ACCIDENT SURROGATES FOR USE IN ANALYZING HIGHWAY SAFETY HAZARDS

VOL. 1 EXECUTIVE SUMMARY

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**Federal Highway
Administration**

Research, Development,
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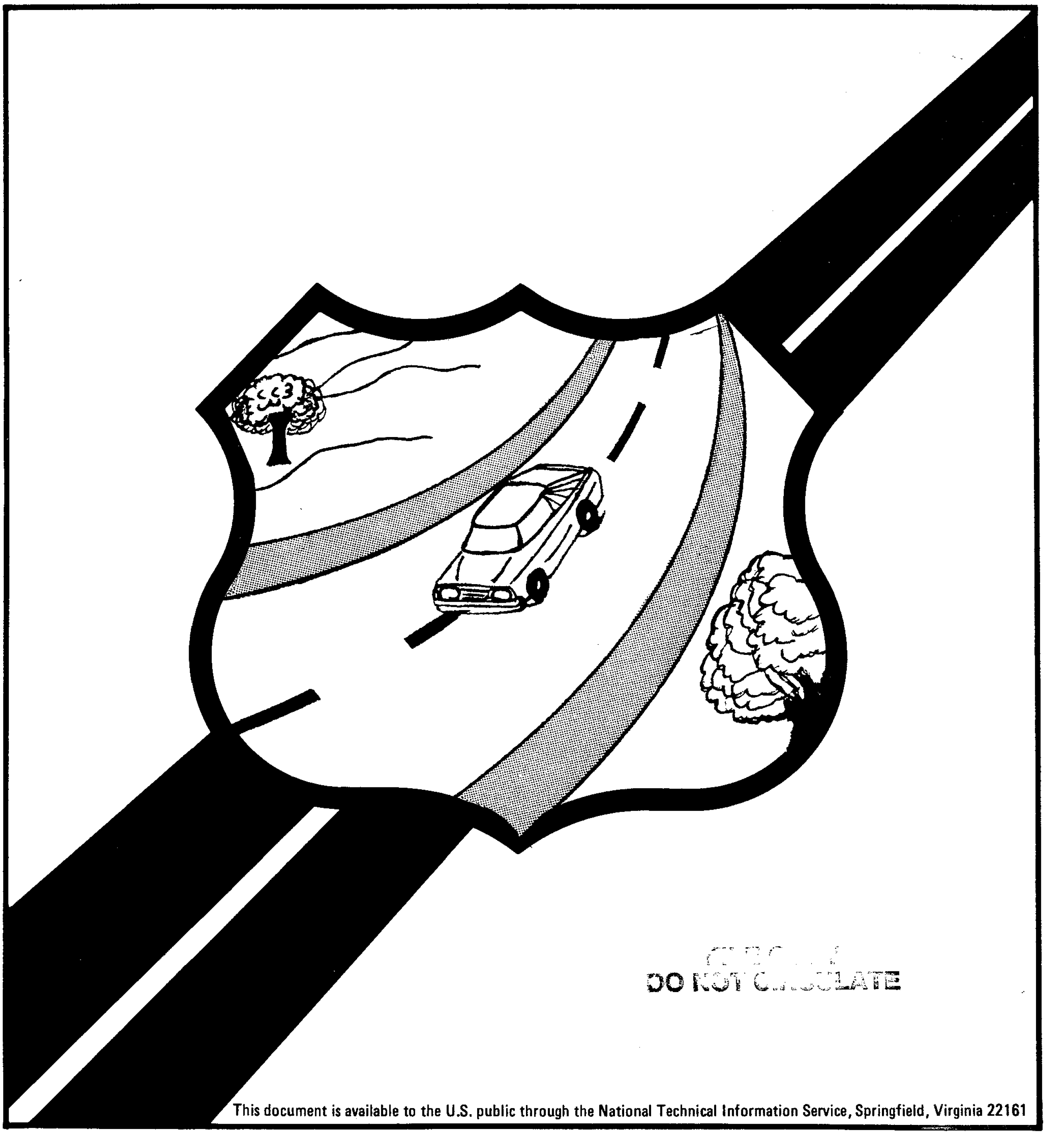
**Final Report
August 1983**



FOREWORD

This report presents the initial efforts to develop surrogate measures that can be used to supplement or replace accident data for highway safety analyses. Additional studies to validate and refine the results for application at rural locations are being conducted.

This report describes the results of a study in Project 1X, "Highway Safety Program Effectiveness Evaluation," of the Federally Coordinated Program of Research and Development. The study was conducted for the Federal Highway Administration, Office of Safety and Traffic Operations Research and Development, Washington, D. C., under contract DOT-FH-11-9492.

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16. Abstract

The principal objective of this research project was to investigate the feasibility of using accident surrogate measures in highway safety analyses. An accident surrogate measure is defined as a quantifiable observation that can be used in place of or as a supplement to accident records.

The study provides evidence that surrogate measures for accident experience can be identified. A procedure for developing and using accident surrogates is presented. Analyses were performed to develop accident surrogate measures for hazardous location identification and countermeasures evaluation at rural isolated curves on two-lane roads, rural signalized intersections and two-lane tangent sections in urbanized areas.

This report is the first in a series. The series is composed of:

FHWA/RD-82/103 Volume I - Executive Summary
FHWA/RD-82/104 Volume II - Technical Report
FHWA/RD-82/105 Volume III - Appendices A-G

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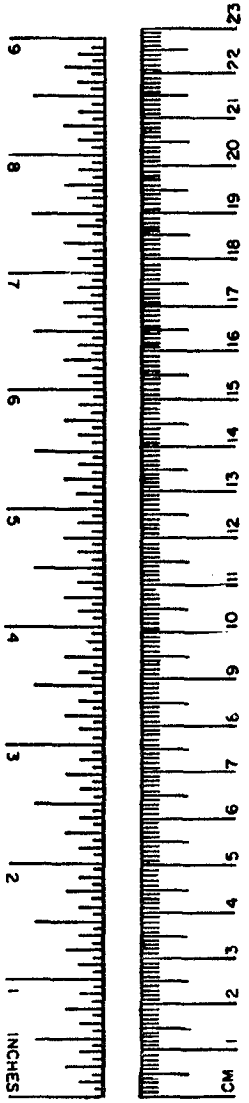
METRIC CONVERSION FACTORS

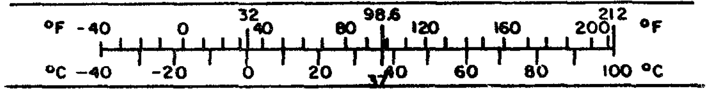
APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.6	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons(2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1 1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares(10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000kg)	1.1	short tons	
	VOLUME			
ml	milliliters	8.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



INTRODUCTION

Highway safety agencies rely heavily on reported traffic accidents to identify problem locations, justify and prioritize safety projects and evaluate their effectiveness. Many highway safety professionals, however, recognize significant shortcomings in the highway safety process when accidents are used as the sole criterion for highway safety planning and evaluation. One problem arises when decisions to continue, modify or remove countermeasures need to be made sooner than the waiting time required to collect accident statistics. In other instances, unreliable or incomplete accident statistics may lead to erroneous decisions regarding countermeasure selection or effectiveness assessment. Another problem arises when the number of accidents occurring at a specific location is relatively small, and safety problems are best characterized by accident potential as opposed to the occurrence of accidents. This situation often occurs on low volume roads, in rural areas and at rail-highway grade crossings.

Because of these limitations, many highway safety professionals support the premise that identification of problem locations and effectiveness evaluations should consider measures in addition to accidents. Past studies indicate that highway system characteristics such as geometrics, operations, environment and driver behavior are related to accident experience. Several research efforts have identified precise relationships between individual characteristics and accidents. However, there has been insufficient systematic effort to investigate the feasibility of using such relationships as surrogates for accident experience in highway safety analyses.

This study investigates the feasibility of using accident surrogate measures in highway safety analyses. For the purpose of the study, an accident surrogate measure is defined as a quantifiable observation that can be used in place of or as a supplement to accident records. From a theoretical viewpoint, an accident surrogate measure must possess a definite relationship with accidents and be sensitive to safety-related changes in the highway system. From a practical viewpoint, surrogate measures must be relatively easy to collect with minimal manpower, training and equipment.

The objectives of the study are:

- To identify observable roadway system features and characteristics that indicate the relative hazardousness of highways.

- To develop accurate, quantitative measures of selected factors to be tested as potential surrogate measures.

- To quantify the relationship between these selected measures and accident experience.

- To develop methodologies that utilize accident surrogates for identifying hazardous sites and sections of roadway, for evaluating the effectiveness of completed safety countermeasures and for reviewing design plans of new facilities or improvements.

METHODOLOGY SUMMARY

The objectives of the study were accomplished by (1) identifying highway system variables to serve singly or in combination as surrogate measures, (2) developing explicit mathematical relationships between selected surrogate measures and accidents, and (3) developing and testing methodologies which incorporate the resulting relationships in highway safety analysis procedures.

The identification of variables having potential as candidate surrogate variables was accomplished by obtaining information on actual and perceived relationships between accidents and elements of roadway, driver and vehicle systems. Four information sources provided input on these relationships; (1) literature, (2) a two-day workshop to obtain opinions and observations of highway safety professionals, (3) analysis of an existing data base containing accident, geometric, operational and environmental data, and (4) selected field data collected at ten typical roadway situations. These sources of information were synthesized to identify highway system variables that warrant further detailed analyses as surrogate measures. The variables resulting from this synthesis were stratified according to their relevance to specific highway locations and associated predominant accident types. The variables were further stratified as non-operational and operational. Non-operational variables consist of static highway system elements of the roadway, roadside and environment. Operational variables consist of dynamic highway system elements including traffic flow and driver behavior characteristics.

The literature review, workshop and preliminary data analysis resulted in lists of candidate surrogate measures for ten highway situations (Table 1). Each situation was examined to determine those that exhibit the greatest potential for testing and development of significant mathematical relationships between a predominant accident type and the candidate surrogates. Three highway situations were selected based on assessments of the convergence of research evidence, qualitative and quantitative support from the information sources and the requirements for an implementable surrogate. The selected situations were:

- Isolated curves on rural two-lane roads

Table 1. Summary of selected candidate surrogates* by highway situation and type of highway safety analysis.

Highway Situation	Application in Highway Safety		
	Identification of Hazardous Locations	Evaluation of Countermeasures	Design Plan Review
Urban Undivided Tangent Sections	. Access Points/Mile . Turning Volumes . Speed Changes/Mile . Fixed Objects/Mile	. Speed Changes/Mile	. Access Points/Mile . Projected Turning Volumes
Rural Undivided Winding Sections	. Curves/Mile . Lane Width and Shoulder Width . Physical Evidence of Driver Error . Speed Changes/Mile	. Physical Evidence of Driver Error . Speed Changes/Mile	. Curves/Mile . Lane Width and Shoulder Width
Rural Isolated Curves	. Speed Reduction Efficiency . Curvature, Grade and Distance Since Last Curve . Physical Evidence of Driver Error . Erratic Manuevers	. Speed Reduction Efficiency . Physical Evidence of Driver Error . Erratic Maneuvers	. Design Speed Differential . Curvature, Grade and Distance Since Last Curve
Lane Drop Locations	. Erratic Manuevers . Merge Gap Availability . Taper Length . Posted Speed and Sight Distance	. Erratic Maneuvers . Merge Gap Availability	. Taper Length . Posted Speed and Sight Distance
Narrow Bridges	. Bridge deck to pavement width ratio . Traffic Mix . Sight Distance (Time) . Physical Evidence of Driver Error	. Sight Distance (Time) . Physical Evidence of Driver Error	. Bridge Deck to Pavement Width Ratio . Traffic Mix
Exit Gore Areas	. Deceleration Lane Length . Sight Distance . Erratic Maneuvers	. Erratic Maneuvers	. Deceleration Lane Length . Sight Distance
Urban Non-Signalized Intersections	. Traffic Volume . Approach Speed and Sight Distance . Traffic Conflicts	. Approach Speed and Sight Distance . Traffic Conflicts	. Projected Traffic Volume
Rural Non-Signalized Intersections	. Traffic Volume . Approach Speed and Sight Distance . Traffic Conflicts	. Approach Speed and Sight Distance . Traffic Conflict	. Projected Traffic Volume
Rural Undivided Tangent Sections	. Access Points/Mile . Speed Changes/Mile . Lane Width . Physical Evidence of Driver Error	. Speed Changes/Mile . Physical Evidence of Driver Error	. Access Points/Mile . Lane Width
Rural Signalized Intersections	. Traffic Conflicts . Traffic Volume . Sight Distance . Delay	. Traffic Conflicts . Delay	. Projected Traffic Volume . Sight Distance

*Note: Selected surrogate definitions are provided in Appendix E.

- Signalized intersections on rural two-lane roads
- Undivided two-lane tangent sections within urbanized areas

Selected locational and geometric characteristics for each situation were identified to facilitate study site selection and reduce accident variance by limiting the range of variables other than the candidate surrogate variables.

The following situations were selected for further investigation:

Isolated Curves

The curves should be located on two-lane, undivided roads with a central angle of at least 20°. Traffic volumes (AADT) should not exceed 8,000 vehicles and posted speeds on curve approaches should be between 35 and 55 mph (advisory speeds on the curves may vary). Lane widths should be between 10 and 12 feet with gravel shoulders. At least 1/4-mile should separate the study site from a preceding highway event that necessitates driver action to adjust vehicle path and/or speed (i.e., another curve, railroad crossing, stop sign, traffic signal, etc.). The curves should not have unusual roadside features.

Rural Signalized Intersections

The intersections should be located on two-lane roads with 10-12 feet lane widths. The pavement surface should be in good condition with functional characteristics within acceptable guidelines, and there should be no unusual signs, signals or pavement marking in the intersection. Major approaches should have either left-turn or right-turn lanes. There should be no major traffic generators on the corners and the signals should be fixed-time two-phase controlled.

Urban Undivided Tangents

All tangents should have two 10-12 foot lanes. Speed limits should be between 25 and 50 mph. All tangents should be at least 1/2 mile in length.

Twenty to thirty sites meeting the criteria for each situation type were selected for analysis. Additional sites were to compare predicted versus actual accident experience using the surrogate measures developed in the study.

All test sites used in model development were located within Oakland County, Michigan because of the availability of recent photologs, a log of highway projects implemented since 1975, and reliable accident and volume data. Some of the test sites used for testing the final surrogate measures were selected from an adjacent county.

For each situation, candidate surrogate measures were selected for subsequent field collection and analysis. Candidate surrogates were generally drawn from Table 1. However, not all candidates were selected. For example, traffic conflict data were eliminated since it was specifically excluded from this study; physical evidence of driver error was not included because it is difficult to collect; and the frequency and existence of roadside fixed objects was not included in the analysis of urban tangents because of the existence of wide shoulders. The selected variables were then reviewed to ensure acceptable ease of data collection, logical association with accidents and their affectability (by countermeasure implementation). Table 2 shows the non-operational and operational variables selected for each situation that were used in the surrogate development process.

Three years of accident data (1976, 1977, 1978) were also collected for each highway location. Printouts were obtained for the specified limits of the site plus all accidents occurring within 200 feet of the site boundaries. Each accident was examined with respect to relationship to the vicinity of the highway situation, vehicle involvement, contributory circumstances, and vehicle paths. Locations with unusual accident patterns such as a high incidence of car-animal accidents were eliminated from further consideration.

Regression techniques (the Maximum R^2 Improvement technique (MAX R^2) contained in the Statistical Analysis System (SAS) was selected as the most appropriate regression technique) were used in the analysis with the selected candidate surrogate variables used as independent variables and 3-year accident rates for total accidents and predominant accident types used as dependent variables. Stepwise regression was used as the analysis procedure to test for statistically significant relationships between one or a combination of candidate surrogate variables and accident experience at the selected highway situations.

Regression analyses were performed for specific stratifications within each highway situation to search for statistically significant relationships between accidents and; (1) combinations of non-operational and operational variables, (2) non-operational variables only, and (3) operational variables only. Surrogates developed from these three analyses can be used for identification of hazardous locations, design plan review and countermeasure evaluation, respectively.

RESULTS OF THE ANALYSIS OF RURAL ISOLATED CURVES

The analysis failed to identify a good surrogate measure for total accident rate when all locations were analyzed. The only variable that was both independently correlated with total accident rate and remained in the MAX R^2 model at the 0.05 level of significance was degree of curvature. However, the R^2 value for this one variable model was only 0.16,

Table 2. Candidate surrogates tested in the study.

HIGHWAY SITUATION	Type of Highway System Variable	
	NON-OPERATIONAL	OPERATIONAL
Rural Isolated Horizontal Curve	. Degree of Curvature . Grade . Shoulder Width . Distance Since Last Curve . Superelevation . Slope of Roadside (Ditch, Shoulder) . Type, Location & Frequency of Fixed Objects	. Encroachments . Speed Reduction
Rural Signalized Intersection	. Vertical and Horizontal Alignment . Sight Distance to Signal and at Intersection . Posted Speed . Signal Characteristics (# Phases, Amber Time, Etc.) . Distance Since Last Intersection	. Percent Trucks . Turning Volume . Traffic Volume . Approach Speed . Erratic Maneuvers
Urban Undivided Tangent	. Access Points . V/C Ratio*	. V/C Ratio* . Speed Changes . Percent Midblock Turns

*Note: The candidate surrogate measure, volume to capacity ratio (v/c ratio)Consists of both non-operational (capacity) and operational (peak hour volume) measures and was therefore included in both analysis categories.

and thus degree of curvature is not a strong surrogate for total accidents.

The results are consistent with those from the literature review, the workshop and the analysis of MIDAS*, in that this factor was identified as "important" in all three. It is also not suprising, however, that there is no single surrogate strongly correlated to all accidents at all locations.

The most clearly defined surrogate measure for rural isolated curves resulted from the analysis which used outside lane accidents as the dependent variable on a limited sample of highway sections with few driveways and a speed limit greater than or equal to 45 mph. The coefficient of multiple correlation for this model was 0.81, and the significant variables were "distance to last traffic event on the outside lane (V13)" and "speed differential between the approach speed and curve midpoint speed for traffic in the outside lane (V38)". The form of the predictive model is:

$$\text{Outside lane accident rate} = 0.032 + 0.595\ (V13) + 0.151\ (V38)$$

The relatively high R^2 value is not unexpected since both the independent variable and the dependent variable contain only a subset of the total sample (n=15). For this particular situation, it was possible to define a surrogate measure that is easily measured, capable of being measured soon after implementation of a safety countermeasure, and correlated to at least one particular type of accident.

One of the primary objectives of this study was to demonstrate that the use of surrogates for accident experience is feasible and could be accomplished through a logical procedure using both the experience of practicing engineers and statistical testing. This objective has been met for this particular subset of the data. Similar results were obtained for other accident classifications, situations and groupings. Some of the more promising results are described in the following paragraphs.

For rural isolated curves, reasonably good models ($R^2>0.65$) were obtained for predicting:

- Outside lane accident rate for a group of sites with zero or one driveways and posted speed of 45, 50 or 55 mph, using the variables "distance to last event" and "degree of curve".

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* The Michigan Dimensional Analysis System (MIDAS) is a computerized data base containing geometric, environmental, control, operational and accident data for the State Highway System in Michigan.

- Rear-end accident rate for a group of sites on grades less than 4%, using the variables "ADT" and "side slope angle".

- Rear-end accident rate for a group of sites on grades less than 4% and few driveways, using the variable "ADT".

- Run-off-road accident rate for a group of sites with restricted sight distance and zero or one driveways, using the variables "degree of curve" and "superelevation error".

RESULTS OF THE ANALYSIS OF RURAL SIGNALIZED INTERSECTIONS

The most clearly defined surrogate measure for rural signalized intersections resulted from the model developed to predict opposing left-turn accident rate using signal violation rate (V56), and the percent trucks (V60). This surrogate is applicable for both identification of hazardous locations and evaluation of selected deployed accident countermeasures because of the operational nature of the variables. This model was developed for a group of sites which consists of intersections with unrestricted sight distance to the signal heads. The R^2 value was 0.63, indicating a relatively weak surrogate. The form of the predictive model is:

$$\text{Opposing left-turn accident rate} = 0.5895+0.4101\,(V56)-0.0801\,(V60)$$

The analysis suggests a limited potential for accident surrogates at rural signalized intersections. This may be due to the increased complexity of the driving and decision-making tasks associated with signalized locations (as contrasted with these tasks at rural isolated curves).

RESULTS OF THE ANALYSIS OF TWO-LANE URBAN TANGENT SECTIONS

The most clearly defined surrogate measure for urban tangents is for "fixed object accident rate". The variable used to predict this accident experience is "volume-to-capacity ratio". The R^2 value, however, is quite low (0.25) for this regression model (see Table 36). The same variable (volume/capacity) is the independent variable in the only model developed for predicting "rear-end accident rate". This finding confirms the intuitive belief that traffic volume (perhaps modified by roadway capacity) is the best predictor of accident rates on urban tangent roadway sections.

The results from this analysis indicates a limited potential for accident surrogate measures on two-lane urban tangent sections. Possible reasons for this may be that this situation represents a "section" as opposed to a "spot". On sections, the complexity of the accident picture increases dramatically over that of spot locations due to the wide variations in the driving tasks, highway information systems and driving environments, and the interactions thereof. For spot locations a driver is faced with fewer decisions and actions which, in turn, increases the feasibility of identifying specific variables on which to develop accident surrogates.

APPLICATION OF RESULTS

Another objective of the study was to develop methodologies that utilize accident surrogates for identifying hazardous locations, evaluating the effectiveness of completed countermeasures and reviewing design plans for new facilities or improvements. To accomplish this objective, procedures are presented to guide the user in applying accident surrogates in the context of the three highway safety activities.

Methodology for Identifying and Ranking Hazardous Locations

The objective of this methodology is to identify hazardous locations which warrant safety improvement and rank the resulting locations according to relative safety deficiencies. The locations are to be drawn from a listing of locations which are presumed to be hazardous by virtue of accident experience, or are suspected of being hazardous because of certain geometric or operational characteristics or because of complaints received from the public.

The methodology consists of five sequential steps:

1. Identify Potentially Hazardous Sites and Groups by Situation
2. Develop Data Collection Plan
3. Collect and Reduce Field Data
4. Determine Accident Potential (using surrogate measures to predict accident potential)
5. Rank Locations

Methodology for Evaluating Accident Countermeasures

The objective of this methodology is to evaluate the effectiveness of highway safety projects implemented to reduce accidents and/or hazard potential at a specific highway location (spot or section). The effectiveness of a countermeasure is based on an observed change in the value of the surrogate measure(s) between the improved and unimproved condition. This methodology provides a "short-term" indication of the effectiveness of the project. Planning for the evaluation study, in advance of the implementation of the project, is mandatory. The use of a surrogate for this methodology however is subject to the affectability of the surrogate measure to the implemented countermeasure (i.e., the countermeasure must result in a change in the surrogate measure).

The methodology consists of the five sequential steps:

1. Develop the Evaluation Plan (including the selection of surrogate measures to be used in the study as a measure of effectiveness)
2. Collect and Reduce Field Data
3. Determine Project Effectiveness
4. Document Evaluation Results
5. Develop and Update Effectiveness Data Base

Methodology For Design Plan Review

The objectives of this methodology is to identify and evaluate highway design features for safety considerations. The design features to be evaluated may include roadway geometrics, cross-sectional elements and roadway configuration, depending on the identified relationships to accidents at the type of highway situation being studied.

The methodology consists of the five sequential steps:

1. Identify Safety-Related Design Features
2. Determine Safety Deficiencies
3. Determine Potential Design Changes
4. Review Design Plans for Consistency
5. Revise Design Plans

SUMMARY AND CONCLUSIONS

This study provides evidence that surrogate measures for accident experience can be identified. Furthermore, a procedure for doing so has been developed and demonstrated to a limited degree. This study involved extensive review of the literature pertaining to studies of the effect of various operational and non-operational highway, driver and traffic variables on accident experience; the judgments of highway safety professionals on which variables were most promising in terms of developing mathematical relationships with accidents; the analyses of existing data bases to assess probable relationships for selected variables; a limited amount of field data collection to supplement the other sources; and a synthesis of all these inputs to select the variables most likely to provide a meaningful surrogate.

Comprehensive sets of data were collected for 25 rural isolated curves, 19 rural signalized intersections, and 30 two-lane urban tangent sections -- three of the ten situations shown in Table 1. The data included measurements of operational and non-operational characteristics as independent variables, and various categories of accident types as dependent variables.

Statistical analyses of these data sets yielded five models for predicting specific types of accident rates at rural isolated curves, two weaker models were developed for rural signalized intersections, but no meaningful relationships could be developed from the available data for urban tangent sections.

The strongest model developed in the study indicates that the "outside lane accident rate" at rural isolated curves can be predicted from measurements of the "distance since last traffic event on the outside lane" and "speed differential between the approach speed and curve midpoint speed for traffic in the outside lane". The model applies only to locations with limited land use development and a posted speed limit of 45 mph or greater.

In all cases, the success of developing acceptable regression models was dependent on the specificity of the accident variables and the characteristics of the test sites used in the analysis. The statistical strength of the regression models increased when the dependent variable was related to specific types of accidents as opposed to total accidents. Similarly, better regression models resulted as additional constraints were placed on locational characteristics of the test sites included in the regression.

The feasibility of identifying useful surrogate measures for accident prediction models is related to the type of highway situation and the complexity of the driving task -- as evidenced by the relative successes in developing models for rural isolated curves, rural signalized intersections, and two-lane urban tangent sections. On rural isolated curves the driver need only perceive the direction and degree of curvature, assess the related highway and traffic environmental factors (superelevation, shoulders, other traffic, etc.) and select an appropriate speed and path. Roadway geometry, sight distance, traffic volumes and other factors will dictate what the speed and pathway should be, but the "ideal path" can be fairly well defined and the results of inappropriate decisions (encroachments, and/or accidents) are obvious and measurable. However, as the complexity of the highway situation increases, the number of temporal and spatial decisions and possible actions increases. This creates difficulties in identifying and measuring inappropriate driver responses, and relating measurable roadway, driver and traffic characteristics to accidents.

The prediction models formulated in this study are based on data from a limited geographic area, and may be appropriate only for safety studies within that area. Some caution should be exercised in extrapolating the models to other areas with differing laws, law enforcement, driver behavior, terrain, weather and traffic control practices. It is quite possible that the models are applicable in wider areas (and that is certainly desirable, given the effort required to construct such models), but testing will be required to determine the loss in explanatory power that occurs as the models are used in other geographic areas.

Overall, with qualification imposed by the size of the data set, the primary objective of the study -- to demonstrate that accident surrogates can be developed through a systematic identification and measurement of roadway, driver and traffic characteristics -- has been accomplished. Generalizing the surrogates formulated herein and developing new surrogates can now proceed at a much faster pace with more efficient data collection and analyses.

RECOMMENDATIONS

The primary intent of this study was to test the feasibility of using surrogates for accident experience in highway safety analyses. The results obtained in this study contributes to the feasibility of using surrogate measures in highway safety analyses. However, additional testing and analysis is necessary to more fully develop other accident surrogates and to demonstrate their potential use in highway safety analyses:

- Further testing and analysis should be performed for those accident surrogates identified in this study. Development of surrogates on a statewide (or nationwide) basis would enhance the utility of these accident surrogates.

- Other types of highway situations should be examined for the purpose of identifying surrogates. Emphasis should initially be given to "spot" location as opposed to sections. Complexity of the driving task should be considered as an important factor in assessing the feasibility of identifying "useful" accident surrogates.

- Long term study should be directed at identifying the effect of accident countermeasures on both accident experience and surrogate measure values. This is a prerequisite to the expanded use of surrogate measures for countermeasure effectiveness evaluation.

FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

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* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.