brake applications. Although this statistic surely lends itself to the premise that brake application alone is at least conceptually inadequate, it should be noted that the percentage increased as conflict severity increased, indicating a degree of positive correspondence.

Parker also raised an extremely important point concerning the adequacy and availability of police collision reports. In our study, all police reports of collisions occurring during the data collection phase were obtained. Of some 20 police reports, only eight collisions were identified by scanning the video records. This was caused by a combination of equipment failure, night recording conditions, and the fact that our records covered only one approach at the intersection. Perhaps more significantly, the police records did not contain information on 17 (68 percent) of the collisions identified by the video records. The implications of such a weak correspondence for correlation between conflict and collision occurrence are obvious.

Finally, we agree completely with Mr. Parker when he states that important hypotheses on use of the traffic conflicts technique "must be thoroughly investigated before researchers and practitioners can either accept or abandon" the procedure. Emphasis on the words "either" and "or" is extremely important, and we hope that this approach will guide future research into this very interesting and important traffic safety topic.

Publication of this paper sponsored by Committee on Methodology for Evaluating Highway Improvements.

Abridgment

Evaluating Highway Guide Signing

Fred R. Hanscom, BioTechnology, Inc., Falls Church, Virginia
Wallace G. Berger, U.S. Senate Appropriations Committee

An operational method for the field evaluation of highway guide signs that is readily applicable by traffic engineers or researchers was developed on the basis of valid measures of effectiveness (MOEs) and sensitive, off-the-shelf data-collecting techniques.

The need for this method arises from the diversity of approaches in previous guide sign evaluations and the lack of an established, uniform, valid method for appraising results. A recent NCHRP effort (1) addressed this problem through a literature synthesis, the field development of guide-sign MOEs, and a sensitivity assessment of applicable data-collecting techniques. The product of this effort is the evaluation method reported here.

MOEs OF GUIDE SIGNS

The field development of measures established four types of vehicle behavior at interchanges as guide-sign MOEs. Each is listed and operationally defined in Figure 1, which summarizes the evaluation procedures. An analysis of over 1100 interviews that compares responses of drivers behaving in these ways with those of drivers not behaving in any of these ways revealed group differences linking driver guide-sign responses with each type as follows:

1. Gore weave and high-risk gore weave: (a) greater information-processing difficulty with all guide signs on interchange approach, (b) less certainty of action response to all guide signs on approach, (c) less time available to read and respond to intermediate exit direction guide signs, (d) lower preference rating for intermediate exit direction guide sign, and (e) less likelihood of detecting at least one guide sign.
2. Late lane change: (a) greater information-processing difficulty with at least two guide signs and (b) less certainty of action to be taken to gore-located exit direction guide sign and one advance sign.
3. Driving slowly: (a) greater information-processing difficulty with at least one guide sign and (b) lower preference rating of gore-located exit direction sign.

FIELD STUDY APPROACH

There are currently two approaches for examining the effects of a traffic control device: a study and an experiment. A study is an examination of effects only at the site where the device is installed. Generally, before-and-after observation at the site would form the basis for a judgment regarding the effectiveness of the new guide sign. An experiment, on the other hand, involves simultaneous before-and-after observation at another location (control site) not receiving the treatment. The advantage of the experiment is to permit insight into other changes in traffic behavior that are not caused by the new sign.

Data-collecting methods and guide-sign MOEs suggested here are equally applicable to a study and an experiment. Although the experiment is favored in view of the increased sensitivity of the MOEs to a signing change, a study may apply in situations where control of spurious effects is not considered necessary. The before data-collecting period must closely follow the signing change, and the after period should allow for a minimum adjustment period of 30 d. Before-and-after data-collecting periods must be matched by time of day and day of week. Sound experimental procedure dictates that these periods occur exactly 52 weeks apart. It is important that all data be gathered concurrently at the test and control sites to maintain the experimental integrity of the design.

DATA COLLECTION TECHNIQUES

Statistical reliability of off-the-shelf techniques was obtained by comparing the data with those of the traffic evaluator system (TES), a highly reliable collection method involving electronic road switch sensors. Recommendations for applicable techniques took into account the cost and general suitability of each method for use by a practicing traffic engineer. For the four guide-sign MOEs, the following reliable method factors were found.

1. Gore weaves—manual coding of vehicle weaves occurring in two directions over a gore approximately 183 m (600 ft) long was found to be 98 percent reliable using 30-min coding periods with 10-min rest intervals between each for the duration of a normal working day.

2. High-risk gore weaves—these maneuvers require tracing a vehicle's path within an interchange area; thus, time-lapse photography at an exposure rate of 2 frames/s is recommended.

3. Late lane changes—exit maneuvers before the gore can be obtained by using manual coding with equal accuracy as described above for gore weaves, given that a compatible length of highway section is monitored. Yet, for lane-changing maneuvers before the gore, which require monitoring of longer sections of highway, manual coding was only 88 percent accurate. Therefore, the recommended method for gathering data on these maneuvers is to deploy a time-lapse camera before the interchange and position it so that lane changing occurs in the foreground of the picture.

4. Speed measurements—stopwatch timing of vehicles between two inconspicuous roadway markings was found to be an inexpensive, unobtrusive, and reasonably accurate method of gathering vehicle speeds. A currently available digital-display stopwatch (cost: $100) that displays time increments to the nearest 0.01 s was found to reliably gather speed data with an accuracy of 1.8 km/h (1.1 mph) for any given vehicle. Sample means were obtainable with no statistically significant error using this type of stopwatch.

DATA-SAMPLING PROCEDURE

Field sampling procedures are discussed for each of two classes of data to be gathered.

Gore Weaves and Lane Changes

Figure 1 depicts the preferred orientation of the time-lapse camera. Although manual coding of these measures has been shown to be quite reliable, the advantage of time-lapse photography cannot be overemphasized. This technique permits a permanent, accurate record of traffic volume and weaving maneuvers. As the camera runs unattended, the operator is available to code some of the measures; the remainder can be reduced from the time-lapse film. The coder can record gore weaves and late lane changes while at the site; this leaves only volume and high-risk gore weaves for subsequent film data reduction. For gore areas longer than 305 m (1000 ft), manual coding can be used for gore weaves, and time-lapse photography for high-risk gore weaves and late lane changes. The recommended camera position, in this instance, would be overhead and before the interchange so that lane changes occur in the foreground and gore weaves remain in the field of vision.

Half-hour data collection periods with 5-min rest intervals are suggested, because one 15-m (50-ft) film cartridge will store 30 min of data. Two days are suggested as a minimum before or after study period. Sundays and holidays are recommended to sample unfamiliar motorists.

Driving Slowly

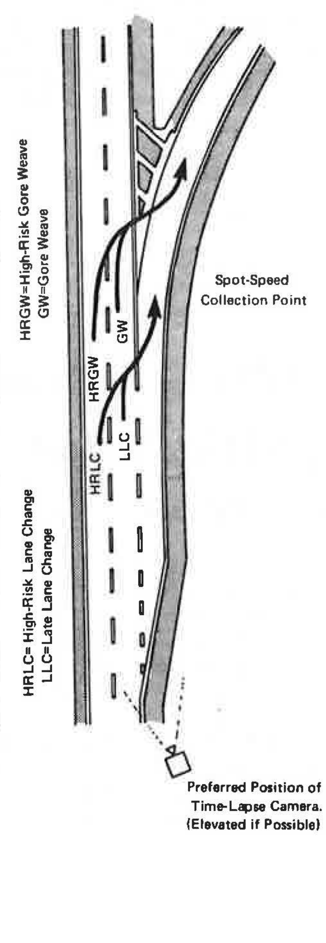
Incidences of vehicles traveling at least one standard deviation below the mean speed are obtained by two alternatively applied manual timing steps. The first procedure is to randomly sample spot speed, while the second involves timing slow vehicles. The former is discussed first.

The suggested method for determining the speed of an individual vehicle is to manually time arrivals of the

Figure 1. Guide-signing MOEs in before-and-after study or experiment.

Guide-Sign MOE:	High-Risk Gore Weave	Gore Weave	Late Lane Change	Drive Slowly
Operational Definition:	A vehicle movement into deceleration lane across painted or physical gore, in addition to crossing at least one through traffic lane.	A vehicle movement into deceleration lane across painted or physical gore.	A vehicle movement into deceleration lane across painted gore extension line.	A vehicle speed ≤ one standard deviation below mean, 240 m in advance of physical gore point.
Collection Method:	Time-lapse photography	Manual coding* or time-lapse photography *Manual coding is preferable if total weave area is 305m or longer	Time-lapse photography	Manual timing via electronic stopwatch
Collection Procedure:	Measure or count all occurrences continuously for half-hour periods simultaneously at experimental and control sites at time of day and day of week to permit matching data in before and after conditions.			Slow and mean speeds during alternate periods.
Analysis Procedure:	Pre-post design with control group: apply two-by-two factoral analysis of frequencies or proportions for each target behavior type and exit volume. Use χ^2-test for frequencies, Z-test for proportions.			
Impact of Deficiency Correction:	Decrease of 35 to 100 percent.	Decrease of 25 to 54 percent.	Decrease of 4 to 19 percent.	Decrease of 6 to 77 percent.

Note: 1 m = 3.28 ft.



vehicle (using a specific point of reference such as the front wheel) between two unobtrusive transverse pavement markings extended across all lanes and spaced 91 m (300 ft) apart. Dark green paint or tape may be used for markings. It is clearly visible to an observer, yet would probably not be detectable to the driver. One very important aspect of this procedure is to obtain a random sample of the total vehicle population. Common observer bias, for instance, too-frequent sampling of large or fast vehicles, in collecting spot data must be avoided. Approximately 60 vehicles can be sampled in a period of 30 min. Using this sample, the mean and standard deviations will be calculated as a baseline against which speeds of slow vehicles are compared.

Slowly traveling vehicles can be timed during alternate 30-min periods. Our manual coding reliability study demonstrated that vehicles traveling one standard deviation below the mean speed can be correctly estimated in 80 percent of the cases. The field procedure suggested here is to time all vehicles appearing to meet the slow-driving criterion; data on those actually traveling faster than one standard deviation below the mean speed can be discarded during the subsequent data reduction.

The measure obtained will be the proportion of exiting traffic volume meeting the slow-speed criterion. Each lane must be separately analyzed for speed variations between lanes. Since trucks, particularly large combinations, are generally driven by professional drivers, a general procedural suggestion for data collection is to observe automobiles and trucks as separate subpopulations.

ANALYSIS OF DATA

Recorded data must permit analyses of vehicle behavior as a proportion of exit volume. Comparisons of before data between test and control sites in an experiment provide a check of site configuration match. Before-and-after differences at the test site provide a gross indication of the impact of guide signing changes. Comparative before-and-after differences and the test versus the control site provide a rigorous indication of signing change impact with the time element effectively factored out and the effects of confounding variables minimized.

For each of these comparisons, it is important to use data that are collected during corresponding time periods. It is suggested that traffic volume differences be first examined for significant differences between the before-and-after condition using the chi-square test. Proper designation of before-and-after data collection periods (1-year interval) will likely result in insignificant volume differences. In this case, one should examine differences in target behavior occurrence, using the chi-square test to make the comparisons cited above. If before-and-after volumes differ, one should convert traffic behavior data to proportions of exiting traffic volume and perform the comparisons using the z-test to determine significant differences. The conversion to proportions should reduce the likelihood of spurious results caused by changes in volume.

A reduction in the frequency of the behavior types designated in Figure 1 should indicate that a measurable benefit was elicited by the signing change. The significance tests described above are the primary means for determining changes in MOE behavior.

ACKNOWLEDGMENT

The work reported in this paper was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program. Opinions and conclusions expressed in this paper are solely those of the authors.

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Publication of this paper sponsored by Committee on Methodology for Evaluating Highway Improvements.

Abridgment

Macroscopic Simulation Models for Use in Traffic Systems Management

Stephen L. Cohen, Office of Research, Federal Highway Administration

In recent years, traffic simulation has become a powerful tool for testing alternate traffic control strategies. The NETSIM (formally UTCS-1) network simulation model (1) was developed for the Federal Highway Administration for this purpose and has found increasingly widespread application.

More recently, the favored approach to urban transportation problems has shifted from traffic control to transportation systems management (TSM). Here, too, simulation should be a powerful tool in testing alternate strategies. These strategies, however, will in general be very different from the pure control strategies developed previously in that they will involve route changes.

Unfortunately, the NETSIM model, which is so successful in testing these strategies, is inappropriate for testing many TSM strategies because of its microscopic vehicle-tracing interactions. This microscopic approach is responsible for the flexibility and accuracy of UTCS-1 but is too expensive in terms of computer time and core