

MAR 05 1974

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**A QUESTIONNAIRE FOR ANALYSIS
OF DRIVER-VEHICLE FACTORS CONTRIBUTING
TO SELECTED TRAFFIC ACCIDENTS**

Craig M. Jorgeson
Rudolf G. Mortimer

*Highway Safety Research Institute
University of Michigan
Ann Arbor, Mich. 48105*

December 10, 1973

Project No. 329330
Motor Vehicle Manufacturers Association
320 New Center Building
Detroit, Michigan 48202

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ABSTRACT

A questionnaire was developed to evaluate driver-vehicle factors in the pre-crash phase. Driver, vehicle, and environmental faults were identified, and the information needed to avoid the crash was determined. Twenty Multi-Disciplinary Accident cases were evaluated by 14 raters and the information needed by drivers to have aided them in avoiding the crash were categorized as: (1) warning of impending vehicle failure, (2) training in vehicle-handling, (3) driver education of accident predisposing situations, (4) knowledge of the distance and relative speed with respect to other vehicles or objects, and (5) road signing and hazard marking. Appropriate countermeasures can be taken to reduce vehicle accidents based on these information needs.

High rater response consistency and discrimination among the characteristics of the cases was obtained. Raters were able to use the questionnaire reliably with little training.

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ACKNOWLEDGEMENTS .

We are pleased to acknowledge the assistance of L. Segel, Head, Physical Factors Department and R. Scott, Systems Analysis Department, during development of the questionnaire.

S. Sturgis aided in some of the data collection and analyses.

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INTRODUCTION

The aims of this project were to develop a simple means of evaluating the driver-vehicle factors in the pre-crash phase of collisions, to structure hypotheses of driver-vehicle performance failures, and to suggest appropriate countermeasures to prevent accidents from occurring.

In order to obtain our objective it was first necessary to determine the circumstances leading up to the accident (the pre-crash phase). These were the circumstances we sought to change so the accident would never occur. Consequently, we did not look at the history of accidents beyond the initial collision, thus excluding occupant injury, secondary crashes, safety device effectiveness, and vehicle damage. Numerous studies are available of these aspects, which are emphasized in current multidisciplinary accident investigation (MDAI) team reports. A review of previous attempts to evaluate the pre-crash phase of collisions was first conducted.

Cautiousness is emphasized in investigating accident causation and reconstruction. In The Causes and Prevention of Road Accidents (Cohen & Preston, 1968) the writers stated "it is generally pointless to consider the 'cause' of an accident or even the 'causes,' because some of the important factors are still likely to be overlooked, but it is possible and useful to consider how accidents can be prevented." Baker (1960) points out that the information available, the ability to recognize signs, the knowledge of basic principles, and the skill and experience of the investigator determine how accurately it is possible to estimate pre-crash variables such as speed or position.

The task of accident causation and reconstruction is simplified somewhat by division into three categories - the driver, the vehicle and the environment. The percentage of accidents attri-

butable to each of these factors varies from one report to another and depends on the subset of the accident population being investigated, the purpose of the investigation, and the experience and bias of the investigator.

In a Summary of 1968-1970 Multi-disciplinary Accident Investigation Reports (1972) a total of 448 cases were analyzed. In those cases where information processing failure was reported on the part of the driver, 23% were perception/comprehension failures, 52% were decision failures, and 25% were action errors. The primary reasons for these driver behaviors were consumption of alcohol (156 cases), inattention or distraction (83 cases) physical incapacitation (32 cases), driving inexperience (25 cases), and risk-taking behavior (147 cases).

Vehicle factors were reportedly much less involved than human factors. Brake (27 cases) and tire (51 cases) failures were most frequent followed by improper or inadequate maintenance (17 cases). Environmental factors contributed to collisions slightly more frequently than vehicle factors. Primary factors were wet pavement (70 cases), inadequate signing (34 cases), inadequate roadway maintenance (34 cases), and inadequate sight-distance (31 cases).

In another study the driver was also most often found to be the causal factor in an accident. Fifty-nine percent of accidents investigated by Clayton (1971) were attributed to driver errors such as failure to look or excessive speed. Another study (King, 1960) attributed 70% of accidents to human causal factors. Blossom (1958) felt that the underlying causes of accidents are not drunken driving, speeding, etc., but anxiety, preoccupation, etc. According to Ross (1960) the two main reasons accounting for unawareness of a collision course are delayed perception and erroneous prediction. Thedie (1958) discusses the probability of an accident occurring based on the given circumstances at a given moment and their probability of contributing to an accident.

A study of employees of the Toyota Motor Company (Shingui, 1971) who were involved in traffic accidents, concluded that 96% of direct causes were human error, primarily errors of perception rather than information, judgment or action by the driver with greatest responsibility for the accident; 2% were vehicle malfunctions; and 2% were due to environmental factors. In terms of indirect causes, 76% were mostly due to misjudgment by the driver that the other vehicle would stop; 11% to vehicle malfunctions, with indistinct brake lamps being the most frequent cause; and 13% to environmental factors such as visual obstructions. A lack of mutual communication occurred in 92% of the accidents involving more than one vehicle. Rear-end collisions were most numerous, followed by side contact. In comparing the accident involved group with a non-accident involved group, the accident involved group scored lower on forecast ability, positiveness for work, humanity, observance of rules, and self-controllability. The author concluded that 60% of all accidents are caused by unconscious psychological processes while only 40% can be attributed to conscious behavior.

The Baylor College of Medicine (Finch, 1971) gave psychological tests to drivers involved in accidents. It was reported that of the 22 (44%) judged to have abnormal personalities, 20 were ticketed. Of the 28 drivers diagnosed as psychologically normal, only five were judged at fault in the crash. The study concluded that an individual with a poor psychiatric diagnosis is more likely to be at fault in a crash.

The same study found that vehicle defects contributed to two (4%) accidents in automobiles less than two years old. However, a previous study (Finch & Smith, 1970) with vehicles three years and older found 76% had defects which caused or contributed to a crash. The defects found on these older cars were a product of subsystem degradation through prolonged use.

Road and environmental factors which the study reported as being contributory to accidents were: inadequate or absent traffic markings or signals, faulty street surfaces or shoulders with rigid objects too close to the roadway, inadequate coefficient of friction, obstruction of vision, poor traffic funneling, and fog. These factors were involved in 58% of the cases.

Some other factors observed in this study during the pre-crash phase were: traffic patterns and conditions, assumptions made by drivers, points on the road where danger of collision was first recognized, decisions and subsequent actions by drivers, obstructions to adequate viewing, distractions (in and outside the vehicle), and braking and steering activities of drivers.

Another study of 50 accidents (Fairchild - Hiller, 1968) found the causal factors in descending order of importance to be vehicle failure, street or highway failure, driver incompetence, and deliberation based on malice or physical depression.

White (1969) devoted an entire book to mechanical design defects and mechanical failures. Among the topics discussed are investigating procedure, accident reconstruction, tires, payload limits, and brakes.

The Highway Safety Foundation (1971) reviewed 390 multidisciplinary accident investigations and found 37 were caused by vehicle factors. Each vehicle factor was dichotomized into whether the "failure" or "accident productive feature" was "foreknowable" or "unforeknowable." "Foreknowable" factors are a subset wherein the capability for manifestation can be recognized by either: (1) analysis of vehicle design, manufacture, or use; or (2) formal or informal vehicle inspection. Examples of "foreknowable" factors in the brake system would be: low fluid level, maladjustment, or glazed linings. "Unforeknowable" factors are defined as "a subset of vehicle factors not contained in the 'foreknowable' vehicle factors." An example of an unforeknowable" factor in the brake system would be a ruptured hose.

Vehicle factors classified by foreknowledge and capability (i.e., the manner in which the problem originates) are shown in Table 1. From the table it is observed that most of the vehicle factors in accidents were foreknowable, and furthermore could be corrected prior to private ownership. This system of analysis of vehicle factors is used to suggest the cost-benefit of particular countermeasures, such as periodic vehicle inspection.

Support for the HSF report is given by two other articles suggesting that the primary vehicle defect causing accidents was degraded brakes (Finch & Smith, 1970), and that motor vehicle inspection saves lives (Buxbaum & Colton, 1966).

In Causes and Effects of Road Accidents (1969) each of the drivers involved in an accident was assessed to determine if he had made an error in his behavior on the road. The model for good behavior was the British Highway Code, and any contravention of the code was deemed to be an error. The error categories decided upon were those based on sensing and information processing: (1) failure to look (FL), (2) error of misperception (M), and (3) unknown perceptual error (UP). If the driver perceived correctly all the relevant sensory cues then one or more of the following errors of decision and implementation could have occurred: (4) excessive speed with regard to conditions (ES), (5) panic reaction (PR), (6) other error of decision (OED), (7) error of implementation (I), (8) other errors (OE), (9) unknown errors (UE), and (10) no error (NE). Table 2 indicates the incidence of error categories for the driver sample, and Table 3 shows the distribution of errors based on the maneuver. In Table 4 the proportion of error and non-error road users in each group was compared with the proportion expected in terms of the total sample. The hypothesis was that those maneuvers in which the road user had the right-of-way would be less likely to be associated with an error and vice versa. Going through a junction (intersection)

TABLE 1. Vehicle Factors Classified According to Foreknowledge and Capability (from Highway Safety Foundation 1971).

Capability	Foreknowledge	
	Foreknowable	Unforeknowable
Intrinsic	Exterior: Color (1) *	
	Lighting System: Size, Design (2)	
	Mirror System: Blind Spot (2)	
	Acceleration System: High Idle Speed (1) Pedal Stuck (1)	
Emerging	Brake System: Leaks (5) Maladjustment (5) Low Fluid Level (2) Broken Parts (1) Glazed Lining (1)	
	Exhaust System: Leaks (1)	
	Lighting System: Broken Lens, Bulb (2) Maladjustment (1)	
	Mirror System: Maladjustment (1)	
	Steering System: Looseness (2)	
	Suspension System: Worn Shock Absorbers (2)	
	Tires: Highly Worn Tread (8)	
Instantaneous	Steering System: Tie Rod Separation (1)	Acceleration System: Engine Stall (1)
	Suspension System: Elevated Rear-end (1)	Brake System: Ruptured Hoses (2)
	Tires: Manner of Use (3)	

*Note: Frequencies are shown in parentheses.

Intrinsic Factors are defined as: "The subset of vehicle factors containing element characteristics wherein the capability for assuming the role of a vehicle factor is found uniformly throughout the life of the vehicle."

Emerging Factors are defined as: "The subset of vehicle factors containing element characteristics wherein the capability for assuming the role of a vehicle factor is nonuniform throughout the life of the vehicle and where the degree of capability changes in a continuous rather than discrete manner to the extent that indicative measurements are possible within present technology."

Instantaneous Factors are defined as: "The subset of vehicle factors not belonging to either the subset of emerging vehicle factors or the subset of intrinsic vehicle factors; a subset of vehicle factors containing element characteristics wherein the capability for assuming the role of a vehicle factor fully develops after the vehicle is in use and essentially in an instant of time."

TABLE 2. Incidence of Error Categories for
Total Road-User Sample (from Causes
and Effects of Road Accidents, 1969).

	No.	%
Failure to Look	45	13.0
Error of Misperception	29	8.3
Unknown Perceptual Error	15	4.3
Excessive Speed with Regard to Conditions	40	11.5
Panic Reaction	14	4.0
Other Error of Decision	30	8.6
Error of Implementation	0	0.0
Other Errors	3	0.9
Unknown Errors	30	8.6
No Errors	136	39.1
Not Known	6	1.7
Total	348	100.0

TABLE 3. Error Group and Road-User Maneuver (from, Causes and Effects of Road Accidents, 1969).

Maneuver	Failure to Look	Error of Misperception	Unknown Perceptual Error	Excessive Speed with Regard to Conditions	Panic Reaction	Other Error of Decision	Other Error	Unknown Error	No Error	Total
Going ahead, no junction	13	9	4	32	6	5	1	22	65	157
Going through junction	11	4	1	2	3	2	2	2	36	63
At junction turning left	3	-	-	1	1	1	-	-	3	9
At junction turning right	10	8	4	-	2	4	-	3	10	41
Overtaking	1	8	2	5	2	12	-	3	12	45
U-turn	3	-	2	-	-	1	-	-	-	6
Merging into stream	-	-	-	-	-	-	-	-	3	3
Stopping to park	-	-	1	-	-	1	-	-	-	2
Stopping at hazard	-	-	-	-	-	-	-	-	2	2
Stopping temporarily delayed	-	-	-	-	-	1	-	-	3	4
Pedestrian maneuver	4	-	1	-	-	3	-	-	3	11
Total	45	29	15	40	14	30	3	30	137	343

TABLE 4. Error/Non-Error Proportion by Road User Maneuver
(from, Causes and Effects of Road Accidents, 1969).

Maneuver	Error	Non-Error	Sig. Level
Going ahead, no junction	92	65	NS
Going through a junction	27	36	1%
At junction turning left	6	3	NS
At junction turning right	31	10	5%
Overtaking	33	12	NS
U-turn	6	0	NS
Merging into stream	0	3	NS
Stopping to park	2	0	NS
Stopping at a hazard	0	2	NS
Stopping temporarily delayed	1	3	NS
Pedestrian maneuver	8	2	NS
Total	206	136	

TABLE 5. Human Causal Factors by Error Type (from, Causes and Effects of Road Accidents, 1969).

Behavior	Failure to Look	Error of Misperception	Unknown Perceptual Error	Excessive Speed with Regard to Conditions	Panic Reaction	Other Error of Decision	Other Error	Unknown Error	Total	Percent
Pre-collision state	6	6	-	2	2	1	2	9	28	12.8
Lack of knowledge of site	1	2	-	2	2	-	-	-	7	3.2
Lack of knowledge of vehicle	1	-	-	1	-	-	-	-	2	0.9
Lack of driving experience	1	-	-	-	-	1	-	-	2	0.9
Visual factors	-	3	-	-	-	-	-	-	3	1.4
Preoccupation/distraction	25	1	-	-	-	-	-	1	27	12.3
Set	-	7	-	-	-	2	-	-	9	4.1
Pressure/hurry	-	-	-	1	-	-	-	-	1	0.5
No factors	13	7	8	19	3	17	-	7	74	33.8
Not known	6	7	7	15	8	9	1	13	66	30.2
Total	55	33	15	40	15	30	3	30	219	100.0

N.B. Some errors were associated with several causal factors.

was unlikely to involve an error, whereas turning right at a junction from the left-hand lane in England, and making a U-turn were likely to involve committing an error. The human causal factors by error type are shown in Table 5.

The following results of vehicle causal factors were found. Limitations in forward vision occurred in 17% of accident involved vehicles, especially in urban areas. Twenty percent of night accidents involved some vehicle lighting deficiency (in England parking lights only are used in the cities). Causal braking factors appeared in 5% of the vehicles, having a higher incidence in commercial vehicles. Steering was a causal factor in 3% of cases. Although over 40% of the vehicles had tire pressure deviations, tire pressure was considered a causal factor in only 7% of cases. Tire tread was less than 1/16 inch on at least one tire in one quarter of all vehicles, and lack of tread was evaluated to be a causal factor in 5% of crashes.

The primary environmental causal factors were sight-distance restrictions (25%) and low pavement-tire friction (16%).

In Accident Cause Analysis (Perchonok, 1972) a system was developed to describe the process of accident generation. A form for coding the causal structure of accidents from diagrams and narratives of accidents (Table 6) was developed. The proportion each critical event contributed to the total sample of accidents is shown in Table 7. While the critical event described the activity which produced the critical condition, the critical reason described why the driver/vehicle behavior occurred. The proportion each critical reason contributed to the total sample of accidents is shown in Table 8. Vehicle breakdowns accounted for 4% of the culpable involvements. It can be noted that driver breakdowns accounted for approximately 65% more culpable accident involvements than did vehicle breakdown. Culp-

TABLE 6. Items Used for Coding the Events Leading to a Crash
(from Perchonok, 1972).

1. <u>Accident #</u>		7. <u>Target Location (1)</u>		Compulsory:	
2. <u>Subject #</u>		Forward	01	External	11
3. <u>Prior Event (1)</u>		Right Front	02	WP-Over R	12
Continue	02	Right	03	WP-Phant	13
Cont. steer angle	03	Right Back	04	WP-NAC	14
Start	04	Back	05	Secondary	15
Stop	05	Left Back	06	Logistic	16
Accelerate	06	Left	07	Park	17
Decelerate	07	Left Front	08	Voluntary	18
Start-Back	08	NA	98	NAC	99
Direction Change:		NAC	99	12. <u>Critical Source (2)</u>	
Steer Ang. R	09	8. <u>Target Path (1)</u>		Veh. No.	0
Steer Ang. L	10	Same	01	Nonacc. veh.	10
Both R	11	Opposite	02	Ped.	11
Both L	12	Par-Same	03	Bike	12
NAC	13	Par-Opp	04	Train	13
NA*	98	Intersecting:		Animal	14
NAC**	99	RF	05	Object	15
4. <u>Prior Reason (2)</u>		R	06	Sign	16
V. Bkdn.	01	RB	07	Nonexist. sign	17
D. Bkdn.	02	LB	08	Signal	18
P. Contr.	03	L	09	Road	19
I. Contr.	04	LF	10	Surface defects	20
IF:		NAC	11	Cover	21
Pres.	05	None	12	NA	98
Sens.	06	NA	98	NAC	99
Rec.	07	NAC	99	13. <u>Source Location (1)</u>	
Proj.	08	9. <u>Subject Path (1)</u>		Forward	01
Conf.	09	Forward	01	RF	02
NAC	10	R. Curve	02	R	03
Compulsory:		R. Turn	03	RB	04
External	11	L. Turn	04	B	05
WP-Over R	12	L. Curve	05	LB	06
WP-Phant	13	Back	06	L	07
WP-NAC	14	R. Back	07	LF	08
Secondary	15	L. Back	08	NA	98
Logistic	16	Ends	09	NAC	99
Park	17	Mot. Imm.	10	14. <u>Source Path (1)</u>	
Voluntary	18	None	11	Same	01
NA	98	NAC	99	Opposite	02
NAC	99	10. <u>Critical Event (1)</u>		Par-Same	03
5. <u>Prior Source (2)</u>		Imposed Upon	01	Par-Opp	04
Veh. No.	0	Continue	02	Intersecting:	
Nonacc. veh.	10	Cont. steer angle	03	RF	05
Ped.	11	Start	04	R	06
Bike	12	Stop	05	RB	07
Train	13	Accelerate	06	LB	08
Animal	14	Decelerate	07	L	09
Object	15	Start-Back	08	LF	10
Sign	16	Direction Change:		NAC	11
Nonexist. sign	17	Steer Ang. R	09	None	12
Signal	18	Steer Ang. L	10	NA	98
Road	19	Both R	11	NAC	99
Surface defects	20	Both L	12	15. <u>Culpability (1)</u>	
Cover	21	NAC	13	Culp	1
NA	98	NAC	99	Culp or Contrib.	2
NAC	99	11. <u>Critical Reason (2)</u>		Contrib	3
6. <u>Target (1)</u>		V. Bkdn.	01	Contrib. or	
Veh. No.	0	D. Bkdn.	02	Nonculp	4
Ped.	10	P. Contr.	03	Nonculp	5
Bike	11	I. Contr.	04	NAC	9
Train	12	Info. Failure:		16. <u>Causal Details</u>	
Animal	13	Pres.	05		
Object	14	Sens.	06		
Road Dep.	15	Rec.	07		
Roll	16	Proj.	08		
NAC	99	Conf.	09		
		NAC	10		

* Not Applicable
** Not Able to Classify

TABLE 7. The Proportion Each Critical Event Contributed to the Total Sample of Accidents (from Perchonok, 1972).

Critical Event	Proportion	Critical Event	Proportion
Imposition	.29	Start-Back	.00
Continue	.31	Direction Change	
Continue Steer Angle	.05	Right	.09
Start	.06	Left	.16
Stop	.01	NAC*	.00
Accelerate	.01	NAC*	.02
Decelerate	.01	Total	1.00

* Not able to classify.

TABLE 8. Critical Reasons for Culpable Units (from Perchonok, 1972).

Critical Reason	Frequency	Proportion
Primary Control	93	.13
Recognition	69	.10
Recognition/sensing	53	.08
Information failure (NAC)*	52	.07
Sensing	50	.07
Presentation	47	.07
Induced control	47	.07
Driver breakdown	45	.06
Compulsory - external	45	.06
Projection	30	.04
Vehicle breakdown	27	.04
Induced control/primary control	20	.03
Information failure (NAC)/voluntary	18	.03
Voluntary	18	.03
Information failure (NAC)/primary control	13	.02
Others	71	.10
Total	698	1.00

*Not able to classify.

ability proportions based on human, vehicular, and environmental reasons for critical events are shown in Table 9, and the accident directional patterns are shown in Table 10.

It could be concluded from the analysis that driver failure was the primary causal factor in 57% of the crashes, and driver-environmental interactions in 30%. Vehicle breakdown was listed as a critical event in 4% of the sample of crashes. For crashes that occurred when vehicles were on intersecting paths most often either both continued or one started after being stopped. Left turning vehicles were largely involved in opposite direction crashes. Vehicles traveling in the same direction were involved most often when one was stopped and about half as often when one had decelerated.

Perchonok concluded that information failures accounted for over 40% of the reasons for the culpable generation of accidents. Help for the driver could come from improved communications to the driver or reducing the information processing demands placed upon him. Improved rear lighting systems would probably reduce rear-end collisions. Alcohol increases the likelihood of causing an accident. The major reasons given for drinking driver accident involvement were control failures, information processing problems, and driver breakdown.

In What Are the Causes of Traffic Accidents (Baker, 1961), the factors contributing to an accident are classified based on trafficways, people, and vehicles (Tables 11-13). The attributes are divided into those relating to recognition, decision, and performance. Furthermore, temporary and/or permanent modifiers have an influence on the attributes. To complete a trip successfully without an accident, a vehicle must avoid a critical event, which is an action by a vehicle which results in loss of control. To avoid a critical event the operations of preparation, strategy, and evasive action must be performed correctly. The entire interaction is shown in Figure 1.

TABLE 9. Human, Vehicular, and Environmental Reasons for Critical Events (from Perchonok, 1972).

	Frequency	Proportion
Culpable Units Only		
Human	385	.57
Driver breakdown, primary control, sensing, recognition, projection, voluntary		
Vehicle	27	.04
Vehicle breakdown		
Human/vehicle	7	.01
Human/environment	200	.30
Induced control, presentation, conflict, logistic, compulsory-external, compulsory-secondary, and their combination with induced control or critical reason listed under Human		
Accidents With No Culpable Units		
Environment	51	.08
Conflict errors, induced control failures, imposition by non-vehicles, direct environmental influences		
Total	670	1.00

TABLE 10. Accident Directional Patterns (from Perchonok, 1972).

Major Types	Subclassifications	Frequency	Proportion
Vehicles approaching at right angles	Both continued	64	.09
	One stopped, then started	71	.10
	One decelerated but did not stop	15	.02
	Subtotal	150	.21
	Others	42	.06
	Total	192	.27
Vehicles in parallel but opposite directions	One turned left	108	.15
	One stopped, then turned left	20	.03
	Subtotal	128	.18
	Other	22	.03
	Total	150	.21
Vehicles in same lane	One was stopped, and other continued	96	.13
	One had been decelerating, and other continued	17	.02
	One decelerated or stopped imposing on other	18	.03
	Subtotal	131	.18
	Others	17	.02
	Total	148	.21
Others		223	.31
Total multivehicle accidents		713	1.00

TABLE 11. Condition Factors of Trafficways (from Baker, 1961).

Attributes		Modifiers
Generally relating to recognition	T11 Light	Temporary 11 Weather, Atmospheric conditions 12 Natural light 13 Temporary warning devices 14 Temporary roadside activities 15 Roadside objects 16 Objects on the road 17 Loss of adjustment, alignment 18 Social and legal symbols 19 Surface deposits, ruts 20 Road damage, holes
	T12 Visibility	
	T13 View obstructions	
	T14 Recognizability	
	T15 Recognizability aids	
	T16 Distractions, monotony	
	T17 Confusion, standardization	
	T18 Warning signs	
	T19 Guide signs	
Generally relating to decision	T21 Signals	Permanent 41 Wear 42 Deterioration, age
	T22 Traffic Signal controls	
	T23 Regulatory signs and markings	
Generally relating to performance	T31 Alignment	
	T32 Surface character	
	T33 Dimensions	
	T34 Restraining devices	

TABLE 12. Condition Factors of People (from Baker, 1961).

Attributes		Modifiers
Generally relating to recognition	P11 Observing habits	Temporary 11 Sun exposure 12 Glasses, etc. 13 Emotional upset 14 Pressure, stress, hurry 15 Preoccupation 16 Weather 17 Irritants 18 Ingestion, inhalation 19 Fatigue, boredom 20 Temporary illness 21 Injury 22 Clothing 23 Things carried 24 Prosthetic devices
	P12 Sensory abilities	
	P13 Signaling habits	
	P14 Recognizability (mainly pedestrian)	
	P15 Knowledge	
Generally relating to decision	P21 Intelligence, judgment	Permanent 41 Deterioration, age 42 Chronic illness 43 Permanent injury 44 Experience, training 45 Customs, tradition 46 Authority, enforcement
	P22 Attitudes	
	P23 Emotional stability	
	P24 Alertness, concentration	
Generally relating to performance	P31 Operating skill, habits	
	P32 Size, weight, strength	
	P33 Freedom of movement	

TABLE 13. Condition Factors of Vehicles (from Baker, 1961).

Attributes		Modifiers	
Generally relating to recognition	V11 Recognizability	Temporary	11 Glare
	V12 Recognizability aids		12 Weather
	V13 Road Illumination		13 Surface deposits
	V14 Sensory aids		14 Cargo
	V15 View obstructions		15 Passengers
	V16 Distractions		16 Social and legal symbols
	V17 Instruments		17 Adjustment loss, defective
	V18 Signaling devices		18 Damage, Contamination
	V19 Control feedback		
Generally relating to decision	V21 Comfort	Permanent	41 Deterioration, age
	V22 Symbolism		42 Irreparable damage
	V23 Automatic controls		43 Wear
Generally relating to performance	V31 Control arrangement, function		
	V32 Operating space		
	V33 Dimensions		
	V34 Weight		
	V35 Performance		
	V36 Stability		

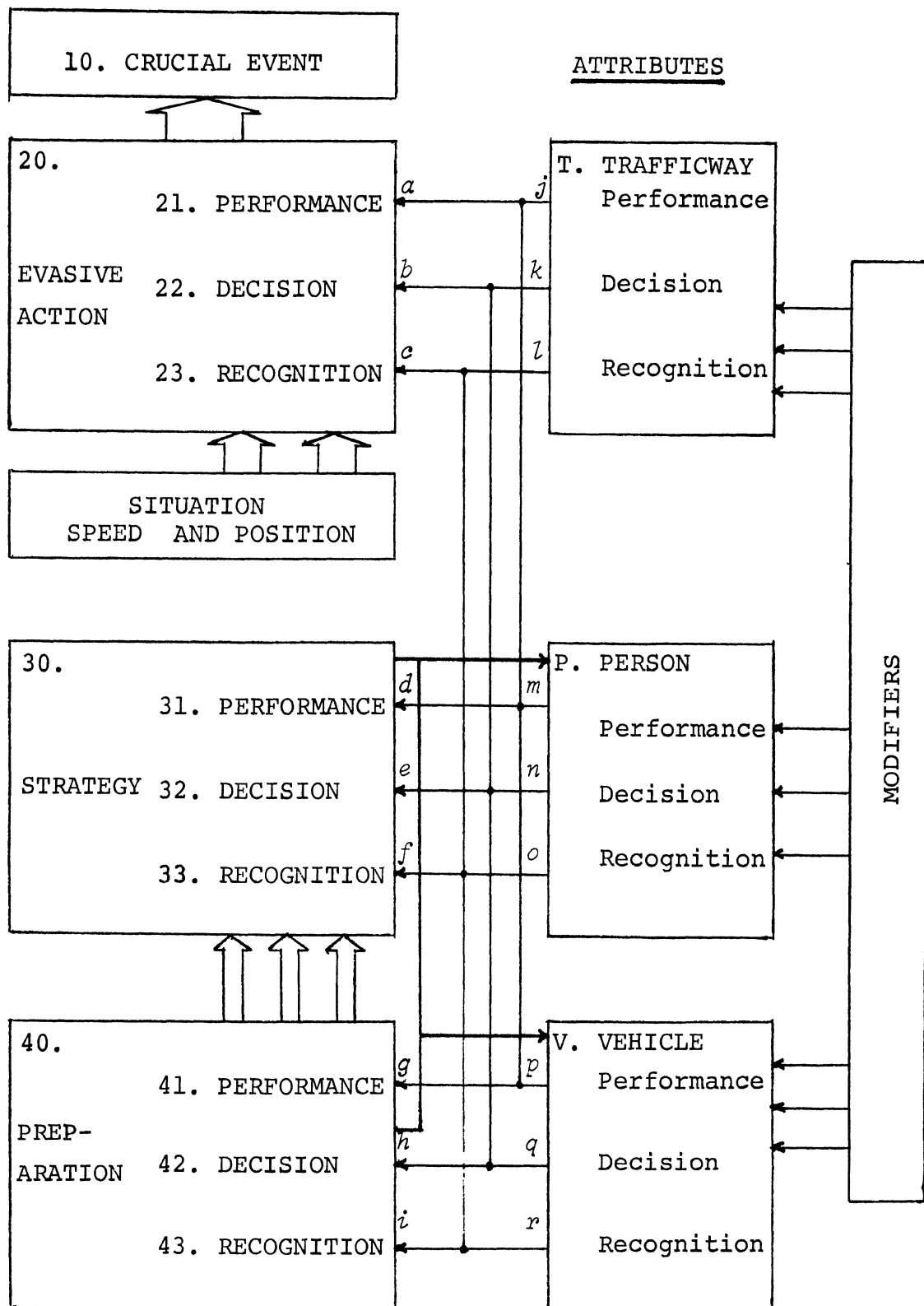


Figure 1. Condition factors and operational factors.
From Baker (1961).

ACCIDENT RECONSTRUCTION

Two interesting methodologies have been suggested for reconstructing accidents. In one, Cook (1967) has suggested reconstructing the accident using model cars. Surface material was varied to provide suitable coefficients of friction. Mass considerations were eliminated by using two models of identical size, shape, and weight. Speed was controlled by ramp incline. A hypothetical accident was reconstructed at 1/25th scale, and kinematic similarity to the real world was maintained on a space-velocity-time basis with encouraging results.

In another approach, Thorson (1971) and Ekner (1972) divided the pre-crash phase into a perception phase and an avoidance or prevention phase. They then work back on a time-space basis to determine the measured avoidance point, A_m , where braking occurred; the necessary avoidance length, A_n ; the possible perception point, P_p , where it is possible to detect and understand that a critical situation is created; and P_n , the necessary perception point which is the last point at which the critical situation should be perceived in order to avoid the accident. If the measured avoidance length is greater than or equal to the necessary avoidance length, the driver has started the avoidance action in time to prevent the accident and perception and speed have no importance. Driver and vehicle avoidance are the only possible remaining factors contributing to the accident. If the measured avoidance length is less than the necessary avoidance length the accident will occur. If the perceived perception point was greater than or equal to the necessary perception point then the contributing factors were driver or vehicle perception and avoidance. If the perceived perception point was less than the necessary perception point then the contributing factors were unadjusted speed, vehicle avoidance, or environmental perception or avoidance.

Both accident reconstruction methodologies depend upon a relatively accurate time-space description of the pre-crash phase which is often difficult to obtain.

PROCEDURE

Since the areas of human behavior, vehicle performance and accident investigation are relevant to this study a team of psychologists and engineers performed the study. In this way we hoped to optimize our understanding of the pre-crash phase so that the correct driver-vehicle performance failures could be determined and appropriate countermeasures identified.

The major tasks carried out were:

1. Determination of the types of accident reports and the subclass of accident types to be analyzed.
2. Development of a methodology for restructuring the pre-crash phase.
3. Conduct of sample analyses to evaluate the procedure and its overall feasibility, and to measure the confidence in the findings.
4. Execution of a series of analyses.
5. Provision of a summary of results, conclusions, and recommendations, as appropriate.

DETERMINATION OF THE TYPES OF ACCIDENT REPORTS AND THE SUBCLASS OF ACCIDENT TYPES TO BE ANALYZED

During early discussions among the investigators a preliminary decision was reached to include the data collected in the current Oakland County accident project, which utilizes the GM Long Form. The cases in this project are entered on this form,

and in addition an overall review of the circumstances leading up to the crash, the extent of damage to the case vehicle, an analysis of the occupant kinematics, interior damage, and occupant injury details are provided. The on-site investigators' 35 mm slide pictures are also available. The Oakland County, GM Long Form, data file consists of about 400 cases, largely of U.S., 1971-73 model year vehicles involving injury-producing accidents. Major interest in the potential use of the data is in injury-causation factors. To obtain the data six police agencies are contacted each day for potentially suitable accidents. An accident report is obtained from the Police Department and the vehicle is located, described and photographed. When convenient the accident scene is visited and in minor injury cases only, the drivers are contacted to check on the injury pattern since this information would not likely be available from the hospital. Examination of some cases revealed that the pre-crash information was not sufficiently detailed to be used in this work.

Therefore, the multidisciplinary accident investigation (MDAI) cases were evaluated. Approximately 2500 cases are on file of which 700 cases are non-injury Washtenaw County, level II cases. About 1500 cases are level III and contain information concerning the pre-crash phase, describing the accident scene, and including a narrative of the estimated sequence of events based in part upon interviews with the drivers.

The decision was made to use the MDAI files because of the more extensive description of the pre-crash phase, and the larger population of cases to work from provided an opportunity to look at a more limited subset of the population with an adequate number of cases available. The selection of accidents was to hinge upon types of crashes which had relatively unambiguous antecedents and which were likely to involve aspects of driver-vehicle performance in steering or braking control.

After discussion of a number of potential subsets of collision types, the investigators decided to use one which was concerned with collisions on wet as well as dry pavements, on a limited set of conditions. These were tentatively to include the following: personal injury, daylight, straight and level limited access highway, no driver impairment reported, dry and wet pavement (the latter being defined as being found under conditions of light and/or moderate precipitation), collision type, and speed prior to impact. Figure 2 diagrams the manner in which the subset was selected, and also shows the dictionary code numbers involved.

The analysis provided the total number of cases in each of the collision types by speed distribution separately for dry and wet road conditions, in the set of other conditions listed.

When this analysis was conducted, from a population of over 2500 accident cases, 50 cases passed all of the filters. Tables 14 and 15 indicate the estimated speed of the case vehicle on dry and wet roads prior to impact for vehicles, pedestrians, and objects of first contact. Vehicles consisted of autos, motorcycles, large trucks, trains or buses, light trucks, tractors without trailers, vans, straight trucks, tractor-trailer combinations, and vehicles with road and off-road capability (e.g., "Jeeps"). Animate objects struck included pedestrians, large animals, and bicycles. Inanimate objects consisted of ground, guardrails, bridges, signs, ditches, embankments, culverts, fences, poles or trees, buildings, objects disengaging from other vehicles, hydrants, posts, stumps, mailboxes, piers, pillars, retaining walls, impact attenuators, and breakaway fixtures.

Case vehicles are newer model vehicles and are not necessarily the striking vehicle. Because of the small number of

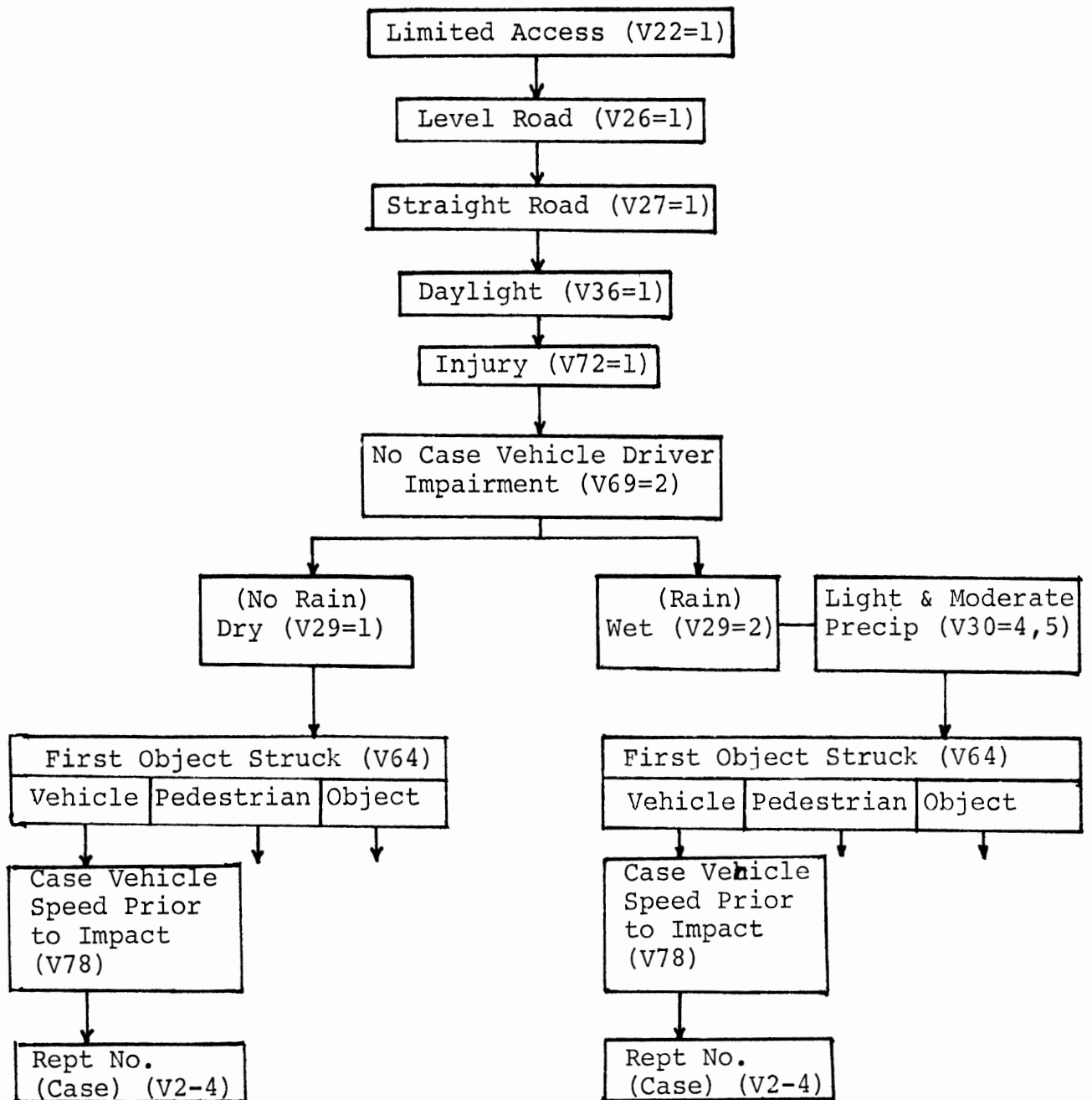


Figure 2. Variables entering into the collision subset.

TABLE 14. Estimated Speed of Case Vehicle Prior to Impact and Object First Contacted - Wet Road. (All entries indicate frequency.)

Wet	Estimated Speed of Case Vehicle Prior to Impact in mph										
	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	Wild	Total
Vehicles	0	0	0	0	0	1	2	0	0	0	3
Pedestrians	0	0	0	0	0	0	0	0	0	0	0
Objects	0	0	0	0	1	1	0	0	0	0	2
Other (99)	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	1	2	2	0	0	0	5

TABLE 15. Estimated Speed of Case Vehicle Prior to Impact and Object First Contacted - Dry Road. (All entries indicate frequency.)

Dry	Estimated Speed of Case Vehicle Prior to Impact in mph										
	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	Wild	Total
Vehicles	6	2	0	0	2	4	6	9	0	4	33
Pedestrians	0	0	0	0	0	0	0	0	0	0	0
Objects	0	0	0	1	0	1	3	4	1	1	11
Other (99)	0	0	0	0	0	0	0	1	0	0	1
Total	6	2	0	1	2	5	9	14	1	5	45

cases occurring on wet roads, they were excluded. Of the 45 remaining cases, some of the hard copies of the accidents were not available and others contained insufficient information. After close examination of the remaining cases, 10 were rejected because they did not meet the constraints imposed by the filter. For example, six of these cases involved alcohol.

DEVELOPMENT OF A METHODOLOGY FOR RESTRUCTURING THE PRE-CRASH PHASE

While reviewing the data from the accident files a form was developed by which the individual who is attempting to obtain a concise description of the accident can be prompted to seek the relevant information, which would also help in summarizing the salient aspects of the crash. The procedure followed by the investigators was to develop a set of questions which sought the pertinent information, have the questionnaire used independently by a number of evaluators on several case reports, and then assemble the evaluators to discuss problems and ideas which occurred in using the form.

A total of six forms were successively developed using this procedure. Each form evolved from the previous one and was directed toward a more explicit statement of relevant information resulting in greater investigator agreement.

The form which has been developed allows for a quick review of a crash description using the MDAI report and/or GM Long Form data, and results in the development of hypotheses made by the evaluator concerning the information needs of the driver which were lacking and involved in the crash. These information needs are basic descriptors of either the sensory and perceptual information required by the driver in order to have potentially avoided the crash, or they may refer to vehicle responses which act as feedbacks to the driver to assist him in steering, braking, and/or accelerating the vehicle to avoid the crash.

CONDUCT OF SAMPLE ANALYSES TO EVALUATE THE PROCEDURE AND ITS OVERALL FEASIBILITY, AND TO MEASURE THE CONFIDENCE IN THE FINDINGS

Each of the first three forms were used by the investigators to evaluate five of the daytime, limited access highway crashes described earlier (Figure 2). Although there was seldom unanimous agreement among the investigators in their answers to some of the more probing questions, discussion revealed that unanimous agreement could be obtained.

Consequently, whereas the first three evaluation forms provided spaces for the investigators to fill in their answers, the last three forms incorporated a means of comparing responses of different evaluators in an objective way. This was done by classifying most response possibilities beforehand on the form and requiring only that the evaluator check the appropriate responses. This method was expected to provide greater agreement among experimenters without limiting their responses. The response categories were derived from MDAI and GM Long Form Accident Investigation Reports as well as from pertinent material covered in the literature review. Five goals were sought in using the categories chosen: (1) use as few categories as possible to minimize time, (2) be as specific as possible with each category to avoid confusion and multiple responses, (3) be as mutually exclusive as possible with each category again to avoid confusion and multiple responses, (4) provide as much information as possible in each category so that more response categories will not be needed, and (5) be as comprehensive as possible in the choice of response categories so that other categories would not have to be provided later.

EXECUTION OF A SERIES OF ANALYSES. Once the fourth form was completed it was again used for five daytime limited access highway accidents by four investigators who were thoroughly familiar with the Driver-Vehicle Factor Investigation Accident Analysis Form being developed. Five additional accident reports,

which contained adequate pre-crash information, were then pulled at random because it is necessary to not only develop a form and obtain information on one subset of accidents, but to provide a form which is useful in analyzing an accident which may occur. Only in looking at a random sample of accidents can the form be shown to be satisfactory for all accidents and not just the subset for which it was designed initially.

The five random accidents were evaluated by two of the four experienced investigators and several changes were made in the form, producing a fifth form. The subset of five selected accidents and the five random accidents were then typed up on individual pages providing a description and diagram of the accident. These 10 descriptions were then given to ten employees of the Highway Safety Research Institute who were unfamiliar with the accident analysis form being developed. They were asked to complete an Accident Analysis Form for each accident case. Two of the ten people answering the questionnaire were familiar with other accident investigation forms and procedures; the other eight were not. The purpose of the questionnaire and individual questions were discussed with each of the eight employees before they completed the forms.

Results of this initial administration of the pre-crash evaluation form are discussed below, for each questionnaire item.

Question 1. "Identify the number of the vehicle which you interpret as the precipitating vehicle-driver combination, and as the other vehicle driver. A precipitating driver-vehicle, is defined as one which is approaching from the rear, is out of lane in a head-on, or violates a traffic control at an intersection. As defined, the precipitating driver-vehicle is not necessarily the combination causing the accident." Out of a

total of 200 responses required to this question only 8 errors occurred. Two were errors of omission; the other 6 involved either a reversal of the vehicles or the inclusion of another vehicle. Five of the 8 errors came from people experienced with accident investigations. All errors occurred in four of the five daytime, limited access highway cases.

Question 2. "Is information available on the distance and speed of the vehicle(s) to reconstruct the crash sequence?" Out of 100 possible correct "yes" responses, 10 were negative.

Question 3. "Were the precipitating events avoidable?" For 9 of the 10 cases (90 answers) there were 4 "no" responses and 1 blank. The remainder were "yes" responses. The four "no" responses came from one evaluator with no accident investigation experience. The tenth case involved a car that swerved to avoid striking a deer on the roadway. For this case there were 5 "yes" responses and 4 "no" responses to question 3. This disagreement is probably to be expected in a case like this where there is little or no human control over animals and the time sequence of events is not available from the accident report.

Questions 4 and 5. "Is accident avoidance taken by the precipitating/other vehicle classifiable by braking, steering, both, or no apparent action?" The appropriate answers to these questions are not always clearly discernible from the case reports. Out of the 20 questions (2 questions and 10 cases) there was unanimous agreement in 5 cases, only 1 disagreement in 6 cases, and 2, 3 or occasionally 4 disagreements in the remaining cases. These results are quite satisfactory considering the lack of specific information available in the report. Some evaluators, with a lack of information, are likely to indicate no action taken; whereas other evaluators will assume that based on the circumstances some action had occurred.

Questions 6 and 7. "What is the apparent major fault in the precipitating/other vehicle-driver? If more than one, number in order of importance beginning with 1 as most important." The dispersion of answers is greater here than for any question; however, more response choices are available to the evaluator, and frequently more than one factor is of major influence. In 5 of 10 questions concerning the precipitating vehicle there is high agreement as to the major fault. This is true for 3 questions involving the other vehicle-driver. The major faults in the precipitating vehicle/driver for the 10 cases reviewed are: avoidance maneuver, failure to judge speed or distance or vehicle, inattention, and wrong-way. For the other vehicle major faults are failure to remove disabled car from roadway, failure to use mirrors, failure to signal, and no error. The only effect the selected subset of cases had on the results as compared to the random subset was to reduce the "no error" ratings for the "other" car.

Questions 8 and 9. "What is the major fault in the precipitating/other vehicle design (performance)?" For the 20 questions (2 questions and 10 cases) the most frequent fault was "none." This response was unanimous for 5 questions; had 1 dissent in 4 questions; 2 dissents in 6 questions, and 3 or 4 dissents in 4 questions. The question did not apply in one case. Of 190 potential responses, 161 were "no major fault in vehicle design." Twenty responses of possible vehicle faults were given with 5 responses to "brake" and 5 responses to "marking and signaling."

Questions 10 and 11. "What is the major fault in the road used by the precipitating/other vehicle?" Of 190 responses, 130 responses indicated no fault. Of the 51 responses indicating a fault, 15 were to road design, 9 to traffic control, 8 to sight distance, 7 to delineation, and 5 to signing.

Questions 12 and 13. "Was the precipitating/other driver's accident avoidance action appropriate?" In 47% of all responses made to these questions, the raters agreed that no action appeared to have been taken by the drivers. In the remaining cases, 28% of the responses indicated that the raters judged the action taken was appropriate, and 25% indicated it was inappropriate.

Question 14. "What information was needed by either driver-vehicle combination to avoid the crash?" This is the key question in the Pre-Crash Accident Analysis Form because the answers to this question reveal the information requirements which, if available to the driver, would have been useful in potentially reducing the likelihood of the crash occurring. The degree to which there is communality among these informational items will tend to suggest the types of countermeasures, in the form of vehicle or road design performance revisions, or driver training and improvement, that may be helpful in reducing these types of crashes.

The responses to this question are very case specific, that is, they deal with the information problem of a specific case. As the number of cases analyzed increases, it is expected that certain information deficiencies will become common to an increasing number of accidents, and that these are the areas where appropriate countermeasures can best be taken to prevent the accident from occurring in the future. For this initial study the information requirements receiving more than 1 response for each case will be briefly discussed. The last 5 cases are the limited access freeway subset.

BRIEF DESCRIPTION OF CASES ANALYZED.

Case 624. The driver of the precipitating vehicle swerved to avoid striking a deer and ran off the left side of the road striking the guardrail. Information needed was considered to be: warning or knowledge of the presence or actions of deer, and

the existence of a deer area (7 responses); and that a less severe avoidance maneuver should be attempted (2 responses).

Case 854. Two vehicles on intersecting courses collided at a signalled intersection. Both drivers needed earlier knowledge that another vehicle was in the intersection on a collision path (19 responses).

Case 143. In a light fog the precipitating vehicle drifted across the center line into the approaching lane and struck an oncoming vehicle. The precipitating driver needed knowledge that he was leaving the proper lane (9 responses). The other driver needed knowledge that the precipitating driver was in the wrong lane (6 responses), and no information (3 responses).

Case 105. Precipitating vehicle driver was southbound on a northbound freeway. Precipitating driver needed knowledge of wrong-way driving (9 responses). The other driver needed warning of oncoming vehicle (6 responses), and should have known to steer rather than brake (2 responses).

Case 775. The precipitating vehicle driver was making a left turn when struck in the front by a car in the approaching lane. The precipitating driver needed to know the relative speed and distance or presence of the approaching vehicle (8 responses). The other driver needed to know that the precipitating driver would turn in front of him (8 responses).

Case 497. Vehicle slowing down on freeway for previous accident was struck in rear. Precipitating driver needed to know of the deceleration of the lead car (10 responses). The other driver needed to know of the presence or relative speed of the following vehicle (8 responses), and no information (2 responses).

Case 512. Precipitating vehicle struck a car stopped in his lane on the expressway. The precipitating driver needed to

know of the presence of the stopped car on the road ahead (8 responses). The other driver needed information of impending vehicle failure (3 responses), an awareness of following vehicles which might strike the car (3 responses), and no information (4 responses).

Case 022. Precipitating vehicle struck a car stopped in his lane on the expressway. The precipitating driver needed to know of the presence of the stopped car on the road ahead (10 responses). The other driver needed to know that the vehicle would break down (3 responses), that there was a danger in leaving the stopped vehicle on the roadway (4 responses), and no information (3 responses).

Case 553. Precipitating vehicle was in passing lane overtaking a car when a car in right lane attempted to cut across median in front of precipitating vehicle. Precipitating vehicle struck other car. Precipitating driver needed knowledge that the other car would attempt a U-turn (9 responses). The other driver needed to know of the presence of the precipitating vehicle behind him (5 responses) and that the U-turn was dangerous and illegal (5 responses).

Case 523. Precipitating vehicle driver swerved sharply to avoid collision with a vehicle changing into his lane ahead and lost control. Information needed by precipitating vehicle was intent of lead vehicle to change lanes (8 responses), and that less severe avoidance maneuver should be attempted (2 responses). The other driver needed presence and speed/distance information of precipitating vehicle behind him (8 responses), and no information (2 responses).

Summary of Responses to Question 14: Information Needs.

Although the number of different information needs may appear to be quite large to cover all of the accidents discussed, it is possible to collect the responses into some broad areas of informational needs. These areas are: impending vehicle failure,

vehicle response behavior in collision avoidance maneuvers, education of situations predisposing to hazards, and distance and relative speed with respect to other vehicles. With the exception of 14 "no information needed" responses, all of the (177) responses discussed in the 10 cases above can be placed in one of these informational need categories. The categories do not preclude the possibility that additional categories will be required as further cases are analyzed.

DISCUSSION OF MAJOR CATEGORIES OF INFORMATION NEEDED.

Impending Vehicle Failure. Six responses cited this need. In two of the cases a vehicle failure resulted in a car being parked on the roadway. Although it is almost inconceivable to think of a driver voluntarily leaving a disabled car in the road lane, a number of cases did involve crashes with vehicles abandoned on the road. In some instances no other lanes or shoulders were available. Warning of a vehicle failure would certainly be beneficial in those cases where the driver could and would get his car off the road, given sufficient warning. Several of the most common vehicle failures are already displayed with warning lights or gauges. It is not known if problems exist with these indicators, in not being sufficiently attention-getting or otherwise informative. Since the MDAI reports did not describe the vehicle failure, the nature of the solution to the problem cannot be inferred, but an investigation of such problems would be worthwhile.

Vehicle Handling. Six of the cases elicited 18 responses relating to acquisition of information about the response of the vehicle to drastic brake or steer inputs. In three of the cases either the avoidance maneuver was too severe, resulting in loss of control, or an inappropriate action may have been taken such as braking instead of steering. A formal training course or personal experience, might have prevented the inappropriate action from being taken by informing the driver of the correct

way to respond in an emergency situation and to learn the limits of the vehicle and himself.

Driver Education of Accident Predisposing Situations. Three other cases involved informing the driver of the danger in leaving a parked car on the roadway and of the danger in making a U-turn. Perhaps drivers can be made more aware of the dangers and severe consequences of such actions.

Distance and Relative Speed with Respect to Other Vehicles or Objects. Out of the 163 responses indicating informational needs by the driver, 139 or 85% of the responses fell in this category. This category is admittedly broad but the problem is always the same; if the vehicle or vehicles remain on their present course and do not change speed, a collision will occur. Each of the ten cases discussed involved this category. In each case the driver needed to know that there was another object or vehicle(s) present, entering or in the path of his vehicle, that was either stopped, slowed, traveling too fast, or headed in the wrong direction. This is a difficult problem to solve because driving situations frequently involve approaching vehicles in opposing lanes of traffic, changing lanes and slowing down or stopping. These collisions may be reduced by aiding the driver.

For example, the case (775) of a head-on collision with a turning vehicle may have been avoided by the driver who had the right-of-way, if he knew that the turning vehicle was under power or not braking. The concept of a forward-facing stop signal (Post and Mortimer, 1971) may have merit in this type of situation.

Also, rear-end collisions with vehicles stopped on the pavement may be avoided by a rear signaling display that denotes the vehicle is stopped or traveling at less than about 5 mph. Such a display should be visible through or over intervening passenger cars to provide maximum warning distance. The signals need to be of appropriate intensity for visibility in daytime and

nighttime. Other forms of providing drivers with warning of high relative velocity and/or short intercar distance, such as by electronic sensing equipment (e.g., radar), and possibly supplementing this with semi-automatic or automatic vehicle braking, could be considered as means of reducing front and rear collisions.

Parenthetically, it was regretted that in none of the cases where the use of vehicle turn, stop or hazard warning signals may have been beneficial, did the MDAI reports indicate if such existing vehicle signals were in use. Thus, their role in the crashes could not be considered.

Question 15. Express the degree of confidence (in percent, where 100% is maximum confidence and 0% is minimum confidence) that you have in the conclusions drawn to question 14 for the information needed by both driver-vehicle combinations. Confidence ratings were distributed from 10% to a mode of 100%. The overall mean for the precipitating driver-vehicle was 86% confidence; for the other driver-vehicle 82% confidence.

DEVELOPMENT OF A FINAL PRE-CRASH ACCIDENT EVALUATION FORM

Based on the responses to the fifth accident analysis form a set of instructions was prepared for the user and several of the questions were omitted, reordered, or reworded to try to clarify the information sought and to obtain greater subject agreement.

This questionnaire, along with 10 new cases - 5 limited access and 5 from randomly selected crashes, was then distributed to nine HSRI employees. Three of the nine were members of the project, and five of the other six persons are familiar with accident case reports. Results of the responses made to the questionnaire in its final format for each of the questions are discussed briefly below.

RESULTS

Question 1 asks for identification of the precipitating and other vehicle. Seventy-six percent of the responses were correct for the precipitating vehicle, 69% of the responses were correct for the other vehicle. Most of the incorrect responses occurred for limited access road cases.

Question 2 asks if there is enough information available to reconstruct the crash sequence. The response was "yes" 86% of the time. Twelve times the evaluators said enough information was not available yet continued to answer the questionnaire.

Question 3 asks for the precipitating driver accident avoidance action. Braking responses were given 31% of the time, steering responses 35% of the time, acceleration responses 7% of the time, and no apparent action 26% of the time.

In Question 4 the precipitating driver's accident avoidance action is judged appropriate 46% of the time, inappropriate 25% of the time, and no apparent action 29% of the time.

Question 5 asks for the other driver's accident avoidance action. Braking responses were given 22% of the time, steering responses 6% of the time, acceleration 0% of the time, and no apparent action 72% of the time.

For Question 6 the other driver's accident avoidance action is judged appropriate 18% of the time, inappropriate 6% of the time, and no apparent action 75% of the time.

Questions 7 and 8 (see questionnaire in Appendix 1) ask for the specific driver action, contributing behavior, and predisposing factors that relate to the accident for the precipitating and other driver. Questions 9 and 10 concern vehicle faults and Questions 11 and 12 concern environmental faults, and were used in the prior version of the questionnaire.

Figure 3 shows the mean of the importance ratings received by each response option in question 7A from the nine raters, and the standard deviation of the ratings for each response option, for one of the cases reviewed. Such computations were made for each question, 7A-12. The mean rating provides a measure of the perceived importance of the response option, while the standard deviation is an indicator of the degree of the agreement among the raters in assigning importance to the response options. The standard deviation can have a maximum value of 4.75, showing maximum lack of agreement between raters in determining the importance of a response category. The maximum value of 4.75 for the standard deviation is obtained in these cases because there were a total of nine raters, such that an item would have maximum variability in ratings if there were five ratings of nine and the rest zero, or the converse.

In order to provide a summary of the mean and variability of the ratings, the mean rating of the response option receiving the highest mean importance rating for each question and case, together with the mean standard deviation of all the ratings made to each response in a question for a case, were used. This is shown for the data in Figure 3, by Figure 4. Figure 4 shows the mean standard deviation of the ratings in question 7A, for one case, and the response option receiving the highest mean rating. Thus, the variability of the raters' responses and the element they considered most important for the question, and its mean importance value, are described.

The response to each question, for all the ten accident cases, are summarized in this way in Figures 5-14.

In Figure 5, the responses to the question "what was the precipitating driver's action?" are shown. Mean standard deviations go from a low of 0.60 to a high of 2.20. Loss of control

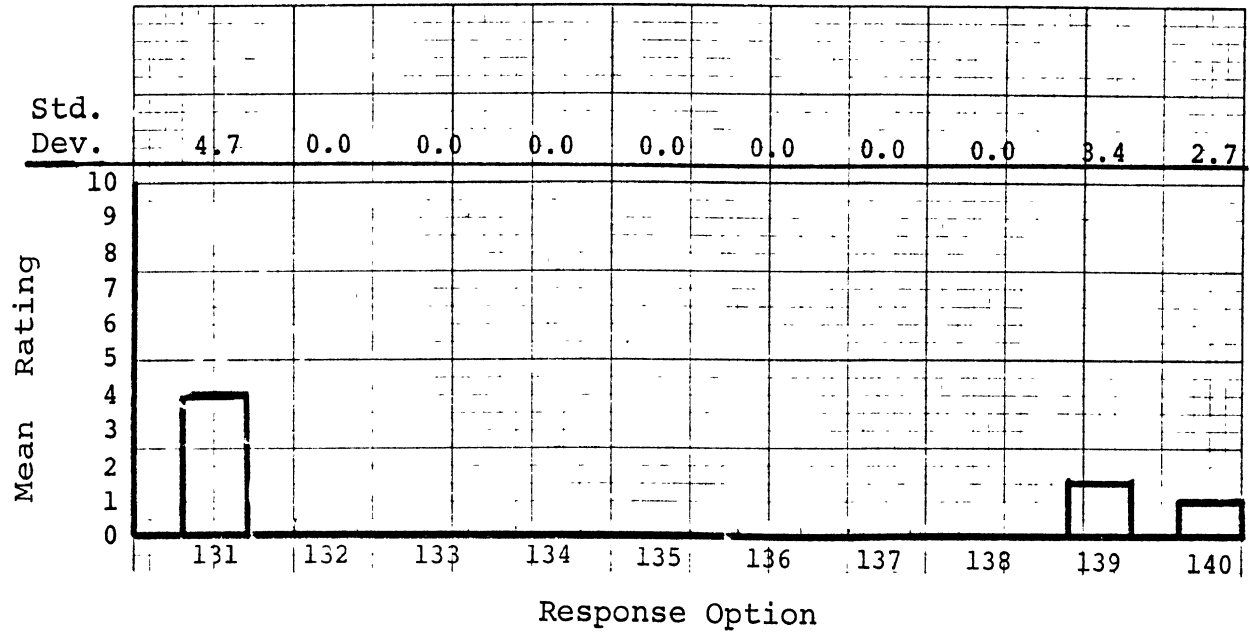


Figure 3. Example showing mean ratings and standard deviations of responses to question 7A, "Rate the absolute importance of each precipitating driver action," Case M13.

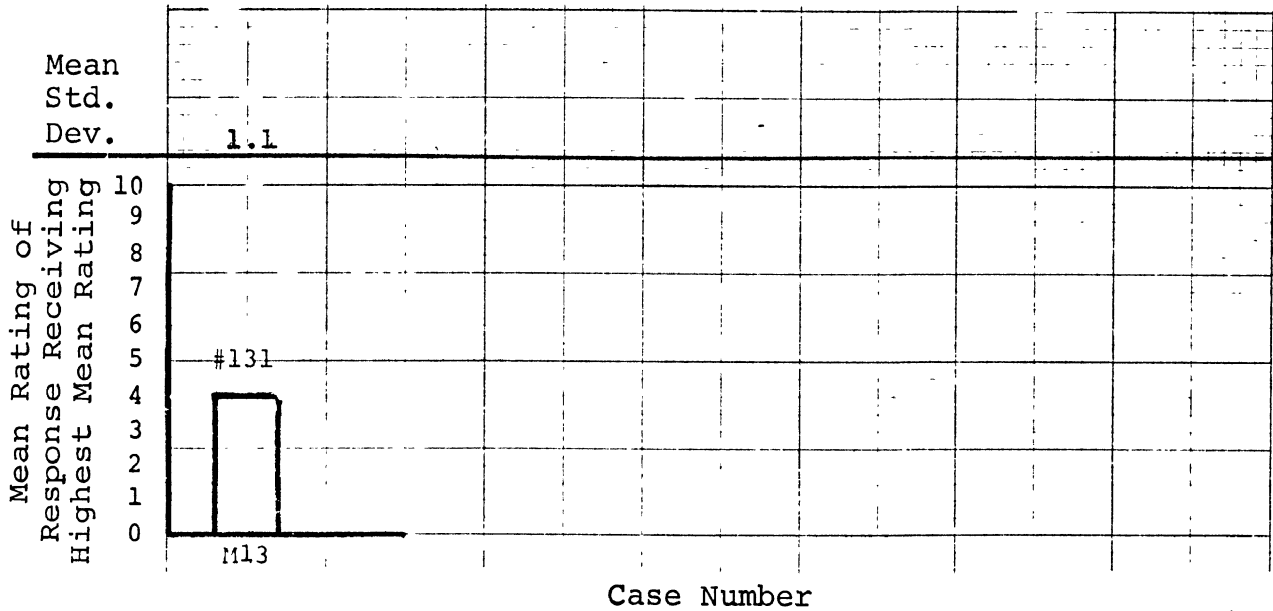


Figure 4. Example showing derivations of response option having highest mean rating, and the overall mean standard deviation of all responses to question 7A, Case M13.

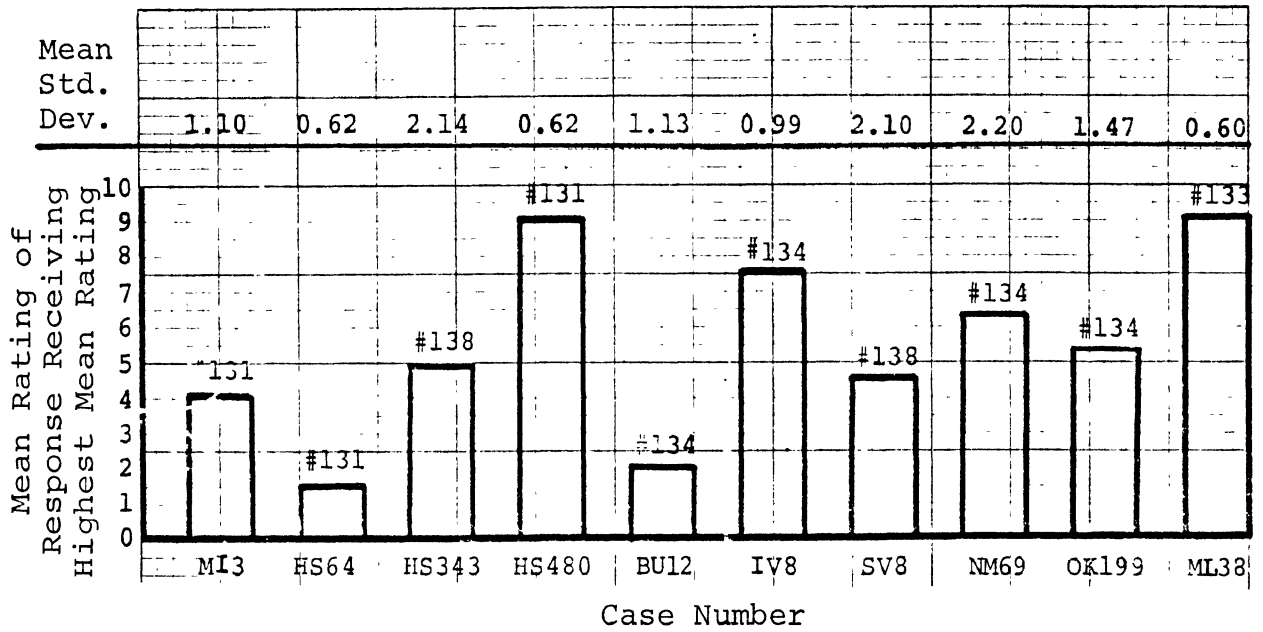


Figure 5. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 7A, "Rate the absolute importance of each precipitating driver action."

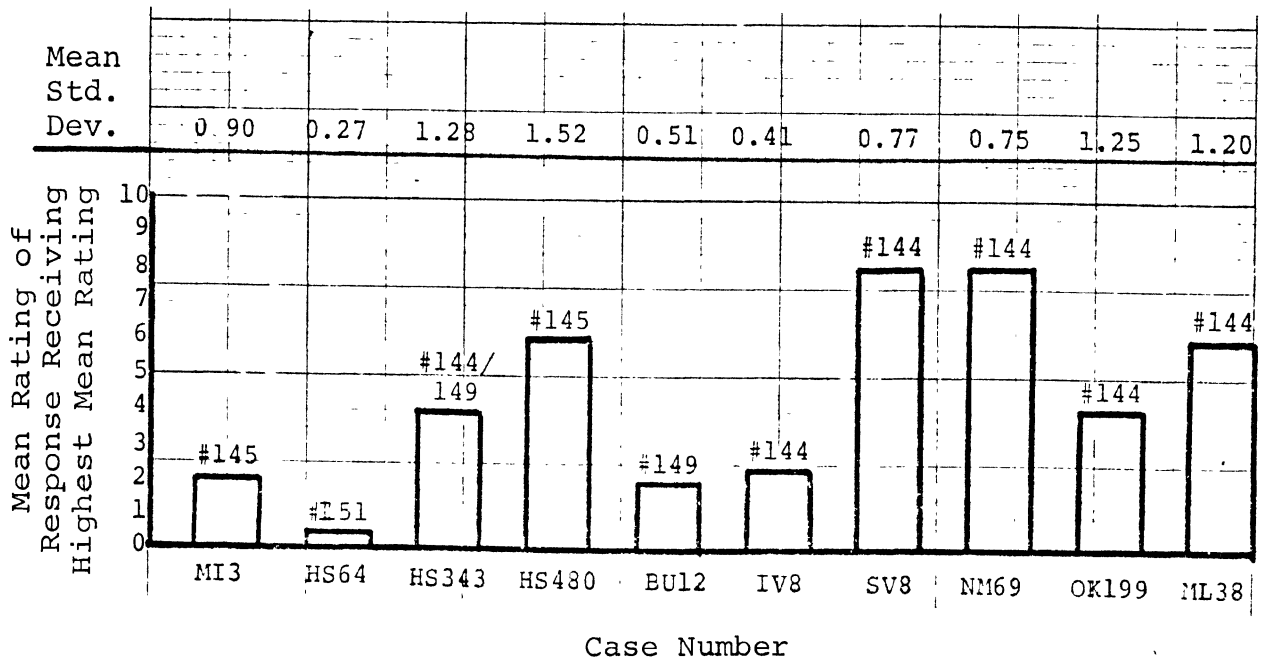


Figure 6. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 7B, "Rate the absolute importance of the contributing behavior of the precipitating driver."

during an avoidance maneuver was the most frequent highest mean rating to appear, had an average overall mean rating above 5.0, and usually occurred with the cases drawn at random. Failure to stop or slow in a safe distance received the greatest mean rating in three of the five limited access cases with mean ratings ranging from 1.5 to 8.8. The random cases had higher mean ratings and higher mean standard deviations than the limited access cases.

Responses to the question "what was the contributing behavior of the precipitating driver?" are shown in Figure 6. Mean standard deviations extend from 0.27 to 1.52. Speed too fast for conditions always received the highest mean rating in the random cases, and the ratings were from 2.3 to 8.0. Failure to judge speed or distance and failure to look or see directly each accounted for two of the highest mean ratings in the limited access cases. The limited access cases had lower highest mean ratings (0.5 to 6.2) than the random cases but mean standard deviations were comparable.

Responses to the question "what were the predisposing factors of the precipitating driver," are presented in Figure 7. Mean standard deviations were very low going from 0.0 to 0.99. The greatest mean ratings were less than 2.0 for eight of the ten cases. Inattention received the greatest mean rating in four out of the five limited access cases. The precipitating factor in the fifth case was drugged or drunk and had a high mean rating of 8.7. Drugged or drunk had the highest mean rating in two of the random cases and inexperienced driver accounted for two other cases. No data are presented for the fifth case because all subjects responded with "none" or "unknown" predisposing factors. These were not rated and are excluded from the discussion.

Figure 8 shows the responses to the question "what was the other driver's action?" No responses are presented for five of

the ten cases. In three of the random cases there was no "other car" or it was legally parked. In the other two limited access cases the other car was struck in the rear and the driver was not at fault and probably could have done nothing to avoid the accident. For the five cases presented the mean standard deviations are 0.30, 1.10, 1.63, 1.64, and 1.94 and the respective highest mean ratings are 0.6, 8.8, 6.9, 3.0, and 5.7. Lane changing without adequate warning and failure to stop or slow in a safe distance each had the highest mean ratings for two cases.

Contributing behavior responses of the other driver are shown in Figure 9. Mean standard deviations are 1.40 and 0.16 for the two random cases; the respective highest mean ratings are 3.7 for speed too fast for conditions and 0.7 for failure to look or see directly. Responses are given to all limited access cases, but the two cases involving vehicles struck in the rear have negligible values, probably indicating only one subject responding. The remaining three mean standard deviations are 0.90, 1.36, and 2.10; and the corresponding highest mean ratings are 4.0, 4.4, and 5.4. The principal contributing behavior was failure to look or see directly.

Results of ratings of the "predisposing factor" for the other driver are presented in Figure 10. Data are present for only one random case and it is insignificantly weighted. The limited access mean standard deviations vary from 0.06 to 2.20, with four of the five below 0.85. The highest mean ratings vary from 0.1 to 8.7 with four at or below 3.0. Inattention, diverted attention, asleep, and inexperienced drivers receive the highest mean ratings.

Figure 11 indicates the responses to the question "what factors may have been at fault in the performance of the precipitating vehicle?" Differences among cases are smaller to this question than to the prior questions. Mean standard deviations vary from 0.27 to 1.72. The highest mean ratings vary

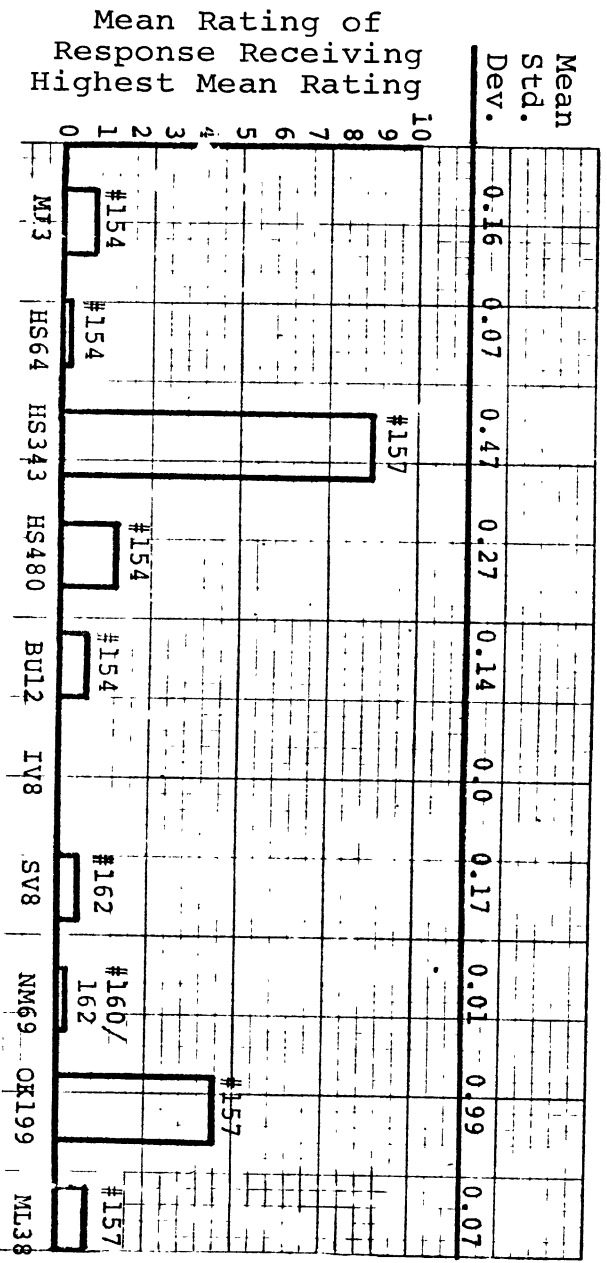


Figure 7. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 7C, "Rate the absolute importance of the predisposing factors of the precipitating driver."

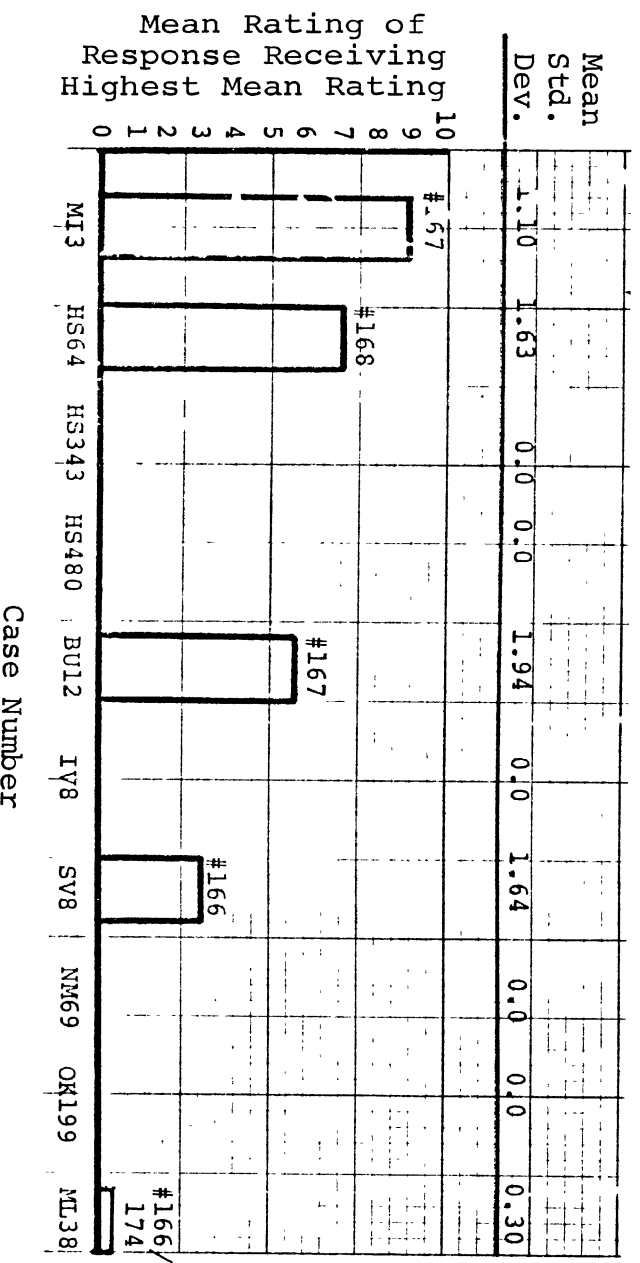


Figure 8. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 8A, "Rate the absolute importance of each action of the other driver."

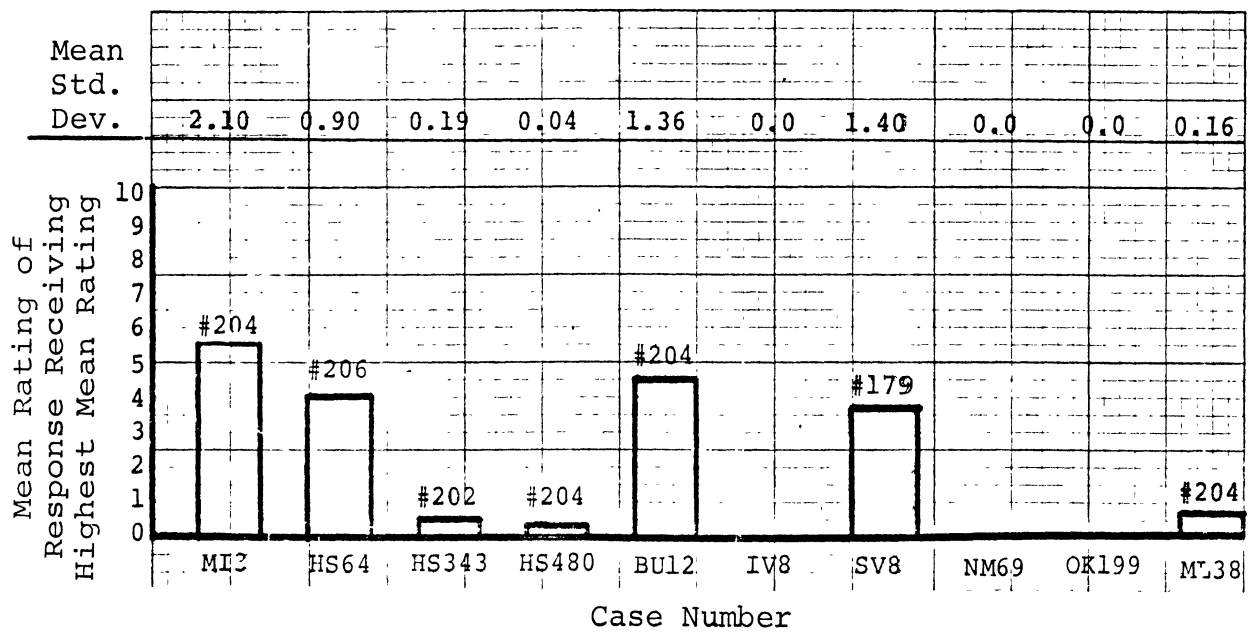


Figure 9. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 8B, "Rate the absolute importance of the contributing behavior of the other driver."

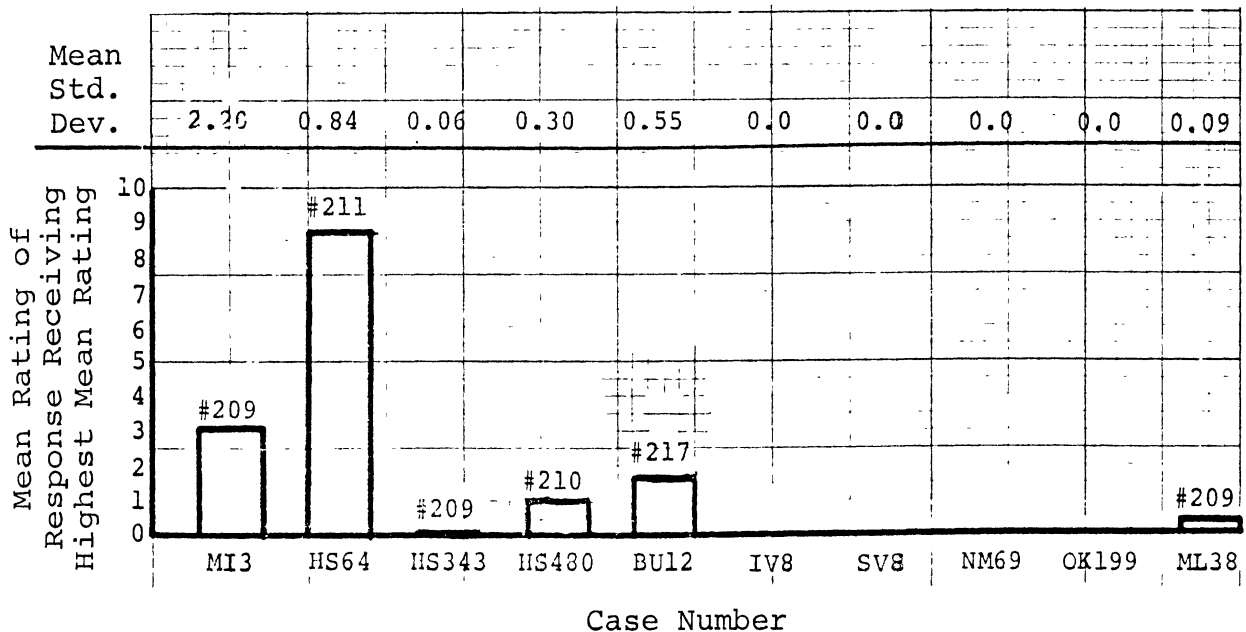


Figure 10. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 8C, "Rate the absolute importance of the predisposing factors of the other driver."

from 1.1 to 4.7. The principal responses were brakes, tires and steering, in descending order.

Responses to the question "what factors may have been at fault in the performance of the other vehicle?" are shown in Figure 12. Data for the three random cases in which a second vehicle was involved, indicate mean standard deviations from 0.27 to 0.64 and greatest mean ratings from 1.0 to 3.1. Brakes were again prominent. For the limited access cases mean standard deviations vary from 0.31 to 1.40 and greatest mean ratings from 0.6 to 3.9. Marking/signaling and side visibility had high mean ratings for two cases each.

Responses to Questions 11 and 12 are concerned with the road factors at fault for the precipitating (and other) vehicle (Figure 13). The magnitudes of the ratings for the limited access cases are considerably lower than for the randomly selected ones. For the limited access cases mean standard deviations vary from 0.30 to 1.24, and highest mean ratings are low, varying from 0.6 to 1.8. For the random cases, mean standard deviations vary from 1.12 to 1.76 and highest mean ratings from 2.4 to 6.3. Pavement friction and sight distance each account for 4 cases with no significant limited access/random case distinctions.

Responses to Question 12 (faults in the road used by the other vehicle) are shown in Figure 14. Mean standard deviations varied from 0.19 to 1.37 and highest mean ratings from 0.6 to 6.8. Ratings were not made in three cases; two were random cases in which no second car was present. The third case involved a car crossing the median on a limited access roadway and striking an oncoming truck. The most frequent highest mean ratings were for traffic control and speed limit on limited access roads, but many other variables were also listed.

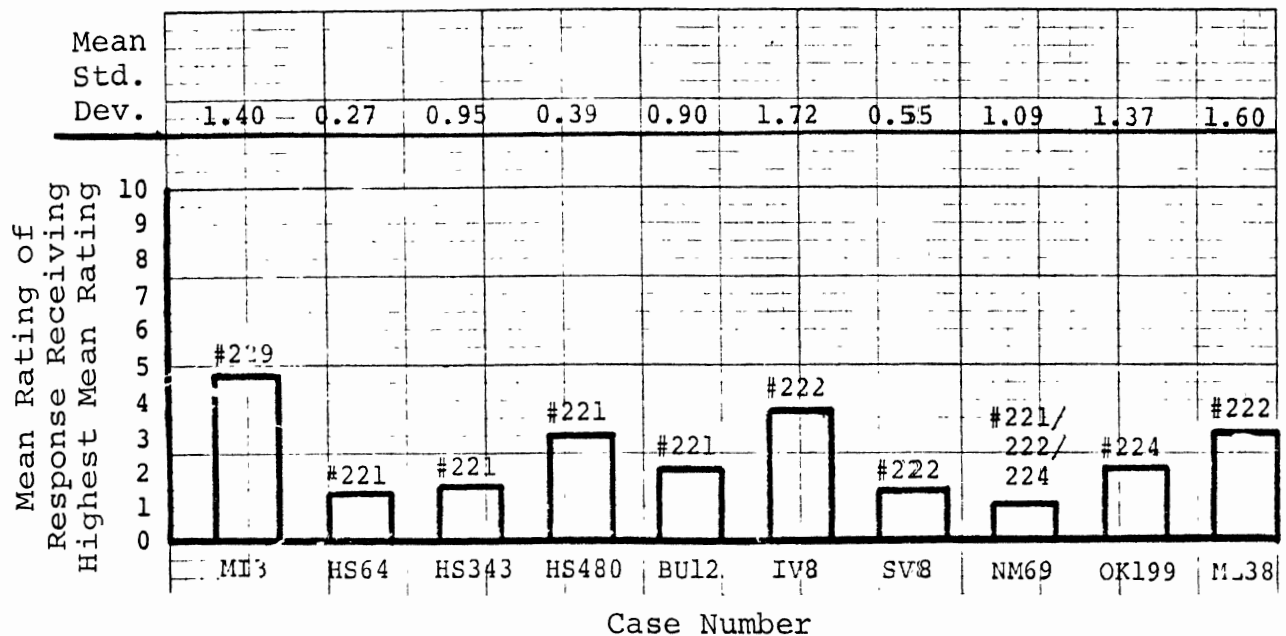


Figure 11. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 9, "Rate the absolute importance of each factor which may have been a fault in the performance of the precipitating vehicle."

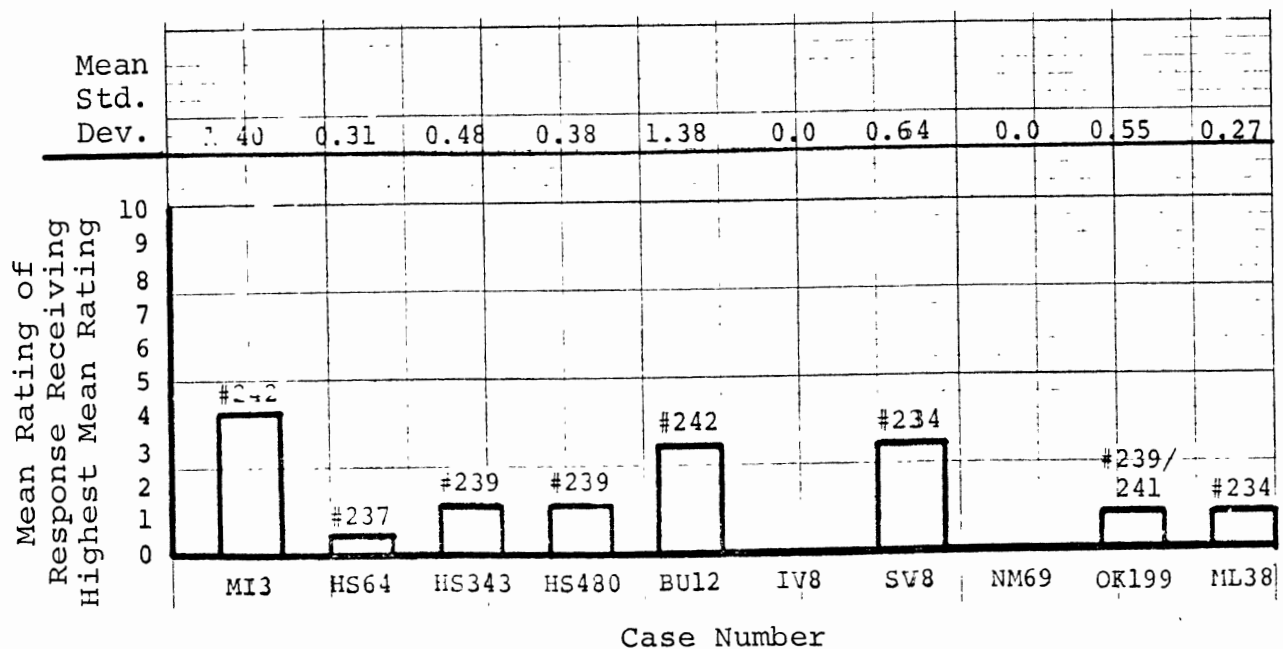


Figure 12. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 10, "Rate the absolute importance of each factor which may have been a fault in the performance of the other vehicle."

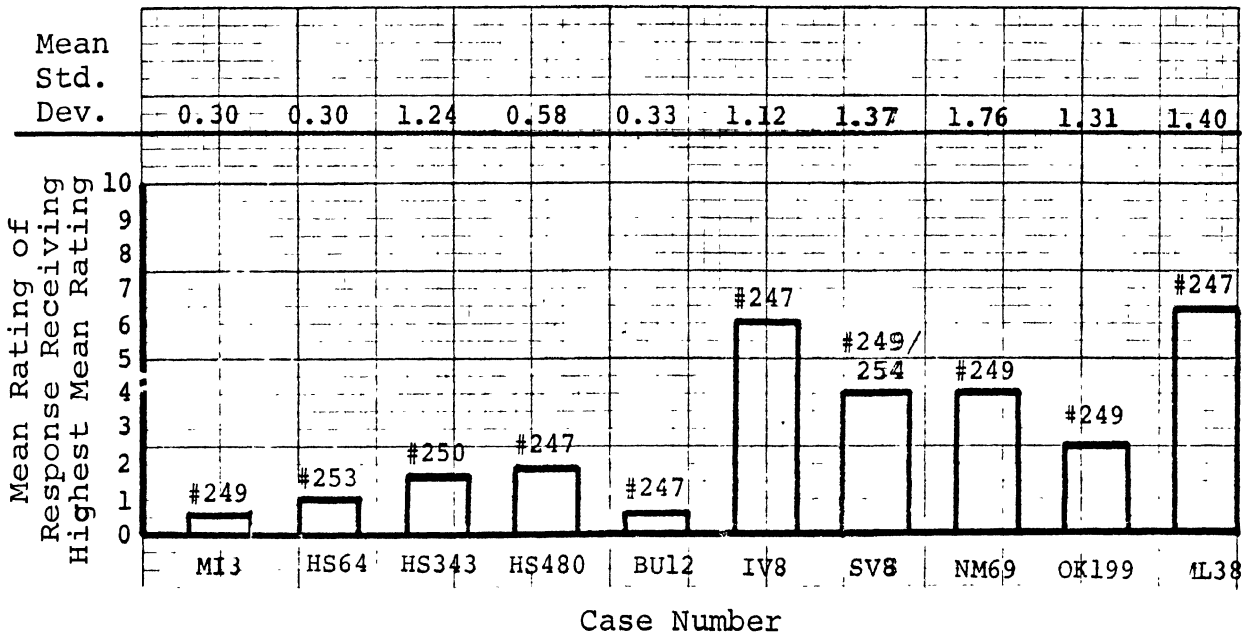


Figure 13. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 11, "Rate the absolute importance of each factor which may have been a fault in the road used by the precipitating vehicle."

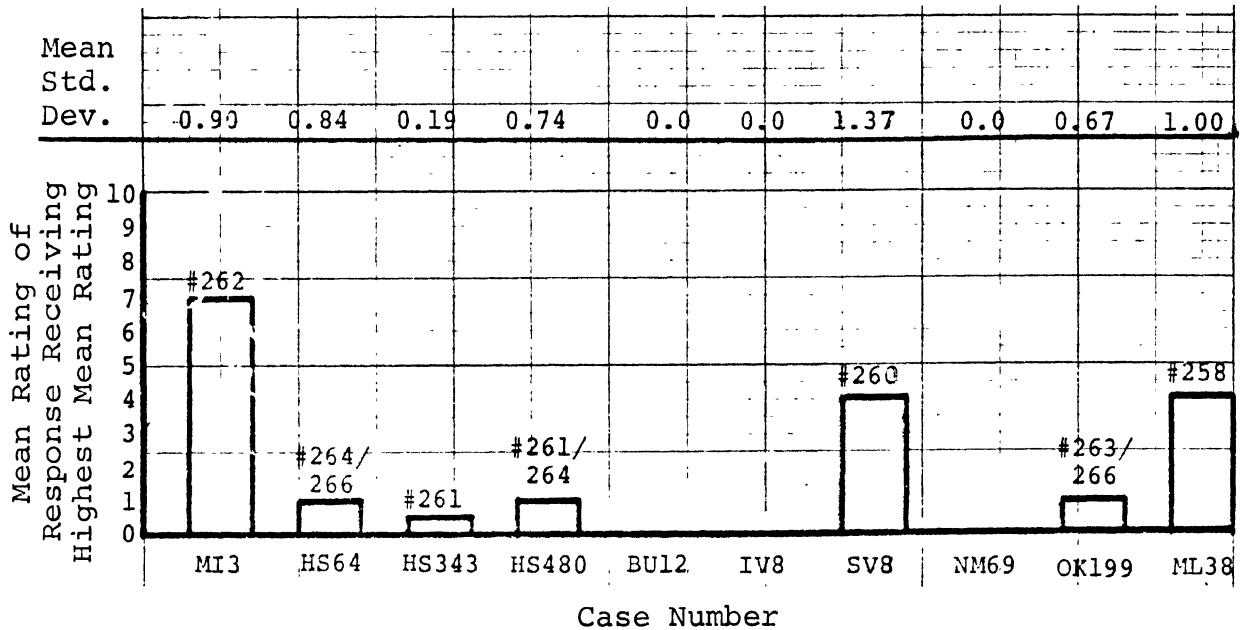


Figure 14. Summary of response options of items receiving highest mean rating and overall mean standard deviation of responses for all cases to question 12, "Rate the absolute importance of each factor which may have been a fault in the road used by the other vehicle."

INFORMATION NEEDED TO AVOID THE CRASH

Question 13 asks the raters to assess the information needed by each driver to avoid the crash. A brief description of the cases and responses to Question 13 follow.

Case 008-I. The driver braked to avoid hitting a deer and lost control sliding off the roadway and striking a tree. Information needed was reported as knowledge of the deer's presence or of a deer crossing area (4 responses), and that the maneuver would result in loss of control (2 responses).

Case 008-S. A speeding motorcyclist was unable to make a turn and skidded into the path of an oncoming car. The precipitating driver needed a better warning that his speed was too fast for conditions (5 responses), and no information (2 responses). The other driver needed no information (4 responses) and a warning that a vehicle was approaching out of lane (3 responses).

Case 069. A speeding driver had to steer to avoid striking pedestrians in the roadway and struck a light pole. The driver needed to know that his speed was too fast (4 responses), knowledge of the presence of pedestrians in the roadway (3 responses), and that the maneuver would result in loss of control (2 responses).

Case 199. The precipitating driver, who had been drinking, swerved to avoid striking a parked car and struck another parked car. The driver needed to know that his speed was too fast for the curve (3 responses), an awareness of parked cars (4 responses) and the control envelope of the car (2 responses).

Case 038. The speeding, precipitating drunk driver lost control on the wet roadway while overtaking another vehicle and crossed the median, impacting the approaching vehicle. The precipitating driver needed to know that he should not drive when drunk (5 responses), the hazards of wet roads (3 responses)

and to reduce his speed (2 responses). The other driver needed to know that the precipitating vehicle was approaching out of control (3 responses).

Case 003. The driver of a vehicle traveling on the inside lane crossed three lanes of traffic to exit and was bumped by another vehicle, causing loss of control. The precipitating (i.e., striking) driver needed no information (3 responses) and knowledge that the other car was entering the lane on a collision course (3 responses). The other driver (the one crossing to exit) needed an earlier indication of the exit ramp (7 responses), and a better knowledge of the presence of the other vehicle (6 responses).

Case 064. The other driver apparently fell asleep at the wheel and went off the shoulder and then back onto the roadway striking another car. The precipitating driver needed an earlier warning of a car approaching from the side out of control (3 responses), and needed no information (3 responses). The other driver needed to know that he was falling asleep and was about to lose control (6 responses), and no information (2 responses).

Case 343. The precipitating vehicle swerved into the median to reportedly avoid a car which pulled into his lane. He then swerved back to avoid construction flashers and struck another vehicle. The precipitating driver needed knowledge of vehicle handling limits (5 responses), information needed unknown (2 responses), and construction zone warning (2 responses). The other driver needed no information (7 responses).

Case 480. One vehicle slowed for traffic and was struck in the rear by another car. The precipitating driver needed an earlier warning of slowing traffic (7 responses). The other driver needed no information (5 responses) and knowledge that the vehicle approaching from the rear was not reducing speed sufficiently (2 responses).

Case 012. A car in the second lane from the median inched over toward the median and was struck by the car in the inside lane. The precipitating driver needed to know that the other driver was intruding into his lane (4 responses) and that he should drive in the right lane except to pass (2 responses). The other driver needed to know that the precipitating car was adjacent to him (5 responses).

The responses to Question 13 for these 10 cases can be classified, in a similar manner as was done in the previous cases. Although there were no cases where information of "impending vehicle failure" was considered useful, the other responses can be classified by "vehicle handling," "driver education of accident predisposing situations," "distance and relative speed with respect to other vehicles or objects," and an additional classification, "earlier route guidance signing or marking of a road hazard."

Twenty-eight of the 125 responses given indicated that no information was needed. These responses encompassed half the cases. The eleven vehicle handling responses involved loss of control by the precipitating driver and were given to 4 of the accident cases. Sixteen responses in three cases were classified under "driver education of accident predisposing situations." In one case, the driver needed to know that he was falling asleep and was about to lose control (6 responses). In another case the driver should have known to drive in the right lane except to pass (2 responses). In the final case the driver needed to know that he should not drive when drunk (5 responses) and he should have known of the hazards of wet roads (3 responses).

Again, "distance and relative speed with respect to other vehicles or objects" accounted for the largest number (67%) of the responses concerned with the information-required by

other drivers. Nine of the 10 cases had responses in this category. This category of informational needs was derived from the following situations: Vehicle approaching out of control or out of lane (16 responses), speed too fast (14 responses), greater awareness of the location of nearby vehicles (11 responses), and traffic slowing ahead (9 responses).

An additional category was added because two cases involved accidents which might have been prevented if earlier warning of road conditions had been given to the drivers. In one case the driver needed an earlier indication of an exit (7 responses). In another case the driver needed warning of a construction zone (2 responses). Thus, the classification, "earlier route guidance signing or hazard marking" was added.

CONFIDENCE IN THE DERIVED INFORMATION NEEDS. The last question required a numerical assessment of confidence with which the evaluator reached the conclusions to the previous question. Confidence ratings were distributed from 49% to 93%, with little difference between the "precipitating" and "other" driver ratings.

DISCUSSION

As stated earlier, the responses we are most interested in are those to the question "what information was needed by the precipitating and other driver-vehicle combination to avoid the crash?" The questions prior to this one help the evaluator determine if enough information is available to answer this question and to systematically examine the accident.

Correct identification of the precipitating and other vehicle was considerably better for the first set of ten cases than the second set (96% vs. about 73%). The former cases were selected partly on the basis of ease in identifying the precipitating vehicle. However, a reversal of vehicles is not critical because the responses to the other questions can be,

and were, appropriately reversed as needed.

Evaluators thought there was sufficient information available to reconstruct the crash sequence in most cases, and they completed the questionnaire even more frequently. Thus, enough information was usually available from CPIR or MDAI reports to have raters attempt to complete the questionnaire.

This should not, however, be taken to suggest that these accident reports deal with the pre-crash phase in the desired level of detail. It was quite clear to the raters that the crash investigations were deficient in many details of the elements leading up to the crash.

In reviewing the cases, no apparent action is taken by the precipitating driver about 47% of the time. Steering is primarily involved in 23% of the cases, braking in 23% of the cases, and acceleration in 7% of the cases. About half the time this action was considered appropriate by the raters.

No action is taken by the other driver about 61% of the time. It was expected that this frequency would be greater than for the precipitating driver, because the other driver frequently has less time to react or is not even aware of the impending accident. For the other driver braking occurred 31% of the time and steering 8% of the time, with acceleration occurring less than 1% of the time. Over two-thirds of the time the evaluators felt that the other driver acted appropriately in taking no avoidance action.

The major precipitating driver action was loss of control during an avoidance maneuver. The major contributing behavior was failure to judge speed or distance, and excessive speed. The major predisposing factor was inattention. The faults for the other driver were more varied than for the precipitating driver. Driver action involvement came primarily from failure to remove the disabled car from the roadway, and lane changing.

Failure to look directly, failure to use mirrors, and failure to signal were major contributing behaviors. The prime predisposing factor was inattention. Evaluators found no major faults for the other driver more frequently than for the precipitating driver, as expected.

In the first set of cases very few vehicle faults were found in either the precipitating or other vehicle. In the second set of cases considerably more vehicle faults were found. The primary potentially faulty systems were brakes, tires, side visibility, and marking/signaling.

Responses for environmental faults followed the same course as for vehicle faults; that is, more faults were found with the second set of cases. Primary environmental faults were sight distance, pavement friction, traffic control, road design, and speed limit.

Information needs were categorized by (1) warning of impending vehicle failure, (2) vehicle handling training, (3) driver education of accident predisposing situations, (4) knowledge of the distance and relative speed with respect to other vehicles or objects, and (5) earlier route signing or marking. The fourth category contained the majority of cases. Based on these information needs some countermeasures can be suggested to reduce vehicle accidents.

The confidence ratings of the informational requirements varied from a low of 10% to a high of 100%. The overall mean was 78% for the 20 cases, indicating that raters expressed a generally good degree of confidence in the conclusions.

The consistency in response of the raters is an indication of reliability and is shown by the mean standard deviation. A high mean standard deviation indicates a lack of consistency among the raters and, consequently, low reliability. A low mean

standard deviation indicates agreement among the raters in choosing responses, and high reliability. Figure 15 shows that no mean standard deviation was greater than 2.20 and that 88 of the 100 mean standard deviations were less than 1.50. Only three of the questions, 7A, 9 and 11, have five or six mean standard deviations above 1.00. The low mean standard deviations are indicative of a reliable test.

Figure 16 shows the cumulative frequency of mean ratings of responses receiving the highest mean ratings. Nineteen percent of the mean ratings were rated 5 or higher, with 43% rated 2 or higher. High mean ratings indicate agreement among the raters in choosing one important factor and agreement among the raters in rating the factor as having great importance to the accident. Moderate or low mean ratings consequently do not indicate a lack of agreement among the raters in choosing one important factor or a lack of agreement in rating the importance of the factor in contributing to the accident. The raters do, in fact, agree fairly well in choosing the more important factors, as is shown by the low mean standard deviations. The low mean ratings which do occur usually indicate the most important factor did not contribute greatly to the accident, frequently because only 1 or 2 subjects thought the factor important.

In looking at Figures 5-14 it is apparent that one or two factors frequently play an important part in more than one accident. The precipitating driver frequently failed to stop or slow in a safe distance, lost control during an avoidance maneuver, was driving too fast for conditions, was inattentive, or drunk. The other driver, when he could be faulted, lost control exclusive of an avoidance maneuver, failed to look or see directly, and was perhaps inattentive.

For the precipitating driver, vehicle factors of brakes and tires were faulted; for the other driver, marking and signaling

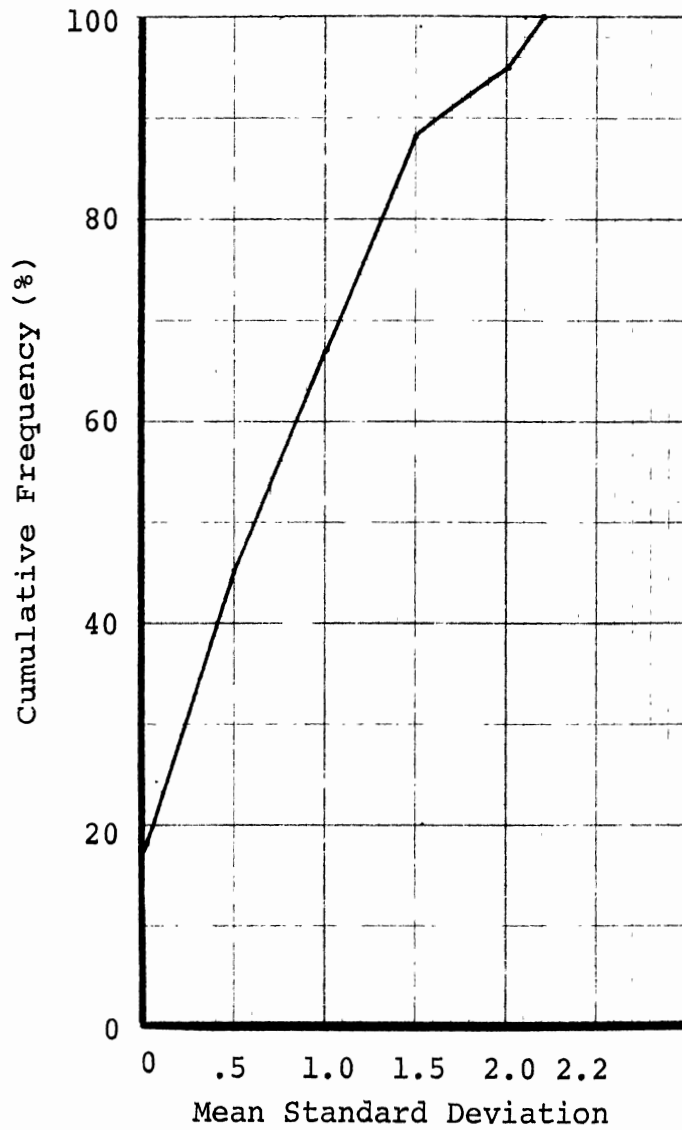
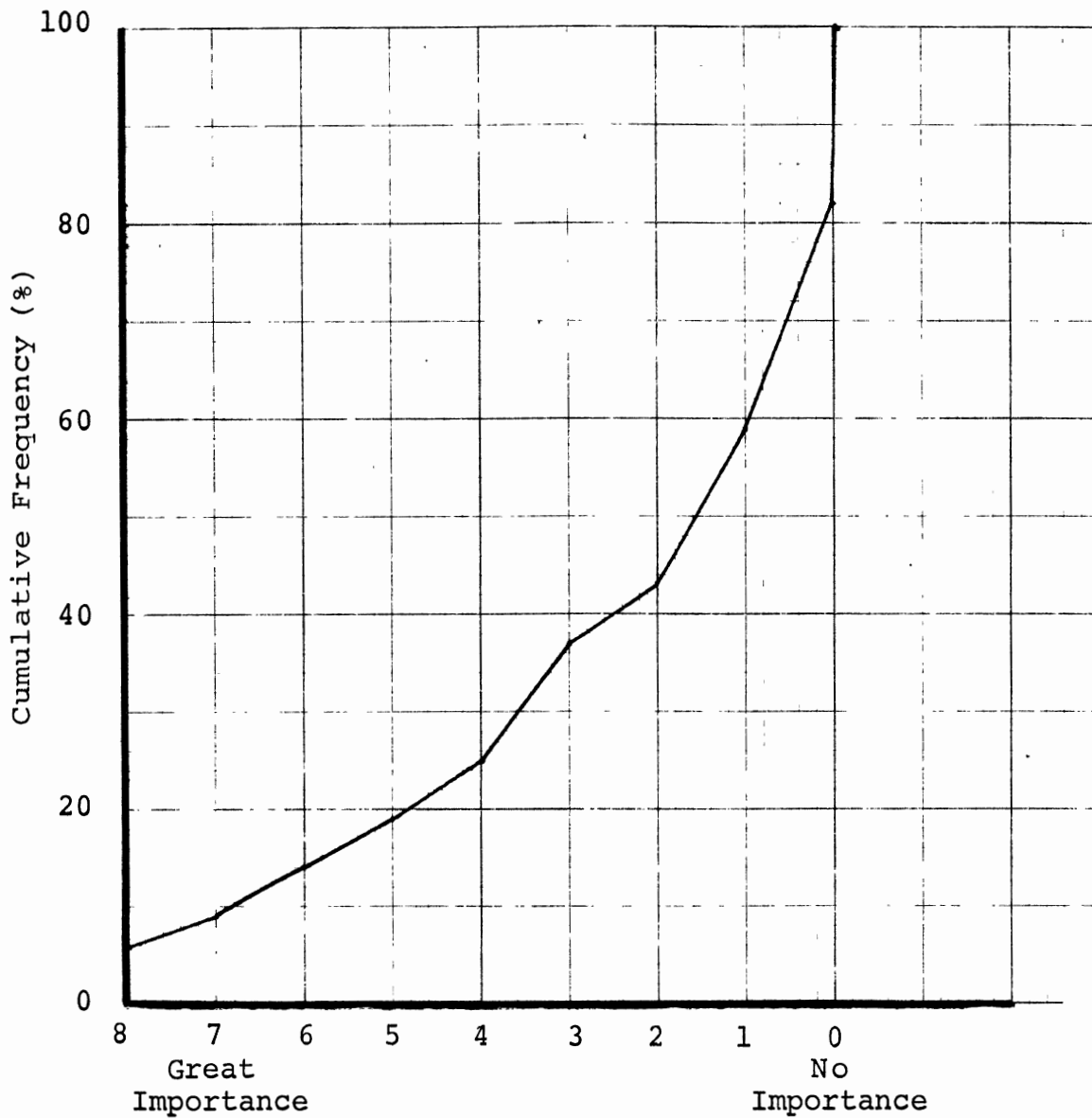


Figure 15. Cumulative frequency of mean standard deviations for questions 7-12 (from Figures 5-14).



Highest Mean Rating

Figure 16. Cumulative frequency of highest mean ratings for questions 7-12 (from Figures 5-14). Frequencies are plotted from the lower end of the interval.

was most often faulted with brakes and side visibility also mentioned. None of these had mean response ratings above 5. The environmental factors which contributed to the accident were pavement friction and sight distance for the precipitating driver. Mean ratings were considerably higher for the cases drawn at random than for the limited access cases. No strong environmental factors were found for the other driver.

CONCLUSIONS

The accident questionnaire provides a simple means of evaluating the driver-vehicle factors in the pre-crash phase of accidents, of structuring hypotheses of driver-vehicle performance failures, and of suggesting appropriate countermeasures to prevent accidents from occurring. With a few basic facts about an accident, the rater is able to fill out the questionnaire indicating the driver-vehicle factors contributing to the pre-crash phase. Results have shown that rater agreement is satisfactorily high. In answering the question "what information was needed to avoid the crash?" the rater provides a hypothesis of the driver-vehicle performance failure. These failures can usually be placed in one of five categories: impending vehicle failure, vehicle handling, driver education of accident predisposing situations, distance and relative speed with respect to other vehicles or objects, and earlier route signing and hazard marking. Appropriate countermeasures can be chosen based on such results.

The questionnaire developed here is a tool for analyzing accident pre-crash phases and deriving the drivers' information needs. For the 20 cases analyzed, no obvious differences were found between the crashes which occurred on limited access highways and those on other roads. Perhaps no basic behavioral, vehicle or environmental differences exist on these two types of roads which predispose drivers to suffer crashes. Evaluation of a large sample of cases will help to improve definition of the problems underlying the events leading to a crash.

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APPENDIX

Pre-Crash Accident Analysis Form

HSRI PRE-CRASH ACCIDENT ANALYSIS FORM

(101-108) Case Number _____

(110-112) Initials of Evaluator _____

Name of Evaluator _____

Date Form Filled Out _____

1. Identify the number of the vehicle which you interpret as the precipitating¹ driver-vehicle combination, and as the other driver vehicle.

A. (113) Precipitating

B. (114) Other

2. Is enough information available to reconstruct the crash sequence?

(115) Yes

(116) No

3. Is accident avoidance taken by the precipitating driver classifiable by (check those that apply)

(117) Braking

(118) Steering

(119) Acceleration

(120) No Apparent Action Taken

4. Is precipitating driver's accident avoidance action appropriate?

(121) Yes

(122) No

(123) No Apparent Action Taken

5. Is accident avoidance action taken by other driver classifiable by (check those that apply)

(124) Braking

(125) Steering

(126) Acceleration

(127) No Apparent Action Taken

¹A "precipitating vehicle" is defined as one which is approaching from rear, out of lane in head-on, through traffic control at intersection.

6. Is other driver's accident avoidance action appropriate?

- | | | |
|-------|--------------------------|--------------------------|
| (128) | <input type="checkbox"/> | Yes |
| (129) | <input type="checkbox"/> | No |
| (130) | <input type="checkbox"/> | No Apparent Action Taken |

7. In each of the following three categories, rate the absolute importance of each individual item for the PRECIPITATING driver. Use numbers 0-9 with 9 representing greatest importance and 0 representing no importance. Different items in the same category may have the same rating. (Ratings of 0 may be left blank.)

A. Precipitating driver action (What did the driver actually do that resulted in his involvement?)

- | | | |
|-------|--------------------------|--|
| (131) | <input type="checkbox"/> | Failure to stop or slow in safe distance (rather than avoid by steering) |
| (132) | <input type="checkbox"/> | Lane change without adequate warning |
| (133) | <input type="checkbox"/> | Loss of control- exclusive of avoidance maneuver |
| (134) | <input type="checkbox"/> | Loss of control - during avoidance maneuver |
| (135) | <input type="checkbox"/> | Disregarding (or failure to heed) traffic control |
| (136) | <input type="checkbox"/> | Stopping or leaving disabled car on road |
| (137) | <input type="checkbox"/> | Entering traffic stream without adequate caution |
| (138) | <input type="checkbox"/> | Failure to keep vehicle within defined road boundaries |
| (139) | <input type="checkbox"/> | Failure to avoid obstruction (rather than stop or slow) |
| (140) | <input type="checkbox"/> | Other (specify) _____ |
| (141) | <input type="checkbox"/> | None |
| (142) | <input type="checkbox"/> | Unknown |
- } check if none of the above

B. Contributing behavior (what behavior(s) contributed to the actions described above?)

- | | | |
|-------|--------------------------|------------------------------------|
| (143) | <input type="checkbox"/> | Failure to signal maneuver |
| (144) | <input type="checkbox"/> | Speed too fast for conditions |
| (145) | <input type="checkbox"/> | Failure to judge speed or distance |
| (146) | <input type="checkbox"/> | Following too closely |
| (147) | <input type="checkbox"/> | Failure to use mirrors |
| (148) | <input type="checkbox"/> | Failure to obey signing or signals |
| (149) | <input type="checkbox"/> | Failure to look or see directly |

- (150) Wrong way driving
 - (151) Other (specify) _____
 - (152) None
 - (153) Unknown
- } Check if none of the above

C. Predisposing factors (what factors increased the likelihood of the driver's involvement?)

- (154) Inattention
 - (155) Diverted attention
 - (156) Asleep
 - (157) Drugged, drunk
 - (158) Emotionally upset
 - (159) Medical incapacitation
 - (160) Fatigue
 - (161) Infirmities, physically handicapped
 - (162) Inexperienced driver
 - (163) Other (specify) _____
 - (164) None
 - (165) Unknown
- } Check if none of the above

8. In each of the following three categories, rate the absolute importance of each individual item for the OTHER driver. Use numbers 0-9 with 9 representing greatest importance and 0 representing no importance. Different items in the same category may have the same rating. (Ratings of 0 may be left blank.)

A. Other driver's action (What did the driver actually do that resulted in his involvement?)

- (166) Failure to stop or slow in safe distance (rather than avoid by steering)
- (167) Lane change without adequate warning
- (168) Loss of control - exclusive of avoidance maneuver
- (169) Loss of control - during avoidance maneuver
- (170) Disregarding (or failure to heed) traffic control
- (171) Stopping or leaving disabled car on road
- (172) Entering traffic stream without adequate caution

- | | | | |
|-------|--------------------------|---|------------------------------|
| (173) | <input type="checkbox"/> | Failure to keep vehicle within defined road boundaries | |
| (174) | <input type="checkbox"/> | Failure to avoid obstruction (rather than stop or slow) | |
| (175) | <input type="checkbox"/> | Other (specify) _____ | |
| (176) | <input type="checkbox"/> | None | } check if none of the above |
| (177) | <input type="checkbox"/> | Unknown | |

B. Contributing behavior (what behavior(s) contributed to the actions described above?)

- | | | | |
|-------|--------------------------|------------------------------------|------------------------------|
| (178) | <input type="checkbox"/> | Failure to signal maneuver | |
| (179) | <input type="checkbox"/> | Speed too fast for conditions | |
| (180) | <input type="checkbox"/> | Failure to judge speed or distance | |
| (201) | <input type="checkbox"/> | Following too closely | |
| (202) | <input type="checkbox"/> | Failure to use mirrors | |
| (203) | <input type="checkbox"/> | Failure to obey signing or signals | |
| (204) | <input type="checkbox"/> | Failure to look or see directly | |
| (205) | <input type="checkbox"/> | Wrong way driving | |
| (206) | <input type="checkbox"/> | Other (specify) _____ | |
| (207) | <input type="checkbox"/> | None | } check if none of the above |
| (208) | <input type="checkbox"/> | Unknown | |

C. Predisposing factors (what factors increased the likelihood of the driver's involvement?)

- | | | | |
|-------|--------------------------|-------------------------------------|------------------------------|
| (209) | <input type="checkbox"/> | Inattention | |
| (210) | <input type="checkbox"/> | Diverted attention | |
| (211) | <input type="checkbox"/> | Asleep | |
| (212) | <input type="checkbox"/> | Drugged, drunk | |
| (213) | <input type="checkbox"/> | Emotionally upset | |
| (214) | <input type="checkbox"/> | Medical incapacitation | |
| (215) | <input type="checkbox"/> | Fatigue | |
| (216) | <input type="checkbox"/> | Infirmities, physically handicapped | |
| (217) | <input type="checkbox"/> | Inexperienced driver | |
| (218) | <input type="checkbox"/> | Other (specify) _____ | |
| (219) | <input type="checkbox"/> | None | } Check if none of the above |
| (220) | <input type="checkbox"/> | Unknown | |

9. Rate the absolute importance of each factor which may have been a fault in the performance of the precipitating vehicle. Use numbers 0-9 with 9 representing greatest importance and 0 representing no importance.

(221)	<input type="checkbox"/>	Brakes	(228)	<input type="checkbox"/>	Visibility - Front
(222)	<input type="checkbox"/>	Tires	(229)	<input type="checkbox"/>	Visibility - Side
(223)	<input type="checkbox"/>	Suspension	(230)	<input type="checkbox"/>	Power -Drive Train Failure
(224)	<input type="checkbox"/>	Steering	(231)	<input type="checkbox"/>	Other (specify) _____
(225)	<input type="checkbox"/>	Headlighting	(232)	<input type="checkbox"/>	None } check if Unknown } none of } the above
(226)	<input type="checkbox"/>	Marking/Signaling	(233)	<input type="checkbox"/>	
(227)	<input type="checkbox"/>	Visibility-Rear			

10. Rate the absolute importance of each factor which may have been a fault in the performance of the other vehicle.

(234)	<input type="checkbox"/>	Brakes	(241)	<input type="checkbox"/>	Visibility - Front
(235)	<input type="checkbox"/>	Tires	(242)	<input type="checkbox"/>	Visibility - Side
(236)	<input type="checkbox"/>	Suspension	(243)	<input type="checkbox"/>	Power - Drive Train Failure
(237)	<input type="checkbox"/>	Steering	(244)	<input type="checkbox"/>	Other (specify) _____
(238)	<input type="checkbox"/>	Headlighting	(245)	<input type="checkbox"/>	None } check if Unknown } none of } the above
(239)	<input type="checkbox"/>	Marking/Signaling	(246)	<input type="checkbox"/>	
(240)	<input type="checkbox"/>	Visibility - rear			

11. Rate the absolute importance of each factor which may have been a fault in the road used by the precipitating vehicle. Use numbers 0-9 with 9 representing greatest importance and 0 representing no importance.

(247)	<input type="checkbox"/>	Pavement Friction	(253)	<input type="checkbox"/>	Speed Limit
(248)	<input type="checkbox"/>	Delineation	(254)	<input type="checkbox"/>	Geometric Design
(249)	<input type="checkbox"/>	Sight Distance	(255)	<input type="checkbox"/>	Other (specify) _____
(250)	<input type="checkbox"/>	Traffic Control	(256)	<input type="checkbox"/>	None } check if Unknown } none of } the above
(251)	<input type="checkbox"/>	Route Guide Signs	(257)	<input type="checkbox"/>	
(252)	<input type="checkbox"/>	Lighting			

12. Rate the absolute importance of each factor which may have been a fault in the road used by the other vehicle.

(258)	<input type="checkbox"/>	Pavement Friction	(264)	<input type="checkbox"/>	Speed Limit
(259)	<input type="checkbox"/>	Delineation	(265)	<input type="checkbox"/>	Geometric Design
(260)	<input type="checkbox"/>	Sight Distance	(266)	<input type="checkbox"/>	Other (specify) _____
(261)	<input type="checkbox"/>	Traffic Control			
(262)	<input type="checkbox"/>	Route Guide Signs	(267)	<input type="checkbox"/>	None
(263)	<input type="checkbox"/>	Lighting	(268)	<input type="checkbox"/>	Unknown

} Check if none of the above

13. What information was needed by the precipitating and other driver-vehicle combination to avoid the crash? If you determine that no information was needed write "none".

A. Precipitating:

B. Other:

14. Express the degree of confidence (in percent)* that you have in the correctness of the conclusions drawn in question 13.

Precipitating _____ % Confidence
 Other _____ % Confidence

*100% = maximum confidence, 0% = minimum confidence.

