AN EVALUATION OF ACCIDENT SURROGATES FOR SAFETY ANALYSIS OF RURAL HIGHWAYS

Vol. III: Appendixes

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101

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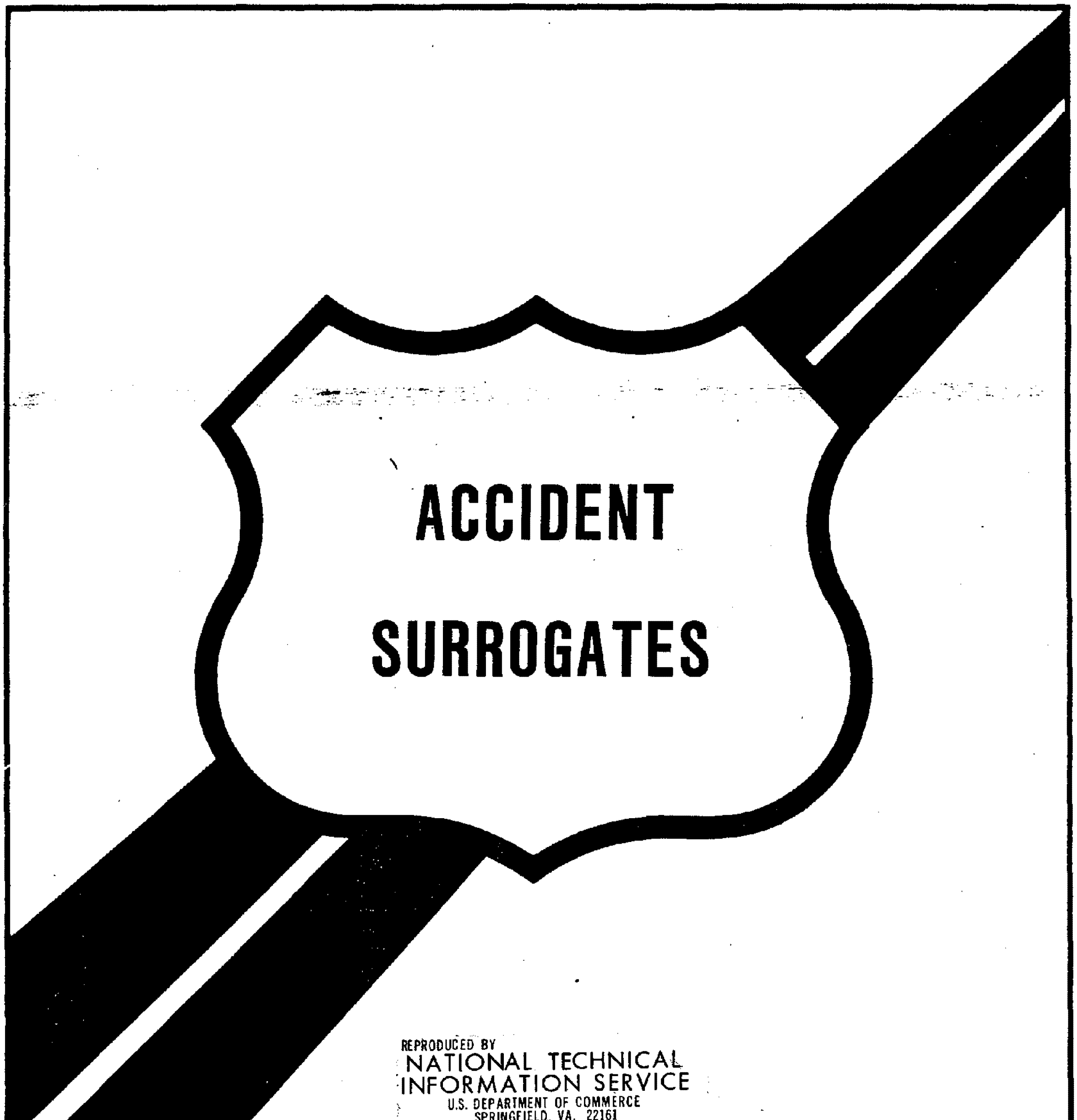
Final Report
May 1986



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16. Abstract

The objective of this study was to validate the use of accident surrogate measures for analyzing safety on rural highways. Emphasized were inexpensive, quickly obtained measures. They were tested for isolated horizontal curves and unsignalized intersections.

This volume contains eight appendixes which supplement information presented in summary form in the technical report. Appendixes A through E provide data collection details including the data forms, equipment, the training manual and training program, and accident data collection. Appendixes F and G contain the algorithms used to derive selected surrogate measures and the results of the regression analyses. Appendix H presents a synopsis of the problems encountered when operational variables were collected at night.

This volume is the third in a series. The other volumes are:

Vol. I - FHWA/RD-86/127 - Executive Summary
Vol. II - FHWA/RD-86/128 - Technical Report

17. Key Words

Accident surrogates, accident rates, accident prediction, nonoperational and operational variables, isolated curves, unsignalized intersections.

18. Distribution Statement

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NOTICE

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LIST OF ABBREVIATIONS AND SYMBOLS

AADT = annual average daily traffic

AASHTO = American Association of State Highway and Transportation Officials

acc = accidents

CC = change of curvature on compound or reverse curves

df = degrees of freedom

DMI = distance-measuring instrument

DOT = Department of Transportation

LT = left-turning vehicles

PC = point of curvature, i.e., beginning of curve

PT = Point of tangency, i.e., end of curve

R = coefficient of multiple correlation

RT = right-turning vehicles

SV = single-vehicle

thru = vehicles proceeding straight through intersection

veh/h = vehicles per hour

OVERVIEW

This study was conducted to develop and validate accident surrogates for isolated horizontal curves and unsignalized intersections on rural, two-lane State highways. A synopsis of the research is provided in Volume I. Executive Summary, and a detailed description of the study procedure and findings is given in Volume II. Technical Report. This volume contains eight appendixes which supplement information presented in summary form in the technical report. The material is provided for the researcher or reader who is interested in the specific details of the data collection and analysis processes.

Appendixes A through E provide additional details concerning data collection in western New York State, and in Alabama and Ohio. A copy of the field and accident data collection forms is provided in appendix A. A list of the equipment used by each team to measure the candidate surrogates is presented in appendix B. The manual that was used to supplement the formal training program for the data collectors is given in appendix C. The manual describes the measurement procedure for each nonoperational and operational variable, and was used by the teams as a reference source throughout the data collection period. A description of the formal training program presented to the data collectors is given in appendix D. Appendix E provides details of the accident data collection and screening processes used for the validation sites in Alabama and Ohio.

Appendixes F and G provide additional information pertaining to data analysis. While some of the variables, such as shoulder width, were measured in the field and analyzed in their raw form, other variables, such as salience of curve advanced warning, were derived from several field measurements. The algorithms used to derive the salience of curve advanced warning and estimated annual average daily traffic variables are given in appendix F. A summary of the regression models examined for predicting accident rates for isolated horizontal curves in western New York State is presented in appendix G.

Appendix H contains a synopsis of the problems encountered when the operational variables were collected at night.

APPENDIX A: Data Collection Forms

The forms that were used to record the field data and the accident information are presented in this appendix.

FORMS USED IN WESTERN NEW YORK STATE

Data were collected for isolated horizontal curves and unsignalized intersections located on rural, two-lane State highways in western New York. The forms used for data collection are given in figures 1 through 8. Definitions of the variables listed on the forms and measurement procedures are described in appendix C.

Four forms were used for collecting the horizontal curve data. Horizontal curves were coded as site type 1. Shown in figure 1 is the three-page form that was used to collect the nonoperational data. The form shown in figure 2 was used to code the computed nonoperational variables. Volume and encroachment data were recorded on the form shown in figure 3, and the outside lane speed data were recorded on the form given in figure 4.

Three forms were used to collect the unsignalized intersection data. Intersections were coded as site type 2. The nonoperational data were recorded on the one-page form shown in figure 5. Directional volumes were recorded on the form given in figure 6, and minor and stopped delay data were recorded on the form shown in figure 7.

The form used to record information for each reported accident at the horizontal curves and intersections is given in figure 8. As noted on the accident form, the boxes identify the location of each data element on the police report, and the brackets specify the code used on the accident report. This convention was employed to reduce the opportunity for coding errors that sometimes occur when data is transferred from the police report to the data collection form.

FORMS USED IN ALABAMA AND OHIO

As shown in figures 9 through 11, three forms were used to collect the surrogate and accident information for the horizontal curve sites in Alabama and Ohio. The nonoperational and operation data were recorded on the forms shown in figures 9 and 10, respectively, and the accident data were coded on the form given in figure 11.

Calspan Field Services Inc.

Accident Surrogates Study

CURVE Data: Nonoperational

Recorded By: ______________

Date Recorded: ______________

Coded By: ______________

Date Coded: ______________

OFFICE CODE ONLY

Site Type ---------------------------- 1 (col. 1)

Card Number --------------------------- 1 (col. 2)

Site Number ------------- ___ ___ ___ (3, 4, 5)

County ------------------------ ___ ___ (6, 7)

Erie	01	Wyoming	05
Niagara	02	Cattaraugus	06
Orleans	03	Chautauqua	07
Genesee	04	Livingston	08

Reference Markers

Begin ___ ___ ___ End ___ ___ ___

___ ___ ___ ___ ___ ___ ___ ___

___ ___ ___ ___ ___ ___ ___ ___

Distance, in miles (Begin) - (End) ___ ___.___ (8, 9, 10)

DOT Volume (100's) ___ ___ (11, 12)

Direction of Survey ___ (13)

North = 1
South = 2
East = 3
West = 4
Both = 5

Curve Direction ___ (14)

North–South = 1
East–West = 2

Proceeding North–East Curve Turns ___ (15)

Right = 1
Left = 2

Middle ordinate, in inches ___ ___ ___.___ (16, 17, 18, 19)

Length of curve, in feet (P.C. to P.T.) ___ ___ ___ ___ (20, 21, 22, 23)

Distance to last event, outside lane, in miles (> 2 miles, code 3.00) ___.___ ___ ___ (24, 25, 26, 27)

Shoulder width, to nearest foot ___ ___ (28, 29)

Grade -------------------------------- ___ (30)

Flat (< 1%) = 1
Moderate (1% - 4%) = 2
Steep (> 4%) = 3

Superelevation

"d" dimension, in feet ___ ___ (31, 32)

"e" dimension, in inches ___ ___ ___.___ (33, 34, 35, 36)

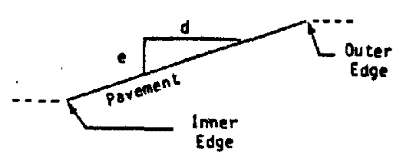


Figure 1. Form used to collect nonoperational horizontal curve data in western New York State.

Calspan Field Services Inc.

Accident Surrogates Study

Site Number: ______________

County Name: ______________

CURVE Data: Nonoperational

Inside Lane Warning Signs in Advance of Curve

Present = 1   Not present = 2

Speed advisory*, e.g.

___ 37

Curve, e.g.

___ 38

Winding section, e.g.

___ 39

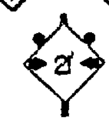
Sharp turn, e.g

___ 40

Reverse turn, e.g.

___ 41

Flashing beacon, e.g.



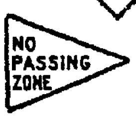
___ 42

Oversize curve warning ___ 43

Limited sight distance, e.g.

___ 44

No passing zone, e.g.



___ 45

Other (describe) ___ 46

____

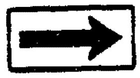
____

*Advisory speed (Not applicable = 99) ___ 47 ___ 48

Inside Lane In-Curve Warning Devices

Code number of each of the following (00 = none)

Directional arrows, e.g. ___ 49 ___ 50



Chevrons, e.g. ___ 51 ___ 52

Post delineators ___ 53 ___ 54

Roadside Hazard Rating

Give your judgement of the appropriate rating for the roadside zone 0-15 feet from the edge of the paved surface.

Inside lane roadside ___ 55

Outside lane roadside ___ 56

Clear, no fixed objects, fairly level terrain	= 1
Vegetation or yielding objects, fairly level terrain, no rigid fixed objects	= 2
Isolated rigid fixed objects, fairly level terrain	= 3
Ditch through most of curve, no embankment or side slope > 3:1	= 4
Embankment or side slope > 3:1	= 5
Numerous or continuous rigid fixed objects	= 6

Figure 1. Form used to collect nonoperational horizontal curve data in western New York State (continued).

Calspan Field Services Inc.

Accident Surrogates Study

Site Number: ____________________

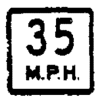
County Name: ____________________

CURVE Data: Nonoperational

Outside Lane Warning Signs in Advance of Curve

Present = 1 Not present = 2

Speed advisory*, e.g.



____ 57

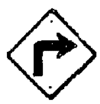
Curve, e.g.

____ 58

Winding section, e.g.

____ 59

Sharp turn, e.g



____ 60

Reverse turn, e.g.

____ 61

Flashing beacon, e.g.

____ 62

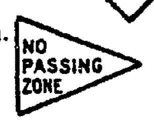
Oversize curve warning

____ 63

Limited sight distance, e.g.

____ 64

No passing zone, e.g.



____ 65

Other (describe)

____ 66

____

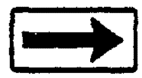
____

*Advisory speed
(Not applicable = 99) ____ 67 ____ 68

Outside Lane In-Curve Warning Devices

Code number of each of the following
(00 = none)

Directional arrows, e.g.



____ 69 ____ 70

Chevrons, e.g.

____ 71 ____ 72

Post delineators

____ 73 ____ 74

Figure 1. Form used to collect nonoperational horizontal curve data in western New York State (continued).

Calspan Field Services, Inc. Coded By: ____________

Accident Surrogates Study Date Coded: ____________

CURVE Data: Nonoperational

OFFICE CODE ONLY

Site Type - - - - - - - - - - - - - - -				1
				1
Card Number - - - - - - - - - - - - - -				4
				2
Site Number - - - - - - -		___	___	___
		3	4	5
Degree of curvature	___	___	___ •	___
	6	7	8	9
Average speed (mph)			___	___
			10	11
AASHTO superelevation rate	___	• ___	___	___
	12	13	14	15

Figure 2. Form used to code computed nonoperational horizontal curve variables in western New York State.

Calspan Field Services Inc.

Accident Surrogates Study

CURVE Data: Volume & Encroachment

Recorded By: ____________

Date Recorded: ____________

Coded By: ____________

Date Coded: ____________

Site Type ---------------------------------- 1 (1)	County: ____________
Card Number -------------------------------- 2 (2)	Measurement Set (1-5) --------------------- ___ (6)
Site Number ------------------ ___ (3) ___ (4) ___ (5)	Light ----------------------------------- ___ (7) Daylight = 1 Darkness = 2

Time Period		Outside Lane				Inside Lane			
		Total Vehicles		Centerline Encroachments	Edgeline Encroachments	Total Vehicles		Centerline Encroachments	Edgeline Encroachments
From	To	In Platoons	Isolated			In Platoons	Isolated		
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								

Figure 3. Form used to collect volume and encroachment data on horizontal curves in western New York State.

Calspan Field Services Inc.

Accident Surrogates Study

Site Number: ____________________

County Name: ____________________

CURVE Data: Volume & Encroachment

Time Period		Outside Lane				Inside Lane			
		Total Vehicles		Centerline Encroachments	Edgeline Encroachments	Total Vehicles		Centerline Encroachments	Edgeline Encroachments
From	To	In Platoons	Isolated			In Platoons	Isolated		
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
AM PM	AM PM								
TOTALS -- OFFICE CODE ONLY									
Hours		Vehicles In Platoons	Isolated Vehicles	Encroachments	Encroachments	Vehicles In Platoons	Isolated Vehicles	Encroachments	Encroachments
8 . 9 10		11 12 13 14	15 16 17	18 19 20	21 22 23	24 25 26 27	28 29 30	31 32 33	34 35 36

Figure 3. Form used to collect volume and encroachment data on horizontal curves in western New York State (continued).

Calspan Field Services Inc.
Accident Surrogates Study

CURVE Data: Outside Lane Speed

Recorded By: ____________
Date Recorded: ____________
Coded By: ____________
Date Coded: ____________

Site Type ---------- 1 (1) Card Number ---------- 3 (2) Site Number ---------- ___ ___ ___ (3 4 5)	County: ____________ Measurement Set (1-5) ---------- ___ (6) Weather ---------- ___ (7) Clear = 1 Overcast = 2 Light fog/drizzle = 3

Time Period		Speeds 250 Feet Prior to P.C.	Speeds at Curve Midpoint
From	To		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		

Figure 4. Form used to collect outside lane speed data on horizontal curves in western New York State.

Calspan Field Services Inc.

Accident Surrogates Study

Site Number: ____________________

County Name: ____________________

CURVE Data: Outside Lane Speed

Time Period		Speeds 250 Feet Prior to P.C.	Speeds at Curve Midpoint
From	To		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
OFFICE CODE ONLY		(1) Total vehicles ______ (2) Sum of speeds ______ (3) Average speed [(2) ÷ (1)] __ __ . __ __ (8 9 10 11)	(4) Total vehicles ______ (5) Sum of speeds ______ (6) Average speed [(5) ÷ (4)] __ __ . __ __ (12 13 14 15)

Figure 4. Form used to collect outside lane speed data on horizontal curves in western New York State (continued).

Calspan Field Services Inc.

Accident Surrogates Study

INTERSECTION Data: Nonoperational

Recorded By: ______________________

Date Recorded: ______________________

Coded By: ______________________

Date Coded: ______________________

OFFICE CODE ONLY

Site Type ---------------------------------- 2 (1)

Card Number -------------------------------- / (2)

Site Number ------------------ ___ ___ ___ (3 4 5)

County ------------------------------ ___ ___ (6 7)

Erie	01	Wyoming	05
Niagara	02	Cattaraugus	06
Orleans	03	Chautauqua	07
Genesee	04	Livingston	08

Reference Markers

Begin ___ ___ ___ End ___ ___ ___

___ ___ ___ ___ ___ ___ ___ ___

___ ___ ___ ___ ___ ___ ___ ___

Distance, in miles (Begin) - (End) ___ ___ . ___ (8 9 10)

Minor Road Name ______________________

Intersection geometry ---------------------- ___ (11)

Tee (T) = 1
Cross (+) = 2

Angle of intersection ---------------------- ___ (12)

Right angle (T or +) = 1
Skewed (T or +) = 2

Type of control ---------------------------- ___ (13)

None = 0
Yield sign = 1
Stop sign = 2
Other = 3

Posted speed limit on major road ----- ___ ___ (14 15)

Number of luminaires within 200 feet ___ ___ (16 17)

Number of driveways within 200 feet ___ ___ (18 19)

Number of right turn lanes ___ (20)

Number of left turn lanes ___ (21)

Horizontal alinement (curvature)

Tangent (straight) = 1
Isolated curve = 2
Winding = 3

Major roadway alinement ---------------- ___ (22)

Minor roadway alinement ---------------- ___ (23)

Vertical alinement (grade)

Flat (< 1%) = 1
Moderate (1% - 4%) = 2
Steep (> 4%) = 3

Major roadway alinement ---------------- ___ (24)

Minor roadway alinement ---------------- ___ (25)

Sight distance, minor road ---------------- ___ (26)

Unrestricted (> 500 feet), both approaches = 1
Restricted (< 500 feet), one approach = 2
Restricted (< 500 feet), both approaches = 3

Figure 5. Form used to collect nonoperational intersection data in western New York State.

Calspan Field Services Inc.

Accident Surrogates Study

INTERSECTION Data: Volume

Recorded By: ____________________

Date Recorded: ____________________

Coded By: ____________________

Date Coded: ____________________

Site Type ---------------------------------- 2 (1)	County: ____________________
Card Number ---------------------------------- 2 (2)	Measurement Set (1-5) ------------------------- ___ (6)
Site Number ------------------ ___ (3) ___ (4) ___ (5)	Light --- ___ (7) Daylight = 1 Darkness = 2

Time Period		Major Road: ________						Minor Road: ________					
		Approaching from the:						Approaching from the:					
		North East			South West			North East			South West		
From	To	LT	Thru	RT	LT	Thru	RT	LT	Thru	RT	LT	Thru	RT
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												

Figure 6. Form used to collect volume data at intersections in western New York State.

Calspan Field Services Inc.

Accident Surrogates Study

Site Number: ______________________

County Name: ______________________

INTERSECTION Data: Volume

Time Period		Major Road: ______						Minor Road: ______					
		Approaching from the:						Approaching from the:					
		North East			South West			North East			South West		
From	To	LT	Thru	RT	LT	Thru	RT	LT	Thru	RT	LT	Thru	RT
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
AM PM	AM PM												
TOTALS -- OFFICE CODE ONLY													
Hours		LT	Thru	RT	LT	Thru	RT	LT	Thru	RT	LT	Thru	RT
_ 8 _ 9 _ 10		_ 11 _ 12 _ 13	_ 14 _ 15 _ 16 _ 17	_ 18 _ 19 _ 20	_ 21 _ 22 _ 23	_ 24 _ 25 _ 26 _ 27	_ 28 _ 29 _ 30	_ 31 _ 32 _ 33	_ 34 _ 35 _ 36 _ 37	_ 38 _ 39 _ 40	_ 41 _ 42 _ 43	_ 44 _ 45 _ 46 _ 47	_ 48 _ 49 _ 50

Figure 6. Form used to collect volume data at intersections in western New York State (continued).

Calspan Field Services Inc.

Accident Surrogates Study

INTERSECTION Data: Minor Road Delay

Recorded By: ______________

Date Recorded: ______________

Coded By: ______________

Date Coded: ______________

Site Type ---------------------------------- 2 (1)

Card Number -------------------------------- 3 (2)

Site Number ------------------- ___ ___ ___ (3 4 5)

Major Road Route No. ______________

Minor Road Name ______________

County: ______________

Measurement Set (1-5) ------------------------ ___ (6)

Weather ------------------------------------- ___ (7)

Clear = 1

Overcast = 2

Light fog/drizzle = 3

Time Period From	Time Period To	Approaching from the: East North — Stopped Delay in seconds (For each vehicle sampled)	No. Not Stopping	Approaching from the: West South — Stopped Delay in seconds (For each vehicle sampled)	No. Not Stopping
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				

Figure 7. Form used to collect minor road delay data at intersections in western New York State.

Calspan Field Services Inc.

Accident Surrogates Study

Site Number: ____________________

County Name: ____________________

INTERSECTION Data: Minor Road Delay

Time Period From	Time Period To	Approaching from the: East North — Stopped Delay in seconds (For each vehicle sampled)	No. Not Stopping	Approaching from the: West South — Stopped Delay in seconds (For each vehicle sampled)	No. Not Stopping
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				
AM PM	AM PM				

OFFICE CODE ONLY

Total Hours	(1) Total stopping __ __ __ (8 9 10); (2) Σ delays ________ sec.; (3) Avg. delay [(2) ÷ (1)] __ __ __ . __ __ (23 24 25 26 27)	__ __ __ (11 12 13) Total Not Stopping	(4) Total stopping __ __ __ (14 15 16); (5) Σ delays ________ sec.; Avg. delay [(5) ÷ (4)] __ __ __ . __ __ (29 29 30 31 32)	__ __ __ (17 18 19) Total Not Stopping
__ . __ __ (20 21 22)				

Figure 7. Form used to collect minor road delay data at intersections in western New York State (continued).

Calspan Field Services, Inc.
Accident Surrogates Study
Individual Accident Code Form

Coded by: ______
Date coded: ______
Checked by: ______

1. Site number — 1 2 3

2. Accident sequence number — 4 5

3. Locational clarity — 6
At site = 1
Unknown = 8

4. Location of accident — 7
Curve inner lane/roadside = 1
Curve outer lane/roadside = 2
Curve centerline area = 3
Intersection major road = 4
Intersection minor road = 5
Intersection center area = 6

5. Number vehicles in accident — 8

6. Highest injury level — 9
[Cols. 14-16, bottom]
No injuries = 0
Nonfatal injuries = 1
Fatal = 2

7. Manner of collision — 10 11
[Diagram]
Single vehicle in motion
Road departure = 01
Other S.V. = 02

2 or more vehicles in motion
Rear-end [1] = 03
Sideswipe [2,8] = 04
Left turn [3,0] = 05
Intersection [4] = 06
Right turn [5,6] = 07
Head-on [7] = 08
Other 2+ veh. = 09

8. Light condition — 12
[Box 4]
Daylight = 1
Dawn = 2
Dusk = 3
Dark-lit = 4
Dark-unlit = 5

9. Surface condition — 13
[Box 6]
Day [1] = 1
Other [2,3,4,5,10] = 2

10. Alcohol involvement — 14
[Boxes 19-22]
None = 0
Yes [Any code 2] = 2

11. Vehicle 1 travel direction — 15 16
[Box 23]
North [01] = 01
East [03] = 03
South [05] = 05
West [07] = 07

12. Vehicle 2 travel direction — 17 18
[Box 24]
North [01]
East [03]
South [05]
West [07]

13. Vehicle 1 travel roadway — 19
Curve inner lane = 1
Curve outer lane = 2
Intersection major road = 3
Intersection minor road = 4

14. Vehicle 2 travel roadway — 20
Curve inner lane = 1
Curve outer lane = 2
Intersection major road = 3
Intersection minor road = 4

Boxes specify location on police report;
Brackets specify code at that location.

Figure 8. Form used to code accident data for horizontal curves and intersections in western New York State.

Calspan Field Services Inc.
Accident Surrogates Study
Validation Phase
Curve Data: Nonoperational

Recorded By: ____________
Date Recorded: ____________
Coded By: ____________
Date Coded: ____________

Site Type ------------------------------ 1 (1)

Card Number --------------------------- 1 (2)

Site Number -------------- ___ (3) ___ (4) ___ (5)

State ____________

County --------------------------- ___ (6) ___ (7)

____	01	____	05
____	02	____	06
____	03	____	07
____	04	____	08

Reference Markers

Begin — End

DOT Volume (100's) ___ (11) ___ (12)

Direction of Survey ___ (13)

North = 1
South = 2
East = 3
West = 4
Both = 5

Curve Direction ___ (14)

North-South = 1
East-West = 2

Proceeding North-East Curve Turns ___ (15)

Right = 1
Left = 2

Middle Ordinate, in Inches ___ (16) ___ (17) .___ (18) ___ (19)

Length of Curve, in Feet (P.C. to P.T.) ___ (20) ___ (21) ___ (22) ___ (23)

Distance to Last Event, Outside Lane, in Miles (> 2 Miles, Code 3.00) ___ (24) .___ (25) ___ (26) ___ (27)

Landmark Information

Record nearest address and utility pole at or just beyond each end of the curve.

	Address	Pole Number
North or East	____	____
South or West	____	____

Other Identifying Landmarks

North or East ____________

South or West ____________

Figure 9. Form used to collect nonoperational horizontal curve data in Alabama and Ohio.

Calspan Field Services Inc.
Accident Surrogates Study
Validation Phase
Curve Data: Volume

Recorded By: ____________
Date Recorded: ____________
Coded By: ____________
Date Coded: ____________

Site Type ------------------------------ 1 (1)

Card Number ---------------------------- 2 (2)

Site Number -------------- ___ (3) ___ (4) ___ (5)

State ____________

County ____________

Time Period From	Time Period To	Outside Lane Total Vehicles	Inside Lane Total Vehicles
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		
AM PM	AM PM		

TOTALS — OFFICE CODE ONLY

Hours	Total Vehicles	Total Vehicles
___ (6) ___ . (7) ___ (8)	___ (9) ___ (10) ___ (11) ___ (12)	___ (13) ___ (14) ___ (15) ___ (16)

Figure 10. Form used to collect volume data for horizontal curves in Alabama and Ohio.

Calspan Corporation — Coded By: ______

Accident Surrogates Study — Date Recorded: ______

Validation Phase Accident Form — Checked By: ______

1. Site Type ------------------------------ 1 (1)

2. Card Number ---------------------------- 3 (2)

3. Site Number ---------------- ___ (3) ___ (4) ___ (5)

4. Total Accidents ------------------ ___ (6) ___ (7)

5. Totals per Collision Type

   Single Vehicle in Motion

   Road Departure --------------- ___ (8) ___ (9)

   Other S.V.I.M. --------------- ___ (10) ___ (11)

   Two or More Vehicles in Motion

   Rear-end ___ (12) ___ (13)

   Sideswipe or ___ (14) ___ (15)

   Left Turn or ___ (16) ___ (17)

   Intersection ___ (18) ___ (19)

   Right Turn or ___ (20) ___ (21)

   Head-on ___ (22) ___ (23)

   Other Two or More Vehicles ___ (24) ___ (25)

   Unknown Collision Type ___ (26) ___ (27)

6. Number of Outside Lane Accidents ___ (28) ___ (29)

7. Number of Wet Surface Accidents ___ (30) ___ (31)

[Check: Sum of all collision types in item 5 should be equal to the total in item 4.]

S (77) U (78) R (79) R (80)

Figure 11. Form used to code accident data for horizontal curves in Alabama and Ohio.

APPENDIX B: Data Collection Equipment

The equipment used to collect the field data for the rural two-lane highway sites located in western New York State is listed in this appendix. Also presented is the equipment used to collect the validation data in Alabama and Ohio.

EQUIPMENT USED IN WESTERN NEW YORK STATE

Three data collection teams were employed to collect the field data in western New York State. Each team consisted of two persons. The first team collected horizontal curve data, the second team collected intersection data, and the third team was assigned to collect data at either horizontal curves or intersections depending upon the progress of the other teams and the study schedule. As the equipment used to collect the data for horizontal curves was different than the equipment needed for intersection measurements, a list of the equipment used by each team is presented below.

Horizontal Curve Team

Quantity	Description
2	clipboards, note tablets, and pencils
1	Kustom Radar Model No. HR4 with tuning fork
1	radar battery
1	Transwave Distance Measuring Instrument Model No. NK-1201
1	Lietz 100-foot (30.5-m) tape measure
1	Denominator single-bank tally board
1	18-inch (46-cm) ruler
1	line level
1	stringline
1	wristwatch with second hand
2	marking crayons

Intersection Team

Quantity	Description
2	clipboards, note tablets, and pencils
1	Lietz 100-foot (30.5-m) tape measure
1	Denominator four-bank tally board
1	electronic digital display stopwatch
1	18-inch (46-cm) ruler
1	line level
1	stringline
1	wristwatch with second hand

Horizontal Curve and Intersection Team

Quantity	Description
2	clipboards, note tablets, and pencils
1	Kustom Radar Model No. HR4 with tuning fork
1	radar battery
1	Transwave Distance Measuring Instrument Model No. NK-1201
1	Lietz 100-foot (30.5-m) tape measure
1	Denominator four-bank tally board
1	electronic digital display stopwatch
1	18-inch (46-cm) ruler
1	line level
1	stringline
1	wristwatch with second hand
2	marking crayons

EQUIPMENT USED IN ALABAMA AND OHIO

Two persons were employed to collect the field data on horizontal curves in Alabama and Ohio. The equipment used in this effort is listed on page 23.

Quantity	Description
2	clipboards, note tablets, and pencils
1	Lietz 100-foot (30.5-m) tape measure
1	18-inch (46-cm) ruler
2	Denominator single-bank tally boards
2	wristwatches with second hand
2	marking crayons

APPENDIX C: Data Collector's Manual

The manual that was prepared for the exclusive use of the data collectors hired for this study is presented in this appendix. The document provides a written record of the definitions of each variable, the measurement technique, and the data collection processes for horizontal curves and unsignalized intersections in western New York State. A copy of the manual was given to each data collector, and used to supplement their formal classroom and field training. The manual was also used as a reference source throughout the data collection period.

INTRODUCTION

This procedures manual provides the basic information for collecting the field data for the developmental phase of the accident surrogates study. The purpose of this manual is to supplement the formal training program for data collection on rural horizontal curves and unsignalized intersections. These guidelines are provided for the benefit of the field personnel and should be used as a reference source throughout the data collection period.

This research is being conducted to determine if roadway geometric features and/or traffic operational characteristics can be used as surrogates for highway accident data. The results of the study are extremely important to highway officials and the motoring public as the findings could directly lead to more effective and efficient procedures for improving safety on rural highways.

Field data collection is a major and vital segment of the research. It is essential that the data collectors follow the systematic process outlined in this manual and during formal training to ensure consistent and reliable results.

Accident surrogates will be developed for (a) rural isolated horizontal curves and (b) rural unsignalized intersections located on two-lane State highways in an eight-county area of western New York State. The study sites were identified during the planning phase of this research and will be assigned to the data collection teams in accordance with the schedule prepared by the principal investigator. Procedures for collecting the field data for horizontal curves differ substantially from the procedures for unsignalized intersections. The data collection processes are outlined below.

DATA COLLECTION FOR HORIZONTAL CURVES

Each data collection team is made up of a two-person crew. The duties and responsibilities of the team members are outlined in table 1. Data collection at each site, including travel to and from the site, will be conducted during an 8-hour work day. In cases where the data collection effort cannot be completed in 1 day at a site, the remaining data should be collected at the beginning of the next work day. Due to the time required to travel to and from sites in the outlying counties, it is anticipated that a 10-hour work day will be initiated for data collection in these areas.

In most cases the data will be collected during daylight hours, i.e., 8 a.m. to 5 p.m., when the pavement is dry, however, some observations will be made at night. Observations should not be made when the pavement is wet as defined in the following rule of thumb. Because wet weather can affect the speed and path of travel of a vehicle, all data collection should be terminated during rain. Data collection should not be stopped if the rain droplets are widely scattered and when the moisture on the pavement does not produce a spray from the tires of passing vehicles. When rain has terminated data collection, the field activities should resume when the pavement has dried to the point that a spray is not produced by the tires of passing vehicles. Data should not be collected during snow or when snow or ice cover any part of the pavement.

Table 1. Responsibilities of the horizontal curve data collection team.

Observer	Responsibility
Team	1. Check equipment list and map daily to locate study sites.
	2. Verify site selection criteria and record locational information for accident data identification.
	3. Determine if the curve is isolated in one or both directions and prepare forms for data collection accordingly.
	4. Measure or observe, and record nonoperational data.
Member A	1. Observe and record volume and encroachment data for outside and inside lanes.
	2. Check completed form of Member B.
Member B	1. Measure and record isolated vehicle speeds at a point 250 feet (76.2 m) in advance of the beginning of the curve and at the curve midpoint for outside-lane vehicles only.
	2. Check completed form of Member A.

Preparing for Data Collection

Before leaving the office for the study location, all of the equipment and materials needed for data collection should be assembled. The list should be checked daily by both members of the team. The checklist includes the following items.

- Schedule and map of study sites.
- List of alternate study sites.
- Study monitor's telephone number.
- Company and personal identification.
- Data collection forms.
- Clipboards and tablets for making notes.
- Radar meter, batteries, and tuning fork.
- Distance-measuring instrument.
- 100-foot (30.5-m) tape measure.
- Stringline, line level, and ruler.
- Denominator tally board.
- Pencils.
- Marking crayons.
- Wristwatch with second hand.
- Safety vests.

After checking to ensure that the equipment is available and in working order, make certain that the location of the site scheduled for data collection is known. Also, check the list of alternate sites and confirm their location in case that data cannot be collected at the scheduled site.

The study monitor should be telephoned whenever the team is unsure of a procedure or when an unusual situation arises. Equipment failures should be reported promptly so repairs and/or alternative work can be scheduled.

Before leaving the office make sure that the vehicle is refueled and in good working condition. Calibrate the distance-measuring instrument using the marked distance.

Arriving at the Study Site

Upon arrival at the scheduled site, the team should check the roadside signing and mile-point markers to verify the locational information provided on the data forms. Report any discrepancies to the study monitor. The sites were selected in accordance with the selection criteria shown in table 2. The study monitor should be notified if the scheduled site does not meet these criteria. The primary responsibility of the data collection team, however, is to check the site for any recent construction or maintenance work such as resurfacing, pavement widening, etc. In the event that it is apparent that road work was recently completed or is being conducted when the team arrives at the site, notify the study monitor and prepare to collect data at the alternate site. Also, in the case of other circumstances such as concentrated or special police enforcement in the area or a traffic accident, the same procedure should be followed. In general, when in doubt, phone the study monitor for instructions.

Each observer should carry company and personal identification in case enforcement officials or property owners question the presence of the team. Always answer all questions courteously, but be brief as your main objective is data collection. Simply state that your job is to collect data for the research study and refer any further questions to the principal investigator.

Upon verifying that the site is appropriate for data collection, locate a place to park the vehicle off the roadway. Never park on or near the traveled surface. Residential driveways or field entrances usually are ideal for parking. Recall that if a major event such as a public street or commercial development exists, the curve is not isolated and data should not be collected. If possible, select a parking place where speed data can be obtained simultaneously for the approach and curve midpoints. Conceal the

Table 2. Site selection criteria for rural isolated horizontal curves.

Item	Criteria
Traffic Volume	1,500 vehicles per day minimum.
Posted Speed Limit	45 mi/h (72.4 km/h) minimum.
Degree of Curvature	2 degrees minimum.
Road Surface	Must be paved.
Isolatedness	There must be no major events, e.g., another horizontal curve, intersections of public streets or major commercial developments, railroad grade crossings, narrow bridges, etc., within 0.25 miles (0.40 km) of the beginning or end of the subject curve. An exception is curves which are isolated in one direction.
Recent Changes	There must have been no major operational or physical changes within the past 4 years, e.g., roadway construction, resurfacing, shoulder widening, etc.

vehicle as much as possible by pulling into an area with natural camouflage. Never use the radar meter in a manner that it can be easily seen by approaching motorists as it may alter a driver's choice of speed and path of travel. If an adequate parking place is not available, collect the data outside of the vehicle. It is important that each observer have a clear, unobstructed view of the curve during collection of the operational data.

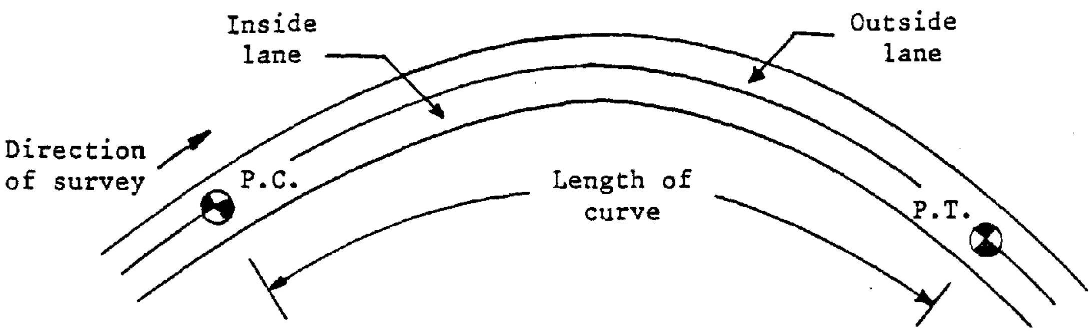
Collection of Nonoperational Data

After parking the vehicle, the first task is to collect the nonoperational or static data for the horizontal curve. As the data collection process for curves isolated in one direction is different from curves isolated in both directions, it is important that the team verify the type of curve selected for data collection.

For the purpose of this study, the pertinent horizontal curve terminology is shown in figure 12. The direction of the survey has been coded on the first page of the data form entitled "Curve Data: Nonoperational." The points on the curve marked P.C. and P.T. refer to the point of curvature (beginning of curve), and point of tangency (end of curve), respectively. The P.C. and P.T. are located in the field by having one team member stand approximately 300 feet (91.4 m) in advance of the curve and sight along the tangent (edgeline or centerline) to estimate the point where the curve begins. The other member of the team will use a lumber crayon to mark the P.C. and P.T. on the pavement. The length of curve is the distance between the P.C. and P.T. which is measured along the centerline. The location of the inside and outside lanes of the curve is dependent upon whether the curve bends to the right or left, as shown in figure 12, when entering the curve in the direction of the survey.

The horizontal curves shown in figure 12 are isolated in both directions, i.e., there are no major events or other horizontal curves within 0.25 miles (0.40 km) of the P.C. or P.T. of the curves. For curves isolated in both directions, all variables shown on the data forms must be collected.

Horizontal Curve Right



Horizontal Curve Left

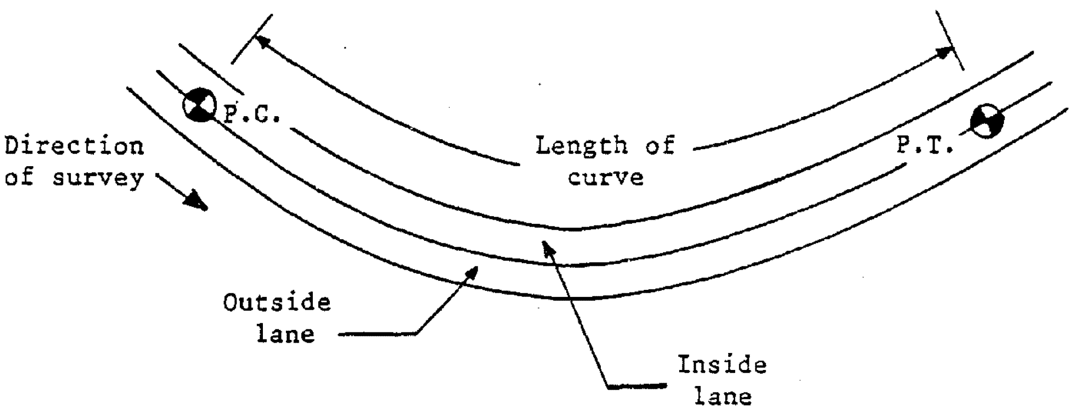


Figure 12. Horizontal curve terminology.

Due to the small number of curves in western New York State that are isolated in both directions, data will also be collected at a sample of curves which are isolated in only one direction. For curves isolated in one direction, there are no major events within 0.25 miles (0.40 km) prior to the P.C. of the curve. In the opposite direction, another horizontal curve exists as shown in figure 13. Sometimes the two curves are connected by a short tangent section. As given in the instructions in figure 13, cross out the appropriate variables before beginning data collection at curves isolated in one direction. Note that the variables which should be crossed out depend upon whether the curve bends to the right or to the left when entering the curve in the direction of the survey.

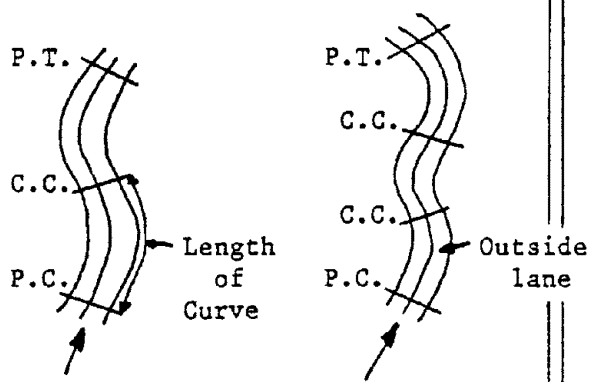
Because many of the variables are directional, i.e., inside lane and outside lane variables, it is essential that the team clearly identify the inside and outside lane at each curve. Always refer to figure 12 or 13 to be certain that the variables are collected for the appropriate lane.

The nonoperational data are recorded on a three-page data form entitled "Curve Data: Nonoperational." The left-hand portion of the first page of the form is filled out in the office. Do not code anything in this section or on any other section marked OFFICE CODE ONLY. If it appears that any of the information in the section is erroneous, make notes on the tablet and turn it in with the forms to the study monitor.

The definitions and procedures for collecting the nonoperational variables are given below.

<u>Curve direction</u>. Record whether the curve is located on a highway that runs predominantly north-south or east-west. As a general rule, odd-numbered highways, e.g., 33, 301, etc., run north-south while even-numbered roads run in an east-west direction. Directional signing is provided on most routes, e.g., Route 33 North, which should be used as an aid in determining curve direction.

If curve bends left, e.g.



Direction of Survey

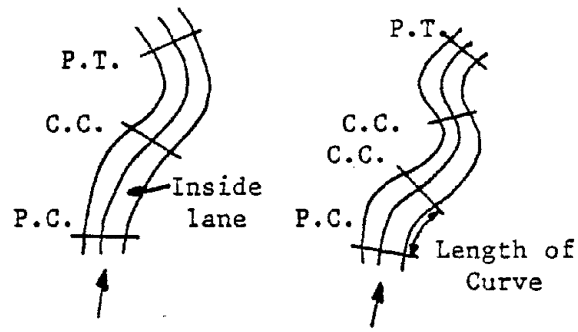
Then cross out on the data forms and record no data on variables pertaining to the inside lane, as noted below.

(a) Inside lane warning signs in advance of curve.

(b) Inside lane in-curve warning devices.

(c) Inside lane encroachments.

If curve bends right, e.g.



Direction of Survey

Then cross out on the data forms and record no data on variables pertaining to the outside lane, as noted below.

(a) Distance to last event, outside lane.

(b) Outside lane warning signs in advance of curve.

(c) Outside lane in-curve warning devices.

(d) Outside lane encroachments.

(e) Outside lane speed data.

Note: Length of curve in reverse and compound curves is from Point of Curvature (P.C.) to Change of Curvature (C.C.), as noted in the diagrams above. The end of the curve section is designated as the point of tangency (P.T.). The length of curve is measured along the centerline of the curve from the P.C. to the C.C.

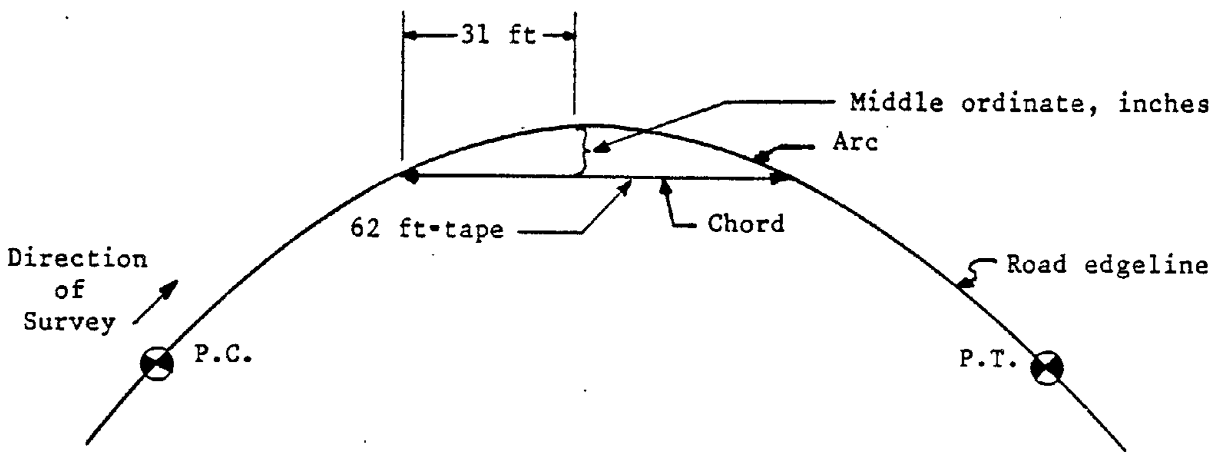
Figure 13. Data collection instructions for curves isolated in one direction.

Proceeding north-east, curve turns. Traveling north on a north-south highway or east on an east-west highway, record whether the curve bends to the right or left.

Middle ordinate. As shown in figure 14, the middle ordinate is the distance between the chord and arc measured near the center of the curve. The chord is a straight line joining any two points on an arc. The arc is the circular portion of the curve. The ordinate is measured by marking a 62-foot (18.9-m) section of chord using the 100-foot (30.5-m) tape and measuring the distance, in inches (cm) to the arc. The middle ordinate is measured with the ruler at a point 31 feet (9.5 m) from the intersection of the chord and arc. The arc is typically approximated by the painted edgelines or centerline. Never measure this distance in the middle of the paved surface for your personal safety and the safety of the motoring public. Always use the edge of the pavement. As in the case with all highway field work, always be alert when working near the highway and never attempt to cross or walk on the roadway when vehicles are approaching. A minimum of three measurements should be made at each curve and the average value should be recorded on the data form. In the event that any of the measurements vary by a half-inch (1.3 cm) or more, then a minimum of five measurements should be made and the average value recorded on the form. The measurements should be taken at different points near the center of the curve.

Length of curve. For curves isolated in both directions, the length of curve is the distance between the P.C. and the P.T. as shown in figure 12. When the curve is isolated in one direction, the length of curve is the distance between the P.C. and C.C. as shown in figure 13. The distance should be measured along the centerline of the road using the distance-measuring instrument. For safety reasons, never stop the vehicle in the roadway while taking this measurement.

Distance to last event, outside lane. For curves isolated in both directions, and curves isolated in one direction and bend to the left only, measure



Note: 1 inch = 2.54 cm
1 foot = 0.30 m

Figure 14. Measurement of middle ordinate.

and record the distance from the P.C. or P.T. of the curve to the nearest major event which could influence the speed or path of vehicles entering the curve. Examples of major events include the following:

- Another horizontal curve.
- Railroad grade crossing.
- Narrow bridge.
- Underpass or overpass.
- Intersection of a public street or major commercial development.

Note: A public street usually is designated with signs identifying the street name. Do not count low-volume commercial driveways or residential driveways as major events. As a rule of thumb, take a short volume count at the intersection or driveway. If more than two vehicles enter or leave the intersection or driveway during a 5-minute period the intersection is a major event.

The distance to last event should be measured with the distance-measuring instrument. Estimated distances using an odometer are not acceptable. In addition to the distance measurement, record the type of major event, i.e., horizontal curve, intersection, narrow bridge, etc., in the margin of the data form.

As noted in figure 13, this measurement is not obtained for a curve which is isolated in only one direction and bends to the right.

Shoulder width. Measure and record to the nearest foot, the average width of the shoulder on both sides of the roadway. For sites where wide variations in shoulder width occur, obtain a minimum of five measurements for each side of the road. The average of the 10 measurements made at the site should be recorded on the data form.

Grade. The grade of the roadway at the curve is estimated using the stringline, line level, and ruler by measuring the vertical fall in a given horizontal distance. For example, in a 5-foot (1.5-m) horizontal distance, a

1 percent grade has a vertical height of 5/8 inches (1.6 cm) and a 4 percent grade has a vertical height of 2-3/8 inches (6.0 cm). Measurements should be taken at the portion of the curve with the maximum or steepest grade. On curves with variations in vertical alignment, e.g., crest or sag vertical curves, a minimum of three measurements should be made throughout the curve and the maximum grade recorded. The information recorded on the data form should be: 1 for grades less than 1 percent, 2 for grades of 1 to 4 percent, and 3 for grades in excess of 4 percent.

Superelevation. Measurement of the vertical fall in a given horizontal distance will be used to determine the existing superelevation of the pavement. As shown on the data collection form, the horizontal distance, d, in feet (m), should be measured near the center of the curve using the stringline, line level, and ruler. The vertical distance, e, in inches (cm), is measured with the ruler. A minimum of three measurements should be made for each curve and the average value of e should be recorded on the form. Also record the distance, d, on the data form. As this measurement must be taken on the roadway, use safety vests and check to be certain that no vehicles are approaching. Obtain the measurements only when no traffic is approaching.

Warning signs in advance of curve. For curves isolated in both directions, the presence of various curve warning signs located prior to the P.C. and beyond the P.T. of the curve should be recorded on the data form for the inside and outside lanes. Check the data collection procedures in figure 13 to be certain which data are needed for curves isolated in one direction. If signs other than the ones shown on the form are present at the curve, describe or sketch the sign(s) on the data form. At the bottom of the form, record the advisory speed, if posted, on the curve. If no advisory speed is posted, code 99.

In-curve warning devices. As shown on the data form, count and record the number of curve warning devices located within the P.C. and P.T. of the curve for the inside lane and the outside lane.

Roadside hazard rating. As a team, review the roadside conditions within 15 feet (4.6 m) of the edge of the paved surface for each lane and record your consensus of the roadside rating using the following rating scale.

Roadside Condition	Rating
Clear, no fixed objects, fairly level terrain	1
Vegetation or yielding objects, no rigid fixed objects, fairly level terrain	2
Isolated rigid fixed objects, fairly level terrain	3
Ditch throughout most of curve, no embankment or side slope >3:1	4
Embankment on side slope >3:1	5
Numerous or continuous rigid fixed objects	6

Collection of Operational Data

After the nonoperational data are collected, the team should return to the vehicle and prepare for collection of the operational or dynamic data. It is imperative that the team members work together in this task because these data are being sampled simultaneously, although one observer is recording volume and encroachment data and the other is recording outside-lane speed data.

The operational data are collected in half-hour increments with 20 minutes of data collection followed by a 10-minute period that is used for recording the information, resetting the counters, and a break. The cycle is repeated each half hour until a minimum of 4 hours of data have been collected. The study monitor is the only person who can authorize a different data collection period.

Both data collectors are responsible for periodically checking their wristwatches to note the beginning and ending of the data collection cycle. To avoid errors, the observations should begin on a 5-minute increment. For example, begin data collection at 10:05 a.m., or 10:10, 10:15, etc. In this case the end of the 20-minute period would occur at 10:25 a.m., or 10:30, 10:35, etc. If for some reason it is necessary to take a break longer than 10 minutes, then begin the data collection period again on an even 5-minute mark after returning from the break. For example, suppose the team leaves at 11:35 a.m. and takes a 45-minute lunch break. When returning, the data collection should begin at 12:20 p.m.

Never terminate the data collection period prior to completing the 20-minute count. If an emergency occurs, simply terminate the count and do not record the data. Begin the next data collection period as soon as the problem has been eliminated.

The definitions and procedures for collecting the operational variables are given below.

Volume and encroachment data. The data form entitled "Curve Data: Volume & Encroachment" is to be used to record the volume and encroachment data. Use additional sheets as needed to record the data for the day.

The volume and encroachment data are to be observed and recorded on the tally boards during each 20-minute data collection period. Record the time period (beginning and ending of each count) along with the other data on the form. One member of the team will make these observations while the other member records speed data for isolated vehicles in the outside lane.

One set of counters on the tally board are designated for the volume count for each lane. The total number of isolated vehicles and vehicles in platoons in each lane during the counting period should be recorded. The other counters will be used to record centerline and edgeline encroachments for each lane.

An encroachment occurs when an isolated vehicle, i.e., a vehicle with a forward and backward headway of 9 seconds or more to the next vehicle, touches the centerline or edgeline with the tire within the limits of the curve. Intuitively, for the majority of observations at the site, a vehicle is isolated when no other vehicles are visible in the vicinity of the subject vehicle.

Outside-lane speed data. The outside-lane speed data are recorded on the form entitled "Curve Data: Outside Lane Speed." Only isolated vehicles, i.e., vehicles with a forward and backward headway of 9 seconds or more, should be selected for speed measurement. The data will be obtained using a radar meter, which must be checked daily with the tuning fork prior to data collection. To calibrate the radar meter, strike the edge of the tuning fork on a wooden surface, such as the edge of a clipboard, and hold the vibrating fork in front of the radar scope. The reading etched on the fork should correspond to the radar reading if the meter is accurate. If the two readings differ by more than 1 mph (0.6 km), the meter is in need of repair.

Vehicle speeds will be recorded at a point approximately 250 feet (76.2 m) prior to the P.C. of the curve for outside-lane vehicles only. Speed samples will also be collected near the curve midpoint for outside-lane vehicles. It is not necessary to measure the speed of the same vehicle at both the P.C. and curve midpoints. Be sure that only vehicle speeds are being measured and no phantom readings are taken. In cases where the curve length exceeds 500 feet (152 m), the observer may have to alternate between the P.C. and curve midpoint to obtain data for both locations.

It is important to reiterate the need for concealing the vehicle, radar, and data collectors during data collection. If concealment is not possible, do not collect data at the site. Bring the problem to the attention of the study monitor.

Completion of Data Collection

Following the data collection periods at a site, the team members should review their forms for errors, omissions, etc. Make sure the time is correctly entered for each period. Then the members should exchange forms. Each form should be reviewed for clarity and completeness. The data collection periods should be identical. Make sure the name, date, and weather information is recorded on the top of the forms and that each sheet is numbered when more than one operational data sheet is used.

DATA COLLECTION FOR UNSIGNALIZED INTERSECTIONS

The duties and responsibilities of the intersection team members are outlined in table 3. The data collection times and schedule closely parallel that for horizontal curves and this information will not be repeated in this section.

Preparing for Data Collection

Before leaving the office, the equipment and materials needed for data collection should be assembled. The list should be checked daily by both team members. The following items are essential.

- Schedule and map of study sites.
- List of alternate sites.
- Study monitor's telephone number.
- Company and personal identification.
- Data collection forms.
- Clipboards and tablets for making notes.
- Pencils.
- Stringline, line level, and ruler.
- Denominator tally board.
- Electronic digital display stopwatch.

Table 3. Responsibilities of the intersection data collection team.

Observer	Responsibility
Team	1. Check equipment list and map daily to locate study sites.
	2. Verify site selection criteria and record locational information for accident data identification.
	3. Measure or observe, and record non-operational data.
Member A	1. Observe and record directional traffic movements for each approach leg.
	2. Check completed form of Member B.
Member B	1. Measure and record stopped delay time of vehicles on minor street approaches.
	2. Check completed form of Member A.

- 100-foot (30.5-m) tape measure.
- Wristwatch with second hand.
- Safety vests.

After completing the checklist, make certain that the locations of the scheduled site and alternative sites are known. Report any difficulties to the study monitor including equipment failures.

Arriving at the Study Site

Upon arrival at the scheduled site, the team should check the directional guide signing and mile-point reference markers to ensure that the locational information is correct. All discrepancies should be reported to the study monitor.

Each of the study intersections were selected in accordance with the site criteria shown in table 4. Note on the tablet if the site does not meet these criteria. The primary responsibility of the data collectors, however, is to check the site for any recent changes such as the installation of a traffic signal, turn lane, or resurfacing. Also, recent construction or ongoing work should be reported to the study monitor before beginning data collection.

Collection of Nonoperational Data

After verifying that data collection can begin at the scheduled site, the vehicle should be parked off the roadway but within 300 feet (91.4 m) of the intersection if possible. In most cases, it is desirable to use the vehicle as a place to sit and observe the operational data.

The nonoperational data will be recorded on the data form entitled "Intersection Data: Nonoperational." The specific variables to be recorded are discussed below.

Table 4. Site selection criteria for rural unsignalized intersections.

Item	Criteria
Traffic Volume	Major roadway 1,500 vehicles per day minimum; minor roadway 100 vehicles per day minimum.
Geometry	Must be T (3-leg) or cross (4-leg) intersections. Y or jogged intersections are excluded.
Type of Control	Major roadway - No control. Minor roadway - No Control, Yield, or Stop.
Major Events	There must be no major events such as another public street or major commercial development, railroad crossing, narrow bridge, or other similar feature within 0.25 miles (0.40 km) of the subject intersection. Horizontal curves were not considered to be major events.
Recent Changes	There must have been no major operational or physical changes within the past 4 years, e.g. roadway construction, addition of turning lanes, resurfacing, etc.

Intersection geometry. Mark whether the intersection has three (Tee) or four (Cross) approach legs. Note that intersections with more than four legs should not be used for data collection.

Angle of intersection. Record whether the major and minor roads intersect at a right angle, i.e., 90 degree, or at an acute angle, i.e., skewed.

Type of control. Record the type of intersection control, i.e., none, yield, or stop, used on the minor road. No control should be used on the major road.

Posted speed limit on major road. Record the posted speed limit on the major road. Speed limit signs should be located on the major road within a 2 or 3 mile (3.2 or 4.8 km) radius of the minor road. If a speed limit sign cannot be located, record 98.

Number of luminaires. Observe and record the number of roadway luminaires located within 200 feet (61 m) of the intersecting roadways.

Number of driveways. Record the number of commercial and residential driveways located within 200 feet (61 m) of the intersecting roadways.

Right- and left-turn lanes. Record the total number of right- and left-turn lanes for each approach on the major and minor roadways and record these data in the appropriate spaces on the data form.

Horizontal alignment. For each intersecting roadway, record the type of horizontal curvature present at the intersection, i.e., tangent, isolated curve, or winding section.

Vertical alignment. Using the stringline, line level, and ruler, measure the steepest grade within 200 feet (61 m) of the intersection area for each approach and record the steepest grade on the data form. If there are variations in vertical alignment due to crest or sag curves, take a minimum of three measurements and record the steepest grade. The data are recorded separately for the major and minor roadways.

Sight distance from minor road. Record the available sight distance from each approach of the minor road in both directions along the major highway using 500 feet (152.4 m) as a guideline for distinguishing between unrestricted and restricted sight distance.

Collection of Operational Data

After the nonoperational data are collected, the team should immediately return to the vehicle or observation point to begin the operational data collection process.

Similar to the approach used for horizontal curves, a half-hour data collection cycle will be used with a 20-minute period for observation and a 10-minute period for recording the data and taking a break. A minimum of 4 hours of data will be collected at each intersection unless a different period is specified by the study monitor.

The operational data should be collected in accordance with the procedures outlined below.

Volume data. Directional traffic counts will be taken at the intersection during each 20-minute counting period. Right, left, and through movements will be recorded for each approach leg. The data will be collected using the tally board and recorded on the form entitled "Intersection Data: Volume." Be sure the counters are set back to zero after each counting period. One team member is responsible for collecting the volume data.

Minor road stopped delay. An electronic digital display stopwatch will be used to sample vehicle stopped delay on each approach of the minor road.

Minor road vehicles will be randomly selected and their actual stopped delay, i.e., when the wheels are not turning, will be measured. When the minor road volume is low, i.e., less than one entering vehicle per minute, it is possible to record stopped delay for every vehicle, however, under higher volume conditions, sampling is appropriate. Under high volume conditions, sample from different vehicles in the platoon. Do not always select the first vehicle in the stream as it will bias the results. Record the actual stopped delay, in seconds, on the data form entitled "Intersection Data: Minor Road Delay." Also, the number of vehicles that do not stop on the minor road approaches should be recorded.

Completion of Data Collection

After the operational data are collected, the team members should review their forms for completeness, then exchange forms with the other member for further review. Any errors or omissions should be corrected or identified, and brought to the attention of the study monitor. All data collection times, date of collection, and observer names should be clearly recorded on each form. The forms should be sequentially numbered when more than one form is used for each data collection variable.

APPENDIX D: Training Program for Data Collectors

This appendix provides a description of the formal training program that was presented to the data collectors who were hired to collect the field data in western New York State.

INITIAL TRAINING PROGRAM

A 6-day formal training program was developed to prepare the observers for field data collection. The six temporary personnel and the study monitor, who served as a backup data collector, received the training.

The first day of training was an orientation period. The principal investigator outlined the study objectives and scope, and gave each trainee a copy of the Data Collector's Manual which is presented in appendix C. Approximately half of the day was devoted to reading the manual which contained written instructions for data collection including the designation of responsibilities, preparations necessary for beginning data collection, verification of locational data and site criteria, detailed definitions of each variable, and procedures for collecting the nonoperational and operational data. The trainees were also given a copy of the data forms which are shown in appendix A. In the afternoon session, an overview of the equipment was presented. The presentation included background information, use, and calibration of the radar meters and the distance-measuring instruments.

The second day of training was divided into two parts. The morning session consisted of classroom lectures and discussion periods. The Data Collector's Manual, the data forms, and a blackboard were used as visual aids to illustrate highway design terminology and traffic measurement procedures. Based on the information given in the Data Collector's Manual, each variable was defined in class and illustrations were drawn on the blackboard to outline data collection techniques. Question and answer periods were held to ensure that the participants were grasping the key issues.

The afternoon session was conducted in the field on a sparsely used roadway near the training location. The trainees were placed in two-person teams and assigned specific measurement responsibilities. Assignments were alternated until each trainee was familiar with the measurements procedures. Specific tasks included calibration of the radar meters and distance-measuring instruments, proper use of the stringline, line level, and ruler to measure grade, use of the tape and ruler to determine degree of curve, estimation procedures for locating the beginning and ending points of a horizontal curve, and use of the tally boards to record traffic volumes. A group discussion was held in late afternoon to answer questions and resolve problem areas. The majority of the questions were related to the horizontal curve terminology and curve measurement techniques. One particular problem was confusion over identifying the inside and outside lanes of horizontal curves when entering the curve in the direction of the survey. Another problem concerned the procedure for measuring grade and superelevation, and simultaneously watching for oncoming vehicles. A third issue involved directional notation at intersections, e.g., traffic approaching from the north is traveling southbound. The issues related to definitions were resolved by referring to the Data Collector's Manual, and with blackboard illustrations. The measurement problems were accommodated through practice sessions held on the subsequent training days.

On the third day the data collectors were taken to a high-volume (approximately 15,000 entering vehicles per day) rural intersection and divided into two-person teams. Each team was guided through the process of collecting the nonoperational and operational data. The afternoon was devoted to data collection on a rural horizontal curve. The trainees had no problems collecting the intersection data, however, their performance at the curve site demonstrated the need for additional measurement practice. On the third day of training, one of the trainees continued to display characteristics that were hazardous to himself and motorists. As repeated warnings failed to initiate any modification in his behavior, he was terminated at the end of the day and replaced the next morning by another trainee.

Due to the difficulties and questions experienced during the first 3 days of training regarding horizontal curves, the fourth day was devoted entirely to data collection on two rural curves. The new trainee was given the orientation section of the training program in the morning, and joined the other trainees for the afternoon session. Particular attention was given to teaching the trainees how to distinguish between a curve isolated in only one direction and a curve isolated in both directions, and the different data collection requirements for each situation. Although the procedures were included in the Data Collector's Manual, the training sessions were devoted to providing the participants with data collection experience through practice. Collection of the operational variables, i.e., volume, encroachment, and speed data were particularly stressed at the two practice sites.

On the fifth day, the data collectors were divided into three permanent two-person teams. One team was assigned to collect data for horizontal curves, another team collected intersection data, and the third team was used for both curves and intersections. Specific data collection equipment, as shown in appendix B, was assigned to each team. The teams were sent to actual study locations, i.e., one curve and two intersections, with instructions to collect the field data. After a half day of data collection, the teams were alternated at the study sites and again requested to collect the data. At the end of the day, the data were compared and discrepancies brought to the attention of all team members. Errors in measurement procedures and variable terminology were identified through group discussions. Pertinent problems included the following items.

- How to determine the point of maximum grade at intersection approaches and in horizontal curves.
- How to identify the last major event for the outside lane of horizontal curves.
- Application of the roadside hazard rating to various conditions observed in the field.

These problem areas received additional emphasis during the next training session.

The final day of training was conducted similar to the procedure followed on the fifth day. Only minimal on-site suggestions were given by the instructor. The results of the data comparisons on the last day revealed that the trainees had developed a good knowledge of the measurement procedures and data variables, however, more on-site measurements were needed to increase the efficiency of the teams.

FOLLOW-UP TRAINING

Discussions with the observers during the first week of data collection revealed that some measurement procedures had not been correctly followed by several team members. The problems were resolved by having the teams repeat the data collection effort. Specific problems that were encountered included incorrect interpretation of how to measure grade at intersections, how to identify major events at horizontal curves, and what variables should be collected at curves isolated in only one direction.

Throughout the data collection period, periodic field inspections were made to identify other problem areas and to ensure the data were being collected in accordance with the procedures outlined in the Data Collector's Manual. No specific problems were found during the inspections.

In October 1984, a 6-hour night training session was held to examine the feasibility of collection the operational surrogates during darkness. The problems encountered are discussed in appendix H.

APPENDIX E: Accident Data Collection in Alabama and Ohio

This appendix describes the site selection and accident data collection processes employed for the horizontal curve sites in Alabama and Ohio.

Following completion of the developmental study in western New York State, a promising relationship between accidents and degree of curvature, traffic volume, and distance to last event was identified for isolated curves. To examine the validity of the relationship, accident and surrogate data were collected for 40 curves in Ohio and for 41 curves in Alabama.

The Ohio data were collected during July 1985 and the Alabama data were obtained during August 1985. Data collection at these curves in a short time frame was made possible by only collecting the three surrogates, i.e., degree of curvature, traffic volume, and distance to last event, which were found to be related to accidents in the New York sample. Two of the data collectors from the original six temporary employees obtained the validation data. The surrogate data were recorded on the forms shown in figures 9 and 10, appendix A, in accordance with the measurement procedures described in appendix C.

The 6-week period allocated for collection of the validation data included site selection, collection of the surrogate variables in the field, obtaining and processing the accident data, and coding the variables for analysis. A description of the site selection and accident data collection procedures is given below.

SITE SELECTION

The horizontal curves selected for analysis were identified in the field using the site selection criteria developed for western New York which are shown in table 2, appendix C. Candidate routes for site selection were chosen based on traffic volume and roadway maps furnished by Alabama and Ohio transportation personnel. Information collected at each site that met the selection criteria included county, route, curve begin and end milepost, and locational details, i.e., name and location of nearby intersections, bridges, and other landmarks. Additional site identification, e.g., utility pole numbers, route addresses, etc., were obtained during field data collection and recorded on the form shown in figure 9, appendix A.

The difficulties experienced in western New York State in finding isolated horizontal curves which meet the site selection criteria also surfaced in Alabama and Ohio. The major problems that created difficulties in identifying sites are listed below.

- Limited mileage of rural two-lane highways that meet the 1,500 vehicle per day minimum volume criterion.
- Proximity of the horizontal curves to developed areas and other major events such as another horizontal curve, public street intersection, narrow bridge, and railroad crossing.
- Limited number of curves in excess of 2 degrees.
- Recent roadway construction that may affect the surrogate-accident relationships.

The Alabama sites were found in an eight-county area primarily located south, west, and east of Montgomery. The Ohio curves encompassed a nine-county area encircling Columbus.

ACCIDENT DATA COLLECTION

Following site selection, the county, route, and milepost limits of each curve were submitted to the transportation officials in each State along with a request for accident data. The minimum elements requested for each reported accident are listed below.

- Date and time accident occurred.
- Type of collision, e.g., road departure, rear-end, sideswipe, left turn, etc.
- Number of vehicles involved.

- Direction of travel.
- Surface condition, e.g., dry, wet, snow, etc.

Accident data for a 3-year period were requested in each State. Three years of accident data were collected in Ohio, however, it was discovered during field data collection that only 2 years and 5 months of data were available from the Alabama Highway Department computer. As time did not permit a search through older records and reports, only 2 years of accident data were collected in Alabama. The accident reporting thresholds in each State remained constant for the time periods for which data were collected.

Alabama and Ohio transportation officials furnished a copy of their accident data codes and computer listings of accidents for the study sites. As the Alabama accident identification system pinpoints accidents between two selected mileposts, these data were processed immediately. An additional step was required to locate the curve termini on the Ohio listing because the printouts provide accident data for an entire route instead of an isolated spot.

Data Processing

Time constraints did not permit obtaining copies of accident reports and conducting a field review of each report as was done in western New York. Thus, it cannot be stated with absolute certainty that the accidents used and discarded were similar to those used in western New York. Two screening processes were employed, however, to ensure that the reported accidents most likely occurred at the curve sites. In the first step, all nonrelevant accidents, i.e., animal and pedestrian, were eliminated from the data base. Approximately 25 percent of the total reported accidents at the sites in both States were eliminated in this step. The majority of the accidents eliminated involved deer.

The second step involved a detailed review of the accident details and the locational and landmark information obtained during site identification and data collection. For example, in one case, a vehicle struck a bridge which was reported at a milepost that encompassed the curve area. Locational information, however, revealed that the bridge was actually located 0.32 mile (0.51 km) south of the end of the curve. In this case the accident was eliminated from the data base. In Ohio, a field trip was made to 11 sites to resolve questions concerning accident locations. Site visits were not necessary in Alabama because of the high number of curves without accidents and the fact that the locational information obtained during data collection was sufficient to resolve discrepancies. Less than 1 percent of the accidents were eliminated in both States as a result of this screening process.

Data Coding

Following the screening procedures, the accident data for each site was summarized and the totals were entered on the data collection form shown in figure 11 of appendix A. A manual check was made to ensure that the totals were transferred correctly from the computer listings. The data were keypunched directly from the coded forms for computer analysis.

APPENDIX F: Algorithms for Selected Derived Variables

Most of the derived variables in this study involved straightforward, simple derivations. For example, vehicles per hour on the minor road was obtained by summing the 20-minute approach volumes, multiplying the result by 3 to convert the counts to hourly estimates, and dividing by the number of counting periods to determine the hourly volume.

As the derivations for the salience of curve advanced warning and estimated annual average daily traffic were complex, the algorithms are presented in this appendix.

SALIENCE OF CURVE ADVANCED WARNINGS

The salience of curve advanced warning is a derived variable based on the type and number of warning signs located in advance of an isolated horizontal curve. The basic concept of the algorithm is that the greater the number or intensity of the curve warning signs, the higher is the salience.

The first step in the derivation is to add a point for each type of warning sign found at the curve. In the second step, additional points were added when the curve sign is oversize, or enhanced by a flashing beacon, or other signs warning of limited sight distance, no passing, etc. The variable was calculated separately for the inside and outside lanes of the curve.

A value of 1 was assigned to each type of advanced warning device present at the curve. A value of 0 was assigned for each device not installed at the curve. A description of the codes used in the algorithm is presented on page 57.

Code	Description
CURVSN	Standard curve ahead sign
WYNDSN	Winding road sign
SHARPSN	Sharp curve sign
REVERSN	Reverse curve sign
SPEEDSN	Speed advisory sign
BEACHSN	Flashing beacon sign
LARGESN	Oversize curve warning
SIGHTSN	Sight distance sign
NOPASSN	No passing zone sign
OTHRSN	Other warning sign

The first step was to calculate the value of the variable, ADVWARN, using the following equation.

ADVWARN = CURVSN + WYNDSN + SHARPSN + REVERSN

The variable, SALWARN, is the salience warning variable which was set equal to ADVWARN.

SALWARN = ADVWARN

The value of SALWARN was calculated in accordance with the following conditions.

If ADVWARN >0, then

SALWARN = SALWARN + SPEEDSN + BEACHSN + LARGESN + SIGHTSN + NOPASSN + OTHRSN

However, if ADVWARN >0 and the posted advisory speed, ADSPEED, was less than 36 miles per hour (58 km/h), then

SALWARN = SALWARN +1

A value of 99 was coded for ADSPEED if no advisory speed signs were found at the curve.

Example

A standard curve ahead sign and a no passing zone sign is installed in advance of an isolated rural curve. There are no advisory speed limits posted for this direction of travel.

The salience of curve advanced warning for the direction of travel is calculated as follows:

ADVWARN = CURVSN + WYNDSN + SHARPSN + REVERSN
= 1 + 0 + 0 + 0
= 1

Thus, SALWARN = 1.

As ADVWARN >0, then

SALWARN = SALWARN + SPEEDSN + BEACHSN + LARGESN + SIGHTSN + NOPASSN + OTHRSN
= 1 + 0 + 0 + 0 + 0 + 1 + 0
= 2

ESTIMATED ANNUAL AVERAGE DAILY TRAFFIC

An estimate of the annual average daily traffic (AADT) at the horizontal curve and unsignalized intersection study sites was made based on the vehicles per hour recorded during collection of the operational data. Using the method of least squares, linear regression equations were developed to estimate AADT. The independent variable used to develop the equations was vehicles per hour (veh/h) recorded at the study site. The dependent variable was AADT obtained from State traffic volume records.

The linear regression equations that were generated to predict AADT are shown below.

Site Type	Location	Regression Equation
Curves	Western New York State	Estimated AADT = 1090 + 10.36 (veh/h)
Curves	Ohio	Estimated AADT = 1685 + 9.48 (veh/h)
Unsignalized Intersections	Western New York State	Estimated AADT = 301 + 13.31 (veh/h)

AADT was not estimated for Alabama curves, where the observed vehicles per hour were not as strongly related to accident frequencies as were the State AADT recorded volumes. In Alabama, the AADT volumes supplied by the highway agency were used as the traffic volume measures.

Example

A data collector recorded 42 vehicles per hour on an isolated curve located on a rural two-lane highway in Ohio. An estimate of the AADT for the curve is derived from the following equation.

$$\text{Estimated AADT} = 1685 + 9.48\ (\text{veh/h})$$
$$= 1685 + 9.48\ (42)$$
$$= 2{,}083 \text{ vehicles per day}$$

APPENDIX G: Regression Models Tested in Hierarchical Analyses for Isolated Curves in Western New York State

Hierarchical multiple regression analysis was used to develop a predictive equation that accounts for the largest possible variance in the accident rates. The results of the hierarchical analyses for the isolated curves in western New York State is presented in this appendix.

Shown in table 5 are the code names and descriptions of variables examined in the analyses. The models and related statistical information are given in tables 6 through 9.

Table 5. Code names for variables examined.

Code	Description
ADTEST	AADT estimated from vehicles per hour
DEGCURV	Degree of curvature
LSTEVNT	Distance to last major event, outside lane
GRADE	Vertical alignment
KEYENCR	Rate of encroachments, centerline of outside lane and edgeline of inside lane
SPEDRDO	Approach speed - midcurve speed, outside lane average
DEGCRVSQ	$(\text{DEGCURV})^2$
LSTVNTSQ	$(\text{LSTEVNT})^2$
KEYENSQ	$(\text{KEYENCR})^2$
DEGADT	DEGCURV x ADTEST
ADTLST	ADTEST x LSTEVNT
DEGRAD	DEGCURV x GRADE
ADTENC	ADTEST x KEYENCR
ADTSPD	ADTEST x SPEDRDO

Table 6. Models tested for predicting curve total accidents per million vehicles.

			Test for Added Term				
Model No.	Terms in Model	R^2	Comparison Model	ΔR^2 With Comparison	F for ΔR^2	d.f.	Signif. of F
1	ADTEST, DEGCURV	0.1884	--	0.1884	4.88	2,42	$p < .05$
2	DEGADT	0.2096	--	0.2096	11.41	1,43	$p < .005$
3	ADTEST, DEGCURV, DEGCURVSQ	0.2312	1	0.0428	2.28	1,41	$p > .10$
4	ADTEST, DEGCURV, DEGADT	0.2169	1	0.0285	1.49	1,41	$p > .10$
5	DEGADT, LSTEVNT (0 intercept)	0.2567	2	0.0471	2.66	1,42	$p > .10$
6	DEGADT, ADTLST (0 intercept)	0.2779	2	0.0683	3.97	1,42	$p < .10$
7	ADTEST, DEGCURV, DEGADT, LSTEVNT	0.3728	4	0.1559	9.94	1,40	$p < .01$
8	DEGADT, ADTLST, GRADE (0 intercept)	0.2946	6	0.0167	0.97	1,41	$p > .10$
9	DEGADT, ADTLST, GRADE, DEGRAD (0 intercept)	0.3117	6	0.0338	0.98	2,40	$p > .10$
10	ADTEST, DEGCURV, DEGADT, LSTEVNT, KEYENSQ	0.3815	7	0.0087	0.55	1,39	$p > .10$
11	ADTEST, DEGCURV, DEGCURVSQ, DEGADT	0.2837	3	0.0525	3.01	1,40	$p < .10$
12	ADTEST, DEGCURV, DEGCURVSQ, DEGADT, LSTEVNT	0.4212	11	0.1375	9.26	1,39	$p < .01$

Note: Models were evaluated not only by the significance of the ΔR^2 added, but by the significance of the individual regression coefficients in the model (not shown).

Table 7. Models tested for predicting curve road departure accidents per million vehicles.

Model No.	Terms in Model	R^2	Test for Added Term: Comparison Model	ΔR^2 With Comparison	F for ΔR^2	d.f.	Signif. of F
1	ADTEST, DEGCURV (0 intercept)	0.2483	--	0.2483	14.20	1,43	$p < .001$
2	DEGADT	0.2881	--	0.2881	17.40	1,43	$p < .001$
3	DEGADT, LSTEVNT (0 intercept)	0.3470	--	0.3470	22.85	1,43	$p < .001$
4	DEGADT, ADTLST (0 intercept)	0.3646	--	0.3646	24.67	1,43	$p < .001$

Table 8. Models tested for predicting curve total accidents per million vehicles for operational variables only.

Model No.	Terms in Model	R^2	Test for Added Term: Comparison Model	ΔR^2 With Comparison	F for ΔR^2	d.f.	Signif. of F
1	ADTEST	0.0448	--	0.0448	2.02	1,43	$p > .10$
2	ADTEST, KEYENCR	0.1420	--	0.1420	3.48	2,42	$p < .05$
3	ADTEST, KEYENCR, SPEDRDO	0.1699	2	0.0279	1.38	1,41	$p > .10$
4	ADTENC	0.1430	--	0.1430	7.18	1,43	$p < .05$

Table 9. Models tested for predicting curve road departure accidents per million vehicles from operational variables only.

Model No.	Terms in Model	R^2	Test for Added Term: Comparison Model	ΔR^2 With Comparison	F for ΔR^2	d.f.	Signif. of F
1	ADTEST	0.0362	--	0.0362	1.62	1,43	$p > .10$
2	ADTEST, KEYENCR	0.1282	--	0.1282	3.09	2,42	$p < .10$
3	ADTEST, KEYENCR, SPEDRDO	0.1598	2	0.0316	1.54	1,41	$p > .10$
4	ADTENC	0.1138	--	0.1138	5.52	1,43	$p < .05$

APPENDIX H: Collecting Surrogates Data at Night

Since some highway engineers may be interested in finding surrogates for night accidents, operational data were collected during darkness for three curves and three intersections. The purpose was not to collect data for statistical analysis, but to gain some insight into the feasibility of collecting night data. (Nonoperational data, of course, need be obtained only during daylight hours.) The following points were learned.

- Collecting curve traffic volume and speed measurements is more difficult at night, because it is not always possible to find a safe observation point on some curves. The data collectors suggested using a tripod-mounted radar gun.
- Centerline and edgeline encroachments cannot be perceived at night.
- The intersection operational data, i.e., directional traffic volumes and stopped delay, can be collected as readily during darkness as during daylight.
- Observer headaches due to oncoming headlights became a problem on the darker, more secluded curves. The data collectors suggested dark glasses as a possible remedy.