DOT HS 600 861

SUMMARY OF 1968-1970 MULTIDISCIPLINARY ACCIDENT INVESTIGATION REPORTS

VOL. 2 of 2

Office of Accident Investigation and
Data Analysis Research Institute
National Highway Traffic Safety Administration

August 1972

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 600 861		

4. Title and Subtitle	5. Report Date
Summary of 1968-70 Multidisciplinary Accident Investigation Reports: Volume 2 of 2	August 1972
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Office of Accident Investigation and Data Analysis	

9. Performing Organization Name and Address	10. Work Unit No.
National Highway Traffic Safety Administration 400 Seventh Street, S. W. Washington, D. C. 20590	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Summary Report 1968-1970
U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

In June 1971, Volume 1 of a two-volume series summarizing the causal factors, conclusions and recommendations which emanated from various in-depth accident reports was published. This first volume contained a listing of these factors according to team and case number from 448 Multidisciplinary Accident Investigation Reports. These 448 cases were the first in-depth reports submitted to the NHTSA during the years 1968 to 1970 by sixteen different Multidisciplinary Teams. Volume 2 of this series is contained herein. This volume contains aggregations of all the factors listed from the individual reports in Volume 1. These aggregations are listed according to the matrix cell they are categorized under, major topic areas under these matrix cells, and the Team and Case Number of occurrence in which the particular aggregated factors appear in. Section I of this volume gives a brief background of the Teams, a description of their accident case selections, the matrix classifications, the purpose and utilization, and a discussion of what the authors consider significant trends. Section II contains the aggregated factors (2206 of them) according to matrix cell, major topic area, and the Team and case number in which they occurred.

17. Key Words	18. Distribution Statement
Multidisciplinary Accident Investigations; causal factors, conclusions, recommendations; human, vehicle, environmental factors; pre-crash, crash, post-crash phases; trends	unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
unclassified	unclassified	71	

Form DOT F 1700.7 (8-69)

CONTENTS

LIST OF TABLES AND FIGURES

SECTION I

Background

Accident Case Selection

Matrix Classification

Volume 2 Purpose and Utilization

Discussion of Trends

References

Background

In June 1971, Volume 1 of a two-volume series summarizing the causal factors, conclusions and recommendations which emanated from various in-depth accident reports was published.[1] This first volume contained a listing of these factors according to team and case number from 448 Multidisciplinary Accident Investigation reports. These 448 cases were the first in-depth reports submitted to the National Highway Traffic Safety Administration (NHTSA) during the years 1968 to 1970 by sixteen different Multidisciplinary Accident Investigation Teams under contract to NHTSA. Except for various Contractor source changes, these multidisciplinary studies have been ongoing efforts and continue to be funded by the NHTSA. For further information on the background of these investigation teams, their make-up, and the Accident Investigation program in general at NHTSA, see Volume 1[1] of this series or a report entitled: "Annual Report to the Secretary on Accident Investigation and Reporting Activities - 1971."[2]

Accident Case Selection

The collisions investigated by these Multidisciplinary Teams contain several built-in biases. These known biases and their justifications are listed below:

- At least one of the vehicles involved in the collisions must be of at least the last three model years from the accident date. This means that the majority of the vehicles in the accident sample are of 1966 vintage or newer (see Table 1). The NHTSA is mainly interested in the crash performance of newer vehicles, vehicles with recent safety features, and vehicles which contain many of the Federal Motor Vehicle Safety Standards. It is the continuous evaluation of the performance of these new countermeasures which needs to be attained.

- The Teams are also asked to investigate crashes which are cost-effective for the expensive deployment of a team of professionals to investigate. Thus, the majority of accidents are fatals or injury-producing in order to study the injury mechanisms, contact points, causation, etc. (see Table 2). It is the saving of lives and attenuation of injury that most interests NHTSA. The Teams are asked to investigate property-damage-only accidents when at least one vehicle is damaged severely enough to require towing. These cases, of course, can provide insight as to why people were <u>not</u> injured in a relatively high energy collision. Only a small portion, however, of this sample are property-damage-only (see Table 2).

TABLE 1

Frequency of Vehicle Model Year Involvement

1950	1
1953	3
1954	4
1955	3
1956	6
1957	8
1958	3
1959	17
1960	22
1961	20
1962	25
1963	32
1964	36
1965	46
1966	52
1967	108
1968	155
1969	119
1970	30
Unknown	42
Total	732 vehicles

TABLE 2

Type of Collision vs. Accident Severity

	Fatal	Injury Producing	Property Damage	Total
Multiple Vehicle				
Head-On	17	14	1	32
Rear-End	12	19	2	33
Angle	57	71	4	132
Other	15	19	4	38
Sub-Total	101	123	11	235
Single	108	87	18	213
Total	209	210	29	448

PROGRAM MATRIX FOR HIGHWAY SAFETY RESEARCH

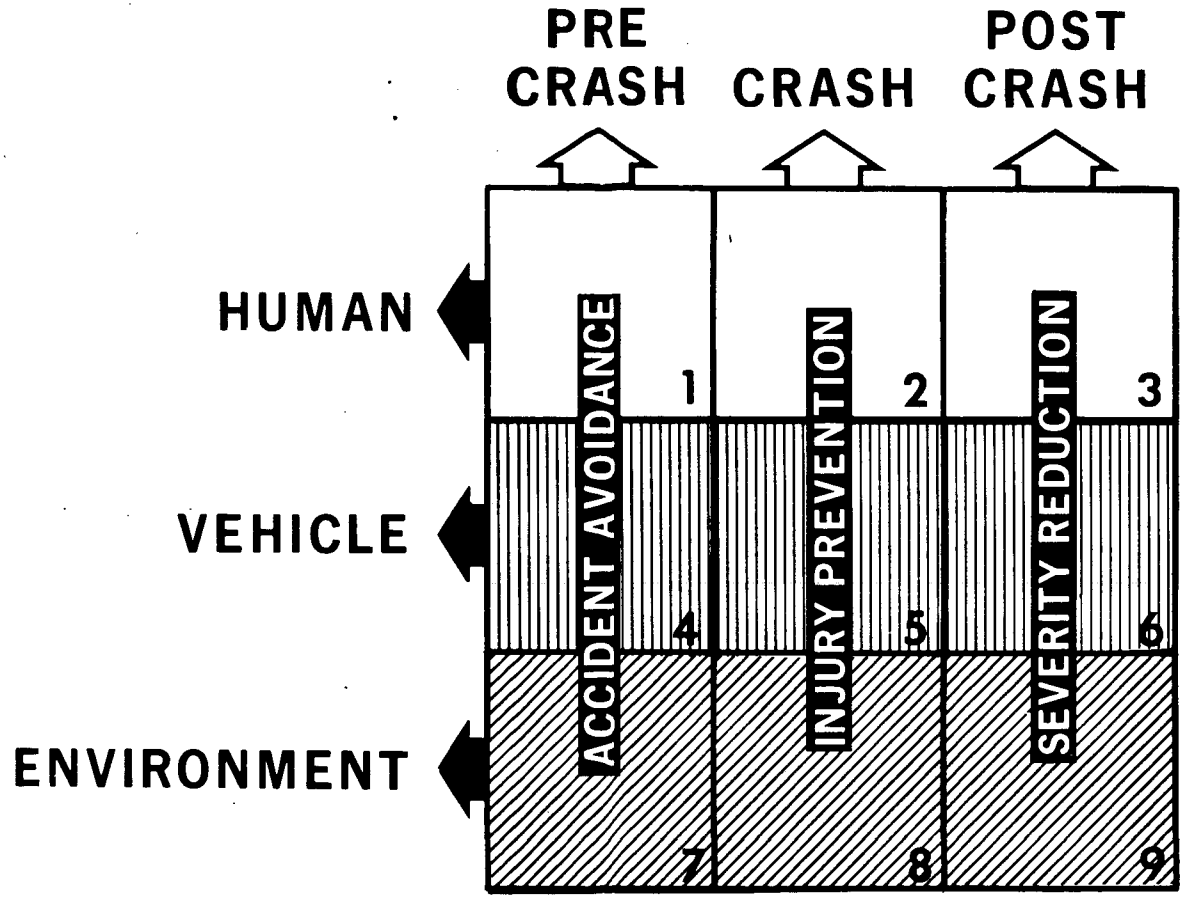

FIGURE 1

- The last known bias in the selection of these collisions is the cooperation of the participants (i.e. drivers, passengers, witnesses, police, etc.). If a team is deprived of certain information, or feels it does not have adequate information to complete the case, the case is dropped from consideration. It is felt that a complete case, with all the facts possible weighed in the causal determinations, is more cost-effective than an incomplete or partially completed case.

Given these known case selection biases, it was felt that a trend analysis of the causal factors and significant findings from the cases would be a fruitful endeavor. There are no other accident case reports known to this office with the depth of investigation applied, the multiple of professional disciplines involved in the investigations, and the amount and quality of data reported as are in these case reports.

As previously mentioned, a total of 448 cases were submitted over this three year period which were subsequently reviewed, printed, and distributed by NHTSA. The cases were summarized and any causal factors, conclusions and recommendations emanating from the reports were categorized. Volume 1 of these two inter-dependent volumes contains a listing of all these factors by team and case number (with a preface to each case containing the collision configuration, vehicles involved, and the accident severity). Each of the factors listed is classified according to the Program Matrix for Highway Safety,[3] briefly described in the next section.

Matrix Classification

Multidisciplinary investigations include a careful analysis of the basic elements of a collision, i.e. (1) human factors, (2) vehicle factors, and (3) environmental factors, in each phase of the traffic system failure, i.e. (1) pre-crash, (2) crash, and (3) post-crash. The combination of these elements and phases logically results into a two-way matrix (see Figure 1).

This matrix was developed by NHTSA to categorize specific areas of study. Each causal factor, conclusion and recommendation contained in Volume 1 of this series, and the aggregations contained in this volume, are classified according to this 9-cell matrix. The matrix system is employed in this sense for the following reasons:

- to conveniently categorize causal factors, conclusions, findings, and recommendations by researchers;

- as a guide for researchers and highway safety users by providing an overview of a particular collision report and as an aid for locating findings of their specific interests;

- to permit aggregating frequencies of occurrence of significant factors in each cell, thus, providing a gross indication of where the problem areas and trends are emerging.

For detailed definitions of the elements and phases of collisions, and specific definitions of each of the 9 cells of the matrix, see Section I of Volume 1[1] or a paper entitled: "Program Matrix for Highway Safety Research."[3]

Volume 2 Purpose and Utilization

Volume 2 contains aggregations of all the factors listed from the individual cases in Volume 1. This volume lists the aggregations according to the matrix cell they are categorized under, major topic areas under those matrix cells, and the Team and Case number of occurrence in which the particular aggregated factors appeared in. The frequencies of occurrence of each factor are purposely not listed to discourage percentage calculations and possible misinterpretation. Volume 1 originally stated that the aggregations in Volume 2 would be listed according to "frequency of occurrence." Because of bias in the selection of accidents for investigation, the frequency of occurrence of accident factors has no statistical meaning and could mislead many users. Consequently, the frequencies are not listed.

The basic use of Volume 2 is to provide reference cases to users interested in certain factors. For example, a user interested in all the cases involving alcohol as a causal factor would find these cases listed under:

- Cell 1, Human Pre-Crash
- Conditions or States (of driver)

The cases involving alcohol then appear under two factors:

- Driver intoxicated (BAC $\geq$ .10% or stated as such)
- Driver had been drinking (BAC $<$ .10% or stated as such)

The user can then refer back to Volume 1 for the type of collision, the severity, the other causal factors, etc. in each one of these cases. If that information is not enough, he can request the Summary or Full case report from NHTSA. Volumes 1 and 2 are, therefore, inter-dependent and should be used in conjunction with each other.

Although the frequencies are purposely not tallied and listed in this volume, there are certainly some obvious trends in the findings and factors which need to be discussed. Since the authors of this report are closest to the types of cases selected, the techniques used to investigate and report these accidents, and the relative credibility of the findings, it is appropriate to discuss what we think are significent trends.

Discussion of Trends

Before the discussion of specific trends, it is appropriate to present three other tables which provide more information on the 448 case sample. Table 3 gives a breakdown of the number of cases by team. It can be seen that the sample is dominated by the original seven teams funded in 1968: Baylor, Boston, Georgia Tech, Maryland, Rochester, Tulane, and UCLA. The cases from these seven sources total 326.

Table 4 gives a more detailed breakdown of the collision types in the sample. These are listed in decreasing order of frequency of occurrence. It can be readily seen that the sample is over-represented with single vehicle, run-off-the-road into an object types (pole, tree, bridge abutment, etc.), the majority of which resulted in fatal injuries to an occupant. The "odd" configurations (i.e. front-side-rollover, etc.) gives one an idea of the number and type of multiple impacts in this sample.

For those interested in the vehicle makes involved in these accidents, Table 5 gives a frequency count of this. As expected, the leading involvees included Chevrolets and Fords, as exposure would predict. There doesn't appear to be any "make" involvement which deviates significantly from the exposure figures, although a statistical test was not performed. To our knowledge, the teams did not key on any specific "make" of vehicle. American made vehicles were probably favored, however.

Given this information, the following frequency aggregations are appropriate for discussion:

HUMAN FACTORS

1

In the pre-crash, accident initiation area (cell 1), there were several interesting findings. These trends certainly warrant further study:

- Of the cases where a direct information processing failure was reported on the part of the driver, the following proportions were noted:

  (1) 23% of these failures were due to perception/comprehension failures. That is, the driver either did not see the danger signal, or the danger signal was in his field of view but he did not comprehend it as such.

  (2) 52% of the failures were decision failures, as expected. These were basically judgment errors on the part of the driver after he detected the danger signal.

  (3) 25% of the remaining failures were action errors, which is somewhat higher than one would expect. These included physical action errors such as oversteering and panic

TABLE 3

Total Cases by Team

1)	Baylor College of Medicine	27
2)	Boston University	44
3)	Cornell Aeronautical Laboratory	25
4)	Georgia Institute of Technology	73
5)	Indiana University	9
6)	Maryland Medical-Legal Foundation	60
7)	Miami University (Fla.)	7
8)	University of New Mexico	8
9)	Ohio State University	7
10)	Research Triangle Institute	14
11)	University of Rochester	36
12)	Southwest Research Institute	31
13)	Stanford Research Institute	10
14)	Tulane University	30
15)	University of California at Los Angeles	56
16)	University of Utah	11
	Total	448

TABLE 4

Detailed Breakdown of Collision Types

Car-Object	181
Front-Side	85
Front-Rear	44
Head-On	32
Roll-over	25
Unclassified	24
Side-Side	10
Side-Front	8
Car-Fire	6
Front-Side-Rollover	3
Head-On-Rearend	3
Side-Side-Object	3
Front-Side-Front	2
Front-Side-Object	2
Rearend-Head-On	2
Side-Rear	2
Side-Side-Rollover	2
Front-Side-Head-On	1
Front-Side-Front	1
Front-Side-Side	1
Front-Rear-Rear-Object	1
Head-On-Head-On-Head-On	1
Rear-Side-Rear	1

Side-Front-Rollover-Fire	1
Side-Front-Side	1
Side-Head-On-Head-On	1
Side-Side-Front	1
Side-Side-Head-On	1
Side-Front-Rear-Side	1
Side-Side-Side-Object	1
Side-Side-Rear-Object-Rear-Rear	1
Total	448

TABLE 5

Frequency of Vehicle Make Involvement

Passenger Cars

Chevrolet	169	Mercedes	1
Ford	120	Cortina	1
Pontiac	62	Porshe	1
Dodge	47	MGB	1
Oldsmobile	47	Alfa Romeo	1
Plymouth	27	Renault	1
Volkswagen	26	Fiat	1
Buick	21	MG Roadster	1
Mercury	19	BMW	1
Cadillac	13	Datsun	1
Rambler	13	Unknown	6
Chrysler	10	Total	610
Opel	4		
Toyota	3		
Triumph	3		
Lincoln	3		
Jaguar	2		
Morris	1		
Studebaker	1		
Volvo	1		
DeSoto	1		
Austin-Healy	1		

Trucks

Chevrolet	23
Ford	16
GMC	7
International	7
White	6
Dodge	5
Mack	4
Freuhaul Trailer	1
Great Dane Van Trailer	1
Kenworth Tractor Trailer	1
Brockway	1
Peterbuilt	1
Unknown	8
Total	81

Buses

Ford	2
Dodge	2
Greyhound	1
International	1
Volkswagen	1
Chevrolet	1
GM Public Trans.	1
Challenger	1
Scenic Cruiser	1
Crown Coach	1
GMC Coach	1
Unknown	1
Total	14

Other Vehicles

Motorcycles	4
Train	3
Trailer	2
Bulldozer	1
Total	10

Pedestrians

Total	15

Objects (moving)

Tire	1
Horse	1
Total	2

Grand Total	732

after danger had been detected and the proper decision to act had been made. Many of these drivers who performed action errors were inexperienced, under the influence of alcohol, or fatigued.

- There were a plethora of reasons for driver nonperformances or errors, as one can see from the vast listing of factors in this human area.

  (1) 32 cases involved total physical incapacitation on the part of the driver. In 20 cases, the driver fell asleep and in 12 cases he experienced some medical incapacitation (e.g. heart attack, seizure, stroke, etc.). This 2-3% medical incapacitation proportion is probably low when looking at fatal accidents in lieu of recent studies involving autopsy findings.

  (2) The predominant condition or state affecting the driver's performance was overwhelmingly the presence of alcohol. 88 cases involved drivers who were intoxicated (i.e. their BAC $\geq$ .10% or the Team stated such if a test wasn't taken), while 68 more cases involved drivers who had been drinking (i.e. BAC $<$ .10% or stated as such by the Team). 156 cases involving alcohol as a contributing factor out of 448 cases certainly cannot be overlooked in any sample. Over 100 of these alcohol-involved cases were fatal accidents.

  (3) Under experience categories, driving inexperience definitely contributed to driver error in 25 cases; vehicle unfamiliarity contributed to 23 cases; and road or area unfamiliarity contributed to 11 cases.

  (4) In 83 cases, the reasons drivers did not detect or comprehend danger signals in time to avoid the collision were due to driver inattention (preoccupation) or driver distraction (inside or outside the vehicle).

  (5) Risk-taking behaviors, next to driver conditions or states, were the second most frequent reasons for driver failure. 147 cases involved drivers speeding or going too fast for conditions, many of these in conjunction with alcohol. Another 77 cases involved some improper maneuver by a driver (e.g. signal or sign violations; unsafe U-turns; lane changes, etc.).

  (6) Finally, 6 cases included strong evidence of intentional self-destruction (suicide). Five different teams reported these six cases so it was not a biased case selection of any one team.

2

In the crash phase (cell 2), there was one human behavior which affected injury causation significantly - the failure of occupants to use available restraints. This public apathy, of course, is well known.

- 120 cases involved at least one driver and/or passenger who did not use an available restraint system and the team reported that the individual occupant would not have been injured as severely, or his life would have been saved, had he been wearing the restraints. The "and" is important here. The 120/448 proportion does not indicate the number of cases involving occupants who merely did not wear available restraints (that was much higher), but the number who definitely would have sustained less severe injuries had they been wearing them.

- In 34 cases, the teams reported that at least one occupant was wearing an available restraint which reduced the potential injury severity of the accident. These, of course, are considered positive factors (indicated by an asterisk (*) in the aggregations) which mitigated injuries.

3

In most of the earlier investigations, the teams did not direct their investigatory activities on the post-crash phase involving human factors (cell 3). There is, consequently, a dirth of factors aggregated in this area. The findings in this phase, therefore, are no where near true proportions. Given this, the following factors were dominant:

- 12 cases involved extrication and/or treatment problems to injured occupants. An additional 5 cases involved reported emergency medical service problems (e.g. excessive ambulance arrival times; inadequate dispatch procedures; etc.)

It should be added that the multidisciplinary teams at present investigating accidents do thoroughly investigate the post-crash phase and are now consistently reporting such factors.

VEHICLE FACTORS

4

Vehicle pre-crash factors (cell 4) were defined as defects, maladjustments, or degradations that either contributed to the initiation of the collision or affected it's configuration or severity. The aggregations of these factors in this sample must be interpreted with extra precaution. Percentages appear to be attached to these factors more often than any other type. This is due

perhaps, to lack of adequately controlled studies or lack of adequate expertise to make such determinations in controlled studies. In any case, percentages should not be applied to this sample. Some of the factors reported in this area were gross failures primarily causing the collision, some were conditions which only contributed to the collision, while others were conditions or degradations which contributed to the manner in which the collision occurred or its severity. A few were even conditions present which the team did not directly associate with the collision initiation. An excellent controlled study, with more than adequately trained expertise performing the investigations, will be released in the latter part of 1972[4] reporting realistic proportions and specific areas of defects on this topic.

In lieu of this, the following trends can be discussed:

- Brake systems were reported as contributory in some manner in 27 cases. These, along with tire failures or poor tire conditions (51 cases), make up the bulk of reported vehicle pre-crash factors.

- General improper or inadequate maintenance resulting in a degraded vehicle condition was the dominant reason for these vehicle factors. 17 cases directly reported maintenance problems as the reason for an overall degraded vehicle condition.

5

In the crash phase (cell 5), the vehicle factors which contributed to injury severity were legion, and the most frequently reported when compared to human and environmental crash factors. Before the negative factors are discussed, a word is in order on some of the more significant positive factors (*) concerning recent vehicle countermeasures which mitigated injuries.

- The energy absorbing steering column performed adequately in 27 reported cases mitigating potentially serious injury. An additional 19 cases reported the force-distributing instrument panel reduced or eliminated injuries to front seat occupants.

- The new HPR windshield was credited with reducing injuries to the head and face in 9 cases.

- Other reported positive factors included head restraints preventing neck injuries and the adequate performance of stronger seat back latches.

On the negative side, the following factors were among the most frequently reported:

- The installation of seat belts and/or shoulder harnesses would have mitigated injuries (if worn) in 32 cases.
- The doors were reported to have flown open upon impact in 17 cases increasing the potential for injury.
- There was seat track separation or slippage in 21 cases, again increasing injury potential.
- 33 cases reported the lack of resistance to side impact intrusion as a definite injury severity factor. An additional 19 cases noted lack of resistance to roof collapse as an injury severity factor.
- The hood latch either released and elevated, contacted, and/or penetrated the windshield in 22 cases compromising the energy absorbing effect of the windshield and, in many cases, causing more severe injury.

In the post-crash area (cell 6), there were two major areas of concern: fuel leakage, and fire. The significant factors in these two areas were:

- 9 cases of fuel tank rupture with resultant fire
- 2 cases of fuel leakage from fuel line with resultant fire
- 7 cases of fuel tank rupture with no fire

In other miscellaneous post-crash areas pertaining to the vehicle, the doors jammed preventing immediate exit by the occupants in 9 cases, and the occupants legs were caught beneath the dashboard in 3 cases making extrication before a fire ensued impossible.

ENVIRONMENTAL FACTORS

Environmental pre-crash factors (cell 7), which contribute to the initiation of collisions, have been categorized into four major areas:

(1) Traffic control inadequacies

(2) Poor roadway geometry

(3) Roadway maintenance

(4) Ambient conditions

- Under traffic control inadequacies, signs (or lack of them) were the leading factor which either misled or did not provide proper information to the driver. 34 cases involved inadequate signing. 11 cases involved inadequate signal operation.

- 31 cases involved inadequate sight-distance for the driver under "poor roadway geometry." Inadequate shoulders contributing to loss of control were present in 14 cases.

- 34 cases involved inadequate roadway maintenance as a problem, with 8 of those cases involving inadequate snow removal procedures. Those 8 cases involved teams in the three cities with the most snowfall - Buffalo, Rochester, and Salt Lake City.

- By far the most frequent factor of occurrence in the environmental area was the presence and contribution of wet, slippery pavement. This ambient condition was present in 70 cases and either initiated loss of control by the driver, or increased the severity of the collision.

8

In the crash area (cell 8), there was one outstanding factor which definitely contributed to the severity of the collisions. This was the presence of an unprotected fixed object (poles, trees, etc.) adjacent and close to the roadway edge. This factor increased the injury severity of the collisions in 44 cases.

- Breakaway supports were found to be effective in 3 cases and not effective in 2 cases.

- The need for guard rails and barriers, or the placement and improvement of such, was present in 39 cases.

9

Finally, in the post-crash phase (cell 9), there were several positive factors (*) concerning traffic control, law enforcement, etc.

- 7 cases reported excellent traffic control and/or clean-up operations.

- 10 cases reported the implementation of some highway recommendation made by the team due to their investigation.

  On the negative side, 5 cases reported that subsequent highway repairs (due to the collision) were either delayed a considerable time, or that the repairs did not remove the hazard contributing to the collision.

The above frequencies of occurrence can probably best be used by referring to the cases they each appear in (from Volume 1) and determining what "other" factors are associated with each occurrence. Mini-correlations and bivariate frequencies can then be studied.

Research Indicators

As a gross indicator as to where, and in what phase of the accidents, the most relevant factors and conclusions are being reported, Table 6 was constructed. This table shows the tally of factors which were reported in each of the 9 cells of the safety matrix. As can be readily seen, the Human area dominates, particularly in the Pre-Crash phase, while factors reported in the Crash phase are mainly concerned with the Vehicle. Post-Crash factors are sparce for reasons explained earlier and no one element dominates there.

Other items of interest might be where the most recommendations are made and where the most positive factors (*) are occurring. Table 7 was constructed to grossly indicate such. By definition, the other factors missing from this table are accident causal factors (cells 1, 4, 7), injury causal factors (cells 2, 5, 8) and negative post-crash factors (cells 3, 6, 9). An example of interpreting this table would be saying that 55 of the 211 factors reported in cell 2 (Human - Crash) were positive factors (*).

TABLE 6

Total Cell Frequencies

	Pre-Crash	Crash	Post-Crash	
Human	877	211	84	1172
Vehicle	182	331	75	588
Environment	301	107	38	446
	1360	649	197	2206

TABLE 7

Positive Factors and Recommendations per Matrix Cell

	1	2	3	4	5	6	7	8	9
Positive Factors	12	55	29	0	65	10	1	8	17
Recommendations	52	6	23	0	0	20	14	9	3

REFERENCES

1. Office of Accident Investigation and Data Analysis, "Summary of 1968-1970 Multidisciplinary Accident Investigation Reports," Volume 1 of 2, National Highway Traffic Safety Administration, DOT-HS-600 596, June 1971.

2. Office of Accident Investigation and Data Analysis, "Annual Report to the Secretary on Accident Investigation and Reporting Activities - 1971," National Highway Traffic Safety Administration, DOT-HS-820 177, February 1972.

3. James C. Fell and Scott N. Lee, "Program Matrix for Highway Safety Research," National Highway Traffic Safety Administration, DOT-HS-820 094, December 1970.

4. John R. Treat and Kent B. Joscelyn, "A Study to Determine the Relationship Between Vehicle Defects and Crashes," Institute for Research in Public Safety, Indiana University, performed under contract DOT-HS-034-2-263, Interim Report - Methodology, Publication No. DOT-HS-800 661, November 1971 (Analysis Report to be released October 1972).

SECTION II

Frequency Aggregations

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
1	**HUMAN PRE-CRASH FACTORS**	
	Information Processing Failures or Nonperformances	
	● Perception/Comprehension	
	Driver false assumption	Baylor 10 CAL 4, 17, 19, 21, 21 Ga. Tech 54, 74 Miami 697001 New Mexico 4
	Driver lost control of vehicle	Baylor 2 Boston 69-8, 69-12, 69-17 CAL 7, 13 Indiana 69-4, 69-8 Maryland 68-21 New Mexico 2 Rochester DOT 2, DOT 8
	● Decision	
	Driver improper evasive action	Boston 69-11, 69-20, 69-27 CAL 8, 11, 15, 21, 78 Ga. Tech 7, 76 Miami 697002, 697022 Maryland 68-8, 68-11 New Mexico 6, 9, Special Report 2 SwRI 7005, 7043 Stanford 06, 12 UCLA 944
	Driver misjudgement	Boston 68-17, 69-16, 69-21 CAL 3, 9, 14, 16, 17, 17, 18 Ga. Tech 43, 54 Indiana 69-8 Maryland 68-4, 68-15, 68-49, Special Report 2 RTI 5 Rochester DOT 1 Tulane 69-12 UCLA 802 Utah 3-69

Driver inadequate communication of intentions	Rochester DOT 6 SwRI 7017
Driver did not have headlights turned on	Maryland 68-26 Miami 697022

- Action

Driver overcompensation/oversteering	Boston 69-17, 69-29, 69-30 CAL 73, 5 Ga. Tech 75 Maryland 68-24, Special Report 1 Miami 105 Rochester DOT 3, DOT 9 RAI 36 SwRI 6906 Tulane 69-4, 69-5, 69-10, 11 UCLA 704, 798 Utah 3-69
Driver panicked	Boston 69-15 Maryland 68-11, 68-33, 68-48

Reasons for Nonperformances

- Physical or Physiological Failures

Driver fell asleep	Baylor 2-ME-13 Boston 68-7 Ga. Tech 46, 48 Maryland 68-36, 68-42, 69-2, 69-9, 69-17, 69-23 RTI 10 Rochester DOT 4, RAI 19, RAI 25, RAI 39 UCLA 787, 895, 965, 1055 Utah 7-69
Medical incapacitation (i.e., heart attack, seizure, etc.)	Baylor 2-ME-17 Boston 68-8, 69-8 CAL 5, 8 Ga. Tech 61 Indiana 70-8 Maryland 69-10, 69-46 Rochester RAI 28 SwRI 7023 UCLA 1188

- Conditions or States

Driver intoxicated (BAC ≥ .10% or stated as such)	Baylor 2, 9, 2-ME-3 Boston 68-4, 68-5, 68-6, 68-10, 68-13, 68-17, 69-1, 69-3, 69-5, 69-9, 69-10, 69-11, 69-16, 69-27, 69-29, 69-30 Ga. Tech 8, 17 Indiana 69-2, 69-3, 70-9 Maryland 68-6, 68-9, 68-14, 68-20, 68-24, 68-25, 68-32, 68-36, 68-40, 68-45, 68-51, 68-52, Special Report #1, 69-2, 69-3, 69-6, 69-10, 69-14, 69-17, 69-23, 69-59, 70-9 Miami 697004 Ohio 4 RTI 8, 9, 17 Rochester DOT 2, DOT 7, DOT 8, DOT 9, RAI 39, RAI 42, RAI 45 SwRI 6904, 6912, 7008, 7011, 7023, 7026, 7027, 7037 Tulane 01, 02, 10, 69-2, 69-5, 69-7, 69-19 UCLA 567, 704, 845, 896, 945, 1000, 1003, 1003, 1023, 1146, 1172 Utah 1-69, 2-69, 12-70 13-70
Driver had been drinking (BAC < .10% or stated as such)	Baylor 3, 7, 2-ME-4, 2-ME-15, 2-ME-19 Boston 68-7, 69-18, 69-2, 69-19, 69-4, 69-20, 69-21, 69-27, 69-30 CAL 21, 59, 83

	Ga. Tech 18, 20, 22, 26, 34, 36, 37, 41, 42, 52, 55, 50, 69 Indiana 69-4, 69-6, Maryland 68-8, 68-13, 68-17, 68-26, 68-39, 68-39, 68-50, 68-28 New Mexico 8 Ohio 7 RTI 3 Rochester DOT 4, RAI 12 RAI 14, RAI 16, RAI 31, RAI 40 SwRI 6906, 6908, 6913, 7004, 7017, 7029 Tulane 69-3, 69-10, 11 69-15, 69-20, 12B1670 UCLA 734, 787, 843, 895, 957, 965, 1079, 1182 Utah 6-69
Driver fatigued	Baylor 7, 9, 2-ME-6 Boston 69-2 CAL 83 Ga. Tech 5, 34, 55, 69, 75 Indiana 69-4 Maryland 68-34, 69-3 Miami 697002 Rochester RAI 19, RAI 25 RTI 1 SwRI 6901, 6906, 6908, 6913, 6914, 6916, 7004, 7008, 7011 Tulane 69-19, 69-20 UCLA 704, 813, 1090, 1177 Utah 2-69
Driver emotionally upset	Baylor 9 Boston 69-9, 69-15 CAL 10 Ga. Tech 23, 55 Maryland 68-6 New Mexico 9

	Miami 697002, 697004 RTI 9 Rochester DOT 2 SwRI 6914, 7011, 7025 UCLA 1182 Utah 2-69, 9-69
Driver physiological condition played contributing role	Boston 68-14, 68-1, 69-30, 69-3 CAL 1 Ga. Tech 55 Maryland 68-15A UCLA 1003
Driver drugged	Baylor 2-ME-2 Boston 68-1, 69-3 Indiana 69-1 Maryland 69-2, 68-34 New Mexico 9
Driver slowed reactions	Maryland 68-17, 68-43 Ohio State 7
Driver pressured or in hurry	CAL 9, 20 Miami 697004

● Experience or Exposure

Driver inexperience	Baylor 6 Boston 69-7, 69-17, 69-20, 69-21 CAL 11, 16 Ga. Tech 56 Maryland 68-6, 68-21, 68-46 Ohio 2 Rochester RAI 13, RAI 20, RAI 23, RAI 39, RAI 60 SwRI 6905, 6908, 7003, 7030, 7030 Tulane 69-4 UCLA 798, 802
Driver unfamiliarity with the vehicle	Baylor 6, 2-ME-3, 2-ME-9 Boston 69-30 CAL 5 Ga. Tech 5, 30, 52 Indiana 69-4 New Mexico 6

	SwRI 6901, 7003, 7011, 7026, 7030, 7030, 7043 Stanford 07 Tulane 06, 12B1670 UCLA 835 Utah 2-69, 5-69
Driver had poor driving record	Boston 68-3, 69-3, 69-9, 69-18, 69-29, 69-30 Ga. Tech 53 Indiana 69-2, 69-4 Maryland 68-14, 68-24 RTI 6 SwRI 7032 UCLA 798, 1120, 1146, 1177 Utah 1-69
Driver unfamiliarity with roadway or area	Baylor 2-ME-8 Boston 69-4 CAL 9 Ga. Tech 24 Maryland 68-22 Miami 697008 RTI 4, 6, 13 SwRI 7004 Tulane 12B1670
Unlicensed driver	Boston 69-3 Maryland 68-6, 68-25 SwRI 7026
Driver overfamiliarity with roadway (complacent)	RTI 2 Tulane 69-9
Driver overconfident with driving skills	SwRI 7003, 7005
Driver did not benefit from driver education course	SwRI 7005
Driver did not complete training course	New Mexico 7

- Conflicting Behaviors or Preoccupation

Driver inattention	Baylor 1, 4, 5, 7, 8, 2-ME-5, 2-ME-6, 2-ME-8, 2-ME-12, 2-ME-8

	Boston 68-3, 68-16, 69-21 CAL 9, 10, 11, 15, 4, 10, 17 Ga. Tech 19, 45, 57, 65, 66 Indiana 69-8, 70-9 Maryland 68-10, 68-13, 68-48, 68-49, Special Report 2, Special Report 2 Miami 69, 70, 22, 105 New Mexico 1, 3, 3, 4, 6, 7, 8, 8 Ohio 2 RTI 1, 3, 6, 11 Rochester DOT 7, RAI 18 RAI 29-30 RAI 40, RAI 51-53, RAI 59 SwRI 6901, 6915, 7005, 7009, 7030 Tulane 05, 07, 69-15 UCLA 811, 843, 844, 852 Utah 1-69, 4-69
Driver distracted	Baylor 6, 9, 2-ME-1, 2-ME-5 CAL 73 Ohio State 10 Rochester DOT 5, RAI 10, RAI 20 SwRI 6915, 7003, 7006 Tulane 05 UCLA 845, 909 Utah 5-69, 6-69
● Risk-Taking Behavior	
Driver speeding or too fast for conditions	Baylor 2, 3, 7, 2-ME-1, 2-ME-2, 2-ME-6, 2-ME-14, 2-ME-15, Boston 68-10, 68-16, 68-17, 69-5, 69-6, 69-7, 69-9, 69-10, 69-12, 69-15, 69-17, 69-18, 69-19, 69-20, 69-27, 69-29 69-30, 68-20,

Boston 69-3, 69-4, 69-6, 69-10, 69-17, 69-18, 69-30
CAL 20, 5, 6, 14
Ga. Tech 9, 11, 20, 27, 29, 32, 37, 38, 40, 44, 51, 52, 57, 60, 63, 67, 39, Special Report, 72
Indiana 69-4, 69-6, 69-3
Maryland 68-1, 68-6, 68-14, 68-15, 68-24, 68-34, 68-35, 68-46, Special Report 1, 69-1, 69-7, 68-2, 68-4, 68-9, 68-17, 68-21, 68-22, 68-28, 68-32, 69-14, 68-36, 70-9
Miami 697001, 697002, 105
New Mexico 7, 9
Ohio 4
RTI 9, 13
Rochester DOT 2, DOT 9, RAI 11, RAI 14, RAI 16, RAI 23, RAI 38, RAI 38, RAI 39, RAI 45
SwRI 6901, 6903, 6904, 6905, 6911, 6913, 6914, 6916, 7003, 7004, 7005, 7006, 7007, 7008, 7014, 7017, 7023, 7025, 7026, 7027, 7029, 7032, 7037, 7043
Tulane 05, 06, 69-2, 69-10, 11, 69-13, 14, 69-15, 69-16, 69-17, 18, 69-22
UCLA 798, 804, 813, 906, 978, 984, 1120, 1183
Utah 2-69, 3-69, 5-69, 6-69, 9-69, 11-70, 12-70

Driver improper maneuver (i.e., signal or sign violations, unsafe U-turns, lane changes, etc.)	Baylor 3, 7, 8, 9, 2-ME-4, 2-ME-9, 2-ME-10, 2-ME-16 Boston 68-16, 69-4, 69-9, 69-13, 69-21, 69-27 CAL 6, 11, 14, 17, 19, 19, 74 Ga. Tech 3, 4, 14, 15, 19, 24, 27, 33, 35, 37, 40, 44, 49, 50, 63, 74, 76, 74, 75 Indiana 69-6 Maryland 68-39, 68-43, 68-51, 68-52, 69-5, Miami 697001 New Mexico 3, 3, 4 Ohio 3, 5, 8, 10 RTI 2 Rochester RAI 20, RAI 24, RAI 31, RAI 51-53 SwRI 6908, 7029, 6901, 6903, 7007 Tulane 09, 69-8, 69-17, 18 UCLA 919, 974, 1188, 667, 945, 1075, 1079, 1172, Baker Bus Utah 1-69, 11-70
Driver personality structure found to be conducive to unsafe driving practices and high risk-taking behavior	Baylor 9 Boston 69-19 Maryland 69-46 Miami 697002, 697025 SwRI 6903, 6903, 6904, 6911, 7014, 7017, 7023 Tulane 12B1670 UCLA 1003, 1023, 1143, 1183
Erratic driving behavior	Baylor 2-ME-10 Maryland 68-1, 68-13, 68-25, 68-35, Special Report 1 Miami 697002 New Mexico 2 Ohio 5 Tulane 69-22, 69-24 UCLA 804, 1172

Driver aware of defective vehicle prior to accident	Indiana 69-0 RTI 7 SwRI 7037
Driver violation of license restriction	Boston 69-16
Occupants pushing stalled vehicle against traffic	Ga. Tech 53

● Intentional Self-Destruction

Evidence of driver or pedestrian suicide	Baylor 2-ME-2 Maryland 68-20, 69-4 Rochester RAI 37 Tulane 69-1 UCLA 1055

Positive Factors (*)

* Driver used correct maneuver to control vehicle	CAL 17, 20 SwRI 6911, 7007, 7014, 7023, 7029 Stanford 06, 07, 13 UCLA 1289
* Lap belt enabled driver to steer to avoid head-on collision	RTI 1

Recommendations

Recommendation: Driver education improvements needed	Ga. Tech 63, 44, 74 Miami 105 Rochester RAI 19, RAI 25 SwRI 7008, 7037, 6901, 6908, 6913, 6915, 7005, 7008, 7025, 7027, 7030, 7007 UCLA 1090 Utah 12-70
Recommendation: Special studies to evaluate efficiency of re-educating problem driver	SwRI 6903, 6905, 6905, 6906, 6908, 6911, 6915, 6916, 7003, 7005, 7006, 7027

Recommendation: Closer medical supervision of driver licensing controls	Boston 68-11, 69-8 Ga. Tech 13, 16, 35, 46, 61 Rochester RAI 28 SwRI 6912 UCLA 1182
Recommendation: Continued efforts to control drinking drivers is needed	Rochester RAI 42 SwRI 6906, 6912, 7011, 7026
Recommendation: Safety programs should be emphasized to companies employing professional drivers or salesmen	SwRI 6915, 6916, 7014, 7027

Pedestrian Factors

Information Failures or Nonperformances

Pedestrian - improper decision	CAL 18 Maryland 68-15A, 68-26, 68-40

Condition or State

Pedestrian intoxicated	Maryland 68-47, 69-4, 68-8, 68-15A, 68-44
Pedestrian - slowed reaction	Maryland 68-40
Pedestrian was in senile, confused state	Maryland 68-3
Pedestrian may have been frightened	CAL 18

Conflicting Behaviors or Preoccupation

Pedestrian inattention	Maryland 68-8, 68-15, 68-49, 69-13

Risk-Taking Behavior

Pedestrian walked into traffic	Maryland 68-7, 68-31
Pedestrian standing in slow lane of traffic	Maryland 68-47

Recommendations

Recommendation:	
Improved pedestrian education	UCLA 931

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
2	HUMAN CRASH FACTORS	
	● Negligent Behavior	
	Driver and/or passenger not using available restraint systems; probably would have mitigated injuries if they had been worn	Baylor 2-ME-1, 2-ME-3, 2-ME-4, 2-ME-8, 2-ME-9, 2-ME-16 Boston 68-5, 68-13, 68-16, 69-1, 69-5, 69-6, 69-10, 69-12, 69-13, 69-15, 69-16, 69-19, 69-20, 69-29, 69-31 CAL 4, 7, 12, 73, 74, 83 Ga. Tech 3, 7, 24, 37, 46, 47, 48, 55, 56, 72, 76 Indiana 69-1, 69-2, 69-3, 69-4, 69-6, 69-8, 70-8, 70-9 Maryland 68-10, 68-24, 68-25, 68-35, 68-38, 68-42, Special Report 1, 69-6, 69-9, 69-46, 69-59, 70-9 Miami 697001, 697002, 697022, 105 New Mexico 2, 4, 6, 8, 8, 9, 1 RTI 6, 10, 11, 13, 17 Rochester DOT 1, DOT 7, DOT 8, RAI 10, RAI 19, RAI 23, RAI 25, RAI 29-30, RAI 31 SwRI 6901, 6906, 6908, 6912, 6913, 7004, 7005, 7011, 7027, 7029, 7032, 7037 Stanford 09, 12 Tulane 69-6, 69-7, 69-10, 69-11, 69-12, 69-16, 69-20, 69-24

	UCLA 704, 787, 804, 895, 906, 1023, 1055, 1090, 1172, 1182, 1183 Utah 4-69, 6-69, 9-69, 11-70, 12-70
Driver and/or passengers would not have been ejected had they been using their restraint system.	RTI 2, 9 Rochester 51-53 SwRI 6905, 7003 Utah 3-69, 5-69
Head restraints not adjusted properly	Boston 69-28 New Mexico 6
Driver left van truck doors open	Ga. Tech 74
● Improper Behavior	
Improperly adjusted seat-belt	Boston 68-9, 69-18 Rochester RAI 28
Helmet worn was inadequate and non-standard	Rochester RAI 21
Driver improper avoidance behavior after initial impact	Rochester RAI 38
● Condition Affecting Severity	
Previous medical condition contributed to injury severity	Ga. Tech 65 Miami 697022 UCLA 1182, 1188
Occupant position increased injury potential	CAL 3 New Mexico 1 Tulane 69-13, 14, 07 UCLA 811
● Pertinent Facts	
Restraints would not have mitigated injuries	Boston 69-28, 69-30, 69-19 Miami 697025
● Positive Factors (*)	
* Driver and/or passengers wearing available restraints; probably mitigated injuries	Baylor 2-ME-19 Boston 69-10 CAL 3, 19 Ga. Tech 51, 74 Indiana 69-1, 70-8

	New Mexico 2 Ohio State 2 RTI 1, 3, 5, 6, 14 Rochester DOT 4, RAI 20 SwRI 6903, 6911, 7004, 7007, 7008, 7009, 7017, 7023, 7026, 7043 Stanford 07, 28 Tulane 03 UCLA 802, 853, 1143, 1188
*Occupant action during impact reduced injury severity	CAL 4, 10, 17, 74 Ga. Tech 62 Miami 697008 New Mexico 4 RTI 4
*Occupant position in seat mitigated injuries	CAL 3, 22 Indiana 69-8, 70-9 RTI 4, 6, 10
*Motorcycle helmet prevented serious or fatal injuries	Rochester RAI 16, RAI 35 SwRI 7030
*Non-use of seat-belt probably prevented injury	RTI 13
*Passenger left vehicle enabling her to avoid injury	RTI 8
*Ejection lessened injuries	Indiana 69-1
● Pedestrian Involvement	
Pedestrian clothing reduced injury severity	CAL 18
● Recommendations	
Recommendation: Pregnant females need instruction on proper techniques of wearing restraints	UCLA 834 SwRI 7032
Recommendation: Education on the need to restrain young children is needed	Indiana 69-3 UCLA 567, 987

Recommendation: Recommend the dangers of driving and use of safety belts be advertised to the public similar to the anti-smoking campaign	Boston 69-7

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
3	**HUMAN POST-CRASH FACTORS**	
	● Emergency Medical Service Problems	
	Ambulance arrival time excessive	RTI 11 SwRI 6906, 6908
	Two ambulances dispatched; inadequate dispatch procedures	CAL 3
	Ambulance attendant clean-up was poor	SwRI 7029
	● Extrication Problems	
	Occupant extrication complicated by lack of adequate equipment	Boston 69-28, 69-30 SwRI 6904, 7005
	Occupant injuries increased during extrication	Indiana 69-4 UCLA 798
	Occupant could not exit vehicle - drowned	Miami 105
	Extrication power tool ignited fuel causing fire	SwRI 6913
	Victim extricated by passersby several hours later	Miami 105
	Occupant disoriented hindering egress	Miami 105
	● Treatment Problems	
	Alcoholism caused complications and contributed to death	Tulane 69-5
	Fatality occurred due to surgical misadventure rather than injuries sustained in collision	UCLA 1172
	Injured party moved by witnesses	Utah 5-69
	Occupant refused medical treatment against physician's advice	SwRI 6913

Driver anticoagulant medication made suppression of hemorrhage difficult	New Mexico 9
Driver not wearing bracelet or device to warn of unusual medical history	New Mexico 9
X-rays failed to reveal serious fatal fracture of cervical spine	Boston 69-28

● Investigation Hindrances

Hit and run driver fled the scene after collision	SwRI 7009
No witnesses available although many saw accident	Boston 69-13
Driver refused to give statement on advice of counsel	Boston 69-13

● Miscellaneous Factors

Driver failed to render assistance or first aid to occupants of V2	Miami 697008, 697022
Driver might have survived had she evacuated her vehicle rather than trying to move it	Ga. Tech Special Report
First person on-scene did not use his fire extinguisher	Indiana 69-2
Driver opened hood without fire equipment	Stanford 47B
Driver 1 and passenger remained in vehicle - made no attempt to warn oncoming traffic	Maryland 68-50
Other drivers would not stop to aid or help move vehicle	Stanford 0081

● Positive Factors (*)

* Witnesses offered assistance	Boston 69-30 Miami 697022, 697025 New Mexico 4 RTI 9 SwRI 7030 Stanford 47, 12 Utah 12-70

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
3	HUMAN POST-CRASH FACTORS	
	● Emergency Medical Service Problems	
	Ambulance arrival time excessive	RTI 11 SwRI 6906, 6908
	Two ambulances dispatched; inadequate dispatch procedures	CAL 3
	Ambulance attendant clean-up was poor	SwRI 7029
	● Extrication Problems	
	Occupant extrication complicated by lack of adequate equipment	Boston 69-28, 69-30 SwRI 6904, 7005
	Occupant injuries increased during extrication	Indiana 69-4 UCLA 798
	Occupant could not exit vehicle - drowned	Miami 105
	Extrication power tool ignited fuel causing fire	SwRI 6913
	Victim extricated by passersby several hours later	Miami 105
	Occupant disoriented hindering egress	Miami 105
	● Treatment Problems	
	Alcoholism caused complications and contributed to death	Tulane 69-5
	Fatality occurred due to surgical misadventure rather than injuries sustained in collision	UCLA 1172
	Injured party moved by witnesses	Utah 5-69
	Occupant refused medical treatment against physician's advice	SwRI 6913

Driver anticoagulant medication made suppression of hemorrhage difficult	New Mexico 9
Driver not wearing bracelet or device to warn of unusual medical history	New Mexico 9
X-rays failed to reveal serious fatal fracture of cervical spine	Boston 69-28

● Investigation Hindrances

Hit and run driver fled the scene after collision	SwRI 7009
No witnesses available although many saw accident	Boston 69-13
Driver refused to give statement on advice of counsel	Boston 69-13

● Miscellaneous Factors

Driver failed to render assistance or first aid to occupants of V2	Miami 697008, 697022
Driver might have survived had she evacuated her vehicle rather than trying to move it	Ga. Tech Special Report
First person on-scene did not use his fire extinguisher	Indiana 69-2
Driver opened hood without fire equipment	Stanford 47B
Driver 1 and passenger remained in vehicle - made no attempt to warn oncoming traffic	Maryland 68-50
Other drivers would not stop to aid or help move vehicle	Stanford 0081

● Positive Factors (*)

* Witnesses offered assistance	Boston 69-30 Miami 697022, 697025 New Mexico 4 RTI 9 SwRI 7030 Stanford 47, 12 Utah 12-70

* Excellent first aid and extrication procedures used by rescuers	CAL 1, 5 SwRI 6916 Utah 11-70
* Calmness of occupant prevented panic of other passengers	CAL 1, 11 Maryland Special Report #2 Rochester RAI 36
* Occupants able to exit unassisted	Stanford 07, 09 UCLA 944
* Driver moved vehicle off roadway	Stanford 47, 47A Utah 12-70
* Several witnesses removed occupants from hazardous area	SwRI 7025 Utah 6-69
* Driver assisted passenger from burning vehicle	SwRI 7009
* Driver cleared passengers from vehicle	Stanford 47
* Driver prevented hood from opening until fire dept. arrived	Stanford 47
* Baby ejected - rescued because of crying	Miami 697008

● Recommendations

Recommendation: There should be statutory requirements for obtaining BAL on surviving drivers when injury or fatality resulted from the crash	Boston 69-31, 69-21, 69-18, 69-12, 69-18, 69-21, 69-31 Ga. Tech 17, 20, 22, 36, 41, 42, 55
Recommendation: Autopsies should be performed on all fatal accident victims	Ga. Tech 13 UCLA 984
Recommendation: Emergency exit briefings needed for bus trips	Baylor 4 UCLA 977
Recommendation: Need for coordinated community planning EMS	Ga. Tech 54

Recommendation: Public must be made aware of calling police in emergency situations before action is taken	UCLA 931
Recommendation: Reexamination of surviving drivers involved in accidents is recommended	Miami 697001
Recommendation: Public education on hazards of spectators at accident scene	SwRI 6913
Recommendation: Companies should have penalties for repeated employee accidents or violations	SwRI 6915

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
4	**VEHICLE PRE-CRASH FACTORS**	
	Vehicle defects, maladjustments, or degradations which either caused or contributed to the severity of the accident	
	● Brake System	
	Directional Instability	Boston 69-2 Ga. Tech 25 Indiana 70-3 Miami 697001 Rochester RAI 51-53
	Hydraulic Failure	Ga. Tech 58, 28, 7 RTI 7 Stanford 6, 10, 36, 50, 51, 91 Tulane 69-6
	Improper Maintenance	Boston 69-10 Stanford 81
	Loss of Effectiveness	Ga. Tech 72 Stanford 75 Tulane 07 UCLA 853
	Mechanical Failure or Degradation (lining, shoe, drum, adjuster)	Ga. Tech 6, 11 New Mexico 36 Stanford 94, 54
	● Tires	
	Dynamic Failure	CAL 5 Ga. Tech 12, 21 Maryland 69-6, 70-9 Stanford 103 Tulane 06 UCLA 704
	Insufficient Tread Depth	Boston 69-2, 69-4, 69-13 Ga. Tech 3, 6, 11, 29, 10, 19, 30, 31, 25 Indiana 69-3

	Maryland 68-33, 68-46, 68-21, 69-20, 69-29 Rochester 13 SwRI 6905, 6906, 6911, 6913, 7009, 7032 Stanford 44
Low or Different Tire Pressures	Boston 68-10, 69-20 Ga. Tech 45 Maryland 68-45 SwRI 7003, 7007, 7008, 7014, 7043
Varying Carcass Construction or Size	Boston 68-10, 69-18, 69-20 Ga. Tech 21 Rochester 23 UCLA 704 Utah 9-69
Miscellaneous	Boston 68-20
● Front Suspension	Boston 69-19, 69-21 SwRI 7005 Stanford 13, 14, 33
● Rear Suspension	Stanford 46, 52, 57, 64
● Steering System	Boston 69-27 Ga. Tech 6, 65 SwRI 7005 Stanford 09, 28, 45, 53, 70
● Wheels	
Failure	Stanford 34, 40, 41, 43, 58, 49, 62, 66, 67, 73, 82, 83, 92, 93
● Internal View Obstruction	Miami 697022 Rochester 18 Tulane 6912
● Handling and Stability	Boston 69-18, 69-10, 69-29 Ga. Tech 72, 43 Indiana 69-1 Rochester 51-53 UCLA 835, 1188

● Visibility Systems	Baylor 2-ME-9 Maryland 68-44, 68-50 New Mexico 1, 4, 9 UCLA 843
● Driver Controls, Displays	Boston 69-14 CAL 78 New Mexico 6 SwRI 7026 Stanford 07 UCLA 852
● Vehicle Overloaded	CAL 5 Ga. Tech 72 Maryland 68-2 SwRI 6915, 7027
● Modification of Vehicle with After-Market Equipment Degraded Performance	Boston 68-16, 69-7, 69-10 Ga. Tech 30 Ohio 5
● Fuel System	
Carb Leaks with Resultant Fire	Stanford 47, 63 UCLA 1289
Fuel Tank Leak with Resultant Fire	UCLA 1212
● Accelerator Linkage	Baylor 2-ME-12 Boston 68-20, 69-11 Maryland 68-11 Rochester 10 Stanford 12 UCLA 1090
● Exhaust System	Boston 69-14, 68-5 Maryland 69-1 SwRI 7043 Stanford 37
● Man-Machine Incompatibility	CAL 22 Indiana 69-4 Miami 697025
● General Improper or Inadequate Maintenance Resulting in Degraded Vehicle Condition	Boston 68-5, 68-12, 69-14 CAL 16 Ga. Tech 47, 53, 58

New Mexico 2
RTI 7
SwRI 6901, 7009, 7025,
7037
Stanford 13
UCLA 977, 1212
Utah 5-69

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
5	**VEHICLE CRASH FACTORS**	
	● Energy Absorbing Steering Assembly	
	* Energy absorbing steering column	Baylor 2-ME-2, Final Report Boston 69-11, 69-18, 69-28, 69-31 CAL 7 Ga Tech 17, 35, 39, 26, 63 Indiana 69-8, 70-9 Maryland 68-38, 69-2, 69-9 Miami 697008 Rochester DOT 4, RAI 25, RAI 42 Tulane 08, 69-19 UCLA 896, 1000 Utah 11-70, 13-70
	Poor performance	Boston 69-28, 69-31 CAL 3 Ga Tech 51 UCLA 1090, 957 Utah 6-69
	Fatal or severe injury due to impact with non-EA column	Indiana 70-9 New Mexico 9 SwRI 6906, 6912, 6914 Stanford 12 Tulane 02
	* Energy-managing instrument panel mitigated injury	Baylor Final Report Ga Tech 63 Indiana 69-8 RTI 2, 3, 5 Rochester DOT 3 SwRI 6901, 7003, 7006, 7008 Tulane 08, 69-16, 12B1670 UCLA 787, 895, 945, 1023, 1188

● Windshield

* HPR windshield mitigated injury	Baylor Final Report Boston 69-11 CAL 7 Ga Tech 26 RTI 2 Rochester 2 SwRI 7011 Tulane 69-16 Utah 11-70
Total bond separation	Boston 69-29 CAL 78 New Mexico 1 UCLA 802, 811, 1079
Occupant penetration	Boston 69-9 Ga Tech 76 Indiana 70-8, 70-9 Tulane 69-7
Hood elevated and moved rearward; contacted; or penetrated windshield	Boston 69-10, 69-31 Ga Tech 53, 27, 41, 46 Rochester RAI 14 Tulane 08 UCLA 822, 945, 1003 Utah 7-69

● Restraint System

Installation of seat belt and/or shoulder harness would have mitigated injuries (if worn)	Baylor 4 Boston 69-2, 69-5, 69-9, 69-18, 69-20, 69-21 Maryland 68-1, 68-2, 68-6, 68-13, 68-17, 68-21, 68-22, 68-28, 68-32, 68-36, 68-46, 69-14 Miami 697022, 697002 Rochester DOT 4, DOT 6, RAI 36 SwRI 6912, 7027 Stanford 06 Tulane 69-2, 69-5, 69-13,14 UCLA 1172

Produced injury	Indiana 69-8 Rochester RAI 40
Attachment or webbing failure	Boston 69-20 Indiana 69-8 Rochester RAI 13
Child restraint	Miami 697008
Ejection increased injuries	Boston 69-15, 69-19, 69-20 Ga Tech 50 Maryland 68-1, 69-17 Rochester RAI 14, RAI 39, RAI 45, RAI 51-53 SwRI 7029 Tulane 06, 69-2, 69-10, 11, 69-13, 14 UCLA 1172
● Doors flew open upon impact	Boston 69-9, 69-19, 69-21 Maryland 68-1, 69-46 New Mexico 1 Rochester RAI 18 SwRI 6903, 7029 Tulane 02, 04 UCLA 567, 734, 896, 919, 1003 Utah 1-69
● Vehicle Side Interiors Produced Injury	
Side glass	UCLA 974
Vent wing	Miami 697022
Door	Baylor 2-ME-8 Indiana 69-3 UCLA 1023, 1075, 1172, 1183
A-pillar	Ga Tech 34, 41
● Vehicle Front Interior Produced Injury	
Dashboard and roof area	Baylor 2-ME-10, 2-ME-14 Miami 697022 Rochester DOT 8, RAI 29, 30, 31 SwRI 7014, 7043 UCLA 974, 1146

Protrusion in instrument panel	CAL 4 Ga Tech 76 Indiana 70-9 Stanford 09 UCLA 896
Parcel shelf	UCLA 919
Gear shift lever	Ga Tech 56 Indiana 69-4 UCLA 1183

● Seats

Track separation or slippage	Baylor 2-ME-15, 2-ME-19 Boston 69-10, 69-11, 69-18, 69-21, 69-27 CAL 4 Indiana 69-6, 70-8, 70-9 New Mexico 8 RTI 10 SwRI 7027, 7043 UCLA 667, 945, 1075, 1079, 1172, 1183
Seatback produced injury	Ga Tech 53
Seatback latch failure	Boston 69-19 Miami 697002 Rochester RAI 10 UCLA 1055, 1172
* Good performance of seatback latches	Boston 69-11, 69-28, 69-29 Rochester RAI 31

● Head Restraints

* Prevented or mitigated whiplash injury	RTI 3 SwRI 7027, 7032 UCLA 978
Released during collision	Utah 12-70
Would have prevented whiplash injury if installed	Baylor 2-ME-12 Rochester DOT 5

● Lack of Resistance to Side Impact Intrusion	Boston 68-18, 68-13, 69-20, 69-5, 69-6, 69-27, 69-15 Maryland Special Report 2, 70-9 Miami 697022 Ohio 7 Rochester RAI 13, RAI 23, DOT 6, RAI 18,31 SwRI 6911, 6915 Tulane 05, 09, 69-8, 69-9 UCLA 567, 834, 852, 919, 974, 978, 1075, 1120, 1172, 1183 Utah 2-69
* ● Side Guard Door Beams Reduced Intrusion into Passenger Compartment	CAL 9 RTI 7
● Lack of Resistance to Roof Collapse	Boston 68-18 Ga Tech 23 Maryland Special Report 2 New Mexico 2, 3, 7 RTI 9 Rochester RAI 36 SwRI 7026 Tulane 10 UCLA 734, 802, 1177, 957, 984, 1003, 1031, 1143, 1177
● Engine Intrusion into Passenger Compartment	Boston 69-1 Ga Tech 27
● Override-Underride Resulted in Excessive Penetration	Boston 69-31 New Mexico 4 SwRI 6915 Stanford 81 Tulane 04, 07, 08, 69-3, 69-8, 69-15 UCLA 843, 1003, 1075, 1183

● Hood Latch Released and Hood Elevated	Boston 69-10, 69-15 69-28, 69-28, 69-31 UCLA 1079, 1143, 1172, 1182, 1183
● Fuel System	
Leakage	SwRI 7009 UCLA 835, 1146
Tank separation from vehicle	Boston 69-2 Miami 697008 SwRI 6915 UCLA 1146
● Internal Loose Objects	Boston 69-19 Maryland 68-45 UCLA 977, 1003
● Inadequate Design of Spare Tire Mount	Boston 69-31 Ga Tech 67 Indiana 70-9 Maryland 70-9 SwRI 7004 UCLA 1079
● Trailer Hitch Failure	UCLA 835, 906
● Truck Cabs	
Cab latch failure	Rochester RAI 51-53
Inadequate structural integrity	SwRI 6916

Matric Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
6	VEHICLE POST-CRASH FACTORS	
	● Fuel Leakage	
	Fuel tank ruptured and fire occurred	Boston 68-2 Indiana 69-2 Rochester 39, 51-53 SwRI 7009 Tulane 69-6, 69-24 UCLA 804, 822
	Fuel tank ruptured, no fire	Rochester RAI 10, 13 UCLA 835, 843, 936, 987, 1079
	Fuel leakage from fuel line, fire occurred	Stanford 47B UCLA 1120
	Fuel leakage from fuel line, no fire	Utah 6-69
	Fuel from carburetor ignited from spark or hot surface	Stanford 47, 47A SwRI 7025
	● Other Fire Hazard, Occurrence	
	Flammable insulation on wire	Stanford 47B
	Fiberglass tunnel in passenger compartment allowed fire to enter	UCLA 1120
	Ether believed to be source of tractor-trailer fire	Ga Tech 50
	Transfer pump carrying flammable liquid malfunctioned requiring a third vehicle	SwRI 6916
	*Fire wall contained fire allowing time for escape	Stanford 47

- Fire Prevention

*Fire prevented by fire department, rescue personnel	Boston 69-28 Cornell 4 Miami 697002 SwRI 7009
*Fire extinguished	Boston 69-30 SwRI 7009

- Occupant Egress, Extrication

Doors jammed preventing immediate exit by occupants	Boston 69-30 Stanford 12 SwRI 7032 UCLA 1079, 937, 1000, 1055, 1143, 1177
Occupant's legs caught beneath dashboard making extrication before fire impossible	Tulane 69-6 UCLA 1120, 1172
Emergency doors failed during impact	UCLA 796, 977
Power windows inoperable preventing egress	Miami 105
*Emergency egress areas were available for use in bus	Baylor 4 Rochester RAI 36

- Vehicle Removal

Vehicle damaged during removal	Miami 105
Vehicle removal delayed	SwRI 7009, 7027
*Vehicle removed quickly by wrecker	Utah 1-69

- Broken Radiator Hose Burned Driver — SwRI 7043

- Recommendations

Should be a firewall between trunk and passenger compartments	New Mexico 4

Emergency first aid equipment on buses should be accessible and in good condition	UCLA 977
Buses should carry emergency equipment to deal with severe trauma	Baylor 4
Safety reflectors carried by trucks need re-evaluation	SwRI 6914
Trucks hauling hazardous materials should have a sign displaying such	Ga Tech 72
Police investigators should carry fire extinguishers	Ga Tech 59
Use of bladder type lines for fuel tank to prevent fire	Rochester RAI 39, RAI 51-53
Fuel line and tank placed in protective area to reduce rupture and intrusion	Baylor 2-ME-12 Rochester RAI 13 Tulane 69-6 UCLA 843, 936, 944, 987, 1079, Baker Bus
Standard to limit burn rate of combustible materials in vehicle interior	Ga Tech 59 New Mexico 4 UCLA 1289

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
7	ENVIRONMENT - PRE-CRASH FACTORS	
	● Traffic Control Inadequacy	
	Signal Operation	Baylor 2ME5, 2ME10, 10, 4 CAL 9, 20 Georgia 32, 54 Maryland 68-11 Miami 697002 Rochester RAI 51-53
	Signs	Baylor 2ME7, 2ME19 Boston 68-13, 69-6, 69-30, 68-18, 69-11 CAL 16 Indiana 63-3 Maryland 69-59 Miami 697022, 697008 Rochester 29-30, RAI 18, DOT 3, RAI 10, RAI 14 RTI 2, 5, 17 SwRI 6904, 6914, 6912, 7006 Tulane 69-20, 12B1670, 69-1718 UCLA 844, 845, 984, 1003, 1120, 895 Utah 1-69
	Markings	Boston 69-21 CAL 3, 83 Maryland 69-59 New Mexico 8 SwRI 7007 Utah 1-69, 6-69 UCLA 895
	Roadway Construction	Georgia 32 Maryland 69-46, 70-9 Rochester 10 Stanford 06

Parking	Boston 68-1 Georgia 64 Miami 697002 New Mexico 3 Rochester 9, 18 Tulane 69-3

● Poor Roadway Geometry

Sight-distance	Baylor 5 Boston 69-28, 69-11, 69-15, 69-30 CAL 1, 20, 21 Georgia 76 Indiana 69-1, 70-8, 69-6 Miami 697008 Ohio 3, 11, 10 Rochester 18, 35, 60 RTI 2, 7, 11, 13 SwRI 6908, 7004, 6915, 7030 UCLA 852, 1003, 829 Utah 11-70
Superelevation	CAL 16 SwRI 6911
Shoulders	Boston 68-1, 68-5 CAL 8, 13, 14 Georgia 37 Indiana 70-8 Maryland 69-46 Miami 105 Rochester 3 RTI 1 SwRI 6904, 6916 Utah 6-69
Traveled-way	Boston 69-31, 69-5 CAL 18 Georgia 20, 41, 51, 67, 39 Maryland 68-36, 69-6 New Mexico 2*, 7 RTI 14 Rochester 11, 12, 16, 21 SwRI 6911, 7005, 7009, 7011, 7017, 7026 UCLA 1188 Utah 3-69

- Maintenance

Roadway	Boston 68-11, 69-4, 69-12, 69-15, 69-18 CAL 11, 6, 14, 7 Georgia 45 Indiana 69-6, 69-3 Miami 697004 New Mexico 2 Rochester DOT 3 RTI 8 SwRI 7004, 7008, 6904, 6903, 6916, 6901, 7014, 7029 Tulane 06 Utah 1-69
Snow Removal	CAL 6, 14, 7, 21 Rochester 1, 2, 3 Utah 9-69

- Ambience

Wet, Slippery Pavement	Baylor 9, 2-ME-16 Boston 69-9, 69-2, 69-3, 69-6, 69-7 CAL 1, 2, 4, 5, 7, 12, 13, 14, 15, 17, 19, 22, 83 Georgia 2, 6, 10, 11, 15, 29, 31, 49, 67, 76 Indiana 69-4, 69-8, 69-6 Maryland 68-2, 68-4, 68-17, 68-21, 68-33, 68-46, 69-59 Miami 697001, 105 Ohio 10, 4, 7 RTI 1 Rochester DOT 1, DOT 2, DOT 3, DOT 5, RAI 13, RAI 36 SwRI 6901, 6903, 6911, 6912, 7006, 7009, 7014, 7017, 7027, 7029 Tulane 69-13, 14, 6917, 18, 6922 UCLA 906, 937 Utah 9-69

Glare - Vision	CAL 83 Indiana 70-9 Maryland Special Report 2 Miami 697008 Rochester 21, 35 SwRI 6914
Roadway Illumination	Maryland 68-44 , 68-49 Miami 697022 New Mexico 9 Tulane 69-20 UCLA 1090
Adverse Weather Conditions	Baylor 2-ME-16 Boston 69-12, 69-13, 69-20 CAL 1, 19 Maryland 68-21, 68-47, 69-13 Miami 697022 Rochester 3
Other Traffic Induced Evasive Maneuver - Environmental Overload	Baylor 2-ME-6 CAL 78, 17, 18 Georgia 75 Maryland 68-25 New Mexico 7 Rochester RAI 10, RAI 11, RAI 12, RAI 59, RAI 60 Stanford 06 SwRI 6905, 6912 Tulane 69-10, 11 UCLA 822, 853
● Pedestrians	Maryland 68-44, 68-3, 68-26, 68-44
● Animal in Roadway	Indiana 69-8 New Mexico 9 Rochester DOT 5, DOT 9
Recommendations	
Barrier-type gates needed at railroad crossings	RTI 8 UCLA 852
Standardization of roadside signs	SwRI 6904
Left turns should be prohibited in high speed rural roads	Georgia 50 SwRI 6915

Median should have mountable type curb to provide easier access	SwRI 7008
Conduct public information campaign on new roadway features	UCLA 1172
Long-term detour warrants good engineering practice	Georgia Special Report
Provide crossover for emergency vehicles	Maryland 69-5
Upgrade the design features of the roads	Georgia 20, 39, 41, 51 New Mexico 7

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
8	ENVIRONMENT - CRASH FACTORS	
	● Roadside Structures	
	Fixed object adjacent to roadway	Boston 69-4 Georgia 14, 21, 39, 57, 61, 63, 46, 76 Indiana 69-2, 69-3, 69-4 Miami 105, 697001 New Mexico 3* Ohio 5 Rochester 8, 16, 19, 21, 29-30 RTI 1 Stanford 28, 09 SwRI 6906, 6916, 7011, 6911, 7006, 6901, 6903, 6908, 7025 Tulane 69-5 UCLA 704, 895, 957, 1000, 1055, 1090, 1120, 1146, 1177 Utah 7-69, 13-70
	Effectiveness of breakaway supports	Stanford 28* SwRI 6901, 7023*, 7025 UCLA 1055*
	Guardrails - barriers	Boston 68-11, 69-19, 69-3, 69-15, 69-18 Georgia 6, 25, 29, 34, 40, 66, 75 Maryland 69-59, 68-34 Miami 105, 697004, 697008 New Mexico 7 Rochester 37, 39 RTI 14 Stanford 09 SwRI 6911, 7043 Tulane 12B1760 UCLA 567, 734, 802, 822, 845, 965, 977, 1075, 734, 1079, 1143*, 1146 Utah 1-69, 6-69, 13-70

Bridge rail	SwRI 6904
Gable chain link fence	Rochester 37
Deep flood channel - ditches	Miami 697008 New Mexico 7
Pavement irregularities - shoulders	Miami 697004 New Mexico 2*
Flat side-slope enabled driver to maintain control, and roadside clearance reduced injury severity	New Mexico 9* SwRI 7003*

Recommendations:

Underground utilities would reduce hazards	Miami 697025 UCLA 914
Bridge rail-ends should be flared away from pavement	UCLA 977
Lower cable needed on guard rail to prevent underride	UCLA 1143, 1031
Breakaway utility poles needed	Georgia 46 Utah 2-69
Open canals need shielding to prevent water involvement	Miami 105 Tulane 01

Matrix Cell (* indicates positive factor)	Explanation of Factor	Team and Case # of Occurrence
9	**ENVIRONMENT - POST-CRASH**	
	● State Highway Department	
	*Implementation of Multidisciplinary Accident Investigation Team recommendations	Georgia 75* RTI 17* SwRI 7009*, 7004* Tulane 69-4* UCLA 829*, 852*, 1079*, 1146* Utah 1-69*
	Highway repairs were delayed	Maryland 70-9 SwRI 6908, 7017
	Highway repairs did not remove hazards	Miami 697008 UCLA 1000
	● Law Enforcement	
	Post-accident traffic control, investigation	Miami 697001, 697022 Stanford 28 SwRI 7005*, 6904, 7032 Utah 1-69*, 6-69*
	Alcohol-drug user testing	SwRI 7011, 7037 Utah 6-69
	Clean-up operation	CAL 5* Georgia 60* SwRI 6913, 6914*, 6916*, 7032*
	Past traffic violations not recorded	Indiana 69-4 SwRI 7004
	Assistance to injured	Miami 697001
	Recommendations:	
	Training of police in evaluating on-scene evidence is needed	Boston 69-28, 69-24
	Rescue and removal services should be arranged by police in heavy demand situations	SwRI 7009