are privately operated under contract to the state. Space in the gazebos is rented based on a fee structure established by the private operator. General motorist services signs are installed by the highway division without charge, because they serve many businesses over large areas. Both general service signs and logo signs may be installed at the same interchange.

As with any signing program of this magnitude, some difficulties have been encountered. Early in the 1970s start-up problems with sign material requirements and spacing requirements resulted in a meeting between state and FHWA officials to review possible changes in the National Standards for Specific Information Signs contained in the FHWA program manual transmittal. To eliminate in the future problems similar to the ones that occurred during the first months of the program, the national standards were revised based on information gained from the Oregon experience. These revisions are still contained in the national standards and provide a more practical approach for motorist services sign installations.

Although Oregon ranks 30th in population (2,656,000 in 1982) and has not realized its full potential in the tourism industry, an estimated 11.8 million pleasure travelers entered the state in the last year. To provide these visitors with information related to their travel needs, 1,100 Interstate and 260 off-Interstate logo signs have been installed.

The tourist-oriented directional sign program is just beginning, so there is no measure of its impact. A 2-year study of the experimental sign program will run concurrently with sign installation. A final report will be published when the study is completed.

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Abridgment

Information Sign Color Evaluation Using a Video Presentation

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ABSTRACT

Signs that provide guidance or navigational information to the motorist are color coded green to facilitate rapid identification and to ensure a clear and unambiguous meaning of the nature of the information. The green color code is not always mandatory at night. The sign backgrounds may have nonreflective green backgrounds that appear black at night unless separately lighted. A laboratory method of evaluating the effectiveness of the green nighttime sign color is presented. This method isolates only the variables of interest--the effectiveness of white-on-green versus white-on-black as a means of providing attention value or target value. The method described uses a video presentation of six identical pairs of highway scenes in which only the color of the guide sign varied. Scenes were presented for a time period of 3.5 seconds, which is comparable to detection and recognition models. The sequence was shown to 313 subjects--all licensed drivers representing all age groups at a variety of locations nationwide. The analysis of results indicated that greater scene complexity and increasing driver age contributed to an increased error rate for both color combinations. There were fewer errors in the recognition and identification of the white-on-green guide signs than the white-on-black signs. For a combination of scenes, this accuracy was 3.2 times greater for the white-on-green signs and is attributable to the green night color of the signs.

Green was selected for the guide sign color following the accepted practice of applying a distinctive yet uniform color to designate the category of information presented by a traffic sign. This selection followed testing by the Bureau of Public Roads in 1957. The tests included full-scale, outdoor tests of various sign colors during both day and night and included color recognition, legibility, and various other measures of sign and color performance using a public audience of professional and lay drivers (1).

Later testing by Forbes (2), and evaluations conducted by departments of transportation (3,4), also dealt with day and night aspects of guide sign color, including subjective reactions to color determined from interviews and driving tests. Woltman (5,6) has reported typical day and night luminance levels for sign copy, sign backgrounds, and surrounds and has attempted to identify various factors that significantly affect sign luminance such as stream traffic, rainfall, and headlamp modification.

Target value, or attention value, is a characteristic that enhances detection and recognition of the sign as a source of guidance information in a frequently complex surround, a dynamic process that must work equally well for the driver, day or night. Good target value implies a conspicuous target. Cole's (7) operational definition of a conspicuous target appears appropriate: "A conspicuous object will attract attention such that the object is seen with certainty within a short observation time regardless of the location of the object with respect to the line of fixation. A conspicuous object then is one that commands attention and requires no search for it to be noticed." The green color is mandatory during the day but may be black at night if nonreflective and unlighted.

EVALUATION

The evaluation of target value for a white-on-green versus white-on-black system in various nighttime settings on a satisfactorily large audience is a task confounded by many variables:

1. Extreme variations in the sign surround. Sign surround consists of the foreground and visible background, including oncoming vehicle headlights and roadway lighting. The night-to-day variation is extreme, and may vary in significant detail from one trial to the next.
2. Sign luminance. Substantial variations in night luminance may occur due to headlamp alignment, the presence of immediately preceding or following vehicles, roadway alignment, and the proximity of luminaires. The contrast of signs to surround is established by their relative luminances. The maintenance of a consistent level of contrast throughout a field test is unlikely.
3. Traffic. Attention to the driving task is highly influenced by the proximity of adjacent vehicles, familiarity with the vehicle, the route, and other external variables.
4. Sign size. Green information signs allow the largest variation in size of any standardized traffic control sign ranging from small street name signs to large guide signs for freeways. Although all signs have the same purpose, that is, to inform about distance or location, lack of size standardization within the series complicates the interpretation of test results.
5. Sign placement. Placement of information signs is more variable than placement of signs for other series, such as regulatory or warning series. The positions include overhead bridges, span wires, right shoulders, wide offsets to the right or left side, medians, and dead ahead at intersections and ramps. Signs placed within one or two degrees of the normal visual axis are relatively easy to detect; however, many information signs are mounted outside this range. In a previous study, Hanson et al. (5) reported an angular separation of guide signs in excess of 10 degrees horizontally on roads with curvature, as in hilly and mountainous terrain. Such signs require more time for visual search.
6. Viewing time. The driver has only a limited time to find, read, and react to guide sign information, and, in the limited time available, must be able to maintain lane position, safe headway, and cope with other distractions. Large vehicles ahead may obstruct the view of critical guide signs, which can result in extremely abbreviated periods of exposure.
7. Subjects. The subjects should represent a reasonable cross section of drivers, who can also be tested simply. Subjects must be relatively unprejudiced with respect to the issues.

The sole evaluation of the green color cue at night must contend with all of the previously mentioned variables whenever a field test is used. A suitable laboratory method that can present the principal variables of interest--that is, white-on-green and white-on-black--is far more likely to derive reliable results.

A video presentation technique for evaluation of guide sign colors is a laboratory method that overcomes most of the variables listed earlier. Unlike most laboratory test methods, the video presentation equipment is portable so that a large number of subjects in diverse locations can be tested. It cannot be assumed that a video image will provide a completely faithful representation of the real visual stimuli. Stimulus of movement and movement parallax is absent, and the luminance scale is compressed. However, these shortcomings are common to any laboratory driving or sign simulation. The video presentation has the unique advantage of extremely uniform presentations to small groups or single subjects.

THE VIDEO SIMULATION

Night driving scenes were first photographed from the driver's point of view using 35 mm color slide film. (ASA 640 color transparency film exposed at 1/15 second at f 2.8 using the lower headlamp beams.) Scenes were chosen that were free of the types of signs to be tested, but were otherwise typical of street or highway scenes at night.

Of more than 100 night scenes photographed, 6 were chosen that represented downtown streets, city arterials, urban arterial highways, suburban arterial highways, and rural Interstates. Scenes included typical white, yellow, and red light sources commonly encountered in night driving.

Next, miniature guide signs were prepared by photographing 10 typical guide signs from the Manual on Uniform Traffic Control Devices (MUTCD) (8) ranging from the advance guide sign (E1-1A) to street name sign (D3). These were produced in white-on-green, as illustrated in the MUTCD, and in white-on-black. (The appearance of nonreflective unlighted green sign backgrounds at night is black.) Five sizes of each of the 10 signs were produced to provide a choice to fit the scene.

The night slide scenes were next projected through a field lens to a video camera. A selection of miniature guide signs were then arranged on a black background, photographed by a second video camera, and superimposed by mixing both signals to form a composite image. By adjustment of the camera's zoom lens, rearrangement of signs, and selection of sign size appropriate to the specific scene, a night scene was composed with signs of logical size and location. Scenes were constructed with all white-on-green or white-on-black signs.

After the composite scene with white-on-black signs was judged satisfactory, it was recorded on 1-in. tape using a computer-controlled editing system. This permitted positioning the scene on the tape in a predetermined sequence for later presentation. A duplicate scene was next constructed with white-on-green sign counterparts, identical in size, message, and position. This segment was recorded at another predetermined space on the tape. Each scene was preceded by a 6-second blank space--2 seconds for recording the answer for the previous scene, 2 seconds in which a letter appeared to identify the next scene, and 2 seconds for that scene to appear. The test scene then appeared for 3.5 seconds. The 3.5-second interval is quite consistent with the detection and recognition times listed for various sign types by Perchonok and Pollack (9). During the

3.5-second interval, the subject was instructed to count the number of signs (white-on-black or white-on-green) that appeared in the picture and write the number of signs on the answer form. Scenes were arranged so that black and green background signs were alternated, then sequenced so that each scene was randomly exposed with the paired scenes some distance apart. This precluded learning the location of signs or their number.

Twelve such scenes were prepared, identified A through L, consisting of six black and six green segments. Following the generation of the 1-in. master tape, a duplicate 0.75-in. tape cartridge was prepared for field use.

Subjects

A standard answer form was prepared that requested information on age, sex, years of driving experience, and color blindness. Spaces following the letters A through L were provided for answers.

Subjects represented a college age group, a number of highway patrol officers, a group of retired senior citizens, and drivers renewing their driver's licenses at a state licensing station. The total number of subjects tested was 313. The subjects all held valid driver's licenses and were from Phoenix and Sun City, Arizona; Atlanta, Georgia; and St. Cloud, Minnesota. Subject age, sex, and location are given in Tables 1 and 2.

TABLE 1 Observers by Location

Location	Number	Percent
St. Cloud, Minnesota	58	18.530
Atlanta, Georgia	84	26.837
Phoenix, Arizona	80	25.559
Sun City, Arizona	91	29.073
Total	313	100.000

TABLE 2 Age Distribution of Observers

Age Group	Number	Percent
0 to 25	81	25.879
26 to 35	75	23.962
36 to 45	41	13.099
46 to 55	19	6.070
56 to 65	26	8.307
66 to 75	62	19.808
76 and up	9	2.875

Actual testing required a video tape player (0.75 in.) and a 19-in. monitor. The monitor was selected for color quality, brightness contrast, and proper horizontal and vertical linearity. The same equipment was shipped to each location to ensure consistency of picture color and quality. Subjects were seated 12 ft from the monitor. Only sufficient light (approximately 1 to 2 footcandles illumination) was provided so that the answer form could be seen. From two to eight subjects were tested simultaneously. There was no discussion during the test. Subjects were uniformly instructed to provide the personal information requested and were told that a series of night scenes would be presented containing either white-on-black or white-on-green signs. They were instructed to count the number of signs in each scene. Subjects were then shown 3 sample scenes to familiarize them with the test after which they were shown the 12 test scenes.

Results

Profiles of the subjects are given in Tables 1 and 2. It is acknowledged that subjects in the 66- to 75-year age group are overrepresented in the sample. Only 2.5 percent of the subjects indicated a color blindness problem. Table 3 gives the number of miscounted black and white versus green and white signs and the distribution of both. Table 4 gives the six pairs of duplicate scenes with the number of subjects having correctly counted the number of black and white signs versus green and white. The percentage of correct counts is significantly higher for white-on-green signs for all comparisons.

TABLE 3 Distribution of Miscounted Black and White Versus Green and White Signs

No. of Signs Missed	Frequency of Black and White Scenes Miscounted		Frequency of Green and White Scenes Miscounted	
	Number	Percent	Number	Percent
-7	5	0.27	0	0
-6	4	0.21	1	0.05
-5	18	0.96	3	0.16
-4	41	2.18	9	0.48
-3	184	9.80	17	0.91
-2	455	24.23	80	4.26
-1	666	35.46	266	14.16
0	427	22.74	1,374	73.16
1	64	3.41	104	5.54
2	7	0.37	16	0.85
3	3	0.16	5	0.27
4	1	0.05	2	0.11
5	1	0.05	1	0.05
6	1	0.05	0	0
7	1	0.05	0	0
Total	1,878	100.00	1,878	100.00

Note: Number of signs missed by sign color. Zero missed represents number of scenes where signs were correctly counted. Negative values represent one or more signs that were missed. Positive values represent the number of signs overcounted. Total is number of black or green scenes presented times number of subjects.

TABLE 4 Number and Percent of Subjects Seeing Correct Number of Black Versus Green Signs for Each Scene and Totals for All Scenes

No. of Signs	Sign Color	No. of Subjects	Correctly Counted	Percent Correct
2	Black	313	113	36.10
2	Green	313	278	88.82
4	Black	313	30	9.58
4	Green	313	189	60.38
5	Black	313	47	15.02
5	Green	313	231	73.80
7	Black	313	16	5.11
7	Green	313	152	48.56
4	Black	313	103	32.91
4	Green	313	256	81.79
5	Black	313	118	37.70
5	Green	313	268	85.62
All Scenes	Black	1,878	427	22.74
	Green	1,878	1,374	73.16

A paired comparison T-test determined that there was a significant difference between the number of white-on-green signs missed and the number of white-on-black signs missed in the same traffic scenes. The results were significant, ($P \leq 0.0001$), indicateing that there was less than 1 chance in 10,000 that the observed difference was due to chance.

The final result for all subjects and all scenes indicates that white-on-green signs were identified

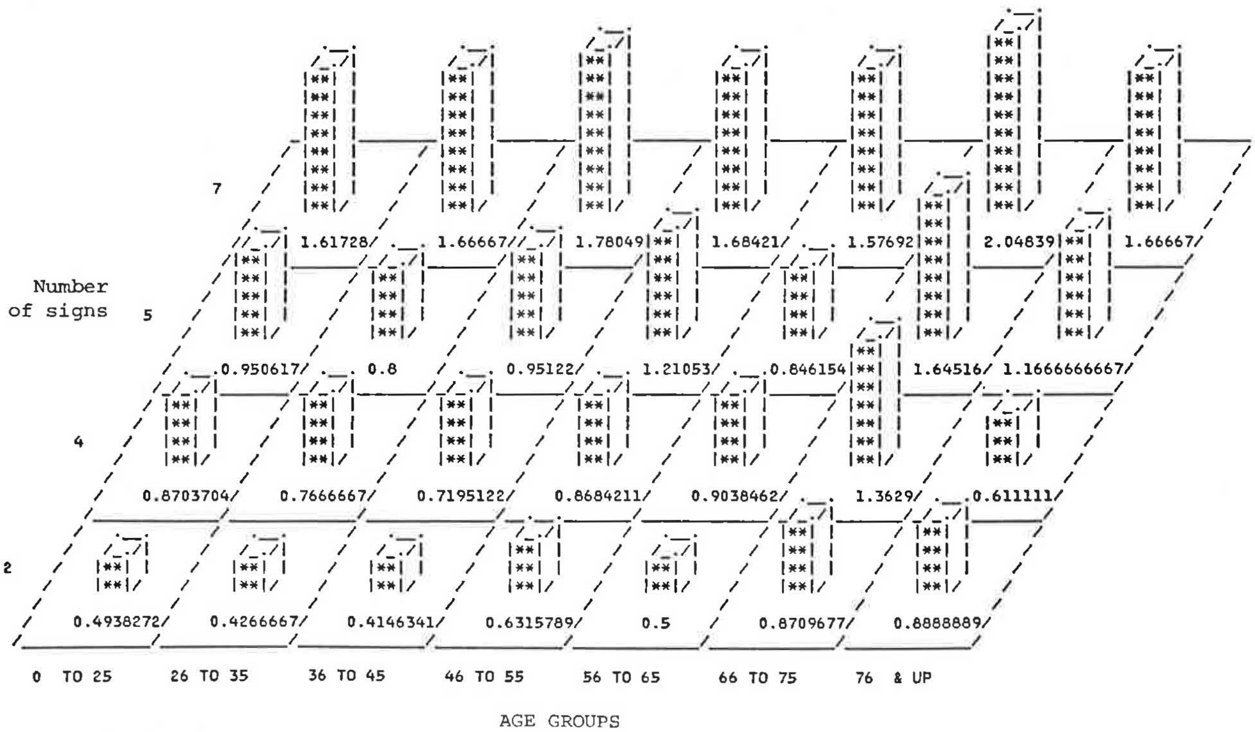

FIGURE 1 Scene complexity and increase in subject age contribute to increase in rate of error.

correctly 73.16 percent of the time versus 22.74 percent for white-on-black signs. Such signs were either undercounted, that is, were missed; or were overcounted, that is, were confused with other visual elements in the scene. Undercounting (signs missed) was far more frequent than overcounting.

Scenes with larger numbers of signs were counted incorrectly more often than scenes with fewer signs. This is apparent in the data presented in Table 4. Two scenes with similar numbers of signs have different results (scenes with four and five signs, respectively) because of different surrounds.

Older subjects had more difficulty counting the scenes correctly than did younger subjects as shown in Figure 1. The data indicate that scene complexity and increasing subject age contribute to an increased error rate.

CONCLUSIONS

A night driving simulation is described that uses a video presentation to evaluate the attention value or target value of white-on-green versus white-on-black guide signs. This technique permits a uniform presentation of the variables of interest to a large number of subjects in diverse locations. The external variables found in field testing in night settings can be eliminated or controlled by using this technique. A series of six identical pairs of highway scenes were synthesized varying only the guide sign background color. Scenes were presented for 3.5 seconds comparable to detection and recognition times reported elsewhere. The sequence was shown to 313 subjects, all having a driver's license, and representing all age groups at a variety of locations nationwide. Subjects were requested to count the white-on-green or white-on-black signs in the scene.

The analysis of results indicated greater numbers of signs, increasing scene complexity, and increasing driver age contributed to an increased error rate. There were fewer errors in the recognition and identification of the white-on-green guide signs than the white-on-black signs. The most common error was not finding, and therefore undercounting, the white-on-black signs. For all scenes combined, the accuracy for the white-on-green guide signs was 3.2 times greater and is attributable only to the green night color of the signs.

REFERENCES

1. Interstate Sign Tests. U.S. Bureau of Public Roads, 1957.
2. T.W. Forbes, R.F. Pain, R.P. Joyce, and J.P. Fry. Color and Brightness Factors in Simulated and Full-Scale Traffic Sign Visibility. In Highway Research Record 216, HRB, National Research Council, Washington, D.C., 1968, pp. 55-65.
3. D.L. Woods, N.J. Rowan, and J.H. Johnson. Summary Report Significant Points from the Diagnostic Field Studies. Report 606-4. Texas Transportation Institute, Texas A&M University, College Station, 1970.
4. N. Bryan, D. Cosner, R. Klotz, and H. Knisley. A Limited Evaluation of Reflective and Non-Reflective Background for Overhead Signs. Research Project 75-19. Pennsylvania Department of Transportation, Harrisburg, 1978.
5. D.R. Hanson and H.L. Woltman. Sign Backgrounds and Angular Position. In Highway Research Record 170, HRB, National Research Council, Washington, D.C., 1967, pp. 82-96.
6. H.L. Woltman and W.P. Youngblood. Evaluating Nighttime Sign Surrounds. In Transportation

Research Record 628, TRB, National Research Council, Washington, D.C., 1977, pp. 44-48.
7. B.L. Cole and S.E. Jenkins. Conspicuity of Traffic Control Devices. Australian Road Research, Vol. 12, NO. 4, Dec. 1982.
8. Manual on Uniform Traffic Control Devices for Streets and Highways. FHWA, U.S. Department of Transportation, 1978.
9. K. Perchonok and L. Pollack. Luminous Requirements for Traffic Signs. FHWA/RD-81/158. Institute for Research, State College, Pa., 1981.

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Level of Service Evaluation of Freeway Guide Signing

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ABSTRACT

The methodological basis for a freeway guide signing level of service evaluation is presented. This level of service evaluation was developed using the level of service concept in the Highway Capacity Manual as the prototype. The level of service evaluation can be performed in the engineer's office on all types of signs, both overhead and ground mounted, either individually, in a series, or sequentially along a freeway. The methodology is divided into four sections: (a) navigational, (b) work load, (c) response, and (d) overall level of service.

The opportunity now exists to critically examine the urban freeway guide signing system and to improve those areas found deficient. To make optimum use of existing resources, a proficient evaluation procedure has been developed that identifies probable trouble areas without requiring an excessive amount of staff time or data collection. The various techniques used in the past (1-5) will still be used to study the effects of signing changes, but they will not be used to evaluate probable problems in freeway signing.

LEVEL OF SERVICE CRITERIA

The criteria used to evaluate the level of service of urban freeway guide signing include the navigational information needs of the motorist, the motorists work load, and the response distance provided to the motorist. The level of service concept developed in this paper was designed by using the same format as the level of service of freeway operations contained in the Highway Capacity Manual. This continuous scale signing level of service may be performed in the engineer's office on a single sign or on a series of signs along a particular freeway.

Motorists Navigational Information Needs

The navigational level of service of a particular guide sign on an urban freeway is determined from a consideration of several principal navigational related factors. These factors are (a) sufficiency, (b) consistency, (c) expectancy, and (d) relatability. These four factors all relate to separate concepts that are embodied in the navigational task. As pointed out in the following discussion of each factor, a certain amount of overlap exists among these factors, but they are separate as they relate to the navigational task. The degree to which these factors contribute to the task of navigation has not been field tested.

Sufficiency

Sufficiency is a term used to denote whether the information presented on each guide sign should be sufficient to satisfy an unfamiliar motorist's navigational information needs. The basic issues are whether the guide signing elements believed necessary are present and in accordance with accepted national guide signing principles. The Manual on Uniform Traffic Control Devices (MUTCD) is used as the chief yardstick of sufficiency. As the number of manual violations increase, the poorer the rating for sufficiency.

Consistency

Destination names are a principal navigational information source; therefore, it is imperative that consistent use of destination names be achieved. Three criteria have been identified as affecting the consistency of destination names:

1. Name familiarity consistent with route priority,
2. Number of names consistent with number of exits, and
3. Names of route destinations consistent areawide.

As the number of violations of these three criteria increase, the poorer the rating for consistency.