrated into the design process. A general basis for handling this translation is presented in the subsequent section.

TABLE 1

TAXONOMY OF TRAFFIC

SYSTEM FACTORS[1]

I. Environmental Factors

A. Natural
1. Terrain
2. Weather
3. Gravity

B. Man-Made Factors
1. Setting/Landscaping
2. Roadway Design
3. Roadway Condition
4. Traffic
5. Legality

II. Driver Factors

A. Personality

B. Abilities

C. Physical Condition

D. Training

E. Past Experience

F. Trip Objective

III. Vehicle Factors

A. Driver/Vehicle Interface

B. Vehicle/Roadway Interface

C. Condition of Vehicle System

D. Number/Type of Passengers

IV. Driving Task Factors

A. Direction Changes

B. Speed Changes

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[1]This is a summary of a detailed taxonomy presented in Appendix B.

4.0 IMPLEMENTATION OF DRIVER EXPECTANCY CRITERIA

Although the concept of driver expectancy may be new to some, it is apparent to the experienced highway engineer from the foregoing discussion that some of the material upon which the concept is based and by which it is influenced is not new. This in turn suggests that some criteria for the driver expectancy concept already exist. These criteria may not specifically relate to the concept, but they do exist and are available in several sources. As a matter of fact, much of what has been published about the design of those features of the roadway which interact with the driver relate in some way to driver expectancy.

For example, design criteria for signing are presently available with respect to letter size, stroke width, spacing, etc., to increase readability. Other criteria for interpretability are also available such as simplicity, clarity, etc. Both of these factors can serve as design inputs for developing appropriate driver expectancies. Similar examples could be given, but this one demonstrates a point. Important here is the fact that some design data are already available, and no useful service would be performed at this time by rehashing these existing data into different formats. Rather, it would seem more profitable if the author could assist the highway engineer to develop for himself a new viewpoint from which to study and utilize what he already has at his disposal. This is the direction taken from this point on in the paper. To accomplish this task, the following sub-sections deal with: (1) a general design philosophy for driver expectancy; (2) a technique for analyzing the driving task; and (3) a checklist methodology for integrating into the traffic system design process, driver expectancy.

4.1 DESIGN PHILOSOPHY FOR DRIVER EXPECTANCY

Good design begins with an appropriate statement of design goals and this statement can take many forms. It may be explicitly formulated in published matter, such as design guides and standards; or the goal may exist only in the mind of the designer, having developed through experience and firsthand knowledge of the design task. Usage also varies. Design guides and standards are primarily used as known requirements in the design process. Experience-related factors are frequently used automatically by the good designer. The results, however, are generally the same. Design goals coupled with the designer's assumptions produce guidelines for concept and design and/or standards for subsequent evaluation of the design process and final product.

The idea of designing the roadway to accommodate driver expectancy, as a general design goal, is fairly novel. Therefore, it seems only proper to begin with a general statement of driving objectives from which the highway engineer can develop a comprehensive design philosophy for driver expectancy. The following ideas are offered in this respect and, as such, as rather broad in nature. Since these statements are generalizations from several sources, no attempt is made to identify reference materials.

1. Generally the driver feels that the roadway ahead will not mislead or confuse him. This positive attitude should

be confirmed by highway design.

a. Sufficient sight distance should be provided to permit making proper judgments under all ambient conditions.

b. Where sight distance cannot be provided, other techniques should be used to inform the driver of impending roadway geometrics.

2. A driver expects in-trip cues and services to guide and assist him in reaching his destination.

a. There should be compatibility between the existing information cues and services and the published material the driver has available for trip planning.

b. The designer should remember that the information he provides the driver through roadway design can potentially cause either correct, incorrect, or inefficient judgments and behavior. The probability and implications of each should be considered prior to final design.

c. Information cues and services should be generally compatible with what the driver has learned or experienced in the past. This points up the importance of having highway engineers provide inputs to driver training programs.

d. The meaning of highway information to the driver and his requirements for services are carried over from one situation to another. This aspect of behavior provides a strong argument for standardization of highway design across the nation.

e. The driver seeks only information and services which he thinks he needs; others, he tends to ignore. This suggests that varying amounts of information and service should be available to the driver depending upon his trip purpose and his experience with the particular section of roadway.

f. The driver generally feels that the information and services which he requires will be provided.

3. The driver expects the roadway information system to indicate his location and to provide information which will allow him to follow his desired route.

   a. Information of this nature can come from a variety of sources, and compatibility among these should be a design goal.

   b. The meaning of information depends upon the drivers' comprehension of that information. This indicates that designers should consider the least experienced legal driver.

   c. The amount of information provided at any one point in time should not exceed a driver's ability to interpret it under any and all prevailing ambient conditions.

d. Roadway designs should be consistent. Abrupt changes in design reduce the ability of the driver to associate the information provided with the situation he encounters.

e. Several items of information should not be presented at the same time or in very close proximity. When this occurs, the driver will have difficulty selecting the relevant information.

4. If there are in-trip requirements for course adjustments, the driver feels that he will be provided the necessary decision making information.

   a. The roadway design should not contain severe changes or unusual conditions which require abrupt adjustments. In situations where this criterion cannot be met, proper, timely and "attention getting" warning devices should be provided.

   b. A previously acceptable and safe driving habit should not abruptly become unsafe and dangerous as a result of changes in the roadway or its regulations. In situations where this criterion cannot be met, i.e. at highway maintenance sites, attention getting devices supplemented with corresponding information should be provided.

   c. Roadway designs requiring normal course adjustments (such as lane changes to avoid being trapped in a turn lane) should be accompanied by appropriate information to identify the task for the driver.

d. Information should be specific regarding what the driver must do and should be presented with enough time for the driver to perform the task under all ambient conditions. Signing should be closely studied from the viewpoint of minimum experienced drivers.

e. Information should be explicit regarding how and when it is to be used by the driver.

f. Information calling for specific responses which the driver is not actually required to make should be removed. If not, the driver will learn to ignore these items and this attitude will carry over to situations where they should not be ignored, and an unsafe condition will exist.

g. Identical information system designs should not be used to convey different requirements calling for different responses and judgments. Again, this points up a need for highway design standardization across the nation.

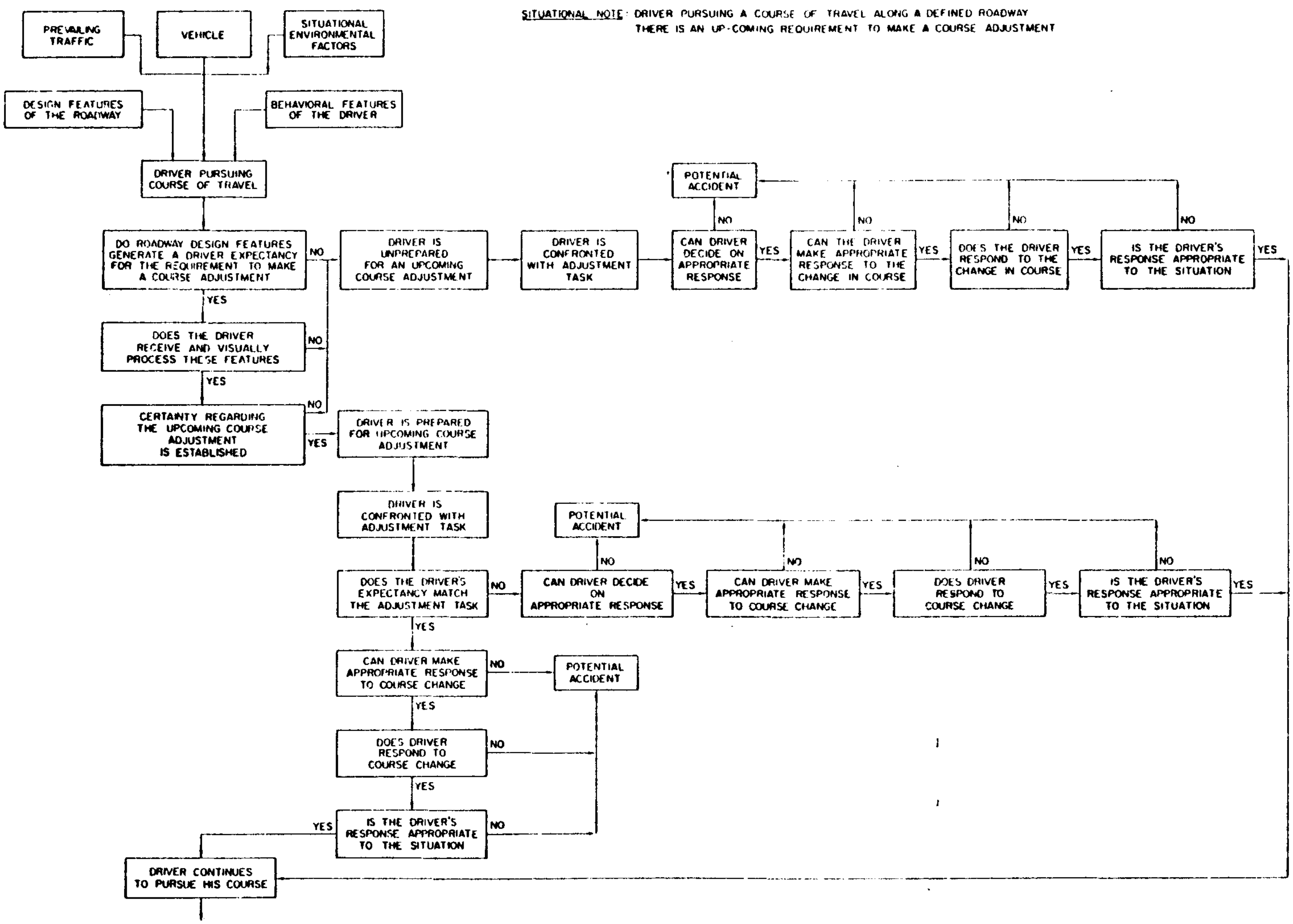
h. Designs calling for course adjustments should not require driving proficiencies beyond the least experienced driver.

i. Designs which require course adjustments or which provide information about such adjustments should not exceed the performance capability of the lowest powered automobile.

Given the foregoing design philosophy and the rationale that driver expectancy essentially is a relatively new way to organize and use existing design data, the question becomes: How can driver expectancy be incorporated in highway design? The answer to this question begins with an explicit definition and understanding of required driver tasks (i.e., driver tasks - See IV, Appendix B) at a specific point in the traffic system. This, in turn, is followed by an analysis of the task and associated traffic system factors and contingencies. The result will be anticipated design requirements for establishing driver expectancies that are essential to accomplishing the driver task. The analytical procedures proposed for examining the driver task is presented in the next subsection.

4.2 ANALYSIS OF THE DRIVING TASK

The procedure proposed for analyzing a driving task is shown in Figure 1. This technique combines in a simplified manner some of the better features of functional flow diagrams (5), information-decision-action analysis (10), and operational sequence diagrams (8). It is suggested that this procedure in conjunction with the diagnostic team approach will provide the highway engineer a unique method to consider driver expectancy in his design.



FLOW ANALYSIS OF DRIVING TASK

Figure 1

Figure 1 illustrates a sequential course of travel along a defined roadway. The situation defined in this case illustrates the sequence of events prior to a major course adjustment. The diagram identifies a sequential series of questions the driver must resolve during the maneuver with assistance from roadway design. Alternative flows of activity are based upon the decision of the driver at critical points. This figure provides insight into how an immediate sequence of events, in addition to the general factors of the traffic system, relate to driver expectancy and the driver's subsequent behavior.

Roadway design provides information to the driver prior to and at decision points to ensure that the behavior is suitable for the driving task. This is accomplished by structuring and controlling driver expectancy. The concept is easy to understand now because, to paraphase the earlier discussion, changes in the driving environment that "get a driver ready" to do something and "keep him ready" until he does it, have been operationally defined as "driver expectancies." Those factors that affect driver expectancy and serve as inputs for consideration in the flow analysis must now be delineated.

4.3 DRIVER EXPECTANCY DESIGN CHECKLIST

A design checklist is proposed to develop driver expectancy criteria and to ensure its implementation in the design process. This approach allows the designer to combine intuition and known design criteria to resolve design problems (15). It is particularly suited to the engineer who is familiar with both the existing criteria and the user of his product. Under these conditions, a checklist becomes a tool to conceptualize the design question by jogging the designer's memory, directing his thought, and ensuring that all facets of the design are considered in the development process. Finally, it can be used as a quality control device by the designer or others to evaluate the final design. This latter feature is particularly important when design validity must be demonstrated.

The utility of checklists can be well illustrated by the fact that pilots, no matter how experienced, use checklists in aircraft operations. They do not view the checklist as an indication of personal deficiency or an infringement upon their task; rather, they use it as a tool to assist them in performing complex tasks in a safe and reliable manner. The design of highways for today's drivers and their vehicles is extremely complex, and a checklist to aid the designer in this task would be beneficial.

The checklist loses some of its value when the designer is either unwilling or unable to place himself objectively in the position of the user. Another disadvantage is that the checklist does not actually produce design data, and sometimes it fails to require the designer to approach a design task systematically (4). Although design data are not provided by checklists, the list can enumerate pertinent design facets which might otherwise be overlooked or considered insignificant by the designer. Then he, through experience, can obtain detailed data from known sources. That the checklist fails to require a systematic approach of design problems is not an inherent weakness; it is merely a shortcoming in the construction of the checklist.

Proper development alleviates this problem. Appendix C contains the proposed driver expectancy checklist, as well as instructions for its use.

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APPENDICES

APPENDIX A

BACKGROUND AND REVIEW

Providing enough information about the driver subsystem to control and predict its behavior is not easy. However, several alternative approaches for developing this information are available: (a) a simple analysis of the driver, (b) a detailed, comprehensive in-depth analysis, or (c) an in-depth study of a restricted number of general factors operating in driver behavior. The first approach is relatively easy, but it is frequently of little value. The second is impossible within the current state-of-the-art of behavior theory and measurement; therefore, the restricted in-depth study of driver factors is perhaps the best approach. For it to have practical value, however, emphasis must be placed upon application and utility rather than theory, and this is the approach taken in the present report. A general concept of behavior called "expectancy" as it relates to the driver, is examined to determine its contribution to traffic system design.

Expectancy is one of the general concepts used by behavioral scientists to explain the activity of people. Although quite complex, it may be simply defined as "a predisposition to perceive or sense specific information as existing in the environment, and to perform responses on the basis of this information." The information 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 implication because it is important that one's behavior be appropriate to his situation. One way to ensure appropriateness is to ensure compatibility between what one expects of his environment and what actually exists. The importance of this relationship serves to highlight the significance of understanding how expectancy operates within the driver subsystem.

A practical generalization of the expectancy concept of man's behavior to those situations in which he is a driver would be extremely valuable. Even from the limited discussion to this point it is easy to see that expectancy plays an important role in determining a driver's behavior, especially within the context of the traffic system. A preliminary basis for defining the problems associated with this concept and its utility in driver situations has been suggested from earlier studies (1 and 9) and from recently-conducted field studies at the Texas Transportation Institute (16).

The logical place to begin the task of defining driver expectancy is with a theoretical treatment of the expectancy concept in behavior theory. Conceptually, some authors (7) distinguish between behavioral phenomena called "expectancy," intention," and "set"; others (11), do not. Theoretically, a case for independence can be made when the behavior under study is simple (e.g., reaction time), but when the behavior is as complex as driving, these distinctions are probably not practical. Again, the time frame in which each supposedly occurs is too short to make useful distinctions. For these reasons, the single concept called expectancy is adopted for use in this paper and is considered general enough to include the concepts of set and intention. Whenever the term "expectancy" is referred to in the paper, the reader can, if he so desires, substitute the term "set."

Definitions of expectancy have been presented by only a few authors, and one (6) implies that there is a basic weakness in the formulations. They have employed, he says, synonyms rather than definable characteristics. Expectancies are called "tendencies," "dispositions," or "readiness," and their effect on behavior is "facilitation," "selection," "determinations," or "guidance." Evidently, the concept of expectancy is not easy to define even for the theoretician; however, for it to have engineering design utility, it must be defined and factors associated with it identified.

The foregoing at least provides a conceptual framework for defining expectancy. Perhaps a review of previous investigations dealing with expectancy would assist the designer to formulate an appropriate definition and provide a means to complete this framework.

Allport (2), in reviewing studies of expectancy (or "set" as he prefers) by behavioral scientists, assembles previous findings into 16 propositions. Some of these propositions are directly pertinent to the purposes of the report; others are not. Summaries of the former are presented in the following paragraphs:

1. Expectancy serves to prepare the individual to perform a response, and these preparatory aspects precede, accompany, and sometimes outlast the response he makes. In addition, preparation facilitates the behavior process from the time a stimulus appears to the time the response occurs. The total behavior happens with greater promptness, speed of execution, and energy.

2. In addition to preparing an individual for some impending stimulus from the environment which elicits a particular response, expectancy serves to develop anticipation for the appearance of the stimulus. Although the stimulus may not be present, this anticipation can be sustained until it actually appears in the environment.

3. The response the individual makes is exactly the same behavior as that which he has been prepared by expectancy to make. Once the behavioral process has been set in motion by expectancy, it will be consummated unless some <u>unusual</u> circumstances intervenes.

4. It follows from the preceding propositions that expectancy performs a selective function for the individual. From a host of behaviors which could potentially occur in any one situation, expectancy serves to select one. The selected behavior is then facilitated, and all others are inhibited. This simply means that the behavior implied by the expectancy will be brought to complete performance, and all others, barring some unusual circumstances, will be excluded.

5. Another logical follow-up from the previous proposition relates to the reaction time of the individual. Time required to react to a stimulus event which the person expects is reduced, whereas reaction time to the unexpected is increased.

6. There is an optimum time interval between that point in time when expectancy initiates a behavior process and that point at which stimulus appears to consummate the behavior. The time interval could be so short that the individual is not adequately prepared. On the other hand, the interval could be so long that anticipation has waned, and preparatory advantages are lost.

7. Expectancy can involve learning. The meaning of a stimulus and the corresponding behavior it causes, both important aspects of expectancy, are learned. This learning can occur consciously under either formal or informal training or it can develop unconsciously in the process of daily living. The learning can be different for different individuals. Through the learning process, the identical stimulus for different people can have different meanings and can cause different behaviors.

8. An expectancy can be developed from a variety of sources. This may include factors associated with the individual, the task in which he has been, is, or will be engaged, and the environmental context in which he has been, is, or will be engaged during the course of his task.

9. Since expectancies involve learning, they are subject to processes associated with memory storage, forgetting, and recall.

Although previous research has led to the development of nine propositions, one author (3) has suggested that of the abundance of research on expectancy, there are two general theoretical postulates which appear to be the basis for explaining all others. These are that expectancy provides an individual with a readiness to respond a particular way and with a persistence to carry through with the behavior. Consequently, these two postulates became the basis for for defining driver expectancy in this report.

APPENDIX B

A TAXONOMY OF TRAFFIC SYSTEM FACTORS

(A General Outline)

I. SITUATIONAL/ENVIRONMENTAL FACTORS

   A. Natural Factors

      1. Terrain

         - Hills/Mountains
         - Valley
         - Prairie
         - Desert
         - Plants/Trees

      2. Weather

         - Wind
         - Rain
         - Snow
         - Fog

      3. Gravity

   B. Man-Made Factors

      1. Setting-Landscaping

         - Rural
         - Urban

2. Roadway Design

- Geometry
  - Horizontal alignment: degree of curve, circular or spiraled curves, tangent lengths, etc.
  - Vertical alignment: length of curves, difference in grades, etc.
  - Roadway width: number and width of lanes, shoulders, median
  - Embankment or cut sideslopes; median berms
  - Special lanes, tapers, ramps
  - Intersection and interchange design: radii, channelization, etc.
  - Drainage and overpass structures
- Signing
  - Regulatory (right-of-way, speed movement, parking pedestrian, misc.)
  - Warning (geometry, traffic control devices, roadway surface conditions, and roadside hazzards)
  - Guide (route markers and auxiliary markers, destination and distance signs, information signs)
- Special Devices
  - Lights: traffic control, roadway illumination
  - Reflectors: roadway delineation
  - Raised pavement markers

- Rumble surfaces
- Traffic monitoring, ramp metering

• Guardrails and Median Barriers

- Rigid: concrete median barriers, bridge parapets
- Semi-flexible: W-section rails, box-type
- Flexible: calbe, chainlink & cable, vegetation

• Highway Markings

- Center and lane stripes
- Edgelines
- Hazard delineation - obstruction approach
- Channelizing lines
- Special markings at exit/entrance freeway ramps
- Stop and crosswalk lines
- Misc. pavement messages
- Parking space limits
- Curb markings

• Pavement Characteristics

- Color
- Texture
- Construction joints

• Vehicle Attenuation Systems

3. <u>Roadway Condition</u>

• Maintenance requirements: Rideability

• Detours

• Repairs: Pot holes, cracks, etc.

4. <u>Traffic</u>

    - Vehicular Volume
    - Vehicular Speed
    - Pedestrians

5. <u>Legal</u> - Liability

II. DRIVER

A. <u>Personality</u>

1. Somatic
2. Motives
3. Attitudes
4. Temperment

B. <u>Abilities</u>

1. Sensory
2. Perception
3. Learning and Retention
4. Thinking and Decision Making
5. Movement and Force Application

C. <u>Physical Condition</u>

1. Illness
2. Fatigue
3. Drugs/Alcohol

D. <u>Driver Training</u>

1. No Formal Training

2. Training in Secondary Education Programs

3. Training in Private Schools

E. Past Experience

1. Driven This Roadway Before

2. Driven a Similar Roadway

3. Never Driven This Roadway or Similar One

F. Populational Expectancies

G. Objective at Roadway Site

1. Originate Trip

2. Terminate Trip

3. Pass Through

4. Change Route

III. VEHICLE FACTORS

A. Man/Vehicle Interface

1. Steering Control Design

2. Displays

3. Layout and Arrangement of Interior

4. Safety Features

B. Vehicle/Roadway Interface

1. Aerodynamic Performance

2. Size

3. Weight

4. Power System Capability

5. Tire Size

C. Condition of System

1. Braking System
2. Power and Fuel System
3. Tires
4. Exhaust System
5. Electrical System
6. Cooling System

D. Number of Passengers

1. Less than Capacity
2. Capacity
3. More than Capacity
4. Adult Passengers
5. Children

IV. DRIVER TASK FACTORS

A. Direction Changes

1. Lane changes
2. Exits/enters freeway
3. Turns from one highway to another
4. Turns to/from accessible properties
5. U-turns
6. Horizontal curves
7. Minor tracking adjustments
8. Climb/descends hill
9. Climbs/descends overpass, depressed underpass

B. Speed Changes

1. Accelerates from 0 to velocity V_1
   - From stop sign
   - From traffic light
   - After other forced stops: busy RR crossing, construction obstacles, yields to heavy traffic
2. Accelerates from V_1 to V_2
   - Speed zone changes
   - Passes slower traffic
   - Upon entering from ramp or cross-street
   - Sudden improvements in level of service, roadway geometry pavement condition, or weather
   - Normal maintenance of speed
   - Accelerate going up a grade
3. Decelerates from V_2 to V_1
   - Speed zone changes
   - Approaching vehicle or other obstacle in roadway
   - Approaching turn
   - Approaching traffic light
   - Approaching stop sign
   - Approaching caution sign
   - Merging with slower traffic stream
   - Sudden deterioration in level of service, roadway geometry, pavement condition, or weather.

4. Decelerates from V_1 to 0

   - Stop Sign
   - Traffic Light
   - Other forced stops: busy RR crossing, construction obstacles, yields to heavy traffic
   - Emergency situations

APPENDIX C

DRIVER EXPECTANCY CHECKLIST

A DESIGN REVIEW TOOL

Developed in response to the
research findings on the Multi-state
Pooled Funds Research Project entitled
"DIAGNOSTIC STUDIES OF HIGHWAY
VISUAL COMMUNICATION SYSTEMS"

Disclaimer

"The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Federal Highway Administration."

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The results of this research point strongly to the fact that good driver communication is only achieved by proper coordination among all roadway and terrain features and the devices used to guide, warn, direct, regulate or control traffic operation. These results indicate that good roadway communication can generally be achieved within the current rules and regulations applicable to design and operation, PROVIDED THEY ARE ADEQUATELY COORDINATED AND PROPERLY INTERPRETED.

Also, it has been shown that driver expectancy plays a very important role in driver communication. The driver uses the geometric configuration, delineation, markings, railings, intersections, and other roadway elements, as well as the natural and man-made features surrounding the roadway to develop an expectancy as to what lies ahead and how he should react to the situation. When the condition exists as he expects, then the road has communicated well with the driver.

The importance of driver expectancy as demonstrated by the research prompted the development of this Driver Expectancy Checklist. It is designed to serve as a convenient reference or reminder for use by the individuals and groups who make decisions regarding the various features that together make up the total roadway environment in which the driver operates. Properly used, it will assure integration of design and operational features of the roadway.

The checklist has been designed to serve the experienced as well as the novice. Although the material within the checklist may be quite familiar to some, it will serve as a reminder or procedural guide in the review process. To the novice, the checklist will serve as a convenient reference to assure the inclusion and coordination of all pertinent points of consideration in the design process.

The checklist has been reviewed by a substantial number of designers and traffic engineers from the 18 sponsoring states. More than 120 representatives of the various states reviewed the checklist, and a vast majority (more than 90%) favored the checklist concept. The checklist has been revised and improved substantially based on their reviews.

The Project Policy Committee views this checklist as a useful tool in achieving coordinated roadway communication systems based on driver expectancy. It is hoped that the various highway departments will make further improvements to the checklist through its application, and that they will share their ideas for improvement with others.

ROADWAY SITE

The most fundamental elements of the driver communication system begin with and to a large extent are determined by the natural features which exist around the roadway. Variations in the weather conditions, the existence of construction and maintenance operations, and a lack of continuity or consistency in basic design alter the environmental situation. The information reaching the driver from these many varied sources must blend into a comprehensive picture of the conditions which exist ahead; otherwise, the possibility for driver confusion and indecision exists.

The driver assimilates the many cues necessary for driving and establishes a course of action which must be taken in the near future. This decision making process is repeated on a continuous basis as the driver is provided new information. The items in this section concern the natural and man-made environmental situations as they relate to establishing driver behavior patterns or as they affect these patterns.

CONSISTENCY BETWEEN NATURAL FEATURES AND ROADWAY DESIGN

CHECK TO SEE THAT:

____ The aesthetic treatment of the median and roadside has been designed to be harmonious with the general topography and vegetation in the area consistent with current safety and operating policies.

____ Where the driver's view ahead will be limited, the upcoming roadway alignment will not conflict with the alignment suggested by natural terrain features.

____ Intersections and interchanges are compatible with the topography and aesthetics (consistent with expected traffic operational requirements).

____ Consideration has been given to physically restraining animal movements, falling rocks, unusual drainage patterns, and other natural environmental elements which could constitute a hazard to the driver.

WHERE INCONSISTENCIES MUST EXIST BETWEEN ROADWAY DESIGN AND NATURAL FEATURES

CHECK TO SEE THAT:

____ Complex geometrics requiring extreme operational changes have been avoided in situations where the driver might encounter unusual alignment due to natural features.

____ Available sight distance to the features of the roadway has been increased to provide the driver better view of any design inconsistencies.

____ Signing, delineation, vegetation, and other means have been used to clarify design inconsistencies.

____ Signing has not been used as a substitute for poor design.

DESIGN FOR WEATHER CONDITIONS

CHECK TO SEE THAT:

____ In mountainous terrain or at other locations where wind gusts significantly increase the driving hazard, the design has been modified to enhance safety.

____ Pavement surface contours have been prepared and appropriate consideration has been given vertical alignment, cross slope and pavement surface to provide proper drainage. Special attention has been given to especially flat grades, curve transitions, and similar situations where drainage of the standard pavement cross-section may be inadequate under heavy rainfall conditions.

____ In areas where sporadic freezing temperatures are experienced, some type of changeable message sign has been provided to warn drivers of potential icing conditions on bridge decks.

____ The alignment on bridges and roadways approaching bridges does not increase the hazard of ice on the structure.

____ The potential for, and expected frequency of, heavy fog has been evaluated, and emphasis has been placed on simplifying the geometric design where fog or other atmospheric interference is likely to cause a significant visual problem.

____ On sections of roadway over which pockets of disabling fog prevail fairly frequently, appropriate warning signs to alert the driver have been considered.

____ Pavement edge striping in combination with either fixed illumination or post-mounted delineators has been included to provide reasonably adequate delineation of major roadways under a variety of adverse weather conditions.

____ Whenever possible, a sight distance greater than the minimum value has been provided to enhance safety during periods of adverse weather.

____ Where minimum design standards must be utilized, the coefficient of friction used in the design process has been selected with due consideration of typical adverse weather conditions.

____ Where adverse weather conditions frequently impair visibility and/or available pavement friction, the "forgiving" roadside design concept has been considered, particularly in areas of high friction demand.

ROADWAY DESIGN FOR RURAL HIGHWAYS

CHECK TO SEE THAT:

____ The spacing between successive intersections is adequate to insure operational safety.

____ All intersections have been located to provide greater than the minimum sight distance for approaching traffic.

____ Consideration has been given to adding lanes for turning traffic at intersections to reduce delay and accident potential.

____ Intersection channelization has been designed to insure a high degree of operational safety.

____ Minor roadways join major roadways with T-intersections wherever possible.

____ On a highway with critical grades or substantially restricted passing opportunities, consideration has been given to the initial construction of climbing lanes or a continuous 4-lane section.

____ Design standards greater than handbook minimums, particularly with regard to sight distance to the roadway features, have been applied to improve the communication of the roadway with the driver.

____ The design provides the highest level of service attainable at reasonable cost.

ROADWAY DESIGN FOR FREEWAYS LOCATED IN RURAL AREAS

CHECK TO SEE THAT:

____ A consistent pattern of interchanges has been utilized to minimize driver confusion.

____ Interchange design has been simplified to provide better driver understanding and to permit effective directional signing.

____ The relatively high potential for wrong-way movements at interchanges has been recognized and considered in the design process.

____ Access and egress areas have been designed to afford the driver maximum visibility at merging and diverging areas.

____ A variable median width has been considered to take advantage of natural features.

____ Consideration has been given to reducing driver monotony on long tangent sections by varying the width or aesthetic treatment of the median.

____ Highway lighting has been considered for critical interchange areas to provide the motorist with adequate information for safe and efficient operation.

ROADWAY DESIGN FOR FREEWAYS LOCATED IN URBAN AREAS

CHECK TO SEE THAT:

____ Interchange spacing is consistent with good design practice and provides proper access to the surrounding arterial street network.

____ A consistent pattern of interchange types has been used to minimize driver confusion.

____ Interchange design has been simplified to provide better driver understanding and to permit effective directional signing.

____ Where a partial interchange is used, a comprehensive scheme of trailblazing to the next interchange has been provided. (Drivers who have exited from a freeway expect to be able to reenter in the same vicinity.)

____ The relatively high potential for wrong-way movements on urban interchanges has been recognized and treated in the design of frontage roads, ramp channelization, and signing.

____ All main lanes have been retained through each interchange area, and necessary lane drops are accomplished between interchanges without other decision points.

STREET DESIGN FOR URBAN AREAS

CHECK TO SEE THAT:

____ The street has been designated as an arterial, a collector, or a local street, based on a review of land use and expected traffic demand.

____ Local streets have been specifically designed to carry light traffic over an indirect, low-speed alignment requiring a minimum number of special control devices.

____ Collector streets have been designed to discourage through traffic in a residential area by following indirect and discontinuous alignment.

____ Major arterials have been designed to protect the traffic function by limiting intersection spacing and direct property access.

____ An effort has been made to maximize the use of T-intersections on local and collector streets.

____ Where reversible lane operation is used, special traffic control devices have been included in the design.

____ Trailblazing with route markers has been considered where the approach to a major interchanging or intersecting facility may not be clear to the unfamiliar driver.

____ Median design for an arterial street satisfies the relative operational requirements for through and left-turning traffic.

CHANGES IN CROSS SECTION ELEMENTS SUCH AS SHOULDER WIDTH, LANE WIDTH, OR SIDESLOPE

CHECK TO SEE THAT:

____ The design provides the driver with a sense of route continuity.

____ Every effort has been made to avoid situations where local roads or exit ramps continue straight ahead when the major roadway turns.

____ Adequate transition and clarifying information has been provided the driver well in advance of the point where a new and different roadway design is encountered by the driver.

____ Additional sight distance is provided at points where adequate transitions cannot be provided between two sections of different cross section design. (Warning signs are not always effective in alerting the driver to this situation.)

____ The need for highway lighting along transitions and at major intersections has been considered.

MAINTENANCE AND CONSTRUCTION OPERATIONS WHICH ALTER THE SITUATIONS EXPECTED BY THE DRIVER

CHECK TO SEE THAT:

____ Detours and other temporary roadways have been designed to the same geometric standards as the connecting roadway.

____ Traffic management during construction and maintenance operations has been properly planned and coordinated, regardless of the expected duration of the activity.

____ Periodic on-site reviews have been scheduled to insure that construction and maintenance signing and delineation are adequate and properly maintained.

____ The speed zones established for construction and maintenance areas are realistic.

____ Provisions have been made for speed zones to apply only during periods when such restrictions are necessary.

____ Specialized channelization and guidance devices (delineation, markings, or lighting) have been considered for maintenance and construction areas.

____ Provisions have been made to replace pavement markings daily when markings are obliterated by construction or maintenance operations.

CONSISTENCY OF TRAFFIC CONTROL AND INFORMATION ON ALL ROADWAYS

CHECK TO SEE THAT:

____ Guide signs have been presented in a consistent manner.

____ All traffic control devices have been applied in a uniform manner.

____ Greater than minimum stopping sight distances have been used wherever practical to provide greater response time and a better view of the roadway.

____ Liberal response times have been used in determining placement and spacing of signs.

____ The lowest expected sign reflectance has been considered in the longitudinal and lateral placement of the signs.

____ Sign design and installation have been applied uniformly in the sense that similar types of signing are presented in similar decision situations.

____ Unique situations have received special attention regarding the types of traffic control devices used.

____ Repetition of directional sign messages has been provided to decrease the probability of drivers failing to see them.

____ The uniform application of control devices and roadway design have been integrated to provide the best possible communication system.

THE DRIVER

The driver is the critical link in the driver-roadway-vehicle system, and the design of every traffic facility involves certain assumptions concerning the expected behavior patterns of drivers. The design engineer frequently must make decisions on the various geometric features which include implicit assumptions regarding how the driver will operate his vehicle. Should the design decision not be compatible with the actual driver response, inefficient operation and a need for an unusual number of traffic control devices may result.

This section concerns the assumptions which a majority of drivers make in driving unfamiliar roadways. The unfamiliar driver is considered to be the "design driver." The communication system required by the unfamiliar driver will in large measure meet the basic needs of the other classes of drivers.

THROUGH TRAFFIC MOVEMENTS

<u>CHECK TO SEE THAT</u>:

____ Care has been taken at points where the highway divides to insure that the alignment and land configuration clearly indicate the major roadway.

____ Horizontal curves are designed to provide proper balance between the operating speed on the approach roadway and on the curve.

____ The safe operating speed on both legs of diverging roadways is consistent with approach speeds.

____ Consideration has been given to optimizing the movement of through vehicles by such traffic engineering methods as progressive signal systems, one-way operation, reversible flow, and separation of turning movements.

TURNING MANEUVERS AND ROUTE CHANGES

CHECK TO SEE THAT:

____ The design of freeway interchanges satisfies the expectancy that all freeway exits will be on the right.

____ The design of the interchange satisfies the expectancy that right turns onto freeways from an arterial are made in advance of the grade-separation structure.

____ The design of the interchange satisfies the expectancy that left turns onto freeways from an arterial are made beyond the interchange structure.

____ Where the above expectancies are not satisfied by an initial design, the use of alternative re-designs has been given first priority, the provision of greater sight distance second priority, and the intensive application of traffic control devices third priority.

____ At major intersections protection of left turning vehicles has been achieved by channelization.

____ Consideration has been given to the operational difficulties imposed on those drivers who enter the arterial from minor side roadways particularly where non-traversable medians are used on an arterial street.

____ Geometric design and pavement markings have been carefully selected in recognition of the fact that extended visibility of the roadway ahead is essential to driver communications.

____ Where pavement messages have been used, they are used in conjunction with signing.

____ The type of signs (i.e., unlighted reflectorized signs, externally illuminated signs, or internally illuminated signs) have been chosen on the basis of the level of illumination in the area.

____ The placement of post-mounted delineators clearly outlines the path for the driver.

____ Diagrammatic signing has been used where needed for complex intersections and interchanges.

POINTS OF INGRESS AND EGRESS

CHECK TO SEE THAT:

____ Operational peculiarities (i.e., one-way flow) of a roadway serving a significant traffic generator have been clearly indicated by a uniform scheme of signing and pavement markings.

____ Where directional signing to important destinations is provided (i.e., hospitals, police stations, parks, public institutions, etc.), a system of directional signs or trailblazers has been consistently applied from the point of their introduction until their purpose is fulfilled.

____ Driveways have been designed to meet the driver's expectancy through effective control of right-of-way encroachment and driveway design standards.

____ Points of access and egress are located in areas with good sight distance and away from sight-restricting features such as curves or grades.

THE VEHICLE

The performance characteristics of vehicles in the traffic stream have a dramatic influence on the safety and efficiency of operation on the highway system. Radical changes in operating speeds result in unexpected traffic situations for the driver. The design process must, wherever possible, eliminate the conditions which result in the necessity for substantial speed changes.

The vehicle performance characteristics for the lowest-powered legal vehicle expected to use the facility on a frequent basis has been assumed. The performance of the vehicle in relation to the various elements of the roadway is of primary concern in this section.

VEHICLE PERFORMANCE

CHECK TO SEE THAT:

____ The vertical alignment has been evaluated to determine the performance on grades of the AASHO design heavy truck.

____ A suitable climbing lane or continuous auxiliary lane has been added on all critical grades which cannot be adequately redesigned.

____ Entrance ramps and acceleration lanes have been designed to account for the effects of the grade and alignment.

____ Deceleration lanes have been designed to provide the greater deceleration distances required by trucks and buses.

____ The length of sag vertical curves exceeds the minimum value wherever possible to provide greater headlight sight distance.

____ In mountainous areas roadways which have long, steep downgrades have been provided with escape lanes to decelerate heavy vehicles which run out of control.

DESIGN REVIEW

When considered separately, the various elements that go together to make up the total design generally result in a design that satisfies all the minimum criteria, but does not necessarily meet the requirements of the driver. In the design review process, the major task is to examine the aggregation of the various design elements to assure that the driver's communication needs have been satisfied.

The items included in this section concern the complexity of the driving task at each point along the roadway. The primary considerations in evaluating task complexity are the number of decisions required of the driver at each point and the separation between decision points.

DESIGN REVIEW

CHECK TO SEE THAT:

____ The complexity of the driving task in which the driver makes a direction change has been examined.

____ The complexity of the driving task in which the driver is expected to make a speed change has been examined.

____ The consistency of the driving task requirements has been examined.

____ Similar situations have been treated in a similar manner throughout the design.

____ Consistency between information supplied to the driver by the communication system and the information gained from the design features of the roadway has been achieved.