Highway Aesthetics—Functional Criteria for Planning and Design

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This report examines the function and use of aesthetic criteria for the highway development process and recommends promising directions for future study and implementation. The major premise established for procedure of the study is that "aesthetics" is not an additive to the process of highway planning and design but must be identified and implemented as an integral component.

The research report identifies the visual parameters of the highway planning process related to a range of disciplines; evaluates them for their relevance to improved highway appearance and use; and driver behavior, suggests a methodology to identify and integrate visual and behavioral criteria for a more complete highway planning process; and applies this methodology in a demonstration case study.

•THE IMPROVEMENT of visual quality of highways, as with many aspects of the environment, has been a matter of increasing concern in recent years. As this concern for obtaining visual values increases for highways, considerable difficulties arise in identifying what the values are and the ways they may be implemented in highway planning and design. The primary problem, the ways in which aesthetics is significant and useful for the driving experience, has received little attention. To date it appears that these difficulties have not been solved. Much of the dilemma seems to relate to the need to identify aesthetics in a relative and functional context, and accordingly, to identify the evaluation and performance criteria with which aesthetics may be meaningfully utilized.

Unfortunately, visual quality in current practice usually implies planting a few flowering shrubs or removing the local junkyard from the roadside. Such actions are helpful but they certainly do not represent objective and comprehensive analysis or application of the role of aesthetics in the highway environment. This might be called the "Band-Aid" approach. Visual quality needs will not be met by such additive panaceas, but will involve functional problem diagnosis and development of criteria for treatment that are integral components of the highway system itself. This is fitting because the most significant aspect of the driver's experience of the highway is that it is comprehensive. It is a matter of interaction of the driver and all that he can see comprising the visual environment of the highway.

Consideration of highway aesthetics must involve all visual factors and the relationships that influence the linkage of a driver's seeing and reacting. Such factors are the major components of the highway environment and imply input to varying degrees of driver experience and behavior. They provide visual impact through the progression of landscape views, road alignment, enclosure by vegetation or buildings, and landmarks. Driver experience relates to his need and the perceptibility and location of highway components. This is the source of significant driver information, guidance, and pleasure.

Visual experience is also qualitative; therefore, it has aesthetic value. With the development of the aesthetic qualities of the road, there can be a more perceptually

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clear and meaningful highway environment. Thus, aesthetic values are integral to the visual geometrics and locale of the highway, making available its meaning and form, clarity and organization for highway components. A suitable analogy is the difference between music and noise. That aesthetics can be a means to a more visually comprehensible highway, and therefore a better functioning and safer highway, demonstrates the importance of development of really basic visual performance criteria; aesthetics is least useful as a tool for highway development when employed in additive or cosmetic ways.

This study has been undertaken on the basis that aesthetic values are integral components of the highway environment and, with behavioral and visual design criteria, offer one of the principal means to improve its organization and form for better driver performance and pleasure. This is the explanation for the title of the study.

Although aesthetics offers values of a primary nature, other criteria obviously must also be utilized for highway planning and development. Like construction criteria, aesthetics is only one part of the total process. Other primary criteria, for example, occur in social, economic, and natural science sectors and relate to different aspects of the planning and design process. It is suggested that among the most important considerations for physical design of highways are criteria of human behavior. Patterns of attention, vision, cognition, expectation, comfort, and pleasure illustrate basic needs and must be identified for performance and evaluation criteria which can be applied through engineering, planning, and visual design techniques for highway design. Without the integration of these resources it is not surprising that certain roads earn the epithets of "monotonous" and "accident-prone" and are visual anomalies of unrelated factors, information, and effects upon the driver. The "ideal" highway should be considered as a total system, interrelating driver and environment.

Techniques must be developed to identify and manipulate criteria from appropriate disciplines. Procedures must be coordinated for evaluation and decision-making for their application to the process of highway development. Almost no work has been done to determine what the driver sees and then reacts to. The problem of the relation of qualitative to quantitative criteria for decision-making has been another reason for the lack of use of visual criteria in highway design. Attention toward improvement of these matters is urgent to meet the needs and opportunities of highway design.

STUDY HYPOTHESES

Initial examination disclosed specific problems and opportunities. To study them, the authors established hypotheses to identify visual components and their relationship to the driver and to highway design. Once defined, however, a second problem arose in investigation of linking the driver's behavior with the factors relating to that behavior. Because of age, ability, prior experience and personality, drivers vary in what they can perceive and consequently as to how they operate a vehicle. However, when certain objects or locations have sufficient visual impact, it was postulated that drivers will respond with a degree of similarity. For example, increase in visual enclosure often induces drivers to decrease speed. Assuming such examples to be true, and emphasizing the significance of objects observed and their strength of impact, a hypothesis was formulated: Visual input = behavioral output, with specific qualifications. These qualifications were discussed on the basis of a postulated system of driver, vehicle, and roadside environment, defined by the authors as the visual performance corridor—all that the highway user can see from his position on the road. Because the study purpose was review, statements were accepted at face value and were not further quantified or tested, but only brought together to identify feasible study possibilities.

To study the relationships and interactions of driver and the "visual performance corridor," the "driver-vehicle-highway environment system" was hypothesized as follows: An understanding of relationships between the driver and his environment was felt to be necessary before meaningful aesthetic design criteria reflecting driver response could be developed. Relation of the visual elements of the roadscape to the total sequence of highway environment was stated as a function of the driver's information

needs. Thus, for study purposes the driver and his environment were regarded as a "closed" system. The principal elements of the system are the driver operating his vehicle on a road complex with some prior driving experience within a physical roadside environment under the situational influence of climate, traffic conditions, and travel objectives.

For study purposes the system was viewed from two aspects: (a) the road complex, consisting of all geometric elements, structures, signs, etc., within the limits of the right-of-way, and (b) the roadside environment, consisting of all physical elements within the visual performance corridor. Thus, as the driver maneuvers his vehicle, he generates certain needs for information required for orientation, steering control, and so on. The information he seeks can be provided in a number of ways—for example, directly by means of signs, or indirectly by means of alignment, geometrics, and the overall visual characteristics of the road itself.

The transmission of visual information to the driver is modified by a number of factors. Conditions of climate and local traffic can be regarded as temporary modifiers of information. The vehicle is an added source of information, and the driver himself is a type of information modifier. His abilities, experience, and particular momentary mental and physical condition may greatly influence his perception and response to information. The driver has become quite different from a walker.

For the conveniences offered, particularly by automobile manufacturers, man has accepted comfort instead of awareness of his environment. The vehicle screens most sensations, except visual, of the highway environment; comfort and safety features and the effort to make "quiet cars" have left man dependent primarily on one sense, vision, for information on speed of his vehicle and its position on the highway in relation to other vehicles or fixed objects.

Relationships between driver and the highway environment are extremely complex. They are not well defined, nor can they be applied as criteria or guidelines for highway design. Relationships postulated by the authors as possibly occurring are shown in Figure 1.

The demands of operating in today's complex highway environment place a great responsibility on the driver to remain visually and mentally attentive to highway

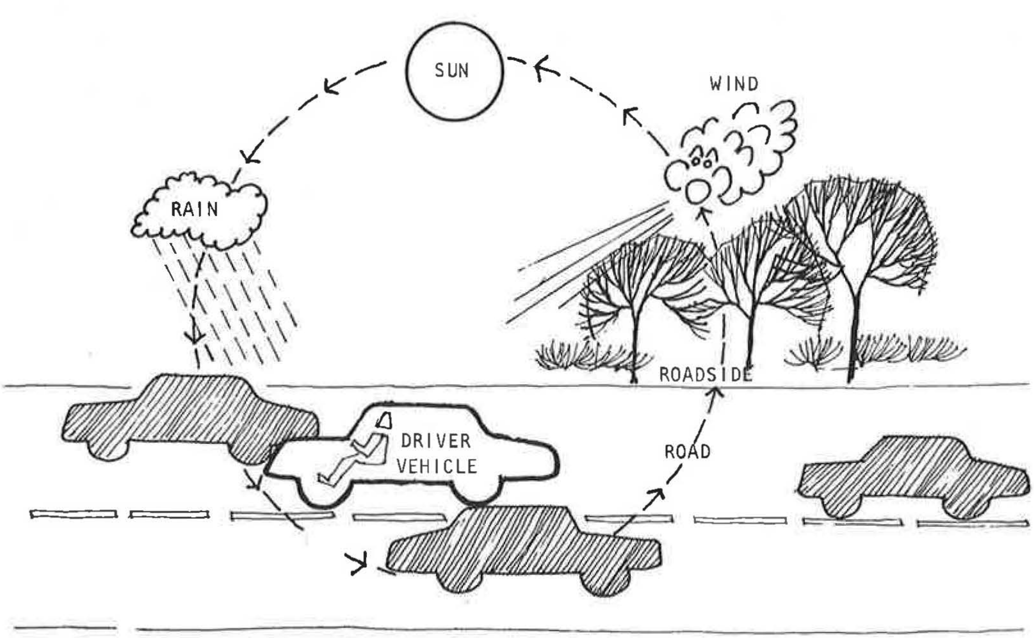


Figure 1. Driver-vehicle-highway environment system.

elements. To perform the driving task safely and pleasurably, and to find his way efficiently, the study hypothesized that the driver must be provided with well-structured, visually clear, and unambiguous information. Because most available information is visual, the sequence of highway experience therefore must be visually articulated to meet as closely as possible the driver's information needs, and must be provided in ways related to his patterns of cognition and response behavior. This might be paraphrased as the "driver system input-output relationship." Because of the many variables and unknowns involved, the study suggested a convenient way to indicate relationships of visual impact and resulting driver behavior—the mechanical input-output system concept. Thus, input comprises information available to the driver from the visual highway corridor. Output is driver behavior and performance in driving tasks (Fig. 2).

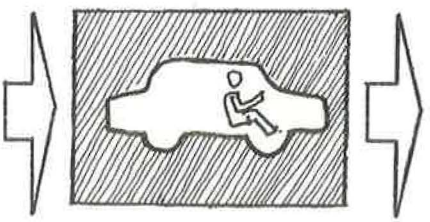
Thus, defining the driver, his vehicle, and the highway as a system may help to identify certain critical factors—those visual components which induce or condition driver response and behavior. These driver-environment patterns, when more clearly and quantitatively understood, should offer significant criteria and guidelines for highway design.

Some of the principal input-output relationships of the driver system were studied as functions of speed, i. e., changes in visual appearance of the highway to the driver, and the driver's ability to understand these changes. As speed increases, the driver's attention is drawn farther ahead of his vehicle, thus shutting out his perception of visual factors lateral to him; distant objects become more important as references to speed and direction. As speed increases, lateral detail disappears, concentration and tension mount, and the need for visual references for orientation and speed control increase. Thus, two general highway design needs arise. First is the need to build in factors which by their properties and arrangement are visually comprehensible for orientation, steering, and speed control, and relief of trip monotony at higher speeds. Second is the use of the same visual references in a corrective manner for increasing driver participation and cognition of the highway environment and prompt speed reduction. Clear and accurate orientation is one of the essential needs of the driving task. Unavailability of proper references and cues for orientation to the route and its environs does not allow the driver convenient decision-making. Orientation is also derived through formal and informal information—signs or specific guidance cues, regional and local character, and symbols and visual connotation of the highway environment. Lack of visual guidance is the primary problem in highway use. The highway should reveal and be related to the features and character of the region through which it passes.

It was suggested that orientation can best be accomplished by understanding and visually clarifying the possible image or character of the road locale for the motorist through geometrics "sympathetic" with landform and scale, selective cutting, planting, etc. Accordingly, the authors hypothesized that the landmark, the district, and the path are major components of an image used for orientation and way-finding, and can be visually revealed and strengthened by design. The view from the road should reveal elements of visual appeal such as trees or wildflowers, but it also should show the important elements in the landscape or city. The highway should indicate to the motorist what is happening beyond the right-of-way for his pleasure and information.

INPUT

Orientation
Apparent speed
Position of car
Climate and
traffic conditions
Automobile "filter"



OUTPUT

Driving task behavior
Destination approach task
Vehicle control task
Safety
Pleasure

Figure 2. Driver input-output system.

Certainly, directional signing provides the only fail-safe method to insure way-finding. Major guidance cues, however, as suggested by Lynch et al (2), are provided by visual components which provide major impact on the driver. These informal cues, which may be considered primary information, are spaces, vistas, and landmarks. Secondary visual guidance for orientation occurs through informal and formal "smaller in scale" visual information, i. e., centerline, guardrails, grading or side-slopes, light standards, and specifically in the formal information of signs.

Primary and secondary information perceived simultaneously must be coordinated as visual support systems to be most useful to the driver. For example, a vista toward a town occurring after signing has indicated a turn toward that town will assist driver orientation and decision-making (Fig. 3). Highway location and visual design development must be coordinated toward these ends. Such visual information and the driver's pre-trip expectations for it relate to the following hypothesis for the linkage of how the driver sees and reacts for the continuity of his experience during travel time.

Behavioral criteria for visual planning of highways are illustrated in the concept of "attentional demand." In examining certain aspects of the visual components of highways, it is clear that the driver has two different tasks for which visual design must be developed and coordinated: (a) vehicle control (steering and speed), and (b) destination approach (identifying destination arrival point). While traveling, the driver does not have to devote the same amount of concentration to both tasks. The need for attention varies from the extremes of high or intense concentration to low or relaxed concentration. This need is called attentional demand. It varies over duration of travel as a function of time and the changing characteristics of the highway environment traversed. "The attentional demand of a road is a characteristic of that road and of the traffic situation which may exist upon it as well as the velocity at which it is traversed" (2).

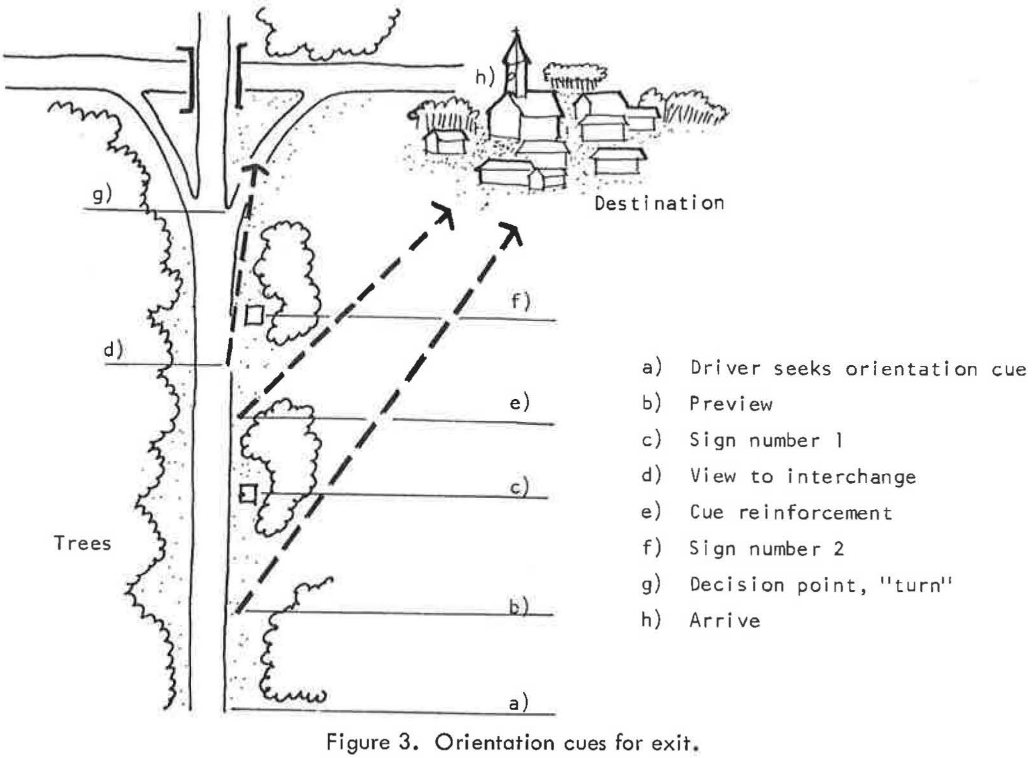
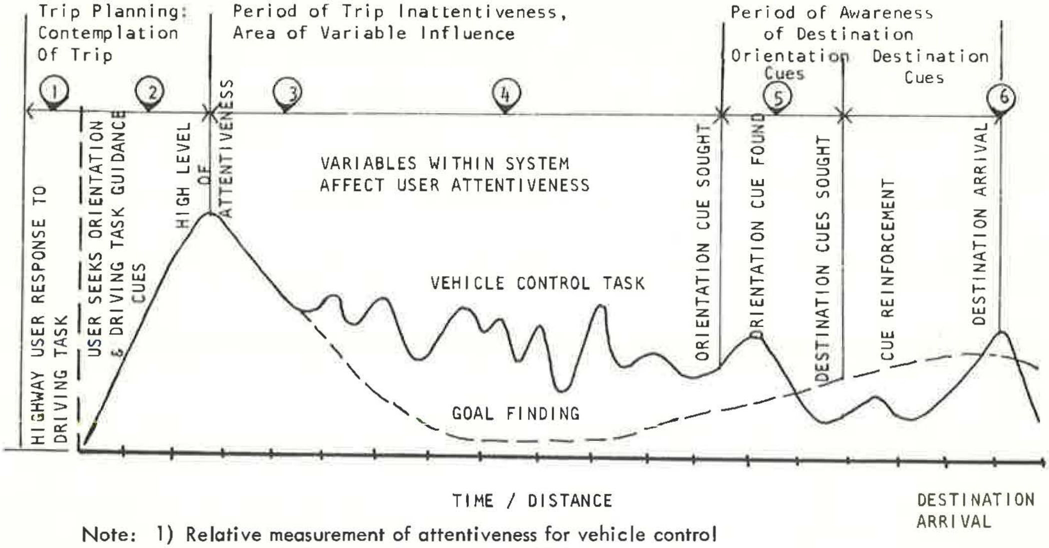


Figure 3. Orientation cues for exit.



Note: 1) Relative measurement of attentiveness for vehicle control
2) Sequence is for rural, limited-access highway
3) Time intervals are possible extreme variables

Figure 4. Attentional demand hypothesis.

The variations of attentional demand are interpreted for a road and are represented in a diagram (Fig. 4). At this stage the graph is not quantified, nor have the levels of low or high attentional demand been determined. But it can demonstrate the following driver situations which can typically occur during the duration of the trip:

Situation 1 represents the pre-trip planning phase. Interest is devoted to the destination approach task.

Situation 2 represents the start of the trip. Here the driver is not only aware of the route he will take, but that he must begin travel and must concentrate on his driving. Attentional demand is high.

Situation 3 represents a stretch of road having low attentional demand; that is, the driver only has to continue speed and steering of the vehicle, owing to lack of visual stimulation from roadside—for example, an area of flat topography, long tangents, and continuous forest enclosure at the right-of-way.

Situation 4 represents a sudden change possible in the attentional demand of the road. It may result from heavy traffic, an intersection, sudden change of lane, road obstacle, lane drop, or stopped lead car.

Situation 5 represents a situation when the driver may suddenly receive new information concerning his location in relation to his destination—e.g., a preview of his destination through a vista framed by trees. Attentional demand increases.

Situation 6 represents the driver approaching the end of the trip on the road, identifying the correct exit, and adjusting steering and speed control. This means high attentional demand and the accomplishment of the destination approach task.

However, along with this definition of attentional demand, Bolt, Beranek and Newman, Inc., hypothesized the following theory (2):

> A rather important notion which underlies the theoretical work is that drivers tend to drive to a limit. We suggest that the limit is determined by that point when the driver's information processing capacity, either real or imagined, is matched by the information generation rate of the road, either real or estimated. The drivers may be wrong in their estimates, but they will tend to achieve this balance of input information rate and information processing rate. A driver in unfamiliar territory sees a great

deal more uncertainty in the situation than a driver familiar with the territory. With familiarity there comes reduction of uncertainty, a reduction of information flow rate, and a higher permissible velocity, granted the same territory and circumstances. This is reflected in the different ways people behave in automobiles in familiar and in unfamiliar terrains. It might be said that a curving familiar road is "perceptually straight" since uncertainty about the road ahead is low.

Lastly, drivers will accept different levels of risk and drive to a limit such that the probability of an accident is not greater than, but approaches, some upper threshold. Subjective acceptable risk level is a measurable charactersitic of drivers and directly influences their behavior on the road.

A number of factors have been identified, which tend to control the speed of the driver traversing a road in the presence of traffic and other dynamic obstacles. These are, in brief: the width of the road and the frequency with which it turns; the estimated probability intrusion from other vehicles and animals; the uncertainty associated with the vehicle dynamics; the precision of the steering mechanism; the residual errors of vehicle aiming; and, lastly, a risk acceptance level which is a characteristic of each driver.

By examining the level of attentional demand, the study postulated that it is possible to predict the speed the driver will be likely to maintain. Conversely, the alignment of the road can be adjusted and the driving speed accordingly influenced by increasing and decreasing the level of attentional demand of the road. The ways in which attentional demand may influence speed change, pleasure, boredom, etc., along highways, and the extreme high and low levels of attentional demand are of great interest to this study as indication of driver needs and reaction to visual stimuli and their organization along the road.

The effect of visual stimuli on the driver's senses can vary in intensity, and the accurate effect of stimulation from the highway is difficult to measure quantitatively; that it occurs in what seem, so far, to be generally predictable patterns and levels indicates opportunity for further definition.

The principal visual factors that affect driver behavior and are of principal visual importance are given in Table 1 with concomitant behavioral relationships. "Tie-in" was made with functional needs for driving task accomplishment.

The driver system is like any mechanical system; it has a definite capacity which copes optimally with a certain amount of input and output. In other words, the system could function best when a certain amount of driving task is expected of the driver at a given time and over a period of time. The exact amounts are undefined and may be unnecessary. From investigation of the current accident rate, it is obvious that there are two extremes when the driver system fails to perform the driving task adequately under high stimulation or not enough stimulation. Like machinery, the driver system must constantly perform at least a minimum of activities to be constantly ready to perform at full capacity when the situation arises. Similarly, the system needs time to warm up to reach top running condition. The driver system also has a maximum capacity. This is mainly determined by the driver and the characteritsics of the vehicle.

SEQUENCE HYPOTHESIS

As suggested, all the visual inputs of the highway to which a driver reacts, such as edge, object dominance, and enclosure, together provide his total visual impact; thus, there is a continuity or sequence of these impacts on a road for optimal conditions. Conceptually, the experience of this sequence must be varied so that it will relate to the range to be identified, preferably the driver's attentional demand. Therefore, it is suggested that a road with a total sequential experience and impact range which fits or relates to the driver's attentional demand level may be developed by manipulating the visual factors of the highway. Criteria for this manipulation can comprise guidelines for visual improvement of old roads and the location of new ones. However, the problem of developing evaluation criteria for the application of this thesis is great. Also, the designing of a highway that is sequentially and visually meaningful is like

TABLE 1

VISUAL FACTORS AFFECTING DRIVER BEHAVIOR

Inputs	Visual Inputs	Behavioral Outputs
1. Edge—i.e., from spatial boundaries which limit view due to adjacent topography, vegetation, etc., within or at right-of-way (Fig. 5a)	a. "Whiz-by" blurring b. Visual impact increases with duration and height of edge over time c. Apparent motion	Steering control
2. Enclosure—sense of confinement and spatial definition, owing to closeness of vegetation, cuts, walls, overpasses, etc., to driver's field of vision (Fig. 5b)	a. Degree of spatial containment b. View enframement c. "In and Out" sequence experience from change in lateral enclosure (Fig. 5c)	Speed control: 1. Speed influence 2. Orientation 3. Attentional demand stimulation
3. Object Dominance—visual prominence of landmarks, etc. (Fig. 5d)	a. Dominance of objects via: (1) contrast (2) size (3) nearness	Attentional demand overload and underload
	b. Meaning, symbolism (emotional significance for the observer)	Orientation and way-finding
4. Object Diversity—unrelated size and shape of objects in driver's visual field; e.g., commercial strip development (Figs. 5e, 5f)	a. Diversity of objects relative to their visual dissimilarity	Attentional demand overload and underload
	b. Nearness to driver (re: edge)	Steering influence Speed influence
5. Visual Alignment—visual consistency of highway with topography and views (Fig. 5g)	a. Horizontal curvature b. Vertical curvature c. Directional views	Attentional demand Speed influence Orientation

TABLE 2

RELATIONSHIP OF VISUAL FACTORS TO ATTENTIONAL DEMAND

Low Attentional Demand	High Attentional Demand
Speed	
Speed increase:	Speed decrease:
1. Lack of apparent motion effect as in highway on high fill in open landscape; little "whiz-by" effect (Fig. 5h)	1. Apparent motion affected by the addition of objects (vegetation, etc.) along the side of the road which provide scale and speed reference (Fig. 5g)
2. Views often unrestricted for long sections of road ahead such as on long tangents (Fig. 5f)	2. Diverse and interesting views
3. Very little stimulation from roadside objects, with infrequent interchanges and decision points	3. Much stimulation from roadside objects as individual objects or as vistas, with frequent interchanges and decision points
4. Long tangents	4. Diversity of horizontal and vertical alignment
5. Low traffic volume and good weather conditions	5. Heavy traffic and bad visability owing to weather
Steering	
Steering easy:	Steering difficult:
1. Long tangents, few and generous curve radii	1. Variation of horizontal, vertical alignment
2. Simple objects along the roadside, if any at all, as guidance reference for steering control; i.e., white line or guardrails	2. Highly complex objects along the roadsides which distract driver as in urban road with commercial strip development
Destination Approach Task	
Destination approach easy:	Destination approach difficult:
1. Little need for orientation information	1. Need for much orientation information
2. Simple, clear signing	2. Complicated, poorly located signing
3. Simple and noticeable objects as landmarks	3. Diverse view of a city; scenic area on ocean

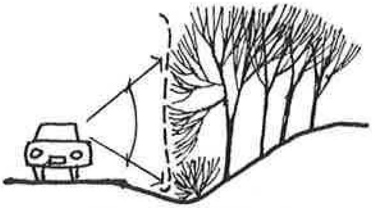


Figure 5a. "Edge."

Figure 5b. "Enclosure."

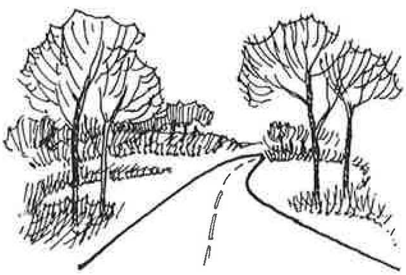


Figure 5c. "In-out" sequence.

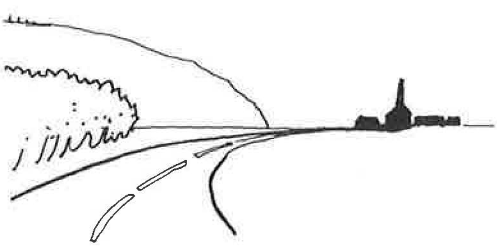


Figure 5d. "Object dominance."

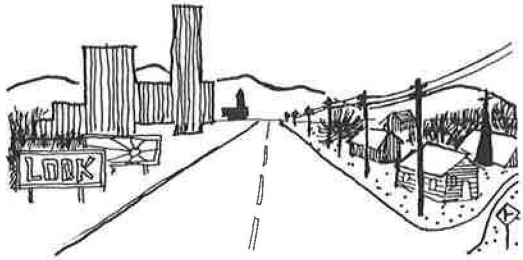


Figure 5e. "High diversity."

Figure 5f. "Low diversity."

Figure 5g. Visual alignment.

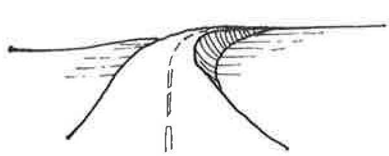


Figure 5h. Lack of speed reference.

making a film that could be played forward and backward from any point and still retain meaning in its entirety and in its parts.

Clarkeson (3) suggests that designing such a sequence is like composing a piece of music. One might first separate components and examine them individually according to their functions, and then group them for desired relationships. In music there are (a) basic elements, (b) theme development, and (c) form or total experience. As an

analogy, if these musical components are compared with the visual components discussed earlier, the following relationships appear:

Musical Components	Visual Components
1. Basic elements (notes, bars, etc.)	1. Visual inputs on the highway (edge, enclosure, objects alignment, profile, cross section)
2. Theme organization	2. Attentional demand
3. Composition or total musical sequence	3. Trip character and total visual sequence
4. Expression (aesthetics)	4. Clarity of effect and meaning (aesthetics)

If the earlier diagram illustrating the probable profile of attentional demand for the duration of a trip is examined (Fig. 4), it can be seen that the total demand during the trip is composed of two separate curves. One relates to execution of the vehicle control task, and the other to the solution of goal finding—the execution of the destination approach task. The variation in levels of attentional demand for the vehicle control task is directly linked with the physical elements in the visual corridor. For example, demand level is high at the beginning of a trip; this is because the driver must perform a certain amount of vehicle manipulation to get his trip under way. This manipulation involves coping with the vehicle and finding initial guidance information in the visual corridor. To a certain degree this is independent of the situation in which the driver is beginning his trip. For example, if a person has been traveling and he stops, his attentional demand for the vehicle control task on starting could be comparable to that of an initial start. This explanation could also apply to the high attentional demand for guidance at the end of travel. The attentional demand at mid-trip when traffic or unforeseeable road complications are met is also an example of direct response to factors in the visual corridor. Thus, task completion is directly linked to factors in the visual corridor, and is generally predictable.

In this way it is postulated that the highway could, in fact, be designed for basic organization of the variations of attentional demand for vehicle control. For instance, the designer could deliberately create more variation in the alignment by varying the degree of curvature and tangents to demand more attention from the driver for execution of vehicle control tasks at certain locations. Increasing lateral enclosure by vegetation or landform often causes drivers to reduce speed. Therefore, by means of varying the attentional demand level for execution of vehicle control tasks by these devices, the designer may visually compose the interim parts of the highway to provide suitable content for driver experience. The visual form and clarity of the highway can thus be seen as a determinant of driver performance and an integral part of the design of the highway.

Having identified probable highway visual components and their impact on the driver, and through the definition of attentional demand, having postulated an operable relationship between visual design of the highway and driver behavior, we may now study these criteria for application to route design. However, as noted, a problem lies with the fact that the entire trip experience does not necessarily coincide with the entire length of the road, and may be experienced either way. Therefore, a road must be designed with no single beginning or end but with the opportunity for identification of various sequence points or highway experience increments. Any segment of the road may become a trip beginning or end. It is suggested that this approach may be useful for two different highway design scales: (a) the (generalized) overall "rhythm" of visual change for the total route; and (b) specific decision-point areas. It is not necessary to design for overall or total prediction of driver behavior (as in a one-to-one relationship) but, because most drivers may react similarly at a very general level to what they see, design should establish only those elements of major visual impact and meaning on the larger scale, with specific attention to specific small-scale locations. Because of selective perception (if related to driver needs with appropriate

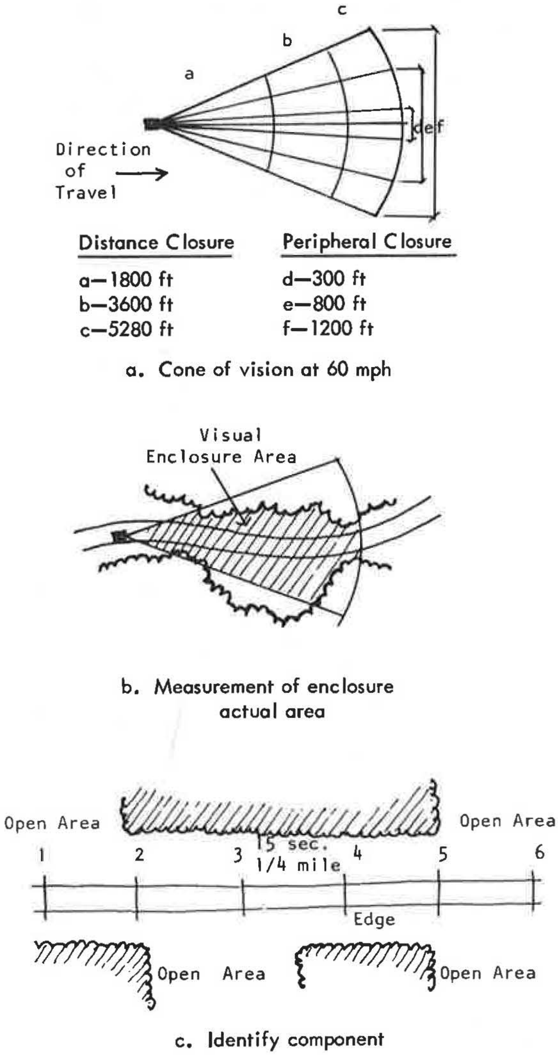


Figure 6. Visual components analysis process.

visual information and stimuli), a trip could take on sequential experience with its relative beginning and end. However, if orientation cues do not exist at the times needed, meaningful sequence experience and proper orientation, decision reinforcement, and guidance may fail to exist. Therefore, it is important for a number of orientation cues of different types to be developed at the location where it is highly probable that the driver will need them. For example, different types of orientation information (from enclosure, directed views, alignment, signs, etc.) should be carefully coordinated near entrance and exit ramps and a short distance before the exit ramp. These must be visually designed and related in proper sequence so that the driver can experience them at travel speed. The destination approach task illustrates a possible sequence of this kind (Fig. 3).

Attentional demand cycles can thus be postulated to occur for trip duration. Because various trips of a very short or very long duration may be undertaken on the same road and may occur over any distance, the highway environment should be designed for minimal attentional demand at the beginning of trips or at their conclusions at all entrance and exit locations, the primary locations for attentional demand requirements. In addition, proper attention level should be stimulated for the through traveler as well as the interchange-to-interchange traveler. Visual stimuli and information must be simultaneously available for completion of driver tasks, including major orientation (macroperformance), coping with traffic, direction finding (mesoperformance) and tracking-speed control (microperformance). The degree of coordination of demand highs and lows as they are prompted by visual conditions and tasks with typical patterns of driver behavior (for expectation, reception of visual stimuli, orientation, and so on) may provide the degree of interesting and meaningful trip experience. Thus, criteria are conceptually available to be developed for aesthetic design of the highway linking visual, behavioral, and engineering criteria.

Two major problems must be solved before this interrelation is fully possible by study and testing. First, it is necessary to identify the degrees of visual impact that are probable from visual factors of the highway. Second, it is necessary to know the relative effectiveness of visual components when in combination as experienced in sequence over various lengths of time.

A real area case study using an actual highway was developed to test and apply the analysis of visual and behavioral criteria for practical highway location and alignment purposes. A route was selected using the visual criteria described.

		DURATION OF EDGE PERCENTAGE OF 15 SEC.			
		100%	75%	50%	25-0%
		4	3	2	1
INCIDENCE OF EDGE	EDGE BOTH SIDES 4	16	12	8	4
	OPEN OPPOSITE SIDE 3	12	9	6	3
	OPEN DRIVING SIDE 2	8	6	4	2
	OPEN BOTH SIDES 1	—	—	—	1

Figure 7. Quantifying matrix (edge as example).

Postulation of Visual Components and Analysis Process

The significant problem in visual component analysis is quantifying qualitative data. Visual factors must be described in terms of duration plus the degree of their impact, in terms of factors along the route under consideration. To accomplish these tasks the authors propose the following process for a case study area. This analysis sequence should be undertaken for each visual component (edge, enclosure, etc.) along an existing or proposed centerline. Evaluation criteria are decided on definition of visual impact factors as identified earlier.

1. Identify—A graphic notation technique is used to locate geographically on a plan to scale (Fig. 6) the existing visual components within the visual corridor of the road (i.e., edge, enclosure, etc.).
2. Quantify—A numerical matrix is used to quantify qualitative values of the visual factor's potential impact upon the driver, which is ascribed a numerical rating for each factor (Fig. 7).
3. Record—The quantitative value relative to each component is ascribed and recorded in 15-second intervals along the chosen route (Fig. 8).
4. Sequence—To illustrate the visual impact in sequence of time/distance, the recorded values are illustrated as composite graphic overlay sheets on a sequential analysis chart which relates the visual impacts to time/distance (Fig. 9).

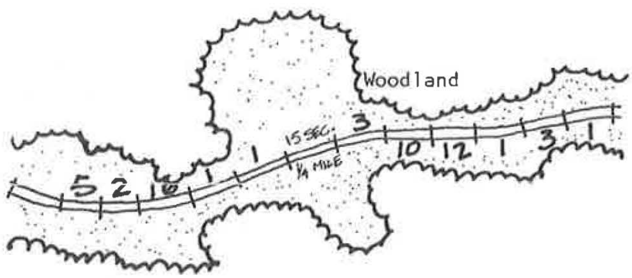


Figure 8. Recording of impact.

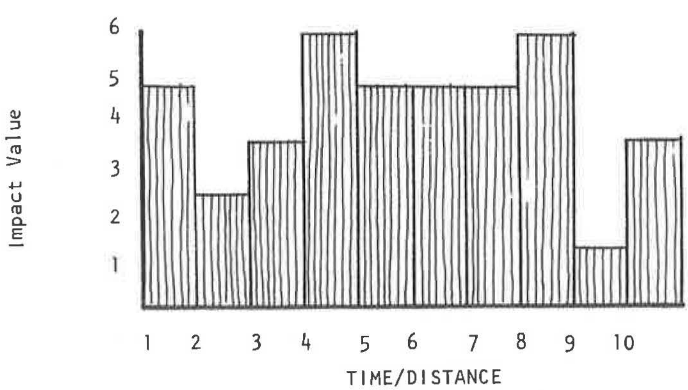
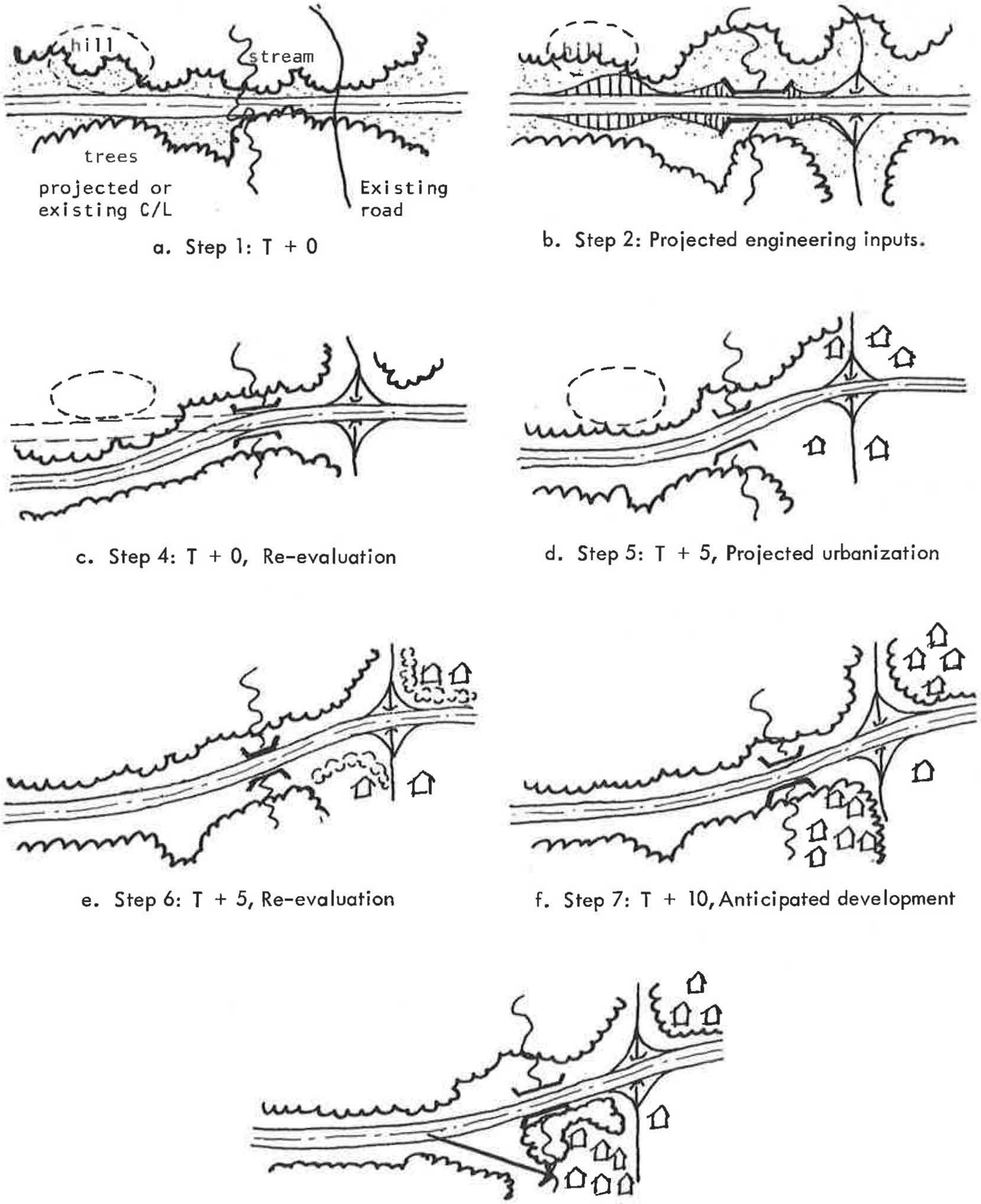


Figure 9. Analysis chart for edge sequence.



a. Step 1: T + 0

b. Step 2: Projected engineering inputs.

c. Step 4: T + 0, Re-evaluation

d. Step 5: T + 5, Projected urbanization

e. Step 6: T + 5, Re-evaluation

f. Step 7: T + 10, Anticipated development

g. Step 8: T + 10, Evaluation

Figure 10. Sensory data manipulation: Comprehensive route selection process.

5. Analysis—The composite visual sequence is analyzed for its assistance or value for task performance at specific situations along the highway. The parameters of analysis for study purposes were attentional demand duration, information needed for driver decision-making, and overall relation of factors to attentional demand cycles, as defined by criteria relative to a driver traveling at 60 mph, looking straight ahead, with weather, traffic, and climate considered as optimums. This study explored the

ramifications of driving under these limited conditions because the authors were primarily concerned with exploring possible criteria for future study. Future research should consider driving at various speeds and under various conditions and possible impact of input from the various visual factors (edge, etc.) upon the driver.

The significance of the process of visual analysis is that it illustrates in a preliminary way the possible sequential driver visual experience over time and distance, and also the possible relative effects of impact of each sequential 15-second increment as postulated for driver behavior, establishing the hypothesis of linkage of visual characterisitcs of highways and their significance for drivers.

The method of visual impact data manipulation to be included as part of a comprehensive route selection process is summarized in the following. Similar analysis may be undertaken to improve existing roads.

Step 1—Using the preliminary route selected on the basis of engineering, economic, and other route selection criteria as a start, record and evaluate the sequential visual component data (edge, enclosure, landmarks, etc.) in terms of visual performance ratings as mentioned earlier (Fig. 10a).

Step 2—Finding selected route satisfactory relative to postulated attentional demand curve, orientation needs, etc., record the necessary engineering inputs—structures, areas of cut and fill, etc. (Fig. 10b).

Step 3—Re-record visual data resulting from step 2 input.

Step 4—Re-evaluate visual impact data to determine areas of optimum driver response, orientation, etc. (Fig. 10c). Adjust visual components and route alignment within the corridor concurrent with engineering feasibility analysis as necessary to maintain optimum attentional demand cycles for all increments of the route.

Step 5—Re-record visual data as a result of predicted development of highway and adjacent area patterns for five years hence, T + 5 (Fig. 10d).

Step 6—Re-evaluate visual data as a result of T + 5 input. Adjust visual components and route alignment or provide right-of-way development constraints as necessary (Fig. 10e).

Step 7—If possible, re-record visual data as a result of anticipated development pattern for ten years hence, T + 10 (Fig. 10f).

Step 8—Re-evaluate and adjust as necessary (Fig. 10g).

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