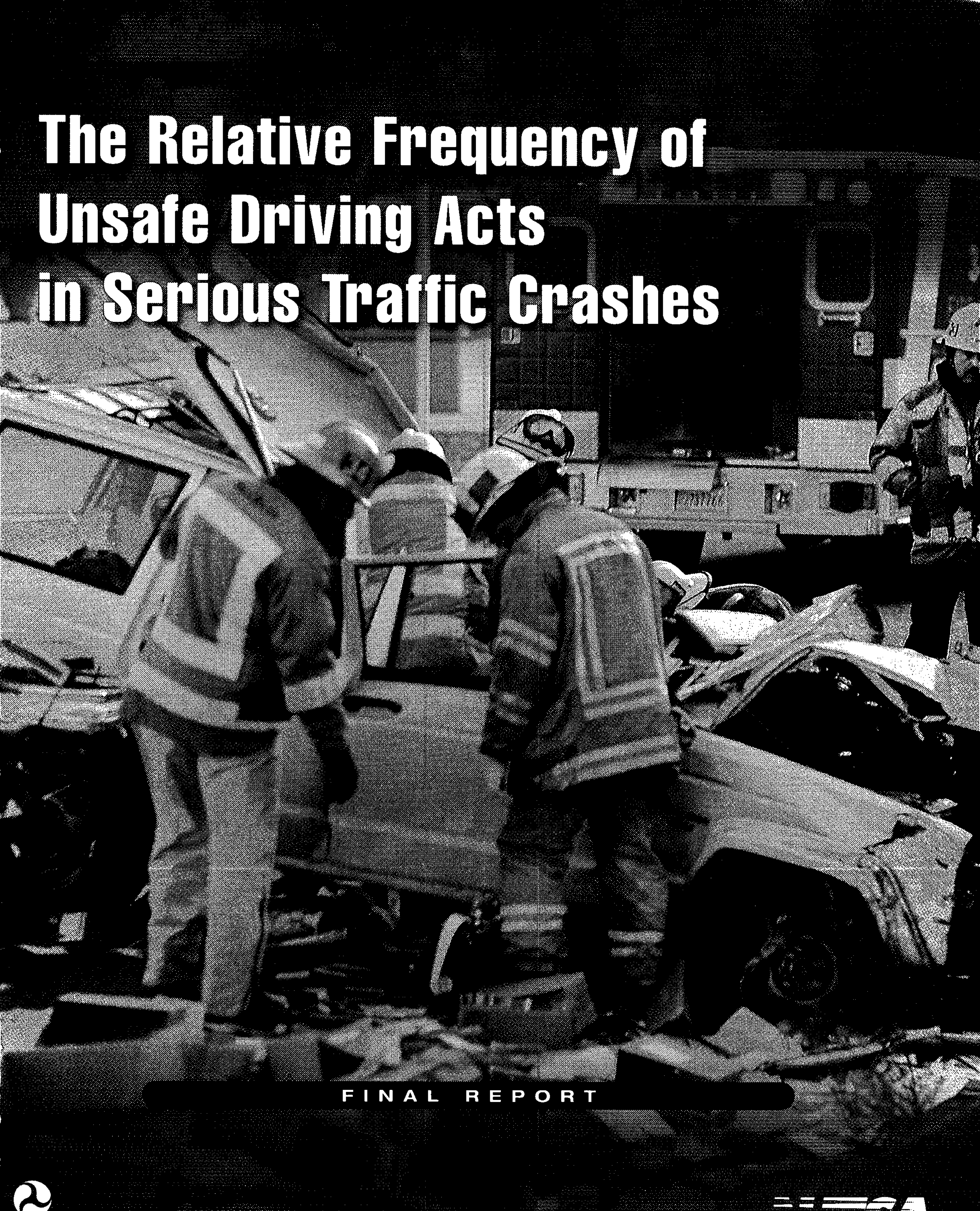

The Relative Frequency of Unsafe Driving Acts in Serious Traffic Crashes

FINAL REPORT

U.S. Department of Transportation
National Highway Traffic Safety

NHTSA
People Saving People

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16. Abstract

This study was conducted to determine the specific driver behaviors and unsafe driving acts (UDAs) that lead to crashes, and the situational, driver and vehicle characteristics associated with these behaviors. A sample of 723 crashes involving 1284 drivers was investigated from four different sites in the country during the period from April 1, 1996 through April 30, 1997. The crashes were selected using the National Automotive Sampling System (NASS) protocol and provide a fair sample of serious crashes involving passenger vehicles in the United States. In-depth data were collected and evaluated on the condition of the vehicles, the crash scene, roadway conditions, driver behaviors and situational factors at the time of the crash. Investigators used an 11 step process to evaluate the crash, determine the primary cause of each crash, and uncover contributing factors.

Crash causes were attributed to either driver behavior or other causes. In 717 of the 723 crashes investigated (99%), a driver behavioral error caused or contributed to the crash. Of the 1284 drivers involved in these crashes, 732 drivers (57%) contributed in some way to the cause of their crashes. There were six causal factors associated with driver behaviors that occurred at relatively high frequencies for these drivers and accounted for most of the problem behaviors. They are: DRIVER INATTENTION - 22.7%, VEHICLE SPEED - 18.7%, ALCOHOL IMPAIRMENT - 18.2%, PERCEPTUAL ERRORS (e.g. looked, but didn't see) - 15.1%, DECISION ERRORS (e.g. turned with obstructed view) - 10.1%, and INCAPACITATION (e.g. fell asleep) - 6.4%

Problem types in terms of crash configuration and specific problem behaviors were also identified. The following seven crash problem types accounted for almost half of the crashes studied where there was a driver behavioral error: SAME DIRECTION, REAR END (Driver Inattention Factors) - 12.9%, TURN, MERGE, PATH ENCROACHMENT (Looked, Did Not See, etc.) - 12.0%, SINGLE DRIVER, ROADSIDE DEPARTURE (Speed, Alcohol) - 10.3%, INTERSECTING PATHS, STRAIGHT PATHS (Looked, Did Not See, etc.) - 4.1%, SAME TRAFFICWAY, OPPOSITE DIRECTION (Inattention, Speed) - 2.6%, and BACKING, OTHER, MISCELLANEOUS, ETC. (Following Too Closely, Speed) - 1.3%

Countermeasures were identified in the areas of education, training, and law enforcement for each of the major problem types described in this effort. A limited number of technology based countermeasures related to the Intelligent Transportation Systems (ITS) initiative were also identified when these countermeasure types were relevant to specific driver error tendencies.

A Technical Summary Report which highlights major findings of this effort has been prepared and is available to the general public.

17. Key Words Unsafe driving acts, driver behavioral errors, crash problem types, causal factors, countermeasures		18. Distribution Statement This report is available from: National Technical Information Service Springfield, VA 22161 (702) 604-6000	
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SECTION 1
INTRODUCTION

Background

Past research has indicated that the vast majority of traffic crashes are caused by human error. A landmark study by Indiana University (Treat, et al, 1979) found that human factors caused or contributed to 93 percent of the crashes investigated. In that study, anywhere from 12 to 34 percent of the crashes involved environmental factors (such as slick roads) while between 4 and 13 percent involved vehicle factors (brake failure, tire problems, etc.) The three major human factors most frequently reported in that study included:

- Improper lookout
- Excessive speed
- Inattention

Other major crash studies have reported similar findings (Lohman et al, 1978, Perchonek, 1978; Tharp, et al, 1970). While these past studies have produced very useful information, efforts to reduce the incidence of these errors have met with only limited success. The studies are also more than 20 years old and the driving environment has changed substantially.

Recently, there has been a renewed interest in problem driving behaviors such as running traffic signals, following too closely, aggressive lane changing, driving too fast for conditions, and driving while inattentive to the driving task. However, there has been a lack of specific data necessary to identify, characterize, and categorize "crash problem types", which has restricted efforts directed at problem driving behaviors. In order to develop more effective countermeasures, specific problem behaviors that cause crashes, and the conditions and situational factors associated with those crashes, must be identified. The Relative Frequency of Unsafe Driving Acts in Serious Traffic Crashes program, more commonly referenced as the Unsafe Driving Acts (UDA) program, was developed to provide these essential data elements.

1.1 Program Objectives

The goal of this research effort was to determine the relative frequency of unsafe driving acts (UDAs) in serious crashes, to categorize these UDAs and associated situational characteristics into "crash problem types", and then recommend countermeasures that have the potential to substantially reduce these types of crashes. Specific program objectives may be summarized as follows:

(1) Determine the driver behaviors that lead to crashes and the situational, driver, and vehicle characteristics associated with these behaviors.

(2) Classify behaviorally caused crashes into "crash problem types" which contain common sets of characteristics.

(3) Develop a ranking of "crash problem types" based upon their relative frequency of occurrence.

(4) Describe potential countermeasures appropriate for each identified "crash problem type".

1.2 Report Format

The format of this report has been structured to parallel the format utilized in an earlier interim report prepared for this effort. The section content may be summarized as follows:

- SECTION 2. APPROACH

  This section describes the methods developed and applied to the unsafe driver acts (UDA) problem and the data collection protocols developed to collect field crash data. The description includes the following elements:
  + Logic sequences associated with the methods
  + Pilot study data collection sites
  + Training elements for NASS Researchers
  + Data collection formats
  + UDA database format

- SECTION 3. STATISTICAL ANALYSIS FINDINGS

  This section describes the analysis findings derived from the UDA database. Major patterns related to UDA occurrence are documented with emphasis placed on documentation of situational factors that assisted in defining problem types. Relationships between these situational factors and other crash/driver characteristics are also developed.

- SECTION 4. PROBLEM TYPE ASSESSMENT

  Clinical analysis findings from a detailed case review sequence are utilized to fleshout the problem type assessment initially identified in Section 3. All of the major characteristics of each listed problem are delineated. Specific crash/driver characteristics and/or situational factors which are amenable to countermeasure application are also identified.

- SECTION 5. COUNTERMEASURE ASSESSMENT

  Countermeasures appropriate for the trends/patterns noted in Section 4. are discussed. Primary emphasis is placed on countermeasures associated with education/training/law enforcement applications. Where relevant, however, countermeasures based on emerging ITS technologies are addressed.

- SECTION 6. CONCLUSIONS AND RECOMMENDATIONS

  Conclusions and recommendations deriving from the analysis effort are presented. Primary emphasis is placed on summarizing characteristics and situational factors associated with defined problem types. Additional emphasis is then given to those countermeasures with the highest probability of success in terms of mitigating crash factors in subsequent applications.

- APPENDIX A COMPARISON OF UDA AND INDIANA TRI-LEVEL CAUSAL ANALYSES

  Due to the landmark nature of the Indiana Tri-Level study, it was important to determine if causal analyses completed in the current effort were consistent with the findings of the Indiana study. A comparison of major causal findings from these two programs is provided in this section.

SECTION 2
APPROACH

Successful development of UDA countermeasures requires a detailed analysis of crashes involving these events. This section presents the method developed by the project staff to clinically analyze crash data and determine the presence of UDA events. The specific data required to support these assessments are identified and the associated data collection formats and field data collection protocols are also presented. As additional background, pilot study site selection criteria and the training program provided to NASS Researchers are discussed as is the format of the UDA database constructed from the field data collection/clinical analysis efforts.

2.1 Clinical Analysis Method

The clinical analysis method that was applied to crash case reports in this program was series of individual steps that analysts completed to derive variables related to crash causation and associated UDAs. This method was derived from earlier crash causation work performed at Veridian. A summary of the method is provided in Table 2-1. Steps 1-7 of the sequence were utilized in a number of preceding programs where establishing crash causal factors was important to achieving program success. Experience obtained in those efforts indicated that this sequence ensured that crash events and circumstances were completely evaluated in the causal determination. Steps 8-11 represent an extension of the analysis sequence that was developed specifically for the UDA program.

A schematic representation of this method is provided in Figure 2-1. Previous experience indicated that most of the data required to successfully execute steps 1-7 was available in the standard NASS CDS case reports. Additional data collection would be required to provide an adequate basis to execute steps 8-11. These data requirements are addressed in the next subsection.

2.2 Data Required For Methodology Application

It was quickly recognized that additional information would be required in the current program to successfully identify UDA events and the circumstances surrounding these events. This additional information related to delineation of what the involved drivers observed as the crash sequence developed, their specific responses to pre-crash and crash events, and their general physiological and psychological states prior to the crash. The project staff developed detailed interview formats to secure the required data.

Table 2-1
Clinical Analysis Method

Step	Notes
1. Assess Crash Participant's Statements Review crash participant's (i.e., driver, occupant, and witness) statements provided in the interview forms and/or the Police Accident Report (PAR). These statements provide separate and differing accounts of the crash event sequence.	The primary emphasis here is to identify potential discrepancies between the various statements.
2. Examine Physical Evidence Examine the physical evidence pattern generated during the crash sequence. This pattern is documented in the NASS crash schematic provided with each case. Additional information is sometimes available in the PAR and/or the Researcher's field measurement log and these sources should also be reviewed.	The intent here is to utilize the physical evidence pattern to evaluate any apparent discrepancies between driver and/or witness statements.
3. Verify Available Data The physical evidence pattern is used to verify driver/witness statements and to resolve discrepancies between these statements.	While the physical evidence pattern is normally sufficient to verify specific statements, on occasion the lack of a distinctive pattern can require an alternative approach. In this circumstance, the preponderance of evidence from all available sources is to be used to resolve discrepancies.
4. Verify Crash Type Using all available data (i.e., interview, PAR, and NASS crash schematic), verify the crash type as assigned by the NASS Researcher.	A crash may be classified as more than one type in the interview forms (i.e., Rear End and Intersection).
5. Assess Pre-Existing Conditions Examine pre-existing conditions of the crash (i.e., driver, roadway, vehicle, and environment) and identify those conditions which may have contributed to the crash.	The intent here is to identify all factors that may have played a role in crash causation. Experience indicates that pre-existing conditions are often overlooked in causation evaluation efforts.
6. Assess Critical Event Using all available data (i.e., interview, PAR, and NASS crash schematic), identify the critical event which precipitated crash occurrence.	The critical event can be an action (i.e., pedestrian darted into roadway) or it can be a point in time (i.e., driver entered the curve without reducing travel speed).

Table 2-1
Clinical Analysis Method
(cont.)

Step	Notes
7. Evaluate Crash Cause Determine the specific reason(s) for the occurrence of this crash and the associated contributions of driver behavior, environmental conditions, roadway conditions, vehicle conditions, and/or other conditions. For those cases not associated with driver behavior, the crash cause is specified and the case is dropped from further UDA analyses.	It is anticipated that a single crash cause can have a number of associated contributing factors. For example, a causal factor such as, "Lost Directional Control on a Wet Surface" might have multiple contributing factors including the wet road surface, the driver traveling too fast for existing conditions, and the presence of bald tires on the vehicle. It is important to identify the full range of contributing factors.
8. Evaluate Driver Behavior (Safe/Unsafe) For those cases where driver behavior is the primary causal factor or is listed as a contributing factor, evaluate the indicated behavior with respect to whether or not an unsafe driving action is involved.	Driver behavior must be assessed within the context of the circumstances of each specific crash (i.e., it is possible that an action is unsafe in one crash and not unsafe in a different crash).
9. Specify UDA For those cases where an unsafe driving action is involved, specify the nature of the UDA. This specification is derived from all available case information including speed estimates developed during the analysis sequence.	The major categories of UDAs may be summarized as follows: • Unsafe speed control • Causing unsafe proximity to other vehicle or object • Proceeding with perceptual deficit • Insufficient directional control/failure to maintain safe path • Illegal, unsafe actions • Presenting an obstacle • Lighting/Signaling misuse
10. Determine Intentionality Based on the driver's response to the questions such as those provided in the right-hand column, answer the followings questions: • Was the UDA due primarily to an element of the vehicle or environment of which the driver was unaware and could not have anticipated. (YES or NO) [examples: (a) speed reductions-sign had fallen down; (b) vehicle tail lights had failed] • Was the driver aware that his/her driving actions (the UDA) had an increased crash risk or were illegal? (YES or NO)	Think about the weather conditions just before the crash. Was there anything that made driving a little more risky or hazardous? (If yes) (a) Please explain that. (b) Did the weather conditions make you drive differently? (If yes) Please explain that.

Table 2-1
Clinical Analysis Method
(cont.)

Step	Notes
10. Determine Intentionality (cont.) In the database, a variable is to be derived from questions 1 and 2 above. If question 1 is answered NO and question 2 is answered YES, than the variable attribute is coded 1 (UDA not intentional). If there was no UDA, this variable should be assigned the "not applicable" code.	Before the crash, could you have driven differently so as to prevent a crash like this from happening? (If yes) Please explain that. Do you think that just before the crash, you were taking a chance in the way you were driving? (If yes) Please explain that. Were you aware of the posted speed limit? Were you aware of your travel speed?
11. Determine Behavior Source of UDA The analyst determines whether the cause of the UDA is attention, perception, decision-making, motor skills, other, or unknown.	More than one behavioral source may be associated with a specific UDA. It is important to identify the primary behavioral source and to identify other sources as contributory.

Use of multiple interview formats in this effort was necessitated by interviewing protocols in the NASS program. Specifically, interviews were only completed in NASS with the drivers of CDS applicable vehicles (i.e., towed light trucks and automobiles). In the UDA program, interviews were required with all involved vehicle drivers, vehicle passengers, and witnesses to the crash event. A combined interview format which satisfied the requirements of both programs was developed for use with CDS applicable drivers. A second format was then developed for use with CDS non-applicable drivers (i.e., drivers of non-towed light trucks and automobiles and drivers of medium and heavy duty trucks). In this format all questions related to CDS requirements were deleted, reducing the length of the format. Finally, a third format was developed for vehicle occupants and witnesses. In this format, material related to the driver's perspective of crash events was deleted since the interview candidate was unlikely to be aware of what the driver did or did not see.

In addition to these interview formats, the project staff also developed a UDA Form which summarized UDA data for each vehicle involved in the crash (i.e., one UDA Form was completed for each involved vehicle). While most of the variables contained on the UDA Form were also found on the driver interview form, the driver was not the only source for UDA Form responses. The intent of this form was to provide the most accurate assessment available for each vehicle in the crash sequence. Therefore, the NASS Researchers were instructed to incorporate findings from other interviews conducted for that crash and from their field investigation work. For example, assume a circumstance where the driver stated that he was looking straight forward prior to the crash, however, in interviews completed with the driver and passenger of the second vehicle involved in this crash and with an independent witness, it was indicated that the subject driver was looking to the left prior to the crash. In this case, the driver interview form would reflect the driver's statement, however, the UDA Form would be coded to the preponderance of evidence and indicate that he was looking to the left.

All of the interview information and the UDA Form variables were examined during the case review/coding sequence conducted for this effort. Key aspects of the NASS CDS data set utilized for this effort included the crash schematic generated by the NASS Researcher, the scene measurement log, the General Vehicle Forms, the Exterior Vehicle Forms, available police reported information, and the vehicle/scene slides. Results of each review were recorded on a format developed by the project staff. A total of 13 variables were coded for each vehicle involved in the crash.

2.3 Field Data Collection Protocols

Since the UDA program was integrated into the NASS program as a special studies effort, virtually all of the field data collection protocols were identical to or paralleled NASS protocols. Specific areas may be summarized as follows:

- *Case Selection* - Crashes were selected in accordance with the NASS sampling protocol (i.e., no alteration of sampling algorithm).

- *Scene Documentation* - Scenes were documented in accordance with the NASS scene protocol with a few minor additions. NASS Researchers were requested to measure and photograph aspects of the roadway geometry/configuration and roadside features which may have influenced crash causation. Particular emphasis was placed on documenting sight lines for crashes occurring at intersections. This protocol typically resulted in four to six additional scene strides in each UDA case as compared to a standard NASS case submission.

- *Vehicle Documentation* - Vehicles were documented in accordance with the NASS vehicle documentation protocol. Since the emphasis of the UDA program was not oriented toward crashworthiness evaluation, a smaller number of vehicle exterior slides were submitted with the UDA case report and interior vehicle documentation forms were omitted from the package of UDA case material. For those cases where vehicle tires may have played a role in crash causation, Researchers were requested to submit tire tread depth readings with the Exterior Vehicle Form.

- *Occupant Injury Documentation* - Occupant injury levels were documented in accordance with standard NASS protocols. Injury severity information was merged into the UDA database from the CDS computerized file.

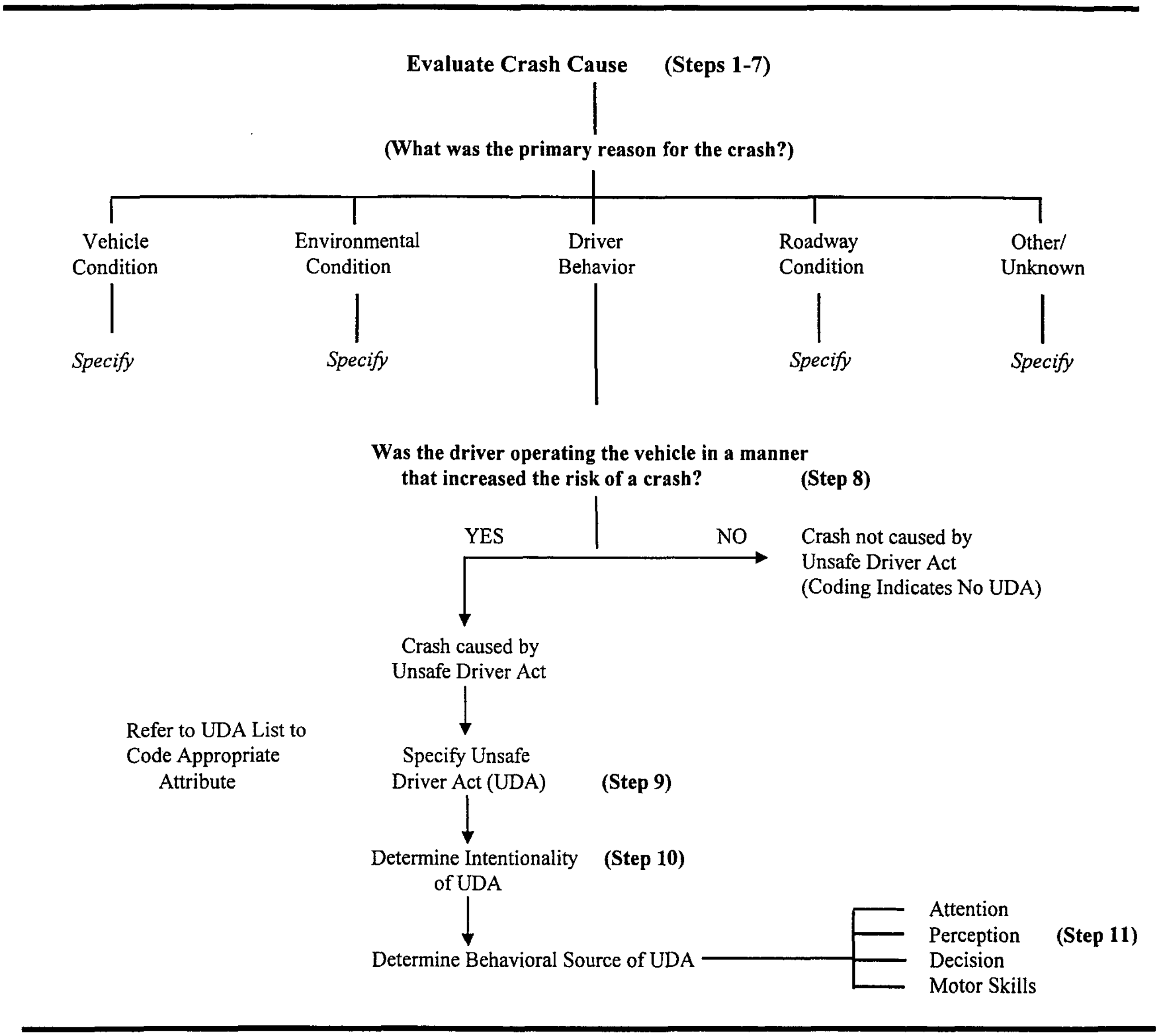

Figure 2-1 Schematic Depiction of Clinical Analysis Method

- *Case Interview Documentation* - The major difference between standard NASS protocols and UDA protocols was the increased emphasis in the UDA program with respect to obtaining interviews with all involved drivers, vehicle occupants, and witnesses to the crash sequence. As indicated previously, this emphasis was needed to ensure that a complete description of the crash sequence and factors related to UDA occurrence were obtained. Copies of all completed interview formats were submitted with the UDA case material.

2.4 Pilot Study Site Selection

There were several concerns with respect selecting NASS sites for the pilot study effort. For example, it was important to select a limited number of sites to ensure adequate oversight could be provided to these sites. In addition, it was important to select sites which had historically achieved high scene/vehicle inspection rates and very high interview completion rates. Of the latter two criteria, the high interview completion rate was considered to be the best predictor of probable performance levels in the UDA program. Finally, there was also concern with respect to having a balanced sample of crashes within the NASS data system in terms of incorporating teams from both regions. The project staff believed that the final set of four sites selected to participate in the pilot study satisfied the concerns as stated above. The final sites were:

PSU Location
Allegheny County, Pennsylvania
Knox County, Tennessee
Jefferson and Gilpin Counties, Colorado
Seattle, Washington

2.5 Site Training, Study Initiation, and Case Submission Protocols

A two day training session was conducted for the four NASS teams participating in the pilot study. The first day of the program was devoted to providing background information, discussion of study objectives, and explanation of the data formats that would be completed for this program. A discussion of interviewing techniques was also provided. The second day was devoted to providing the trainees with practical interviewing experience using scenarios developed from actual crashes.

Data collection at each of the four NASS sites was initiated on April 8, 1996 for crashes occurring on or after April 1, 1996. The pilot data collection period was initially scheduled to be completed on April 1, 1997. Preliminary projections had indicted that approximately 930 cases would be obtained during this interval. For a variety of reasons, however, it became apparent that shortfall would occur in the number of valid cases collected. To partially address this problem, the data collection period was extended through April 30, 1997. The final count of cases submitted to the UDA project staff was 723. Subsequent adjustments to this final total are addressed in later subsections.

Each of the teams submitted completed cases to their assigned Zone Center in accordance with standard NASS protocol. Zone Center personnel performed quality control reviews of the CDS data and for the UDA Form coded by the NASS Researcher. Following completion of the quality control function, the Zone Centers assembled a UDA case report from the available case material and forwarded these reports to the project staff for further clinical review. Each of the UDA case reports contained the following material:

- Copy of the General Vehicle Form (all involved vehicles)
- Copy of the Exterior Vehicle Form (all involved vehicles)
- Copies of the completed interview forms (all drivers, vehicle occupants, and witnesses)
- Original version of the UDA Form (all involved vehicles)
- Copy of crash schematic
- Scene Measurement Log
- Slide Index
- Scene and vehicle slides (all involved vehicles)

2.6 UDA Database

The UDA database was designed as a series of sub-files that described individual crashes. The file record for each crash contained the following information:

- Selected NASS variables (for each involved vehicle)
- UDA Form variables (for each involved vehicle)
- UDA variables coded by the project staff (for each involved vehicle)

A total of 95 NASS CDS variables were incorporated into the UDA database directly from the NASS computerized file. Variables incorporated from the NASS Accident Form were general variables that applied to the overall crash sequence. All remaining variables incorporated from the NASS file were either vehicle or occupant specific and were provided for each vehicle/occupant involved in the crash.

A total of 78 UDA Form variables were incorporated into the database. These variables were coded by the NASS Researchers who investigated each crash. As indicated previously, UDA Form responses were intended to represent the best information available and were designed to reflect a synthesis of the most accurate driver interview responses, witness statements, police reported information, and findings from the Researcher's field investigation effort.

There were a total of 13 UDA variables coded by the project staff for each vehicle involved in crashes selected for examination in this effort. These variables added the following information to the database:

- Primary crash cause
- Nature of crash causation factor
- Assessment of manner of vehicle operation on crash risk
- Primary and contributory UDAs
- UDAs which were a necessary condition for crash occurrence
- Intentionality of primary UDA
- Behavioral sources of UDAs
- Temporal sequencing of UDAs
- Estimated vehicle travel and impact speeds

The UDA types coded for this effort were derived from similar lists developed by Perchonek (Perchonck, 1978) and Lohman (Lohman, et al, 1978) in earlier studies in this topic area.

SECTION 3
STATISTICAL ANALYSIS FINDINGS

Results reported in this section were typically derived using unweighted NASS data. Specifically, the NASS case weights were not assigned to the sample of UDA cases collected in this effort. This approach was necessary because there were a number of problems/limitations that existed with respect to interpreting analysis results. These limitations are addressed in Section 3.1. Following that discussion, findings associated with univariate distributions and cross tabulations completed during the analysis sequence are presented.

3.1 Data Limitations

The interpretation of the findings presented in this report was subject to qualifications due to data limitations. These limitations are briefly reviewed in this section. A critically important limitation arose from the fact that the data were not selected to be representative for the nation as a whole. The 24 sites included in the National Automotive Sampling System (NASS) jointly provide a representative sample of the crash types covered by NASS. However, this study was conducted at only four of the NASS sites. The study sample was, therefore, not representative of the national crash population.

A related limitation of the study sample was that it included only a relatively small number of crashes (723) and drivers (1284). Sample size limitation became especially significant in analyses that simultaneously examined up to five factors - crash cause, primary behavioral source, necessary UDA, first UDA in the sequence, and travel speed - within each of seven uniquely identifiable crash type configurations that were included in this study. The crash configurations had sample sizes ranging between 121 and 389. As the analysis staff proceeded to examine combinations of factors within each of the crash configurations, an unavoidable trade-off was discovered. Specifically, the staff could either take a detailed look at a few events, or a coarse-grained look at many events. In other words, the sample size was reasonably large in analyses that used only one, or perhaps two of the factors, but sample size was reduced to a very small value when all or nearly all factors were brought into the picture. This prevented the staff from reaching statistically reliable in-depth conclusions.

A complex stratified sampling plan with extremely uneven sampling probabilities was used to draw the NASS sample, and consequently, the sample of crashes in this study. An important major feature of the NASS sampling plan was that severe crashes were oversampled relative to less severe ones. For example, the NASS sample included fatal crashes with certainty, but property damage crashes with only a very low probability. The NASS sample relied on sampling weights to account for uneven sampling probabilities in national estimates. Used properly, the NASS crash weights can generate valid national estimates from the full NASS sample. However, since we only had data for 4 of the 24 NASS sites, the sampling weights for our crashes could not be used to generate national estimates. A further complication was that because NASS strongly oversampled severe crashes, sampling weights in our sample varied over a wide range: from a high value of about 3,000 to a low value of about 3. Specifically, sampling rates varied by a factor of 1,000. As a result of this variability and because the sample was not nationally representative, it was not appropriate to use the NASS weights to expand the sample. The approach taken in this study was to tilt all estimates toward severe crashes. Not using weights resulted in a bias relative to national distributions, but accorded more importance to severe crashes

An additional limitation was the fact that the variable BAC Test Result was relatively rarely available in the CDS data - limiting the usefulness of that variable for interpreting the data. For that reason, this variable was included in the reporting of estimated under and over-representation, but was not included in reporting the most frequent combinations of key variables.

3.2 Univariate Distributions

Univariate distributions were prepared for the 75 of the 78 UDA Form variables (i.e., case and vehicle identifiers were excluded) and the 13 derived variables coded by the project staff. Findings associated with the distributions are presented in the subsection below. The distributions represented a sample of 723 crashes and 1284 vehicles. A total of 1283 of the vehicles were crash-involved vehicles. One noncrash-involved vehicle was added to the database because the investigating officer had identified the vehicle driver and had issued a citation for that driver's role in crash causation.

3.2.1 UDA Form Variables

Major findings derived from the univariate distribution of UDA Form variables may be summarized as follows:

- *Violations Charged Against Driver* - No violations were recorded for approximately 64.0 percent of the drivers in the sample. More than 32.0 percent of the drivers had one or more violations charged, 8.2 percent had two or more violations, and 3.1 percent had three or more violations. In the first violation charged category, relevant citations were most frequently issued for failure to yield. These citations were issued to 5.8 percent of the drivers in the sample and 17.8 percent of the drivers receiving citations. The second largest category of relevant violations involved the use of alcohol. These citations were issued to 5.5 percent of the drivers in the sample (16.9 percent of the drivers receiving citations). The third largest category involved violations of traffic signals/stop signs. These citations were issued to 3.1 percent of the drivers in the sample (9.5 percent of the drivers receiving citations). These same violations either disappeared or appeared at much lower frequency levels in the distributions for second and third violations charged.

  The largest category of violations charged in all three distributions involved the other category. Examination of individual case reports revealed that these violations tended to involve a wide array of vehicle registration issues, licensing issues, vehicle condition issues, and insurance issues which were less relevant to driving performance. It should be noted, however, that the category also included a number of infrequently occurring violations that were relevant to performance. These violations could not be tabulated in a useful manner.

Speeding violations accounted for 1.3 percent of the first violation charged category (4.0 percent of the drivers receiving citations) and did not appear in the distributions for second and third violations charged. As will be shown in Section 3.2.2, this circumstance was an under-representation of the proportion of crashes where violations of speed limits occurred.

- *Distance Traveled Impact to Final Rest* - Approximately 10 percent of the crash-involved vehicles reportedly came to rest at the point of impact and 53.7 percent came to rest within 10 meters of the point of impact. In those cases where physical evidence was present, this distance was established by the NASS Researcher with a relatively high degree of precision. However, in cases where there was no defined physical evidence pattern, this distance was typically derived from driver estimates which reflected a much lower degree of precision. These derived estimates, in combination with other factors (e.g., lack of vehicle inspections), influenced the ability of the project staff to provide analytical speed estimates. (NOTE: See discussion of impact and travel speeds in Section 3.2.2.)

- *Risk/Influence of Roadway, Weather, and Traffic Conditions* - An interesting trend was evident for this six variable sequence. For example, 12.9 percent of the crash-involved drivers indicated that roadway conditions made driving riskier, but only 9.2 percent also indicated that the increased risk altered their driving performance. A clinical review of these cases showed that nearly all of the drivers who indicated an influence on driving performance believed that they personally drove more cautiously/slowly in the time period prior to crash occurrence. Of the 3.7 percent who indicated there was no influence on driving performance, there appeared to be two major subgroups. In the larger of these two subgroups, there was retrospective recognition that they personally or other drivers should have driven more cautiously/slowly. In the second subgroup, it appeared that drivers believed that the increased risk was not related to crash occurrence.

  Similar patterns were evident for the weather condition and traffic condition sequences. Specifically, 8.5 percent of the crash-involved drivers indicated that weather conditions made driving riskier and 7.0 percent also indicated that they drove more cautiously/slowly as a result of the increased risk. In this variable sequence, the proportion of drivers who recognized and responded to the increased risk of weather conditions by altering their driving pattern (82.4 percent) was larger than the corresponding value (71.3 percent) noted in the risk of roadway conditions variable sequence. In addition, most of the drivers who indicated that the increased risk of weather conditions did not influence their driving performance also believed that they or other drivers should have driven more cautiously. This again appeared to retrospective recognition of increased risk.

  In the traffic condition variable sequence, 7.1 percent of the crash-involved drivers indicated that traffic conditions increased driving risk, but only 4.8 percent (67.6 percent of drivers reportedly recognizing increased risk) also indicated that they drove more cautiously/slowly as a result of the increased risk. A clinical review of those cases where the drivers indicated that there was no influence of the increased risk on their performance, indicated that this group typically believed that other drivers were behaving inappropriately or that there was no association between the increased risk and crash occurrence.

NOTE: It was difficult to evaluate the significance of the patterns described above due to the lack of more detailed driver data. As a general observation, however, it should be noted that in most cases where the driver indicated that other drivers should have driven more cautiously, there appeared to be evidence of rationalization/blame shifting in reviewed response patterns. In addition, the project staff assessed the role of roadway, traffic, and weather conditions at considerably lower levels of importance than the crash-involved drivers. This issue is further discussed in Section 3.2.2.

- *Driver Estimated Speed of Traffic Flow/Own Pre-Crash Travel Speed* - Crash-involved drivers indicated that surrounding traffic was stopped in 7.9 percent of the pre-crash phases examined in this effort. In those circumstances where the surrounding traffic was moving, speed estimates were normally distributed. The most frequently estimated speed range of the traffic flow as 49-64 km/h (31-40 mph). This range of speed was estimated for 17.8 percent of the pre-crash phases. Driver estimates of their own travel speed were typically lower than the estimates provided for surrounding traffic. Slightly more than 12 percent of the crash-involved drivers reported that they were stopped during the pre-crash interval. For those vehicles that were moving, the most frequently estimated travel speed ranges were 1-16 km/h (1-10 mph), 33-48 km/h (21-30), and 49-64 km/h (31-40 mph). These ranges were estimated at frequency levels of 8.8 percent, 11.9 percent, and 14.7 percent, respectively..

- *Desire To Change Driving Performance* - Slightly less than half of the crash-involved drivers (49.7 percent) indicated that they could not have driven differently to prevent the crash. Approximately 15 percent, however, recognized that they could have altered some aspect of their driving performance to achieve crash avoidance. The proportion of unknown responses for this variable (34.6 percent) was relatively high, however, if unknown values were distributed in the same proportion as the known values, the proportion of drivers who recognized that they could have driven differently to prevent the crash would have only increased to approximately 23.4 percent. Since the project staff only assessed 42.9 percent of the crash-involved drivers as not contributing to crash causation, there was a discrepancy which implied that a substantial proportion of the sample drivers either did not recognize or did not admit to their role in crash events.

- *Chance Taking* - Most drivers (61.8 percent) indicated that they were not taking a chance with respect to the manner in which they were operating their vehicle during the pre-crash interval. A smaller proportion of drivers (6.9 percent), however, recognized that there was an element of risk to their driving performance. If unknown values for this variable were distributed in the same proportion as known values, the proportion of drivers admitting that their was an element of risk to their driving performance only rose to the 10.0 percent range. This circumstance was very similar to the situation described for the preceding variable. Specifically, a substantial proportion of the drivers in the sample either did not recognize or did not admit to their role in crash events.

- *Chance Taking By Other Drivers* - Most drivers (37.6 percent) also indicated that other drivers involved in the crash sequence were not taking a chance with respect to the manner in which they were operating their vehicles during the pre-crash interval. A much larger proportion (28.2 percent), as compared to the preceding two variables, indicated that other drivers were taking a chance with respect to the manner they were operating their vehicles during this same interval. Caution must be used, however, in interpreting this finding. Specifically, in a clinical review of these cases it was noted that slightly more than 29 percent of the drivers who indicated other drivers were taking a chance were assessed by the project staff as having primary responsibility/culpability for crash occurrence. In these cases, the other driver was typically assessed as not contributing to crash causation. Similar to the preceding variables, this occurrence reflected on unwillingness to accept responsibility for crash events and a willingness to engage in rationalization or "blame shifting" approaches. A more accurate representation of the proportion of other drivers who exhibited chance taking behavior would likely be in the 20 percent range (e.g., 27 percent reduced by 29 percent).

- *Aggressive Driving* - Most drivers (51.2 percent) indicated that other drivers involved in the crash sequence were not operating their vehicles in an aggressive manner. The proportion of drivers assessed as being aggressive (12.6 percent) was relatively small. Again, caution must be used in interpreting this finding. In a clinical review of cases with aggressive driving designations, it was noted that approximately 26.0 percent of the drivers who indicated that other drivers exhibited aggressive behavior were, in fact, assessed as having primary responsibility for crash occurrence. A similar proportion of the drivers assessed as being aggressive were assessed by the project staff as either not contributing to crash causation (e.g., typical designation) or as being less responsible than the driver who made the original assessment. Clearly, a significant rate of "blame shifting" had occurred. Therefore, the incidence rate of aggressive driving identified in this study should be considered to be in the 9.0 percent range.

  NOTE: The incidence rate of aggressive driving provided in the above discussion should not be considered as an accurate reflection of the national incidence rate for aggressive driving for the following reasons:

  + For this effort, the aggressive driving variable only addressed multi-vehicle crashes (i.e., Was the other driver operating his or her vehicle in an aggressive manner?). The variable was not relevant to single vehicle crashes and those drivers were not questioned with respect to their own driving behavior. Many of the single vehicle crashes collected in this effort involved high travel speeds and other pre-crash behaviors that reflected aggressive driving traits.

  + There appears to be some evidence that aggressive driving incidence rates are highest in highly urbanized major city locations. These areas were not adequately sampled in the current effort.

+ A clinical review of the cases with these designations indicated that many of the assessments were made on the basis of the assessing driver's perception of crash events as opposed to the intent of the offending driver. For example, there were a number of crashes that involved inattentive drivers where the inattentive driver was either unaware of the presence of a traffic signal or was unaware of the current signal phase. These drivers typically violated the signal and were assessed by the other crash-involved driver as driving aggressively even though there was no intent by the offending driver to violate the signal. Similar patterns were noted in crashes involving perceptual/processing errors by turning drivers or decision errors by drivers who were attempting to turn/cross while having an obstructed view.

- *Drivers View of Intended Travel Path* - Approximately 63.0 percent of the drivers in the sample indicated that they had a clear view of their intended travel path. Of the 8.7 percent who indicated that their view was restricted, the most frequently noted viewing restrictions were terrain features (3.0 percent), moving vehicles (2.4 percent), atmospheric conditions (1.2 percent), and parked vehicles (0.4 percent). An additional 1.6 percent indicated that their view of the intended travel path was clear, but they did not see the approaching principal other vehicle (e.g., perceptual error).

- *How or Why Driver Recognized Need For Evasive Action* - A significant proportion of the drivers in the sample (28.6 percent) indicated that they were unaware of the impending impact and, therefore, did not recognize the need for evasive action. Although this proportion appeared to be high, it was consistent with the relative proportions for intersection and rear end crashes where the striking vehicle was not in the struck vehicle driver's forward field of vision. In addition, a number of the unaware drivers were operating striking vehicles in circumstances where they were inattentive to the driving task and, therefore, were unaware of the impending impact. Of those drivers who recognized the need for evasive action, the highest proportion (20.7 percent) were alerted by the other vehicle's movement pattern and an additional 2.6 percent were alerted by the sudden deceleration movements of vehicles forward of their position. Warnings from vehicles occupants and other drivers (e.g., horn) were relatively insignificant (1.4 percent) in the alerting process. An additional 0.2 percent of the drivers reported that they had previously been inattentive to the driving task and after returning their attention to the roadway suddenly became aware that they were about violate a traffic control device.

- *The Driver's Object of Attention Prior to Start of Collision Course* - Most drivers (33.8 percent) reported that they were focused on the vehicle or object that was struck prior to the start of the collision course, however, the proportion of drivers who reported that they were focused on a non-involved person, object, or event (22.6 percent) was also relatively substantial. A number of drivers in the latter group were inattentive to the driving task. There also appeared to be a significant number of drivers who had simply not identified the other vehicle as a threat at this point.

- *The Driver's Object of Attention After Start of Collision* - In this segment of the pre-crash phase, the proportion of drivers focusing on the struck vehicle or object rose from the 33.8 percent level noted in the preceding variable to a level of 41.8 percent. Similarly, the proportion of drivers continuing to focus on a non-involved person, object, or event decreased from the 22.6 percent level noted in the preceding variable to a level of 11.4 percent. A clinical review of these cases indicated that more than half of the drivers who remained focused on a non-involved person, object, or event were inattentive to the driving task. The remaining drivers were typically unaware of the impending impact because the striking vehicle was outside their forward field of view (e.g., rear impacts, side impacts, etc.).

- *Reason For No Avoidance Maneuver* - Approximately 35 percent of the drivers in the sample indicated that they initiated a pre-crash avoidance maneuver. Conversely, 16.4 percent indicated that at the point where they became aware of the impending impact, there was insufficient time to initiate an avoidance maneuver before the impact occurred. An additional 13.2 percent reported that they were unaware of the impending impact. A clinical review of these cases revealed a pattern similar to the preceding variable in that this group was comprised of inattentive drivers and drivers whose lack of awareness was related to the location of the striking vehicle (e.g., outside their forward field of view). It should also be noted that those drivers reporting insufficient time and reporting an unawareness of the impending impact initially reported that they were unaware of the impending impact in the How or Why Driver Recognized Need For Evasive Action variable discussed earlier.

- *Reason Given For Exceeding Speed Limit* - Most drivers in the sample (67.1 percent) indicated that they were not exceeding the speed limit prior to the crash. The proportion of drivers admitting to exceeding the speed limit (approximately 3.3 percent) was greater than the proportion charged with speeding violations (1.3 percent), but was considerably less than the proportion of drivers assessed by the project staff as exceeding the speed limit. This issue will be examined in more detail in Section 3.2.2.

- *Run-Off-Road Crash Variables* - Of those drivers involved in run-off-road crashes, (25.2 percent) reported that they became aware of the impending departure one or two seconds prior to the departure event. An additional 28.2 percent reported that they became aware as the vehicle departed the roadway and 27.5 percent indicated that they were unaware of the departure. The latter group of drivers was typically comprised of individuals who were unconscious (incapacitated), asleep, or passed out as a result of intoxication.

  Most drivers in this crash group (52.4 percent) reported that they did not initiate braking action prior to the roadway departure. An additional 20.3 percent reported that they initiated braking action one to two seconds prior to the departure and 11.2 percent indicated that they initiated braking action as the vehicle departed the roadway. A clinical review of the cases in the latter two groups revealed that physical evidence of brake application was typically not noted until the vehicle was well off the roadway. This finding tended to indicate a lack of precision with respect to reported driver estimates.

- *Rear End Crash Variables* - In rear end crash sequences, the braking action of the lead vehicle was most frequently described as normal (63.2 percent) by the involved drivers. The braking action of the lead vehicle was characterized as abrupt in 21.7 percent of the sequences. In an additional 7.2 percent of the crashes it was indicated that the lead vehicle did not brake prior to impact. A clinical review of the latter group indicated that most of the vehicles assigned to this category had been stopped for extended periods prior to crash initiation. The category also contained a small number of vehicles who were moving at a constant velocity when they were struck from the rear. The most frequently cited reasons that the lead vehicle was slowing were other slowing or stopped traffic (35.4 percent), traffic control (24.7percent), and making turn (15.2percent). The drivers of the following vehicles in these sequences most frequently indicated that they became aware of the brake lights of the lead vehicle one to two seconds prior to impact (28.4 percent). An additional 25.4 percent indicated that they became aware of the lead vehicle's brake lights more than three seconds prior to impact, but could not avoid the crash. A relatively large proportion of the following drivers indicated that they either did not observe the brake lights of the lead vehicle (26.9 percent) or became aware of the lights at the time of the crash (1.5 percent). Drivers in the latter two groups were typically inattentive to the driving task as they approached the crash site.

  In this variable sequence there was an attempt to assess the following driver's awareness of braking actions initiated by vehicles located forward of the lead vehicle. The proportion of following drivers who reported awareness of these braking actions, when there were vehicles located forward of the lead vehicle, was relatively low (33.3 percent). This finding implies that the crash-involved drivers were not driving defensively with respect to looking ahead and anticipating potential vehicle movement patterns.

- *Opposing Travel Direction Crash Variables* - In opposing travel direction crashes, drivers most frequently were either unaware of the opposing vehicle's presence prior to the crash (30.1 percent) or became aware of this vehicle's presence one to two seconds prior to the crash (43.2 percent). The proportion of drivers indicating awareness of the other vehicle more than three seconds prior to the crash (25.3 percent) was relatively modest.

- *Same Direction Crash Variables* - In this crash type, drivers were most frequently either unaware of the other vehicle's presence prior to the crash (32.8 percent) or became aware of that vehicle's presence one to two seconds (25.9 percent) prior to the crash. In circumstances where the driver was unaware of the other vehicle, the other vehicle was typically the intruding/encroaching vehicle and was outside of the responding drivers forward field of view. The category where the responding driver became aware of the other vehicle one to two seconds prior to the crash represented a combination of both intruding vehicles and vehicles that were intruded upon. In these cases, both drivers were typically unaware of the other vehicle presence until immediately prior to impact. An additional 37.9 percent of the drivers indicated that they became aware of the other vehicle at time intervals that extended from three seconds to more than ten seconds prior to the crash. As a group these drivers tended to be the intruding driver, however, there was a relatively small number of drivers who were intruded upon. In the latter cases, an unanticipated event (such as an erratic or sudden lane change) occurred between the initial sighting and impact.

Of the vehicles that were changing lanes prior to crash occurrence, the most frequently noted reason given for the lane change maneuver was the presence of a non-involved vehicle in the subject drivers traffic lane (41.7 percent). An additional 16.7 percent of the drivers initiating these maneuvers indicated there was no specific reason for the maneuver (e.g., they had merely decided to change lanes).

- *Turning/Intersection Crash Variables* - Most crashes in this crash type occurred at locations that were controlled by traffic signals (51.8 percent). An additional 14.4 percent occurred at locations controlled by stop signs and 0.8 percent occurred at locations controlled by yield signs. The proportion of crashes occurring at locations where there was no traffic control device present (32.8 percent) was relatively high and reflected the incidence rate of non-intersection crashes (e.g., drivers turning into private driveways/commercial accesses).

Of those crashes occurring at locations controlled by a traffic control devices, the traffic control device was reported to be not functioning properly in 2 percent of the relevant crashes. This rate was relatively high and reflected a combination of malfunctioning signals and missing stop/yield signs. Although the proportion was derived from driver statements, it is important to note these assessments were typically verified by the NASS Researcher and/or police reported information.

Again, in locations controlled by traffic control devices, drivers most frequently became aware of the traffic control device more than five seconds prior to the crash (77.6 percent). A significant proportion of the drivers (18.0 percent), however, reported that they became aware of the device less than four seconds prior to the crash. The latter circumstance was typically indicative of driver inattention. The incidence rate of inattention was, in fact, considerably larger than would be implied by the 18.0 percent of the drivers reporting awareness in relatively short time frames. A clinical review of the interview formats of drivers reporting extended awareness intervals indicated that the drivers often became inattentive after first seeing the traffic control device. Specifically, inattentive drivers often reported awareness of a traffic signal located forward of their position. As a result of the inattention, however, they were often unaware of the specific signal phase as they approached the location. This problem was particularly evident in the Traffic Signal Status variable reported in this sequence. A significant proportion of the drivers (58.0 percent) reported that the signal phase for their approach direction was green. A review of a sample of these cases, however, revealed that in reality a number of inattentive drivers in this group were reporting that the signal was green the last time they checked signal status which was an extended interval prior to intersection entry.

In the variables relating to this vehicle's and the other vehicle's approach to the intersection, the most frequently reported circumstances involved this vehicle and the other vehicle being stopped, reducing travel speed, or entering the intersection at a constant velocity. In the variable describing this vehicle, however, 5.3 percent of the drivers indicated that they were accelerating as they approached the intersection. These cases typically involved situations where the traffic signal cycled to green as the driver approached and the driver who had been decelerating, began to accelerate. In the variable describing the other vehicle, the responding driver indicated that the other vehicle was accelerating as it approached the intersection in 14.0 percent of the crashes. This relatively high rate for the other vehicle reflected both legitimate circumstances where the other vehicle was attempting to beat a phasing signal and circumstances where the responding driver was engaging in "blame shifting".

- *Backing Crash Variables* - Backing crashes comprised a very small proportion of the crashes in this sample. Due to a very high interview refusal rate for drivers who were operating backing vehicles, responses for the mirror usage and use of rear window variables in this sequence were considered unreliable and were not tabulated.

- *Reported Vehicle Defects* - The proportion of vehicles in this sample with reported vehicle defects was relatively high (7.9 percent). The most frequently reported components were tires (1.5 percent), braking system components (0.8 percent), and the exhaust system (0.5 percent). Given these results, it is important to note two factors. First, a number of the reported defects did not relate to vehicle safety systems. More importantly, reported vehicle defects were not causally linked to a significant proportion of the crashes in the sample. This issue will be examined further in Section 3.2.2.

- *Length of Time Driven (This Vehicle)* - Most of the drivers in the sample had driven the crash-involved vehicle for more than six months (73.1 percent), however, 15.0 percent reported less than six months experience and 11.8 percent reported less than one month experience. The relatively high proportion of drivers who reported less than one month of experience with the crash-involved vehicle was not causally related to crashes in the sample.

- *Pre-Existing Driver Challenges* - Most of the drivers in the sample did not report pre-existing physical challenges (68.3 percent). However, a significant proportion did report visual (25.4 percent) impairments. Another 6.4 percent reported an array of other physical impairments/challenges. With the exception of older drivers, these challenges did not appear to be causally related to the crash sample. An additional 1.1 percent of the drivers reported a diabetic condition. All of these cases were causally related to crash occurrence.

- *Pre-Crash Driver Physical State* - Most of the drivers in the sample reported feeling normal (84.2 percent) during the pre-crash phase. Of those individuals reporting physical difficulties, the highest proportions were associated with drivers who were fatigued (4.8

percent) or who fell asleep (1.9 percent). Approximately 2.0 percent of the drivers reported feeling ill and an additional 7.4 percent reported a variety of other conditions or a combination of the above conditions. A very high proportion of these physical conditions were causally related to crashes in the sample.

- *Pre-Crash Psychological Condition* - Again, most of the drivers in this sample reported feeling normal (77.5 percent) or happy (12.0 percent). The most frequently reported problem areas were feeling stressed (3.6 percent), feeling depressed (0.8 percent), and feeling anxious/frustrated (3.2 percent). While no direct link between these conditions and crash causation factors was noted, it was very probable that these reported conditions influenced decision making processes and, therefore, were a factor in crashes involving decision errors.

- *Reasons For Possible Discomfort With Pre-Crash Travel Conditions* - A relatively small proportion of the crash-involved drivers reported experiencing discomfort with pre-crash travel conditions (10.5 percent) and the specific reasons for this discomfort were spread over a range of nine factors. As with the preceding variable, no direct link was noted between reported discomfort and crash causation factors. The project staff, however, could not rule out the possibility that reported discomfort levels influenced decision making processes and, therefore, was a factor in crashes involving decision errors.

- *Frequency of Driving on Roadway* - Approximately 8.0 percent of the drivers in the sample indicated that the crash trip represented their first driving exposure on the roadway leading to the crash site. A clinical review indicated that a sizeable proportion of these cases were related to crash causation; primarily in terms of the driver inattention causal factor. Specifically, drivers in this group were at times focused on outside tasks such as locating a street address/building.

- *Years of Licensed Driving Experience* - Most drivers in the sample (84.8 percent) reported driving experience levels which exceeded one year. An additional 5.3 percent indicated experience levels of less than one year and 2.7 percent indicated that they were not licensed drivers at the time of the crash. The limited experience level of a small proportion of those drivers reporting less than one year of experience was found to be causally related to crashes in the sample.

3.2.2 Summary Variables Coded by Project Staff

Very early in the development sequence for this effort, it was recognized that there were a number of variables which could be considered key/critical with respect to achieving project objectives. These variables included assessments of crash causation variables, associated unsafe driving action (UDA) variables, the behavioral source of the UDA variables, and assessments of vehicle travel and impact speeds. It was also recognized that it would be difficult to achieve uniform coding interpretations for these variables if the variables were determined by NASS Researchers who had no prior experience in making these types of assessments. These variables were, therefore, coded by the project staff following review of all available information (e.g, interview formats, police reports, and reconstruction results) for each crash-involved vehicle.

It is also important to note that although the staff making these assessments was highly experienced (e.g., three analysts/over 75 man-years of experience), causal factor and UDA assessments were subjective in nature and, therefore, are open to question. Veridian, in particular, has been conducting these types of analyses for more than twenty-five years and firmly believes that the approach is valid and accurate. In intercoder reliability checks performed during this interval, very high levels of agreement (e.g., Pearson Coefficients in the 0.98 to 0.99 range) were noted between individuals making these assessments and consistent findings have been documented over extended time intervals. For example, in 1992 Veridian, as a subcontractor to Battelle Memorial Institute, completed causal factor analyses for 9 of the 16 crash types which comprised the national crash population (Hendricks et al, 1992). This effort was sponsored by NHTSA. In subsequent efforts, also sponsored by NHTSA (Hendricks et al, 1994 and Pierowicz et al, 1994) Veridian completed more detailed causal analyses for two of the crash types previously examined (i.e., single vehicle roadway departure crashes and intersection crashes). Even though these efforts were separated by approximately three years and the latter analyses used much larger samples, the same causal factor profiles were identified in both efforts and individual factors retained their relative order of importance. Minor variances in the size projections for individual factors were attributed to the larger sample sizes used in the latter efforts.

Major findings related to the variable sequence coded by the project staff may be summarized as follows:

- *Crash Causal Factors* - Causal assessments were completed for 96.5 percent of the drivers in the sample. Specifically, there was insufficient data to complete causal assessments for 45 of the sample drivers. Of the 1284 drivers contained in the database, 507 (40.3 percent) were assessed as not contributing to crash causation. To demonstrate the relative importance of casual factor types, drivers who did not contribute to causation (507) and unknown values (45) were eliminated from the distribution. Proportions were then recomputed using the number of drivers who contributed to causation (732) as the denominator in subsequent calculations. Key trends for these drivers may be summarized as follows:

+ The most dominant component of the causal factor pattern was driver inattention. (NOTE: This factor is commonly referenced as driver distraction.) Inattention was noted as the sole causal factor for 16.7 percent of the drivers who contributed to crash causation and was noted as the primary causal factor in combination with other contributory factors for 5.2 percent of the drivers. In addition, this factor was cited as a contributory factor in combination with other primary factors for 0.8 percent of the drivers. Thus, the total sample contribution of the inattention factor was 22.7 percent.

+ Vehicle speed causal factors were the second largest component of the causal pattern. These assignments typically reflected circumstances where the driver was exceeding the speed limit and the absolute vehicle velocity contributed to crash causation. It should be noted, however, that this same causal factor was assigned in a number of crashes where the vehicle's travel speed was at or below the posted speed limit, but the speed was inappropriate for prevailing weather/roadway conditions and contributed to a pre-crash loss of vehicle control. Vehicle speed was assigned as the sole causal factor 6.8 percent of the drivers who contributed to crash causation and was assigned as the primary factor in combination with other factors for 3.8 percent of the drivers who contributed to causation. In addition, this factor was cited as a contributory factor in combination with other primary factors for 8.1 percent of the drivers. Thus, the total sample contribution of the vehicle speed factor was 18.7 percent.

  NOTE: The proportion of drivers who exceeded the speed limit was significantly higher than the proportion who received citations for this offense or who admitted to exceeding the speed limit (See Section 3.1.1).

+ Alcohol consumption was the third largest component of the causal pattern. Driving while intoxicated (DWI) and driving while under the influence (DUI) of alcohol were the sole causal factors for 6 percent of the drivers who contributed to crash causation and were noted as the primary causal factors in combination with other contributory factors for 11.1 percent of the drivers. In addition, alcohol consumption was cited as a contributory factor in combination with other primary factors for 1.1 percent of the drivers. Thus, the total sample contribution of the alcohol consumption factors was 18.2 percent.

+ The fourth largest component of the causal pattern involved perceptual errors associated with intersection crashes. Two specific scenarios were associated with these errors. In the most frequently occurring scenarios, the driver checked for cross-traffic, but did not see the other crash-involved vehicle approaching (e.g., looked, did not see). This factor was noted as the sole causation mechanism for 8.9 percent of the drivers who contributed to crash causation, was assigned as primary factor in combination with other contributory factors for 0.1 percent of the drivers, and was assigned as a contributory factor for an additional 0.1 percent of the drivers. In the second scenario, the driver checked for cross-traffic, saw the other vehicle, but then either misjudged the distance to that vehicle or misjudged the approach velocity of that vehicle (e.g., accepted inadequate gap to other vehicle). This factor was noted as the sole causation mechanism for 6 percent of the drivers who contributed to causation and did not appear in combination with other factors. Thus, the total sample contribution of the perceptual error factors was 15.1 percent.

+ Decision errors in the form of attempted to turn with an obstructed view (3.3 percent) or attempted to cross with an obstructed view (1.4 percent) were also noted in the causal pattern. While these circumstances typically reflected intersection crashes, there were a number of crashes which occurred at non-intersection locations (e.g., driver attempted to cross the roadway from a private/commercial driveway or attempted to turn into a private/commercial driveway). The relative importance of this group was increased if individuals who were not inattentive or intoxicated, but who did violate red traffic signals (2.6 percent), attempted to beat phasing signals (2.1 percent), or violated a stop sign (0.7 percent), were also included. The total sample contribution of these decision error factors was 10.1 percent.

+ Drivers who fell asleep (4.4 percent) or who were incapacitated (2 percent) also contributed to the causal pattern. These factors, when noted, were always assigned as the primary causation factor (i.e., there were no cases in which these factors were considered to be contributory).

These findings are summarized in Figure 3-1. The six causal factor groups shown in the figure were assigned as single causal factors for 54.7 percent of the drivers who contributed to crash causation in the unweighted sample. These same factors were assigned as primary causal factors in combination with other contributing factors for an additional 21 percent of the drivers who contributed to crash causation. Thus, as sole/single assignments and as primary assignments, these factors accounted for 75.7 percent of the causal factor pattern. Previous experience indicates that this is a relatively high proportion which is undoubtedly influenced by sample characteristics. This does not imply that the causal pattern of the unweighted sample is inaccurate. The pattern is a reasonably accurate description of more severe crashes and can be applied to these crashes on a relatively broad scale.

- *Nature of Crash Causation* - Most of the causal factors assigned to this sample were related to driver behavior (96.8 percent) as compared to vehicle condition (1.9 percent) or to environmental conditions (1.4 percent).

- *Increased Crash Risk* - In those cases where the crash cause was related to driver behavior, there was an increased crash risk associated with that behavior in nearly all (99.3 percent) circumstances.

Causal Category	Assignment Level	% of Drivers Contributing To Causation
		10 20 30
DRIVER INATTENTION	Primary (Sole Factor)	16.7
	Primary (In Combination)	5.2
	Contributory	0.8
Total		22.7
VEHICLE SPEED	Primary (Sole Factor)	6.8
	Primary (In Combination)	3.8
	Contributory	8.1
Total		18.7
ALCOHOL IMPAIRMENT	Primary (Sole Factor)	6.0
	Primary (In Combination)	11.1
	Contributory	1.1
Total		18.2
PERCEPTUAL ERRORS		
(Looked, Did Not See)	Primary (Sole Factor)	8.9
	Primary (In Combination)	0.1
	Contributory	0.1
Accepted Inadequate Gap	Primary (Sole Factor)	6.0
Total		15.1
DECISION ERRORS		
(Turn/Cross With Obstructed View)	Primary (Sole Factor)	4.7
(Violated Red Signal)	Primary (Sole Factor)	2.6
(Attempted To Beat Phasing Signal	Primary (Sole Factor)	2.1
(Violated Stop Sign)	Primary (Sole Factor)	0.7
Total		10.1
INCAPACITATION		
(Fell Asleep)	Primary (Sole Factor)	4.4
(Seizure/Blackout/etc.)	Primary (Sole Factor)	2.0
Total		6.4
		10 20 30
Causal Category	**Assignment Level**	**% of Drivers Contributing To Causation**

NOTE: Due to multiple causal factor assignments, proportions for individual causal factors add to more than 100.0.

Figure 3-1: Six Most Frequently Assigned Causal Factor Groups

- *Primary and Contributory UDAs* - Each driver could be assigned as many as three UDAs (i.e., a primary and up to two contributory UDAs). The primary UDA assigned to each driver was the most relevant UDA with respect to crash causation. A total of 732 drivers were assigned UDAs. All of these drivers were assigned a primary UDA, 531 were also assigned a first contributory UDA, and 219 drivers were assigned a second contributory UDA. Thus, the total number of UDAs assigned to the 732 drivers who committed UDAs was 1482 indicating a mean assignment level of approximately 2 UDAs for each driver who contributed to crash causation. The most frequently assigned UDAs within the three classes of UDAs are shown in Table 3-1. Within primary UDAs, driver inattention (22.9 percent), driving while intoxicated (16.7 percent), and exceeded the speed limit (11.6 percent) were assigned most frequently. The proportion of assignments associated with driver inattention was slightly higher than the corresponding incidence rate (22.7 percent) noted in the causal factor profile discussion. The differential was associated with a slightly higher proportion of unknown responses for the UDA variable as compared to the causal factor variable. Failure to yield the right-of-way was the most frequently assigned first contributory UDA (21.4 percent) and the most frequently assigned second contributory UDA (46.5 percent). Similarly, the exceeded speed limit UDA was the second most frequently assigned UDA in both categories (15.5 percent and 15.9 percent, respectively).

Table 3-1
Most Frequently Assigned UDAs

Primary UDAs	%	1st Contributory UDA	%	2nd Contributory UDA	%
Driver Inattention	22.9	Failure To Yield Right-Of-Way	21.4	Failure To Yield Right-Of-Way	46.5
DUI/DWI	16.7	Exceeded Speed Limit	15.5	Exceeded Speed Limit	15.9
Exceeded Speed Limit	11.6	Turning In Close Proximity	9.0	Drifting To Right Side	12.9
Turning In Close Proximity	11.2	Drifting To Right Side	7.5	Drifting To Left Side	5.3
Driving While Drowsy	3.9	Proceeded Through Red Traffic Signal	5.6	Crossing In Close Proximity	3.5
Crossing In Close Proximity	3.0	Crossing In Close Proximity	5.1	Erratic Lane Change	3.5
Total	**69.3**	**Total**	**64.1**	**Total**	**87.6**

NOTE: The driver inattention and DUI/DWI UDAs corresponded directly to the driver inattention and DUI/DWI causal factors. Similarly, the exceeded speed limit UDA was linked to the vehicle speed causal factor. The failure to yield right-of-way and turning/crossing in close proximity UDAs were associated with the accepted inadequate gap; looked, but did not see; and turning/crossing with obstructed view causal factors. Drifting to left or right side UDAs were again typically associated with the driver inattention and DUI/DWI causal factors and the erratic lane change was associated with a range of causal factor types.

- *UDAs Necessary For Crash Occurrence* - All of the UDAs assigned in the preceding variable were subsequently evaluated to determine if they were a necessary condition for crash occurrence. Of the 1482 UDAs initially assigned, 1352 (91.2 percent) were determined to be a necessary condition. Contributory UDAs were less likely to be assessed as a necessary condition than primary UDAs. Specifically, 723 (98.8 percent) of the primary UDAs were assessed as necessary as compared to 479 (90.2 percent) of the first contributory UDAs and 150 (68.5 percent) of the second contributory UDAs. It is important to note that the very high proportion of UDA assignments that were determined to be a necessary condition for crash occurrence was reflective of the truncated approach used to assign UDAs. A clinical review of those cases where the driver was assigned three UDAs indicated that a high proportion of the drivers could have been assigned four or five UDAs. Since the analyst was limited to a maximum of three UDAs, the most relevant UDAs were selected for coding purposes. If the additional UDAs had been coded, the proportion determined to be necessary conditions for third or fourth contributory variables would have been significantly lower than the level noted for the second contributory UDAs (68.5 percent). The most frequently assigned UDAs within the three classes of necessary UDAs are shown in Table 3-2.

Table 3-2
Most Frequently Assigned Necessary UDAs

Primary UDAs	%	1st Contributory UDA	%	2nd Contributory UDA	%
Driver Inattention	23.2	Failure To Yield Right-Of-Way	22.6	Failure To Yield Right-Of-Way	62.9
DUI/DWI	16.6	Drifting To Right Side	9.9	Drifting To Right Side	12.1
Turning In Close Proximity	11.4	Turning In Close Proximity	9.1	Exceeded Speed Limit	6.0
Exceeded Speed Limit	11.2	Crossing In Close Proximity	5.6	Erratic Lane Change	5.1
Proceeded Through Red Traffic Signal	4.5	Drifting Into Opposing Traffic Lane	4.6		
Driving While Drowsy	3.9				
Total	**70.8**	**Total**	**51.8**	**Total**	**86.1**

NOTE: The driver inattention and DUI/DWI UDAs corresponded directly to the driver inattention and DUI/DWI causal factors. Similarly, the exceeded speed limit UDA was linked to the vehicle speed causal factor. The failure to yield right-of-way and turning/crossing in close proximity UDAs were associated with the accepted inadequate gap; looked, but did not see; and turning/crossing with obstructed view causal factors. Drifting to left or right side UDAs were again typically associated with the driver inattention and DUI/DWI causal factors and the erratic lane change was associated with a range of causal factor types.

There was a fairly significant shift in the distribution shown in Table 3-2 as compared to Table 3-1. Although the driver inattention and DUI/DWI UDAs maintained their relative rankings in the primary UDA assignment distribution and the failure to yield right-of-way UDA maintained its ranking in the distributions of most frequently occurring first and second contributory UDAs, there was a significant shift evident in relative positioning of the exceeded speed limit UDA. This UDA dropped from third position of the most frequently assigned primary UDAs in Table 3-1 to fourth position in primary necessary UDAs in Table 3-2. This same UDA disappeared from the distribution of most frequently occurring first contributory UDAs in Table 3-2 and dropped to third position in the distribution of most frequently occurring second contributory UDAs in Table 3-2. The reason for this pattern was that speed related UDAs in Table 3-1 were not determined to be a necessary condition for crash occurrence in Table 3-2. The specific pattern of assessments is summarized in Table 3-3. The exceeded speed limit UDA was assigned to 196 (26.8 percent) of the 732 drivers who were assigned UDAs. The assignment appeared as a primary UDA for 83 drivers. Of these assignments, 79 (95.2 percent) were determined to be a necessary condition for crash occurrence. This UDA appeared as a first contributory UDA for 81 drivers in Table 3-1, but only 42 (51.8 percent) of the assignments were determined to be a necessary condition in Table 3-2. Similarly, this UDA was assigned as a second contributory UDA for 32 drivers in Table 3-1, but only 8 (25 percent) of the assignments were determined to be a necessary condition in Table 3-2.

Table 3-3
Exceeded Speed Limit UDA Assignments

Category	Primary UDA	1st Contributory UDA	2nd Contributory UDA
Table 3-1 assignments (Frequency)	83	81	32
Table 3-2 assignments (Frequency)	79	42	8
Proportion of assignments that were a necessary condition for crash occurrence (%)	95.2	51.8	25.0

- *Intentionality of Primary UDA* - The intentionality of the primary UDAs shown in Table 3-1 could be determined for 686 of the 732 drivers who were assigned primary UDAs. Approximately 83 percent of the primary UDAs reflected a deliberate intent of the driver to engage in the specific activity indicated by the UDA assignment. This proportion supported the commonly stated viewpoint that most UDAs are willful acts. Most of unintentional UDAs were associated with the driver inattention and looked, but did not see causal factors.

- *Behavioral Source of Primary UDA* - The behavioral source of the primary UDAs shown in Table 3-1 could be determined for 704 of the 732 drivers who were assigned primary UDAs. Slightly less than 59 percent of these assignments were associated with driver decision, 27 percent were associated with driver attention, 12.5 percent were associated with driver perception, and 1.7 percent were associated with driver motor skills. The very high proportion of UDAs related to driver decisions resulted from the fact that a number of UDAs were arbitrarily classified as being decision oriented. These UDAs included operating a vehicle when intoxicated or under the influence, driving while drowsy, and driving while ill (subsequent incapacitation).

- *Contributory Behavioral Sources* - Up to three contributory behavioral sources could be coded for each driver who had behavioral sources determined for their primary UDA. Of the 732 drivers who qualified, an additional first contributory behavioral source was assigned for 562 (76.8 percent). The most common first contributory behavioral sources were perception (47.3 percent) followed by decision (25.4 percent). An additional 160 drivers were assigned a second contributory behavioral source. The most common behavioral sources in this circumstance were motor skills (60.6 percent) followed by perception (31.2 percent). A clinical review of the case reports indicated that most of the first and second contributory behavioral sources were related to the primary UDA assignment. For example, in a typical primary UDA assignment of DUI/DWI, decision was assigned as the behavioral source of the UDA, the first contributory behavioral source was assigned perception, and the second contributory behavioral source was assigned motor skills. Assignment patterns of this type accounted for the relatively high proportion of motor skill assignments (60.6 percent) as the most frequent second contributory behavioral source.

- *Temporal Sequencing of UDAs* - For this variable, the UDAs shown in Table 3-1 were recoded to indicate the sequence of occurrence. The most frequently occurring first, second, and third UDAs are shown in Table 3-4.

Table 3-4
Temporal Sequencing of UDAs

First Occurring UDAs	%	Second Occurring UDAs	%	Third Occurring UDAs	%
DUI/DWI	18.7	Failure To Yield Right-Of-Way	19.0	Failure To Yield Right-Of-Way	47.9
Driver Inattention	17.6	Exceeded Speed Limit	15.3	Drifting To Right Side	16.4
Exceeded Speed Limit	15.8	Turning In Close Proximity	9.4	Drifting To Left Side	8.2
Turning In Close Proximity	10.0	Driver Inattention	8.5	Crossing In Close Proximity	3.2
Total	**62.1**	**Total**	**52.2**	**Total**	**75.7**

Although the distribution of UDAs by order of occurrence was fairly similar to the distribution of UDAs by primary/contributory designation as shown in Table 3-1, several significant shifts in relative magnitudes were noted. First, the DUI/DWI and driver inattention UDAs switched positions in the first occurring UDAs column of Table 3-4 as compared to Table 3-1. This was a logical shift in that alcohol consumption typically occurred before the driver entered the vehicle and was, therefore, the first UDA that could have occurred. Secondly, the driver inattention UDA was the fourth most frequently occurring second UDA in Table 3-4, but did not appear in the first contributory column of Table 3-1. This circumstance implied that for a number of inattentive drivers, an initial UDA (e.g., exceeded the speed limit) occurred prior to the inattention. Again, this shift appeared to be logical. Finally, the exceeded speed limit UDA which was the second most frequent UDA under second contributory UDAs in Table 3-1 did not appear in the distribution of third occurring UDAs in Table 3-4. Again, this shift was logical and merely indicated that the exceeded speed limit UDA tended to occur prior to other assigned UDAs.

- *Pre-Crash Travel Speed and Impact Speed* - A total of 229 of the crash-involved vehicles were stopped during the pre-crash travel phase and 135 were stopped at impact. No reconstructions were completed or were necessary for these vehicles. Of the 1055 vehicles that were moving during the pre-crash phase, hand calculations were completed for 77 vehicles (7.3 percent) and of the 1149 vehicles that were moving at impact, hand calculated impact speeds were generated for 100 vehicles (8.7 percent). Both of these proportions were relatively low and generally reflected the lack of precise trajectory data and/or the lack of vehicle crush dimensions required to complete these estimates. It should also be noted that for a relatively large proportion of the vehicles where subjective estimates were provided, it was possible to either simulate (e.g., delta V levels), or calculate (e.g., velocity loss between impact and final rest) sub-components of the required calculation sequence. For these vehicles the subjective estimates were at least partially based on analytical data, however, since the entire calculation sequence could not be completed, the estimates are best described as being subjective. For the remaining vehicles, the subjective estimates were based on an assessment of all available data including driver and witness statements, police reported information, vehicle crush profiles, and scene evidence. Our best estimate of the error tolerance range associated with these estimates is $\pm$ 25 percent as compared to a tolerance range of $\pm$ 10 percent typically associated with hand calculations.

  Of the vehicles that were moving during the pre-crash travel phase, the speed distribution was fairly close to normal with a mean of approximately 47 km/h (29.2 mph) and a standard deviation of 31 km/h (19.3 mph). This mean travel speed was higher than the mean travel speed estimated by sample drivers. Impact speed estimates had an extended range with a mean of approximately 34 km/h (21.1 mph) and a standard deviation of 23.5 km/h (14.6 mph).

3.3 Multivariate Analyses

In this sequence, emphasis was placed on identifying the most important driver demographic and behavioral characteristics and crash situation descriptors associated with each of a set of seven crash types. This analysis produced a series of profiles of the driver's actions, attributes, and crash conditions.

3.3.1 Analysis Sequence Description

The goal of this analysis was to develop an objective profile of each crash type represented in the data set so that the circumstances and characteristics of each crash type could be appropriately considered for countermeasure development. The process involved eleven steps as follows:

1. Combined the 1996 and 1997 UDA data into one data set that contained all 101 UDA variables.

2. Combined the corresponding 1996 and 1997 NASS Crashworthiness Data System (CDS) data into one data set, that contained a subset of 102 variables selected for their potential to describe the crash characteristics in a manner that could aid in developing countermeasures. These selected NASS CDS variables were of the following types:
   - General Vehicle Form - 45 variables
   - Accident Form - 11 variables
   - Occupant Assessment Form - 12 variables
   - Exterior Vehicle Form - 32 variables
   - Interior Vehicle Form - 2 variables

3. Merged the UDA and NASS CDS data sets.

4. Produced and reviewed frequency distributions for each variable in the combined NASS CDS and UDA file containing 203 variables.

5. Selected a set of 59 "Pattern Variables" that contained information that would likely be useful for describing crashes in terms of unsafe driving actions and other crash, driver, vehicle, and road environment factors. Variables were selected from the following sources:
   - UDA variables - 46
   - NASS General Vehicle Form - 11
   - NASS Accident Form - 0
   - NASS Occupant Assessment Form - 2

6. Recoded selected pattern variables, combining response levels whenever necessary to simplify and improve the analysis.

7. Combined and recoded NASS crash types (Figure 3-2) to simplify and improve the analysis. Combined/redefined crash types into seven classes that had operational differences that were likely to be associated with driver performance or behavior differences.

   - Single Driver, Right or Left Roadside Departure or Forward Impact without Traction Loss [NASS Types I:A (except 02), I-B (except 07), I:C]. These were abbreviated as ***SDRV Left, Right, Forward*** in subsequent analyses.

Category	Configuration	ACCIDENT TYPES (Includes Intent)					
I Single Driver	A. Right Roadside Departure	01 DRIVE OFF ROAD	02 CONTROL/ TRACTION LOSS	03 AVOID COLLISION WITH VEH., PED., ANIM.		04 SPECIFICS OTHER	05 SPECIFICS UNKNOWN
	B. Left Roadside Departure	06 DRIVE OFF ROAD	07 CONTROL/ TRACTION LOSS	08 AVOID COLLISION WITH VEH., PED., ANIM.		09 SPECIFICS OTHER	10 SPECIFICS UNKNOWN
	C. Forward Impact	11 PARKED VEH.	12 STA. OBJECT	13 PEDESTRIAN/ ANIMAL	14 END DEPARTURE	15 SPECIFICS OTHER	16 SPECIFICS UNKNOWN
II Same Trafficway Same Direction	D. Rear-End	20, 22, 21, 23 STOPPED 21, 22, 23	24, 26, 25, 27 SLOWER 25, 26, 27	28, 30, 29, 31 DECEL. 29, 30, 31		(EACH • 32) SPECIFICS OTHER	(EACH • 33) SPECIFICS UNKNOWN
	E. Forward Impact	34, 35 CONTROL/ TRACTION LOSS	36, 37 CONTROL/ TRACTION LOSS	38, 39 AVOID COLLISION WITH VEH.	40, 41 AVOID COLLISION WITH OBJECT	(EACH • 42) SPECIFICS OTHER	(EACH • 43) SPECIFICS UNKNOWN
	F. Sideswipe Angle	44, 45	46, 46, 47			(EACH • 48) SPECIFICS OTHER	(EACH • 49) SPECIFICS UNKNOWN
III Same Trafficway Opposite Direction	G. Head-On	50, 51 LATERAL MOVE				(EACH • 52) SPECIFICS OTHER	(EACH • 53) SPECIFICS UNKNOWN
	H. Forward Impact	54, 55 CONTROL/ TRACTION LOSS	56, 57 CONTROL/ TRACTION LOSS	58, 59 AVOID COLLISION WITH VEH.	60, 61 AVOID COLLISION WITH OBJECT	(EACH • 62) SPECIFICS OTHER	(EACH • 63) SPECIFICS UNKNOWN
	I. Sideswipe/ Angle	64, 65 LATERAL MOVE				(EACH • 66) SPECIFICS OTHER	(EACH • 67) SPECIFICS UNKNOWN
IV. Change Trafficway Vehicle Turning	J. Turn Across Path	68, 69 INITIAL OPPOSITE DIRECTIONS	70, 71, 72, 73 INITIAL SAME DIRECTIONS			(EACH • 74) SPECIFICS OTHER	(EACH • 75) SPECIFICS UNKNOWN
	K. Turn Into Path	76, 77, 78, 79 TURN INTO SAME DIRECTION	80, 81, 82, 83 TURN INTO OPPOSITE DIRECTIONS			(EACH • 84) SPECIFICS OTHER	(EACH • 85) SPECIFICS UNKNOWN
V Intersecting Paths (Vehicle Damage)	L. Straight Paths	86, 87	88, 89			(EACH • 90) SPECIFICS OTHER	(EACH • 91) SPECIFICS UNKNOWN
VI Miscellaneous	M. Backing Etc.	92 BACKING VEH.	93 OTHER VEH. OR OBJECT			98 Other Accident Type 99 Unknown Accident Type 00 No Impact	

- Single Driver, Right or Left Roadside Departure With Traction Loss (NASS Types I:A-02 and I:B 07). These were abbreviated as ***SDRV* Traction** in the subsequent analyses.

- Same Trafficway, Same Direction, Rear End (NASS Type II:D). These were abbreviated as ***SDIR Rear End*** in the subsequent analyses.

- Turn/Merge/Path Encroachment (Included Same Trafficway, Same Direction, Sideswipe/Angle-NASS Type II:F, and Change trafficway, Vehicle Turning, Turn Across Path & Turn Into Path-NASS Type IV:J&K). These were abbreviated as ***Turn, Merge, Path*** in subsequent analyses.

- Same Trafficway, Opposite Direction, Head-On, Forward Impact, or Sideswipe/Angle (NASS Type III:G,H,I). These were abbreviated as ***ODIR Impact*** in subsequent analyses.

- Intersecting Paths, Straight Paths (NASS Type V:L. These were abbreviated as ***Intersecting Straight Paths*** in subsequent analyses.

- Other, Miscellaneous - Backing, Etc. (NASS Type VI:M). These were abbreviated as ***Other*** in subsequent analyses.

- The pilot data contained no observations of Same Trafficway, Same Direction, Forward Impact involvements (NASS Type II:E).

8. Determined unweighted and weighted frequencies of each of 59 variables, treating each driver/vehicle as the unit of analysis. NASS crash weights for 1996 and 1997 were applied to expand the corresponding driver involvements. The following analyses were performed:

   - Cross tabulated of unweighted observations of each variable within crash type.

   - Applied the available NASS national crash weighs, the sample was expanded producing cross tabulations of weighted observations of each variable with crash type. The weighted observations were extremely useful to evaluate the relative involvement of the various conditions represented by the variables in each crash type. The resulting crash frequency estimates, however, were not accurate for several reasons:
     + National weights were applied to the sample from just four PSUs, which did not constitute a nationally representative set of PSUs.
     + The pilot sample was relatively small.
     + NASS sampling weights varied by large orders of magnitude. The highest weights were applied to the least severe (but most frequent) crash types included in the sampling frame which were under-sampled according to NASS data collection protocol. The lowest weights were applied to the most severe (but least frequent) crashes, which were over-sampled.

+ The combination of highly variable weights with a limited sample whose characteristics may have differed considerably from the national sample used to generate the weights was likely to yield highly unstable estimates.

9. For each crash type, the relative involvement for each value of each pattern variable was calculated (excluding missing and unknown values). For each level of the pattern variable, a relative involvement index, I_r was computed to assess the over-and under-representation of the level (i.e., row in the table) for the crash configuration relative to all crash configurations combined. I_r was a logodds like quantify. If $I_r > 0$, then the row was over-represented in the column relative to the total column for a crash type. If $I_r < 0$, then the row was under-represented in the column, relative to the total column for the crash type. The relative involvement index was defined as follows:

$I_r = \ln[T_{Br}/CT_{BR})/(T_r/CT_r)]$, where
$CT_{Br} = T_B - T_{Br}$
$CT_r = T - T_r$

	Crash Type			
Levels of Profile Variable	Type A	Type B	...	All
PV_1	T_{A1}	T_{B1}	...	T_1 = % of T
PV_2	T_{A2}	T_{B2}	...	T_2 = % of T
.	.	.	...	
.	.	.	...	
PV_r	T_{AR}	T_{Br}	...	T_r = % of T
Total	T_A	T_B		$T = T_{All}$

Two sets of tables were prepared showing the frequency, percentage, and relative involvement index for each response level for each of the 59 variables for each of the seven crash types. The tables were annotated to identify the highest frequency, the most over-represented, and the most under-represented response level for each variable and crash type.

10. A limited set of the six "key" pattern variables that were most informative and most likely to be indicative of unsafe driving acts was selected to characterize each crash type. These variables, which frequently had high indices of over-representation, included crash cause, BAC test result, primary behavior source, necessary UDA, travel speed, and first UDA in sequence. Another set of more general variables that did not have frequent high indices including driver age, sex, road surface condition, lighting, etc. was also examined because they were often helpful in understanding crash conditions. The results were presented in tabular and narrative form.

11. Determined the most frequent scenarios for each crash type. Each scenario was defined by a unique combination of values for key and general pattern variables (excluding missing and unknown values). The variable "BAC Test Result" had relatively few observations that were not missing or unknown, consequently it was not included among the key variables in this step. Had it been included, there would have been too few observations in any combination of variables for useful analysis. The five most frequent unique combinations of values for all five remaining key variables together were determined, as were the five most frequent combinations of values for combinations of one, two, three, and four variables. Similar calculations were performed for all six of the general variables.

3.3.2 Analysis Results

Results of the analysis are presented separately for each crash type. The narrative for each crash type describes the most frequent characteristics of each of the pattern variables and also identifies characteristics that were most over-represented relative to their expected frequencies. The most over-represented condition may indicate particular problems and identify situations that have a special need for remediation.

3.3.2.1 Single Driver - Right or Left Road Departure Or Forward Impact (No Traction Loss)

These crashes involved a single vehicle that ran off the road to the right, left, or end of roadway, or struck a stationary object (e.g., parked vehicle, pedestrian, animal) in the roadway, but not because of loss of traction. The data sample included 138 observations of this type.

The most frequent general conditions included a male driver, age 21-34, driving on a lighted road at night, with a dry road surface, on a straight, uphill road segment. The most over-represented conditions that were not also the most frequent included dawn/dusk and a right curving road segment.

Typical key conditions included a crash cause involving perceptual or cognitive failure with attention as the primary behavior source of the action. The necessary unsafe driving act most often involved impaired judgment, while the first UDA in sequence was most often exceeding the speed limit by 16-24 km/h (10-15 mph). Estimated travel speed was most often in the range of 49-72 km/h (30-45 mph) . The most frequent BAC test result was 0.00 percent.

Driver vehicle control failure was the most over-represented crash cause, at a moderate level, with motor skills substantially over-represented as the primary behavior source. Directional control was moderately over-represented as the necessary UDA. DUI was the most over-represented first UDA in sequence, with the BAC test result most over-represented in the 0.05 percent range. An estimated travel speed of 49-72 km/h (30-45 mph) was most over-represented.

Under-represented conditions included excessive speed as crash cause, BAC=0.0 percent, drivers age 55-69, female drivers, daytime slippery road surface, straight sections, and crest/sag profiles. These findings are summarized in Table B-1 in Appendix B. Additional details with respect to the scenarios that occurred most frequently are provided in Section 4..

3.3.2.2 Single Driver - Right or Left Road Departure With Traction Loss

These crashes involved a single vehicle that drove off the road to the left or right, with a loss of traction. There were 127 observations of this crash type.

The most frequent general conditions included a male driver, age less than 21, driving during daylight, with a dry road surface, on a straight, level road segment. The most over-represented conditions that were not also the most frequent included darkness and left curving, downhill road segment.

Typical key conditions included a crash cause involving excessive speed with decision as the primary behavior source of the action. The necessary UDA most often involved speed control, while the first UDA in sequence was most often exceeding the speed limit by 16-24 km/h (10-15 mph). Estimated travel speed was most often >96 km/h (>60 mph). The most frequent BAC test result was 0.0 percent.

Excessive speed was the most over-represented (strongly) crash cause, with decision moderately over-represented as the primary behavior source. Speed control was strongly over-represented as the necessary UDA. DUI was moderately over-represented as the first UDA in sequence, with the BAC test result also moderately over-represented in the 0.10-0.14 percent range. An estimated travel speed of >96 km/h (>60 mph) was very highly over-represented.

Under-represented conditions included perceptual/cognitive failures as the crash cause and perception as the behavior source, BAC = 0.00 percent, drivers age 70 and older, female drivers, daytime, dry road surface, straight sections, and crest/sag profiles. These findings are summarized in Table B-2 in Appendix B. Additional details with respect to the scenarios that occurred most frequently are provided in Section 4

3.3.2.3 Same Trafficway, Same Direction, Rear End

These crashes involved one vehicle striking the rear of a stopped or slower moving vehicle. There were 203 observations of this crash type.

The most frequent general conditions included a female driver (but with only a slight majority), age 35-54, driving during daylight, with a dry road surface, on a straight, level road segment. The most over-represented condition that was not also the most frequent was a downhill road segment. Typical key conditions included a crash cause involving perceptual/cognitive failure with attention as the primary behavior source of the action. The necessary UDA most often involved impaired judgment, while the first UDA in sequence was most often inattention. Estimated travel speed was most often stopped. The most frequent BAC test result was 0.15 percent and higher.

Perceptual/cognitive failure was also the most over-represented crash cause (very strongly), with attention very strongly over-represented as the primary behavior source. Impaired judgment was very strongly over-represented as the necessary UDA. Inattention was moderately over-represented as the first UDA in sequence. The BAC test result in the range of 0.01 - 0.04 percent was very strongly over-represented. Stopped as the estimated travel speed was moderately over-represented. Strongly under-represented conditions included vehicle, environment, or road condition as the crash cause, motor skills as the primary behavior source, and directional control as the necessary UDA. BAC = 0.10 - 0.14 percent, drivers age 50-69, and dark/lighted conditions were also strongly under-represented. These findings are summarized in Table B-3 in Appendix B. Additional details with respect to the scenarios that occurred most frequently are provided in Section 4.

3.3.2.4 Turn, Merge, Path Encroachment

These crashes involved a vehicle sideswiping, turning across the path, or turning into the path of another vehicle. There were 389 crashes of this type in the sample.

The most frequent general conditions included a male driver (but with only a slight majority), age 21-34, driving during daylight, with a dry road surface, on a straight, level road segment. Drivers age 55-69 were slightly over-represented as were dark/lighted conditions. Cases involving crest/sag roadway profiles were moderately over-represented.

Typical key conditions included a crash cause involving perceptual/cognitive failure with decision as the primary behavior source of the action. The necessary UDA most often involved proximity to the other vehicle. Estimated travel speed was most often 49-72 km/h (30-45 mph). The most frequent BAC test result was 0.00 percent.

Inappropriate maneuver was the most over-represented crash cause (moderately), with perception moderately over-represented as the primary behavior source. Proximity to the other vehicle was also moderately over-represented as the necessary UDA, as was turning in close proximity as the first UDA in sequence. The BAC test result of 0.00 percent was very strongly over-represented. Estimated travel speed of 1-24 km/h (1-15 mph) was slightly over-represented.

Strongly under-represented conditions included driver vehicle control failure as the crash cause, attention as the primary behavior source, and presenting an obstacle as the necessary UDA. High speed (>96 km/h/>60 mph) was strongly under-represented, as was DUI as the first UDA in the sequence. In fact, all BACs about 0.00 percent were strongly under-represented. Drivers younger than 21 ears and dawn/dusk conditions were also strongly under-represented. These findings are summarized in Table B-4 in Appendix B. Additional details with respect to the scenarios that occurred most frequently are provided in Section 4..

3.3.2.5 Same Trafficway, Opposite Direction - Head-On, Forward Impact, or Sideswipe/ Angle

This crash type involved two vehicles on the same trafficway moving in opposite directions, striking in a head-on, forward impact, or sideswipe manner, either with or without loss of traction. There were 144 crashes of this type in the sample.

The most frequent general conditions included a male driver, age 35-54, driving during daylight, with a dry road surface, on a straight, downhill road segment. Involvements on slippery roads were moderately over-represented, while right curving alignments were moderately over-represented. Typical key conditions included alcohol/drug impairment as the crash cause, which was strongly over-represented, although vehicle, environment, and road condition was the most strongly over-represented crash cause for this crash type. Decision was the most over-represented (moderately) primary behavior source. The necessary UDA most often involved speed control, also moderately over-represented. The first UDA in sequence was most often described as a "rare mix", but the most over-represented first UDA was driving while intoxicated. The most frequent BAC test result was 0.15 percent and higher, which was also strongly over-represented. Estimated travel speed was most often 25-48 km/h (15-30 mph), which was strongly over-represented.

Strongly under-represented conditions included perceptual/cognitive failure as the crash cause, perception as the primary behavior source, and presenting an obstacle as the necessary UDA. A travel speed of stopped was strongly under-represented, as was turn in close proximity as the first UDA in the sequence. These findings are summarized in Table B-5 in Appendix B. Additional details with respect to the scenarios that occurred most frequently are provided in Section 4..

3.3.2.6 Intersecting Paths - Straight Paths

This crash type involved front-to-side right angle collisions at intersections. There were 162 crashes of this type in the sample.

The most frequent general conditions included a male driver, age 21-34, driving during daylight, with a dry road surface, on a straight, level road segment. Slippery roads were strongly under-represented, as were left curving alignments. Female drivers were slightly over-represented, as were drivers in the 55-69 year age group. Uphill road segments were also slightly over-represented.

Typical key conditions included perceptual/cognitive failure as the crash cause, although alcohol/drug impairment was the most over-represented crash cause. A BAC test of 0.15 percent and higher was both the most frequent and the most over-represented (by a factor of 5) level of that profile variable. The most frequent and (moderately) over-represented primary behavior source was perception. The necessary UDA was most often impaired judgment, but the most (moderately) over-represented necessary UDA was an illegal act. Travel speeds of 49-72 km/h (30-45 mph) were both most frequent and most over-represented to a moderate extent. Although the first UDA in sequence was characterized a "rare mix", the most (moderately) over-involved first was driving while intoxicated.

Strongly under-represented conditions included excessive speed as the crash cause, a low BAC level, high speed, directional control as the necessary UDA, and turning in close proximity as the first UDA in sequence. These findings are summarized in Table B-6 in Appendix B. Additional details with respect to the scenarios that occurred most frequently are provided in Section 4..

3.3.2.7 Miscellaneous - Backing, Etc.

This crash type involved a vehicle backing into another vehicle or object, and other or unknown crash types, including those with no impact. There were 121 crashes of this type in the sample.

The most frequent and most over-represented general conditions included a female driver, age 21-34, driving on a straight road section. Other conditions that were most frequent included daylight, dry road surface, and uphill road profile. Darkness was moderately over-represented while slippery roads were slightly over-represented.

Typical key conditions included driver/vehicle control failure, which was very highly over-represented as the crash cause. The most frequent and (very highly) over-represented primary behavior source was decision. The necessary UDA was most often impaired judgment, but the most (highly) over-represented necessary UDA was presenting an obstacle. Travel speed of stopped was most frequent, but a speed of 73-96 km/h (45-55 mph) was nearly as frequent and most over-represented, to a moderate extent. The most frequent and most over-represented first UDA in sequence was characterized a "rare mix". A BAC test result of 0.00 was both the most frequent and the most over-represented of that profile variable, accounting for all observations of this crash type for which a BAC test result was known.

Strongly under-represented conditions included vehicle, environment, or roadway condition as the crash cause, attention as the primary behavior source, directional control failure as the necessary UDA, and turning in close proximity as the first UDA in sequence. Very low speed 1-24 km/h (1-15 mph), left curves, and crest/sag profiles were strongly under-represented. Male drivers were moderately under-represented and older drivers (70 and older) were strongly under-represented. These findings are summarized in Table B-7 in Appendix B. Additional details with respect to the scenarios that occurred most frequently are provided in Section 4.

SECTION 4
CRASH PROBLEM TYPE SCENARIOS

Two major areas are addressed in this section. Specifically, an estimate is provided for the proportion of the UDA sample that is related to the most frequently occurring problem types identified by the analysis sequence discussed in Section 3.3. The relative size of individual problem types is also identified and a listing of problem types, prioritized by frequency of occurrence, is provided (Section 4.1). Detailed descriptions of these scenarios are then provided in Section 4.2.

4.1 Crash Problem Size Estimate

A prioritized listing of crash problem types within the seven identified crash types is provided in Table 4-1. Collectively, the 23 problem types shown in this table comprised 43.2 percent of the UDA crash sample. These same problem types contributed to an additional 25.2 percent of the crashes in the sample when they were combined with a broad range of other factors. Therefore, the problem types in Table 4-1 contributed to more than two-thirds of the UDA sample crashes.

Table 4-1
Prioritized Listing of Crash Problem Types

Crash Type	Problem Type	% of UDA Sample
3. Same Direction, Rear End	1. Driver Inattention - Mid Range Speeds	5.6
	2. Driver Inattention - Low Range Speeds	2.5
	3. Driver Inattention - High Range Speeds	2.4
	4. Following Too Closely - High Range Speeds	2.4
	Subtotal	12.9
4. Turn, Merge, Path Encroachment	1. Looked, Did Not See	4.1
	2. Accepted Inadequate Gap To Other Vehicle	3.3
	3. Turned With Obstructed View	2.3
	4. Driver Inattention/TCD Violation	2.3
	Subtotal	12.0
2. Single Driver, Right or Left Roadside Departure With Traction Loss	1. Excessive Vehicle Speed	2.3
	2. DUI/DWI With Excessive Speed	1.6
	3. DUI/DWI	1.6
	Subtotal	5.5
1. Single Driver, Right or Left Roadside Departure Without Traction Loss	1. Driver Fatigue	1.7
	2. Driver Inattention	1.6
	3. DUI/DWI	1.5
	Subtotal	4.8
6. Intersecting Paths, Straight Paths	1. Looked, Did Not See	1.6
	2. Driver Inattention/TCD Violation	1.3
	3. Crossed With Obstructed View	1.2
	Subtotal	4.1

Table 4-1
Prioritized Listing of Crash Problem Types
(cont.)

5. Same Trafficway, Opposite Direction	1. Driver Inattention 2. Lost Directional Control 3. Excessive Vehicle Speed **Subtotal**	0.9 0.9 0.8 2.6
7. Other, Miscellaneous	1. Excessive Vehicle Speed 2. Following Too Closely 3. Sudden Deceleration **Subtotal**	0.5 0.4 0.4 1.3
	Total	**43.2**

It is important to note that the fourth most frequently occurring crash problem types within crash types 3 and 4 were included in Table 4-1 even though three problem types were described for the remaining five crash types. This decision was made for the following reasons:

- The fourth most frequently occurring problem types in crash types 3 and 4 were of equal or larger size than all of the problem types noted in the remaining crash types.

- These additional problem types assisted in demonstrating the diversity which occurs within crash types with respect to situational characteristics and causal elements.

It is also important to note that although the identified problem types in Table 4-1 comprised 43.2 percent of the UDA sample, no reliable projection can be made with respect to the national crash population due to sample biases. It is likely, however, that the frequencies associated with these problem types are of a similar order of magnitude in the more severe crashes within the national crash population.

4.2 Crash Problem Types Scenarios

The presentation sequence for scenario descriptions in this section is shown in Table 4-2. The reader may use this information to access crash problem types of specific interest.

Table 4-2
Crash Problem Type Presentation Sequence

Report Section	Crash Type	Problem Type	Report Subsection
4.2.1	3. Same Direction, Rear End	1. Driver Inattention - Mid Range Speeds 2. Driver Inattention - Low Range Speeds 3. Driver Inattention - High Range Speeds 4. Following Too Closely - High Range Speeds	4.2.1.1 4.2.1.2 4.2.1.3 4.2.1.4
4.2.2	4. Turn, Merge, Path Encroachment	1. Looked, Did Not See 2. Accepted Inadequate Gap To Other Vehicle 3. Turned With Obstructed View 4. Driver Inattention/TCD Violation	4.2.2.1 4.2.2.2 4.2.2.3 4.2.2.4
4.2.3	2. Single Driver, Right or Left Roadside Departure With Traction Loss	1. Excessive Vehicle Speed 2. DUI/DWI With Excessive Speed 3. DUI/DWI	4.2.3.1 4.2.3.2 4.2.3.3
4.2.4	1. Single Driver, Right or Left Roadside Departure Without Traction Loss	1. Driver Fatigue 2. Driver Inattention 3. DUI/DWI	4.2.4.1 4.2.4.2 4.2.4.3
4.2.5	6. Intersecting Paths, Straight Paths	1. Looked, Did Not See 2. Driver Inattention/TCD Violation 3. Crossed With Obstructed View	4.2.5.1 4.2.5.2 4.2.5.3
4.2.6	5. Same Trafficway, Opposite Direction	1. Driver Inattention 2. Lost Directional Control 3. Excessive Vehicle Speed	4.2.6.1 4.2.6.2 4.2.6.3
4.2.7	7. Other, Miscellaneous	1. Excessive Vehicle Speed 2. Following Too Closely 3. Sudden Deceleration	4.2.7.1 4.2.7.2 4.2.7.3

The specification format for identified UDA crash problem types includes six major elements. These elements may be summarized as follows:

- *Problem Type Identification* - Problem types are identified within the crash type designations discussed in Section 3.3. Therefore, the initial portion of the identification label refers to crash type. Specific titles are then assigned to each identified problem type based on a combination of UDA/causal factor assignments and other situational factors.

- *Common Crash Scenarios* - Most problem types have more than one associated crash scenario. The crash circumstances and vehicle dynamic patterns within major scenarios are described.

- *Causal Factor/UDA Assignment Patterns* - The most frequently occurring assignment patterns, including combination assignments are described.

- *Relevant Situational Characteristics* - These characteristics include parameters not described in the crash scenarios such as time, weather conditions, lighting condition, traffic volume/congestion pattern, driver braking/steering/acceleration inputs, and travel/impact speed characteristics.

- *Driver Demographic Characteristics* - Over-representation of age, race, or gender characteristics are described for individual scenarios as appropriate.

- *Driver's Perspective of Crash Sequence* - The driver's acceptance of responsibility for the crash sequence and their assessment of the other driver's role in crash causation vary dramatically between crash scenarios. Where there is sufficient data to indicate these parameters or the general nature of these parameters, patterns/trends are described.

The problem types discussed in the material that follows were initially identified through the multivariate analyses described in Section 3.3.2. The detailed descriptions provided in this section, however, were developed through a clinical review of identified problem type cases. Therefore, all assessments noted in the problem type descriptions are clinical in nature.

4.2.1 Crash Type 3: Same Direction Rear End

The four most frequently occurring crash problems in this crash type represented 12.9 percent of the UDA sample. The first three most frequently occurring problem types within this crash type were all associated with driver inattention. Combined, these problem types represented 10.5 percent of the UDA sample.

4.2.1.1 Problem Type 1: Driver Inattention - Mid Range Travel Speeds

This problem type represented 5.6 percent of the UDA sample. The subject driver was traveling in a stream of vehicles, became inattentive to the driving task, and as a result was unaware that traffic forward of the subject vehicle's position was slowing or had stopped. Upon refocusing attention to the forward field of view, the subject driver realized that traffic had slowed/stopped, typically initiated heavy braking, and was subsequently involved in a rear end collision with the vehicle located immediately forward of the subject vehicle's position.

- *Causal Factor/UDA Assignment Patterns* - The driver inattention causal factor and UDA designation were typically the only factors assigned. For a very small proportion of these crashes, however, an additional speed control UDA (13 percent) or a driving in close proximity UDA (10 percent) was assigned to indicate that additional factors contributed. Speed control UDA assignments typically reflected the circumstance where the subject driver was exceeding the speed limit by less than 24 km/h (15 mph).

- *Situational Characteristics* - These crashes typically occurred on suburban arterial roadways or urban principal arterial roadways during periods of moderate to moderately heavy traffic densities. Nearly all of the crashes occurred during daylight hours and in clear weather conditions. All of the subject vehicles were initially traveling at speeds of 49-72 km/h (30-45 mph). The specific types of inattention mechanisms that were associated with these crashes are summarized below:

Inattention Mechanism/Factor	Proportion (%)
Looking to right (unspecified focus)	6.5
Looking to right (buildings/pedestrians/vehicles off roadway)	22.7
Looking to right (traffic in adjoining lane)	3.2
Looking to right (traffic signs)	3.2
Looking to left (unspecified focus)	6.5
Looking to left (approaching traffic)	9.7
Looking down (retrieving dropped cigarette)	3.2
Closed eyes to focus blurry vision	3.2
Focusing on internal thought processes	9.7
Unknown	32.1
Total	**100.0**

- *Driver Demographic Characteristics* - The full range of driver age and gender characteristics were associated with this scenario. Younger drivers (<35), however, were over-represented (80 percent) and younger male drivers, in particular, were over-represented (52 percent).

- *Drivers Perspective of Crash Sequence* - Slightly more than 60 percent of the drivers in this problem type stated that they were inattentive to the driving task and typically did not attempt to shift responsibility for crash occurrence. Inattention assignments for the remaining drivers in this problem type were derived from police reported information, other driver statements, witness statements, and to a lesser degree, interpretation of physical evidence patterns. Approximately half the subject drivers in the latter group indicated that the other driver decelerated/stopped suddenly. These assessments were not supported by available crash information.

4.2.1.2 Problem Type 2: Driver Inattention - Low Range Travel Speeds

This problem type represented 2.5 percent of the UDA sample. Two scenarios were identified. In the most frequently occurring scenario (76 percent), the subject driver was traveling in a stream of vehicles, became inattentive to the driving task, and as a result was unaware that traffic forward of the subject vehicle's position was slowing or had stopped. Upon refocusing attention to the forward field of view, the subject driver realized that traffic had slowed/stopped, typically initiated heavy braking, and was subsequently involved in a rear end collision with the vehicle located immediately forward of the subject vehicle's position.

In the second and less frequently occurring scenario (24 percent), the subject driver was traveling on an entrance ramp to an expressway/interstate roadway/divided principal arterial roadway. The driver became inattentive to the driving task by focusing on traffic in the through lanes and was subsequently involved in a rear end collision with the vehicle located immediately forward of the subject vehicle's position on the entrance ramp.

- *Causal Factor/UDA Assignment Patterns* - The driver inattention causal factor and UDA designations were typically the only factors assigned. The speed control and driving in close proximity UDA assignments noted in the preceding problem type were not assigned in this circumstance.

- *Situational Characteristics* - Nearly all the crashes in this problem type occurred in daylight hours and in clear weather conditions. Crashes in the most frequently occurring scenario were typically located on urban/suburban collector and arterial roadways during periods of heavy traffic densities. Crashes in the second scenario typically occurred when traffic densities on the entrance ramp were light to moderate and traffic densities in the through lanes were moderate to moderately heavy. All of the subject vehicles in these scenarios were initially traveling at speeds of 25-48 km/h (15-27 mph). As indicated previously, all of the drivers in the ramp scenario became inattentive as a result of focusing on traffic in the through lanes. These drivers were either unaware of the presence of a lead vehicle on the ramp (67 percent) or assumed that this vehicle was merging in the same manner that they were (33 percent). Drivers in the first scenario (urban surface streets) became inattentive for a variety of reasons. Specific inattention mechanisms/factors are summarized below:

Inattention Mechanism/Factor	Proportion (%)
Looking to right (unspecified focus)	5.3
Looking to right (building)	5.3
Looking to right (adjusting cassette player)	5.3
Looking to right (conversing with passengers)	15.8
Looking to left (unspecified focus)	21.0
Looking to left (approaching traffic)	5.3
Looking down (unspecified focus)	5.3
Looking in rearview mirror	26.1
Focusing on internal thought processes	5.3
Unknown	5.3
Total	**100.0**

- *Driver Demographic Characteristics* - The full range of driver age and gender characteristics were involved in this problem type. Younger drivers (<35 years), however, were over-represented (61 percent) with younger male drivers (33.3 percent) slightly more prominent than younger female drivers (27.7 percent).

- *Driver Perspective of Crash Sequence* - More than 90 percent of the drivers in this crash problem stated that they were inattentive to the driving task and did not attempt to shift responsibility for crash occurrence.

4.2.1.3 Problem Type 3: Driver Inattention - High Range Travel Speeds

This problem type represented 2.4 percent of the UDA sample. The subject driver was traveling in a stream of vehicles, became inattentive to the driving task, and as a result was unaware that traffic forward to the subject vehicle's position was slowing or had stopped. Upon refocusing attention to the forward field of view, the subject driver realized that traffic had slowed/stopped, typically initiated heavy braking, and was subsequently involved in a rear end collision with the vehicle located immediately forward of the subject vehicle's position.

- *Causal Factor/UDA Assignment Patterns* - The driver inattention causal factor and UDA designations were assigned to each subject driver. In addition, the driving in close proximity UDA (e.g., following too closely) was assigned to 40 percent of the subject drivers to indicate that this UDA was a contributing factor to crash occurrence.

- *Situational Characteristics* - These crashes typically occurred on interstate roadways or divided arterial roadways during periods of moderate to heavy traffic densities. Nearly all the crashes occurred during daylight hours and in clear weather conditions. All of the subject vehicles were initially traveling at speeds of 73-96 km/h (46-60 mph). The range of inattention mechanisms in this problem type was more limited than preceding problem types and is summarized below:

Inattention Mechanism/Factor	Proportion (%)
Looking to right (traffic in adjoining lanes)	20.0
Looking to right (conversing with passenger)	10.0
Looking to left (unspecified focus)	20.0
Focused on internal thought processes	30.0
Unknown	20.0
Total	**100.0**

- *Driver Demographic Characteristics* - The full range of driver age and gender characteristics were associated with this scenario. Older drivers (>55 years) appeared to be over-represented comprising 30 percent of the clinical sample.

- *Drivers perspective of Crash Sequence* - Approximately 40 percent of the drivers in this problem type attempted to shift responsibility to traffic conditions. In general, these assessments were not valid.

4.2.1.4 Problem Type 4: Following Too Closely - High Range Travel Speed

This problem type represented 2.4 percent of the UDA sample. In this problem type, the subject driver was traveling in a stream of vehicles and was traveling in close proximity to the vehicle (lead vehicle) located immediately forward of the subject vehicle. When traffic forward of the lead vehicle slowed (typically as a result of traffic congestion), the subject driver was unable to stop/slow prior to striking the lead vehicle. The inability to stop/slow in a safe manner could be traced to the initial gap distance between the subject vehicle and the lead vehicle before traffic began slowing.

- *Causal Factor/UDA Assignment Patterns* - The following too closely causal factor and driving in close proximity UDA designation were typically the only factors assigned to this problem type.

- *Situational Characteristics* - All of the crashes in this problem type occurred on interstate roadways or divided principal urban arterial roadways during periods of heavy traffic densities (typically rush hour). All of the subject vehicles were initially traveling at speeds of 73-96 km/h (45-60 mph). The subject vehicle in this problem type most frequently struck the lead vehicle while that vehicle was still moving. In cases where the lead vehicle was stopped at impact, the impact occurred as the lead vehicle came to rest. The initial gap distances between the subject vehicles and lead vehicles in this problem type are commonly found in rush hour/heavy density circumstances. These gap distances, however, may have also reflected aggressive driving traits.

- *Driver Demographic Characteristics* - The size of this problem type was not sufficient to accurately establish demographic characteristics. However, all of the drivers in the sample were males between the ages of 22 and 52.

- *Drivers Perspective of Crash Sequence* - Subject drivers typically shifted responsibility for crash occurrence to either the lead vehicle or to general traffic density conditions.

4.2.2 Crash Type 4: Turn, Merge, Path Encroachment

While this crash type contained the three general configurations specified in the title, the four most frequently occurring crash problems all involved turning movements. These problem types represented 12.0 percent of the UDA sample.

4.2.2.1 Problem Type 1: Looked, Did Not See - Perceptual Error

This problem type was the most frequently occurring problem type within crash type 4 and represented 4.1 percent of the UDA sample. Two major scenarios were noted. In the most frequent occurring scenario (57.5 percent), the approach trajectories of the involved vehicles were initially 180 degrees opposed. All of the subject drivers in this scenario initiated a left turn across the intended path of the approaching other vehicle. When checking for approaching traffic, the subject driver did not recognize the visual cues presented by the other vehicle and in effect, "did not see" that vehicle. As a result, the subject driver initiated the intended left turn and was typically struck by the approaching vehicle.

In the second scenario in this problem type, the approach trajectories of the involved vehicles were initially separated by 90 degrees. Most of the subject drivers in this scenario attempted to initiate a left turn across the intended path of the other vehicle that was approaching the crash site from the subject drivers left (65 percent). A smaller proportion (20 percent) attempted to initiate a left turn into the path of a vehicle that was approaching from the subject driver's right and the remaining subject drivers attempted to initiate a right turn into the path of a vehicle approaching from the subject driver's left. Similar to the preceding scenario, when checking for cross-traffic, the subject driver did not recognize the visual cues presented by the approaching vehicle and in effect, "did not see" that vehicle. While most of the subject vehicles in this scenario were typically struck by the approaching vehicle, a relatively small proportion (10 percent) of the subject vehicles struck the approaching vehicle.

- *Causal Factor/UDA Assignment Patterns* - The looked, but did not see causal factor was typically the only factor assigned to the subject driver. UDA assignments included turning in close proximity to other vehicles and failure to yield the right-of-way.

- *Situational Characteristics* - Most of the crashes in both scenarios described above occurred during daylight hours and in dry/clear weather conditions. A relatively small proportion occurred during daylight hours and degraded viewing conditions (e.g., rain). This problem type typically did not occur during hours of darkness. There were a number of situational variances between these two scenarios which may be summarized as follows:

  + Most of the crashes in the scenario where the approach trajectories of the involved vehicles were 180 degrees opposed occurred at intersection locations (85 percent). The remaining crashes occurred at non-intersection locations where the subject driver was attempting to turn left into a commercial access. More than half the crashes that occurred at intersections occurred at locations where traffic flow was controlled by a traffic signal which displayed a green phase for both involved vehicles. The remaining crashes occurred at intersections where traffic flow was not controlled for the travel directions of the involved vehicles (e.g., subject driver was attempting to turn left from a minor arterial roadway to a local roadway).

  + Most of the crashes in the scenario where the approach trajectories were separated by 90 degrees also occurred at intersection locations (90 percent) with the remaining crashes (10 percent) occurring at non-intersection locations where the driver was attempting to exit from a commercial access. In this scenario, however, all of the crashes at intersection locations involved use of a stop sign (TCD) for the subject vehicle's approach direction. Cross-traffic in this circumstance was not subject to a TCD.

+ Crashes in the 180 degree scenario involved the full spectrum of traffic congestion conditions, from little or no congestion to heavy congestion with high traffic densities. Crashes in the 90 degree scenario, however, typically occurred when traffic densities were light (e.g., no congestion).

+ All subject vehicles in the 90 degree scenario were stopped prior to initiation of the intended left turn. Subject vehicles in the 180 degree scenario tended to be moving during pre-crash phase (e.g., approached intersection and initiated turn without stopping). Specifically, less than half of the involved subject vehicles were stopped prior to turning left.

- *Driver Demographic Characteristics* - Both scenarios in this problem type were most frequently associated with older (>55 years) and younger <35 years) drivers. The specific patterns within scenario type were distinctive and may be summarized as follows:

  + *90 Degree Scenario* - Older drivers were strongly over-represented with 25 percent of the subject drivers exceeding 70 years of age and 50 percent exceeding 55 years of age. This high involvement rate may have been associated with degraded visual perceptual capabilities. Only 10 percent of the subject drivers were in a middle age group (35-54 years) and the underlying reason these drivers did not see the other vehicle appeared to be related to an inappropriate traffic scanning technique. Specifically these drivers initially checked to the left, then checked to the right, and remained focused to the right as they pulled forward to initiate the left turn. Younger drivers (<35 years) were also over-represented with this age group comprising 40 percent of the sample. The underlying reason these drivers did not see the other vehicle appeared to be related to aggressive driving behavior. Specifically, there was evidence that more than 60 percent of the drivers in this age group completed a perfunctory check for cross traffic as a result of being in a hurry.

  + *180 Degree Scenario* - Older drivers were again over-represented with 9 percent of the subject drivers exceeding 70 years of age and 41 percent exceeding 55 years of age. These drivers may have been involved as a result of degraded perceptual capabilities. One driver in this group was identified as using an inappropriate traffic scanning technique (i.e., focused on intended destination before turn was initiated. Drivers in the middle age group (35-54 years) comprised a larger portion of the subject drivers (26 percent) as compared to the 90 degree scenario. Slightly more than half of these drivers were identified as using an inappropriate traffic scanning technique in that they focused on the intended destination before initiating the turn. Younger drivers comprised 33 percent of the subject drivers in this scenario. Slightly more than half of these drivers were identified as completing perfunctory checks for approaching traffic and the remaining drivers in this group were identified as using an incorrect traffic scanning technique (focused on destination).

- *Driver's Perspective of Crash Sequence* - Most of the drivers (98 percent) involved in these two scenarios indicated that they did not see the approaching vehicle and did not attempt to shift responsibility to the approaching vehicle.

4.2.2.2 Problem Type 2: Accepted Inadequate Gap to Other Vehicle - Perceptual Error

This problem type was the second most frequently occurring problem type within crash type 4 and represented 3.3 percent of the UDA sample. Two major scenarios were again identified. These scenarios were identical to the 90 degree and 180 degree scenarios noted in the preceding problem type. In the most frequently occurring scenario (75 percent), the approach trajectories of the involved vehicles were initially 180 degrees opposed. All of the subject drivers in this scenario initiated a left turn across the intended path of the approaching vehicle. In checking for approaching traffic, the subject driver noted the presence of the other vehicle, but either misjudged the distance to that vehicle or misjudged the travel velocity of that vehicle (i.e., accepted inadequate gap). The subject driver then initiated the intended left turn and was typically struck by the approaching other vehicle.

In the second and less frequently occurring scenario (25 percent), the approach trajectories of the involved vehicles were initially separated by 90 degrees. Most of the subject drivers in this scenario attempted to initiate a left turn across the intended path of the other vehicle that was approaching the crash site from the subject driver's left (66 percent). The remaining subject drivers attempted to initiate a right turn into the intended path of a vehicle that was approaching from the subject driver's left. Similar to the preceding scenario, when checking for cross-traffic, the subject driver noted the presence of the other vehicle, but misjudged the distance to that vehicle or misjudged the approach velocity of that vehicle. The subject driver subsequently initiated the intended left or right turn and was struck by the vehicle approaching from their left.

NOTE: The relative size differential between these scenarios (i.e., 180 degree scenario occurred three times more frequently than the 90 degree scenario) and the fact that there were no cases in the 90 degree scenario where the subject vehicle was struck by a vehicle approaching from right verified a commonly stated axiom. Specifically, drivers have the greatest difficulty with accurately assessing the approach velocity of vehicles which are coming straight at them (i.e., approach trajectory is 180 degrees opposed to viewing path). Similarly, in situations involving cross-traffic, drivers experience greater difficulty with accurately assessing the approach velocities of vehicles approaching from their left as opposed to vehicles approaching from their right. This occurs in the 180 degree circumstance because there are few cues with respect to the relative motion of the vehicle in comparison to stationary objects. Some of these cues are provided for vehicles approaching from the left in the cross-traffic circumstance, but higher quality cues are provided by vehicles approaching from the right since these vehicles are longitudinally further removed from the driver's position (i.e., the driver has a better side view of vehicles approaching from the right).

- *Causal Factor/UDA Assignment Patterns* - The accepted inadequate gap causal factor was typically the only causal factor assigned to the subject driver. UDA assignments included turning in close proximity to other vehicles and failure to yield the right-of-way.

- *Situational Characteristics* - The situational characteristics associated with these scenarios essentially paralleled the characteristics noted in the preceding problem type. Specific patterns may be summarized as follows:

+ *90 Degree Scenario* - Most of the crashes in this scenario occurred at intersection locations where the approach direction of the subject driver was controlled by a stop sign (89 percent). The remaining crashes occurred at locations where the subject driver was attempting to exit a commercial access. Most of the crashes also occurred in daylight hours, clear weather conditions, and in circumstances where the surrounding traffic densities were light to moderate. All of the subject drivers in this scenario were stopped prior to initiation of the intended turn.

+ *180 Degree Scenario* - Most of the crashes in this scenario occurred at intersection locations (96 percent) with the remaining crashes occurring at locations where the subject driver was attempting to initiate a left turn into a commercial access. More than half of the intersection crashes occurred at signalized intersections where a green signal phase was displayed for both crash-involved drivers. The remaining crashes occurred at intersections where the approach directions of the crash-involved drivers were uncontrolled. Most of the crashes in this scenario occurred during daylight hours and in clear weather conditions. The proportion of crashes occurring during the hours of darkness, although relatively low, was much higher than in the preceding problem type (Looked, Did Not See). These crashes occurred in a full range of traffic density/congestion patterns, however, the largest proportion (40 percent) occurred during periods of moderate densities. Slightly less than half of the subject drivers in this scenario were stopped prior to initiation of the intended turn.

- *Driver Demographic Characteristics* - The specific patterns within these scenarios were distinctive and may be summarized as follows:

  + *90 Degree Scenario* - Younger drivers (<35 years) dominated the age distribution for this scenario (86 percent). There was evidence to indicate that more than 60 percent of these drivers performed perfunctory checks for cross-traffic.

  + *180 Degree Scenario* - Older drivers were again over-represented in this scenario with 21 percent of the subject drivers exceeding 70 years of age and 42 percent exceeding 55 years of age. Younger drivers (<35) comprised 33 percent of the subject drivers and drivers between the ages of 35 and 54 comprised 25 percent of the subject drivers. One-third of the drivers in the latter two age groups were identified as performing perfunctory checks for approaching traffic.

- *Driver's Perspective of Crash Sequence* - A high proportion of the older male drivers (80 percent) and younger female drivers (33 percent) in this group shifted responsibility for crash occurrence, insisting that the other driver was speeding. These inferences were typically not supported by physical evidence patterns or witness statements.

4.2.2.3 Problem Type 3: Turned With Obstructed View - Decision Error

This problem type represented 2.3 percent of the UDA sample. Two major scenarios were again identified. These scenarios were identical to the 90 degree and 180 degree scenarios noted in the preceding two problem types. In the most frequently occurring scenario (62.5 percent), the approach trajectories of the involved vehicles were initially 180 degrees opposed. All of the subject drivers in this scenario initiated a left turn across the intended path of the approaching crash-involved vehicle. In all of these crashes, the subject driver's view of the approaching vehicle was blocked by stationary vehicles located in the inboard opposing traffic lanes. The subject driver initiated a left turn and was subsequently struck by a vehicle traveling in lanes that were outboard of the stationary vehicles that caused the view obstruction.

In the second and less frequently occurring scenario (37.5 percent), the approach trajectories of the involved vehicles were initially separated by 90 degrees. All of the subject drivers in this scenario attempted to initiate a left turn across the path of a vehicle that was approaching the site from the subject driver's left. In all of these crashes the subject driver had to cross two or more lanes of traffic approaching from the left in order to initiate the intended left turn. In each case, vehicles in the outboard lane of the intersecting roadway (lane closest to the subject driver) blocked the subject driver's view of the crash-involved vehicle approaching in the inboard lanes of the intersecting roadway. The subject driver pulled into the intersection and was subsequently struck by vehicles traveling in lanes that were inboard of the view obstruction.

- *Causal Factor/UDA Assignment Patterns* - The turned with obstructed view causal factor was typically the only causal factor assigned to the subject driver. UDA assignments included turning with an obstructed view, turning in close proximity, and failure to yield the right-of-way.

- *Situational Characteristics* - Specific patterns associated with the identified scenarios may be summarized as follows:

  + *90 Degree Scenario* - Most of the crashes in this scenario occurred at intersection locations where the approach direction of the subject driver was controlled by a stop sign (78 percent). The remaining crashes occurred at locations where the subject driver was attempting to exit a commercial access. Most of the crashes also occurred in daylight hours, clear weather conditions, and in circumstances where the surrounding traffic densities were moderate to heavy. All of the subject drivers in this scenario were stopped prior to entering the intersecting roadway. Most of the non-contact vehicles that provided the view obstruction in this scenario were stopped at the time the subject driver checked cross-traffic (67 percent). The non-contact vehicles that were moving were typically turning right into the street the subject driver was exiting.

  + *180 Degree Scenario* - Most of the crashes in this scenario occurred at intersection locations (87 percent) with the remaining crashes occurring at locations where the subject driver was attempting to initiate a left turn into a commercial access. Most of the intersection crashes occurred at signalized intersections (85 percent) where a green signal phase was displayed for both crash-involved drivers. Most of the crashes also occurred in daylight hours, clear weather conditions, and in circumstances where the surrounding traffic densities were moderate to heavy. More than 60 percent of the subject drivers in this scenario were stopped prior to initiating the intended left turn. All of the non-contact vehicles that provided the view obstruction in this scenario were stopped prior to and during the time the subject driver initiated the intended left turn.

- *Driver Demographic Characteristics* - The specific patterns withing these scenarios were distinctive and may be summarized as follows:

  + *90 Degree Scenario* - Younger (<35) and older drivers (>55) dominated the age distribution for this scenario (56 and 32 percent, respectively). In general, there was no evidence to indicate that the drivers in this scenario were driving aggressively.

  + *180 Degree Scenario* - Older drivers were again over-represented in this scenario with 23 percent of the subject drivers exceeding 70 years of age and 46 percent exceeding 55 years of age. In general, there was no evidence to indicate that the drivers in this scenario were driving aggressively.

- *Driver's Perspective of Crash Sequence* - A number of the subject drivers in these scenarios shifted responsibility for crash occurrence to the approaching vehicle. Older male drivers and female drivers, in particular, believed that the other crash-involved driver was either speeding or could have steered around their vehicle (primarily in the 180 degree scenario) if they hadn't panicked. These claims were typically not supported by physical evidence at the crash site.

4.2.2.4 Problem Type 4: Driver Inattention/TCD Violation

This problem type represented 2.3 percent of the UDA sample. Two major scenarios were again identified. These scenarios paralleled the 90 degree and 180 degree scenarios noted in the preceding three problem types. In the most frequently occurring scenario (64.3 percent), the approach trajectories of the involved vehicles were initially separated by 90 degrees. In this scenario, the subject driver became inattentive to the driving task while approaching an intersection, violated a traffic control device, and then typically struck a vehicle that was initiating a left turn (71.4 percent) across the subject vehicle's intended travel path. In the remaining crashes, the other vehicle was initiating a right turn into the subject vehicle's intended path (14.3 percent) or was intending to proceed straight through the intersection [(i.e., subject vehicle was turning (14.3 percent)].

In the second and less frequently occurring scenario (35.7 percent), the approach trajectories of the involved vehicles were initially separated by 180 degrees. In this scenario the subject driver became inattentive to the driving task while approaching an intersection, violated a TCD, initiated a left turn, and was than typically struck by a vehicle intending to proceed straight through the intersection (66 percent). In the remaining crashes, the subject driver violated a TCD and then struck a vehicle that was turning left across the subject vehicle's intended path.

- *Causal Factor/UDA Assignment Patterns* - The driver inattention causal factors and UDAs were typically assigned in combination with factors that indicated violation of a TCD. Additional UDAs indicating a turn in close proximity (where relevant) and failure to yield the right-of-way were also assigned.

- *Situational Characteristics* - Most of the crashes in these scenarios occurred during daylight hours and in clear weather conditions. Most of the crashes also involved violation of traffic signals (85 percent) as opposed to stop signs (15 percent). This latter finding must be interpreted cautiously since previous research has shown that inattentive drivers typically violate stop signs more frequently than traffic signals due to the stronger visual cues provided by traffic signals. In this study, the reversed trend finding, noted above, may reflect a location type bias in the four NASS PSU sites selected for the data collection effort.

  The specific types of inattention mechanisms associated with these crashes were fairly similar and are summarized below:

Inattention Mechanism/Factor	Proportion (%)
Looking to right (unspecified attention focus)	7.1
Looking to right (conversing with passenger)	7.1
Looking to right (street sign)	7.1
Looking to left (unspecified attention focus)	14.4
Looking to left (street sign)	7.1
Focusing on internal thought processes	28.6
Unknown	28.6
Total	**100.0**

- *Driver DemographicCharacteristics* - Younger male drivers (<35 years) dominated the age distribution for this problem type (42.9 percent). Male drivers, in general, dominated the distribution (85 percent).

- *Driver's Perspective of Crash Sequence* - Most of the drivers in this problem type indicated that they were unaware of TCD prior to entering the intersection. None of the drivers in this problem type attempted to shift responsibility for crash occurrence to the other involved driver.

4.2.3 Crash Type 2: Single Driver, Roadway Departure, Traction Loss - SDRV, Traction

In all of the problem types in this crash type there was an associated loss of vehicle control that preceded roadway departure. The three problem types described in this section represented 5.5 percent of the UDA sample.

4.2.3.1 Problem Type 1: Excessive Vehicle Speed

This problem type was the most frequently occurring problem type within crash type 2 and represented 2.3 percent of the UDA sample. In this problem type, the subject driver was traveling along a roadway and was typically approaching a curve (76.5 percent) while exceeding the speed limit (58.8 percent) by more than 24 km/h (15 mph). As a direct result of the subject vehicle's travel speed, the subject driver was unable to retain directional control. The subject vehicle subsequently exited the roadway and was involved in either an off-road crash sequence or a non-collision rollover event. For this problem type, the vehicle speed factor was part of an aggressive driving behavior pattern.

- *Causal Factor/UDA Assignment Patterns* - The vehicle speed causal factor and UDA designations were typically the only factors assigned to the subject driver. For crashes that occurred on straight segments (23.5 percent), however, the drifting left or right UDA designations were added as appropriate.

- *Situational Characteristics* - Most of these crashes occurred on local or lower level collector roadways (64.7 percent), during periods of darkness (58.8 percent), and during clear weather conditions (88.2 percent). For those crashes involving curved segments (76.5 percent), the subject vehicle typically exited the roadway edge opposite the direction of curvature (e.g., left curve, exit right edge of roadway). In instances where the subject vehicle exited the same edge of the roadway as the direction of curvature (23 percent of curve related crashes) and for departures from straight roadway segments, a series of corrective steering inputs were typically noted. In this circumstance, the subject driver most frequently lost directional control on the third corrective steering input (over-correction input). The proportion of curve departures with a subsequent rollover sequence (46.1 percent) was relatively high.

- *Driver Demographic Characteristics* - Males dominated the age distribution profile for this crash problem (80.8 percent) with males less than 35 years of age over-represented (65.4 percent). Males less than 20 years of age comprised 46.2 percent of distribution.

- *Driver's Perspective of Crash Sequence* - Most drivers in this problem type either did not admit to exceeding the speed limit or provided a speed estimate that was lower than the estimate determined by the project staff. More than half of the drivers also attempted to shift crash responsibility to roadway design characteristics or roadway condition factors (primarily maintenance issues).

4.2.3.2 Problem Type 2: DUI/DWI With Excessive Vehicle Speed

This problem type was the second most frequently occurring problem type within crash type 2 and represented 1.6 percent of the UDA sample. In this problem type the subject driver was either driving while under the influence of alcohol (DUI-40 percent) or was driving while intoxicated (DWI-60 percent) and was exceeding the posted speed limit [typically by more than 24 km/h (15 mph) - 53 percent)]. Most frequently, the subject driver was attempting to negotiate a curve (76.5 percent). As a result of the combination of alcohol consumption and vehicle speed, the subject driver lost directional control. The subject vehicle subsequently exited the roadway and was involved in either an off-road crash sequence or an non-collision rollover event.

- *Causal Factor/UDA Assignment Patterns* - The DUI/DWI and vehicle speed causal factors and UDA designations were assigned to all subject drivers. For crashes that occurred on straight segments (23.5 percent), the drifting left or right UDA designations were added as appropriate.

- *Situational Characteristics* - Most of these crashes occurred on local or lower level collector roadways (64.7 percent). The proportion that occurred on interstate roadways (29.4 percent) was also relatively high. Most of the crashes occurred during periods of darkness (76.5 percent) and most frequently between midnight and five am (58.8 percent). These crashes also typically occurred during periods of clear weather. Similar to the preceding problem type, in crashes involving curved segments (76.5 percent), the subject vehicle typically exited the roadway edge opposite the direction of curvature (e.g., left curve, exit right edge of roadway). In instances where the subject vehicle exited the same edge of the roadway as the direction of curvature (30.8 percent of curve related crashes) and for departures from straight roadway segments, a series of corrective inputs were typically noted prior to roadway departure. The proportion of curve departures with a subsequent rollover sequence (38.5 percent) was relatively high.

- *Driver Demographic Characteristics* - Younger males (<35 years) dominated the age distribution profile for this problem type (58.8 percent). Due to age limit restrictions applying to alcohol consumption, however, the proportion of drivers less than 20 years of age (11.8 percent) was very low in comparison to the preceding problem type.

- *Driver's Perspective of Crash Sequence* - Most of the drivers in this problem type either did not admit consuming alcoholic beverages prior to the crash or did not admit to exceeding the speed limit. More than half of the drivers also attributed crash occurrence to roadway design characteristics, roadway condition factors, or visibility limitations.

4.2.3.3 Problem Type 3: DUI/DWI Crashes

This problem type represented 1.6 percent of the UDA sample. In this problem type the subject driver was either driving while under the influence of alcohol (DUI-42.9 percent) or was driving while intoxicated (DWI-57.1 percent). With the exception of the vehicle speed factor, all other aspects of this problem type either duplicated or paralleled the preceding problem type.

- *Causal Factor/UDA Assignment Patterns* - The DUI/DWI causal factors and UDA designations were assigned to all subject drivers. For crashes that occurred on straight segments (28.6 percent), the drifting left or right UDA designations were added as appropriate.

- *Situational Characteristics* - Due to the absence of the vehicle speed factor, the proportion of rollover events that occurred in this problem type (28.6 percent) was lower than the comparable value in the preceding problem type. All other aspects of this problem type matched the preceding problem type.

- *Driver Demographic Characteristics* - Younger male drivers (<35 years) again dominated the age profile for this problem type.

- *Driver's Perspective of Crash Sequence* - Most of the drivers in this problem type did not admit to consuming alcoholic beverages prior to crash sequence.

4.2.4 Crash Type 1: Single Driver, Left or Right Roadside Departure, or Forward Impact - SDRV Left, Right, Forward

As defined for this effort, this crash type contained roadway departure crashes and forward impacts occurring on the roadway where there was no associated traction loss. The three most frequently occurring problem types in this crash type represented 4.8 percent of the UDA sample

4.2.4.1 Problem Type 1: Driver Fatigue

This problem type represented 1.7 percent of the UDA sample. In this problem type, subject drivers reported feeling fatigued/drowsy prior to the crash event and reported initiating actions to counteract the fatigue (e.g., opening windows, shutting off heater, etc.). These actions were not successful. The subject driver subsequently fell asleep and the subject vehicle typically departed the roadway (87.5 percent) or was involved in a forward impact (e.g., struck parked vehicle) on the roadway. For those vehicles departing the roadway, departure angles were typically very shallow (e.g., 1-3 degrees) and then increased dramatically during off-road travel as the driver slumped either to the left or right and induced inadvertent steering input. Roadway departure events typically resulted in an off-road crash occurrence, however, a number of rollover events were also observed (14.3 percent of departures) in circumstances where the driver woke and initiated panic-induced steering corrections.

- *Causal Factor/UDA Assignment Patterns* - The fell asleep causal factor was typically the only factor assigned. UDA assignments included driving while drowsy and drifting to the left or right as appropriate.

- *Situational Characteristics* - The full range of roadway types were noted in the sample and all but one of the crashes in the sample involved local trips of a relatively short intended duration. Most of the crashes occurred during hours of darkness (56.3 percent) with most of these crashes occurring between 2 am and 5 am (67 percent). All of the crashes that occurred during daylight hours involved workers who were coming home following a night shift (28.6 percent) were coming home following an extended day shift (14.3 percent), or were reporting to work for a day shift (57.1 percent). All of these subject drivers (daytime crashes) reported associated periods of sleep deprivation (i.e., slept 1-5 hours in the preceding 24 hour period).

- *Driver Demographic Characteristics* - Males (87.5 percent) dominated the age distribution for this problem type with younger male drivers (<35 years) clearly over-represented (68.8 percent).

- *Drivers Perspective of Crash Sequence* - All of the drivers involved in this crash problem type admitted to falling asleep during the pre-crash interval.

4.2.4.2 Problem Type 2: Driver Inattention

This problem type represented 1.6 percent of the UDA sample. In this scenario, the subject driver was traveling on a roadway, became inattentive to the driving task, and as a result of the inattention subsequently departed the roadway (85.7 percent) and was involved in an off-road crash sequence. In the remaining crashes, the subject driver struck a vehicle that was legally parked within the roadway. Roadway departure angles in this scenario were relatively shallow (2-5 degrees) with the exception of those departures which occurred on curved roadway segments.

- *Causal Factor/UDA Assignment Patterns* - The driver inattention causal factor was typically the only factor assigned. UDA designations included driving while inattentive to the driving task and drifting to the left or right as appropriate. In addition, a speed control UDA [typically exceeding the speed limit by less than 25 km/h (15 mph)] was assigned to 21 percent of these crashes to indicate that vehicle travel speed contributed to crash causation/severity.

- *Situational Characteristics* - These crashes typically occurred on local and collector roadways which the subject drivers traveled daily. The crashes also occurred during periods of very light to light traffic densities and during daylight hours and clear weather conditions. It should be noted, however, that the proportion of crashes in this scenario which occurred during the hours of darkness (21 percent) was much higher than noted in scenarios associated with rear end crashes. The latter incidence rate may have been associated with the increased roadway familiarity levels noted for crashes in this scenario. The specific inattention mechanisms/factors associated with crashes in this problem type are summarized below:

Inattention Mechanism/Factor	Proportion (%)
Looking to right (unspecified focus)	14.3
Looking to right (adjusting radio/reaching into ash tray)*	28.6
Looking to right (conversing with passenger)	14.3
Looking to right (checking baby passenger)*	7.1
Looking to right (reaching into purse)*	14.3
Looking down (retrieving and lighting cigarette)	7.1
Unknown	14.3
Total	**100.0**

* It is important to note that the proportion of inattention mechanisms associated with reaching movements in this problem type (50 percent) was higher than comparable values noted in rear end crashes. The reaching movements, in this problem type, were typically associated with departures from straight roadway segments. Specifically, the reaching movements induced inadvertent steering inputs that resulted in roadway departure. The more passive inattention mechanisms in this crash type were typically associated with departure from curved segments (e.g., subject vehicle continued straight ahead as roadway curved either left or right).

- *Driver Demographic Characteristics* - Females were over-represented in the age distribution (53.3 percent) for this problem type and females under (<35 years), in particular were over-represented (42.9 percent).

- *Driver's Perspective of Crash Sequence* - Most drivers in this problem type accepted responsibility for crash occurrence. A significant proportion (28.6 percent), however, attempted to mask the significance of the inattention mechanism by indicating that there was an associated loss of vehicle control which led to roadway departure. Since all of the subject vehicles departed the roadway in a tracking attitude (e.g., rear wheels tracking over the path of the front wheels) and at relatively shallow departure angles, these allegations were discounted.

4.2.4.3 Problem Type 3: DUI/DWI Crashes

This problem type represented 1.5 percent of the UDA sample. In this scenario, the subject driver allowed the vehicle to exit the roadway (to left or right). The subject vehicle then became involved in an off-road crash sequence or rollover event. Roadway departure angles were typically in the 2-7 degree range with even larger departure angles noted in cases where the subject vehicle crossed to the left side of the roadway. Departure angles for DUI drivers tended to be more shallow and essentially paralleled the angles noted for drivers who fell asleep. Departure angles for DWI drivers (who often relinquished steering control) tended to be larger and paralleled or exceeded the angles noted for inattentive drivers in the preceding problem type.

- *Causal Factor/UDA Assignment Patterns* - The DUI/DWI causal factor was assigned in every case. UDA assignments included the DUI/DWI designations and drifting to the left or right as appropriate. In addition, speed control UDAs were assigned in 50 percent of the crashes to indicate the contribution of vehicle speed in crash causation (see discussion of situational characteristics).

- *Situational Characteristics* - Most of the crashes in this problem type occurred on collector, local, or minor arterial roadway during periods of darkness (82.1 percent). These crashes, in fact, occurred most frequently between midnight and five am (53.6 percent) with an additional 21.4 percent occurring between 8 pm and midnight. Due to the time of crash occurrence, traffic densities at the crash sites tended to be very low. The relative proportion of these crashes involving subject drivers who were exceeding the speed limit was very high (50 percent). Of those drivers who were exceeding the speed limit 28.6 percent were exceeding the limit by more than 24 km/h (15 mph) and the remainder were exceeding limit by 8-24 km/h (5-15 mph). Although the vehicle speed factor was not the primary causal factor in these crashes, this factor contributed to causation and was a definite factor in crash severity.

- *Driver Demographic Characteristics* - Younger male drivers (<35 years) were over-represented (42.9 percent) in the age distribution profile as were male drivers in the 35-54 year age group (35.7 percent).

- *Driver's Perspective of Crash Sequence* - A relatively small proportion of the subject drivers in this crash type admitted to drinking prior to crash occurrence. Most drivers, in fact, attributed crash occurrence to a wide range of events, roadway conditions, or weather factors which were not supported by available evidence.

4.2.5 Crash Type 6: Intersecting Straight Paths

Problem types in this crash type were very similar in nature to problem types identified in Crash Type 4 (Section 4.2.2). The three most frequently occurring problem types in this crash type represented 4.1 percent of the UDA sample.

4.2.5.1 Problem Type 1: Looked, Did Not See - Perceptual Error

This problem type was the most frequently occurring problem type within crash type 6 and represented 1.6 percent of the UDA sample. All of the crashes in this problem type occurred at intersection locations where the direction of approach of the subject vehicle was controlled by a stop sign and the direction of approach of the other involved vehicle was uncontrolled (i.e., no TCD). In all of these crashes, the approach trajectories of the involved vehicles were initially separated by 90 degrees and the subject driver had intended to proceed straight through the intersection. In most of the crashes, the other vehicle approached the intersection from the subject driver's right (71.4 percent). The subject driver initially checked for cross-traffic, did not recognize the visual cues presented by the other vehicle, and in effect, "did not see" that vehicle. As a result, the subject driver accelerated into the intersection and was typically struck by the approaching vehicle (71.4 percent). In the remaining crashes, (28.6 percent) the subject vehicle struck the side of the other vehicle as the other vehicle passed in front of the subject vehicle.

- *Causal Factor/UDA Assignment Patterns* - The looked, but did not see causal factor was typically the only factor assigned to the subject driver. UDA assignments included crossing in close proximity and failure to yield the right-of-way designations.

- *Situational Characteristics* - These crashes typically occurred during daylight hours (92.9 percent) and during clear weather conditions (92.9 percent). All of the subject vehicles were initially traveling on local roadways or lower level collector roadways. Surrounding traffic densities ranged from very light (typical) to moderate.

- *Driver Demographic Characteristics* - The full range of driver age and gender characteristics were contained in the clinical sample. Older drivers, however, were over-represented with 42.8 percent of the drivers exceeding the age of 55 and 35.7 percent exceeding the age of 70. Very distinctive patterns were noted within age groups as follows:

  + Older Drivers (>55 years) - Crash involvement for this age group may have been related to a degradation of perceptual capabilities.

  + Middle Age Group - Crash involvement appeared to be related to an inappropriate traffic scanning technique. Drivers initially checked for cross-traffic and then refocused to the straight ahead view without rechecking in either direction.

  + Younger Drivers - (<35 years) - Crash involvement appeared to be related to performing perfunctory checks for cross-traffic. Underlying reasons for performing these types of checks appeared to be approximately evenly divided between aggressive driving traits and driver inexperience.

- *Driver's Perspective of Crash Sequence* - Most of the subject drivers involved in this problem type indicated that they did not see the approaching vehicle and did not attempt to shift responsibility to the approaching vehicle.

4.2.5.2 Problem Type 2: Driver Inattention/TCD Violation

This problem type was the second most frequently occurring problem type within crash type 6 and represented 1.3 percent of the UDA sample. All of the crashes in this problem type occurred at intersection locations where the direction of approach of the subject vehicle was controlled by either a traffic signal (80 percent) or stop sign (20 percent). In all of these crashes, the approach trajectories of the involved vehicles were initially separated by 90 degrees and both involved drivers had intended to proceed straight through the intersection. While approaching the intersection, the subject driver became inattentive to the driving task, and as a result violated either an indicated red signal phase or a stop sign (i.e., entered intersection without stopping). The subject vehicle was struck by the approaching vehicle in 50 percent of the crashes and struck the approaching vehicle in 50 percent of the crashes.

- *Causal Factor/UDA Assignment Patterns* - The driver inattention causal factors and UDA designations were assigned in combination with factors that indicated violation of a TCD. An additional UDA indicating the failure to yield the right-of-way was also assigned.

- *Situational Characteristics* - Most of these crashes occurred during daylight hours, in clear weather conditions, and during periods of light to moderate traffic densities. Most of the crashes also involved violation of traffic signals (80 percent) as opposed to stop signs (20 percent). This latter finding, however, must be interpreted cautiously since previous research shows that inattentive drivers typically violate stop signs more frequently than traffic signals due to the stronger visual cues provided by traffic signals. The reverse trend finding in this study may have reflected a location bias in the four NASS sites selected for the data collection effort.

The specific inattention mechanisms associated with these crashes are summarized below:

Inattention Mechanism/Factor	Proportion (%)
Looking to right (searching for street address)	10.0
Looking to right (hanging up cell phone)	10.0
Looking to right (conversing with passenger)	10.0
Looking to right (street construction)	10.0
Looking to left (unspecified focus)	10.0
Focusing on internal thoughts	20.0
Unknown	30.0
Total	**100.0**

- *Driver Demographic Characteristics* - All of the subject drivers in the clinical sample were less than 35 years of age.

- *Driver's Perspective of Crash Sequence* - Most of the drivers in this clinical sample were either unaware of TCD presence or were unaware of the specific signal phase that was displayed for their travel direction. These drivers typically did not attempt to shift responsibility for crash occurrence.

4.2.5.3 Problem Type 3: Crossed With Obstructed View - Decision Error

This problem type represented 1.2 percent of the UDA sample. All of the crashes in this problem type occurred at intersection locations where the direction of approach of the subject vehicle was controlled by a stop sign. In all of these crashes, the approach trajectories of the involved vehicles were initially separated by 90 degrees and both involved drivers had intended to proceed straight through the intersection. The subject driver's view of the approaching vehicle was blocked/obstructed by intervening vehicles that were typically stopped/parked. The subject vehicle was most frequently struck by vehicles approaching from the subject driver's right (57 percent) and in this circumstance the intervening vehicle was either parked at the intersection corner (immediately to the right of the subject vehicle) or was stopped in the traffic lane closest to the subject vehicle and immediately to the right of that vehicle. In crashes where the other vehicle was approaching from the subject driver's left, the intervening vehicle was stopped/parked at the intersection corner immediately to the left of the subject driver.

- *Causal Factor/UDA Assignment Patterns* - The crossed with obstructed view causal factor was typically the only causal factor assigned to the subject driver. UDA assignments included crossing with an obstructed view, crossing in close proximity, and failure to yield the right-of-way.

- *Situational Characteristics* - All of these crashes occurred during daylight hours and all of the subject drivers initially approached the intersection traveling on local roadways or lower level collector roadways. Traffic densities on the intersecting roadway that the subject driver was attempting to cross were typically moderate to moderately heavy.

- *Driver Demographic Characteristics* - This sample was not sufficiently large to accurately establish age and gender characteristics. Given this limitation, it appeared that males in the 35-54 year old age group were over-represented.

- *Driver's Perspective of Crash Sequence* - Most of the subject drivers in this sample stated that they did not see the other vehicle in sufficient time to avoid the crash. They did not attempt to shift crash responsibility to the other driver.

4.2.6 Crash Type 5: Same Trafficway, Opposite Direction - ODIR Impact

In this crash type, the crash involved vehicles were initially traveling in opposite directions. One of the vehicles crossed into the other vehicle's travel lane resulting in a head-on, offset frontal, or oblique front-to-side impact configuration. The three most frequently occurring problem types in this crash type represented 2.6 percent of the UDA sample.

4.2.6.1 Problem Type 1: Driver Inattention

This problem type represented 0.9 percent of the UDA sample. In this scenario, the subject driver became inattentive to the driving task and then drifted to the left as a result of the inattention, entering the opposing traffic lane. In the subsequent collision sequence, the subject vehicle most frequently struck the side of the other involved vehicle (36.4 percent). The second most frequent configuration was the right side of the subject vehicle being struck by the front of the other involved vehicle (33.3 percent). The remainder of the impact configurations involved head-on impacts (18.2 percent) and off-set frontal impacts (18.2 percent).

- *Causal Factor/UDA Assignment Patterns* - The driver inattention causal factor and UDA designations were assigned to all subject drivers. In addition, vehicle speed causal factor and UDA designations were assigned to 45.5 percent of the subject drivers to indicate that the vehicles's travel speed contributed crash causation/crash severity. Drifting into the opposing travel lane UDA designation was also coded as appropriate.

- *Situational Characteristics* - Most of these crashes (87.5 percent) occurred during daylight hours and clear weather conditions. Most of the crashes (72.7 percent) also occurred on rural collector or local roadways during periods when traffic densities were relatively light. In terms of roadway profiles, most of the crashes occurred at locations where the subject driver was negotiating a right curve (45.5 percent) with the remaining crashes occurring on straight segments (36.4 percent) or at locations involving left curves (18.1 percent). The specific types of inattention mechanisms/factors associated with this problem type are summarized below:

Inattention Mechanism/Factor	Proportion (%)
Looking to right (reaching for tools on seat)	9.1
Looking to right (conversing with passenger)	9.1
Looking to right (checking delivery log back on seat)	9.1
Looking down (retrieving object from left floor pan)	9.1
Looking down (reading magazine)	9.1
Focusing on internal thoughts	9.1
Unknown inattention mechanism	45.4
Total	**100.0**

- *Driver Demographic Characteristics* - Younger male and female drivers (<35 years) were equally over-represented with the combined groups comprising nearly 70 percent of the clinical sample.

- *Driver's Perspective of Crash Sequence* - Less than half of the subject drivers in this problem type admitted to being inattentive to the driving task. Drivers who admitted to being inattentive also assumed crash responsibility. Those who did not admit to being inattentive typically shifted responsibility to a variety of design deficiencies or indicated that they didn't know why the crash occurred.

4.2.6.2 Problem Type 2: Lost Directional Control

This problem type represented 0.9 percent of the UDA sample. In this scenario, the subject driver lost directional control as a result of traversing an icy (50 percent) or wet surface (50 percent). The subject vehicle subsequently skidded into the opposing traffic lane and was most frequently involved in a front to side impact configuration (42.9 percent) with the other involved vehicle. In the remaining crashes the subject vehicle was involved in an off-set frontal impact configuration (35.7 percent), in a head-on impact configuration (14.3 percent), or was struck in the rear (6.1 percent).

- *Causal Factor/UDA Assignment Patterns* - The lost directional control causal factor and directional control UDA designations were assigned to all subject drivers. In addition, most subject drivers (92.9 percent) were assigned a speed control UDA that indicated the initial speed of the subject vehicle was within the speed limit, but inappropriate for given weather/roadway surface conditions.

- *Situational Characteristics* - Most of these crashes occurred during daylight conditions (92.9 percent) and all of the crashes occurred on wet/icy surfaces. The crashes also occurred most frequently on curved roadway segments involving a curve to the right (50 percent) followed by crashes occurring on straight segments (42.9 percent).

- *Driver Demographic Characteristics* - Younger female drivers (<35 years) appeared to be over-represented (38.5 percent) as did male drivers in the 35-54 year age group (30.8 percent).

- *Driver's Perspective of Crash Sequence* - Drivers in this scenario typically admitted that they should have driven more cautiously and did not attempt to shift crash responsibility.

4.2.6.3 Problem Type 3: Excessive Vehicle Speed

This problem type represented 0.8 percent of the UDA sample. In this scenario, the subject driver lost directional control while traversing a right curve at a speed which exceeded the posted speed limit by more than 24 km/h (15 mph). All of the crashes in this scenario occurred on dry surfaces and the loss of control in each crash was attributed to excessive vehicle speed. The subject vehicle subsequently skidded into the opposing travel lane and was involved in a head-on impact or off-set frontal impact with the other involved vehicle. The available clinical sample was not sufficiently large to establish the complete range of situational characteristics or driver demographic characteristics. All of the drivers in the sample, however, were younger drivers (<35 years) and were typically male.

4.2.7 Crash Type 7: Other/Miscellaneous Crashes

This crash type contained a wide array of crash types and circumstances which could not be classified in the first six defined crash types. The three most frequently occurring problem types represented 1.3 percent of the UDA sample. Due to the wide array of impact configurations and crash circumstances associated with this crash type and the relatively small size of available case samples it was generally not feasible to develop detailed scenario descriptions or to describe situational characteristics and driver demographic patterns associated with these crashes.

4.2.7.1 Problem Type 1: Excessive Vehicle Speed

This problem type represented 0.5 percent of the UDA sample. A wide array of crash types and circumstances were found in the clinical sample. For example, in one crash sequence the subject vehicle was traveling on a multi-lane roadway, traversing a curve to the left. Due to the travel speed of the vehicle, it rolled over to the right and landed on top of a vehicle in the adjoining lane to the right. In a second case, the front of the subject vehicle struck the bottom surface of the other involved vehicle which had rolled onto its left side and came to rest in the subject vehicle's travel lane. The single common thread which tied all of these crashes together was that the initial travel speed of the subject vehicle was inappropriate and precipitated the subject vehicle's involvement in the crash sequence. While most of the subject vehicle's were exceeding the speed limit, approximately one-third of these vehicles were within the speed limit, but were traveling at speeds that were inappropriate for given surface conditions (e.g., icy) or given weather conditions (e.g., heavy rain).

4.2.7.2 Problem Type 2: Following Too Closely

This problem type represented 0.4 percent of the UDA sample and again involved a range of unusual circumstances. For example, in one crash sequence the subject vehicle was following behind a vehicle that was initially involved in an off-set frontal impact. The subject vehicle struck the side of this vehicle as it spun out following the initial frontal impact. The common thread which defined this group was the subject vehicle following closely behind another vehicle and subsequent crash involvement of the subject vehicle as a result of following too closely.

4.2.7.3 Problem Type 3: Sudden Deceleration

This problem type represented 0.4 percent of the UDA sample. In this problem type, the subject vehicle was typically a lead vehicle that decelerated suddenly to avoid a non-contact vehicle moving across its path. The subject vehicle was subsequently struck in the side (i.e., side impact) by the following vehicle. The misalignment between lead and following vehicles was associated with steering/braking inputs by the subject driver, steering/braking inputs by the following driver, or a combination of both sources.

4.2.8 Problem Type Summary

Key characteristics of crash problem types discussed in preceding sections are summarized in Table 4-3 through 4-9 in the material that follows:

Table 4-3
Same Direction, Rear End Crashes (Problem Types 1-4)

Crash Type/ Problem Type	Key Characteristics
• Driver Inattention - Mid Range Travel Speeds 5.6 Percent of UDA Sample	• Subject driver was inattentive to the driving task and struck the rear of a lead vehicle. • Subject vehicles were initially traveling at speeds of 49-72 km/h (30-45 mph). • Crashes typically occurred on urban/suburban arterial roadways during periods of moderately heavy traffic densities. • Crashes occurred during daylight hours and clear weather conditions. • Inattention mechanisms were varied and included looking at buildings/pedestrians (22.7 percent), traffic in adjoining lanes, (3.2 percent), traffic sign (3.2 percent), approaching traffic (9.7 percent), retrieving objects (3.2 percent), and focusing on internal thought processes (9.7 percent). • Younger drivers (<35 years) were over-represented (80 percent) and younger male drivers, in particular, were over-represented (52 percent). • Drivers admitting to inattention did not attempt to shift crash responsibility.
• Driver Inattention - Low Range Travel Speeds 2.5 Percent of UDA Sample	• Subject driver was inattentive to the driving task and struck the rear of a lead vehicle. • Subject vehicles were initially traveling at speeds of 25-48 km/h (15-29 mph). • Two scenarios were identified. In the most frequently occurring scenario (76 percent), the subject driver was traveling on urban/suburban surface street and in the second scenario the subject driver was traveling on an entrance ramp to an expressway/interstate roadway. • Nearly all crashes occurred during daylight hours, in clear weather conditions, and in heavy traffic densities. • Drivers in the ramp scenario were inattentive as a result of focusing on traffic in the through lanes. Inattention mechanisms for drivers on surface streets were varied and included looking at buildings (5.3 percent), adjusting cassette player (5.3 percent), conversing with passengers (15.8 percent), looking at approaching traffic (5.3 percent), looking in rear view mirror (26.1 percent), and focusing on internal thought processes (5.3 percent). • Younger drivers (<35 years) were over-represented (61 percent) in this problem type. • Drivers did not attempt to shift crash responsibility.
• Driver Inattention - High Range Travel Speeds 2.4 Percent of UDA Sample	• Subject driver was inattentive to the driving ask and struck the rear of a lead vehicle. • Subject vehicles were initially traveling at speeds of 73-96 km/h (46-60 mph). • Crashes occurred on arterial roadways during daylight hours, in clear weather, and during periods of moderate to heavy traffic densities. • Inattention mechanisms included looking at traffic in an adjoining lane (20.0 percent), conversing with passengers (10.0 percent), and focusing on internal thought processes (30.0 percent). • Older drivers (>55 years) appeared to be over-represented (30 percent). • Approximately 40 percent of drivers attempted to shift crash responsibility.
• Following Too Closely - High Range Travel Speeds 2.4 Percent of UDA Sample	• General characteristics duplicated preceding scenarios with the exception that the subject driver struck the lead vehicle as a result of following too closely. • Subject vehicle struck lead vehicle while it was still moving. • Male drivers were over-represented in the sample. • Subject drivers shifted crash responsibility to lead vehicle.

Table 4-4
Turn, Merge, Path Encroachment Crashes (Problem Types 1-4)

Crash Type/ Problem Type	Key Characteristics
1. Looked, Did Not See 4.1 Percent of UDA Sample	• Subject driver did not see other crash involved vehicle. • 90 and 180 degree approach trajectory scenarios identified. • Intended left turn across path of other vehicle or into path of other vehicle. • Occurred at intersections controlled by stop sign - 90 degree scenario. • Occurred at intersections controlled by traffic signal - 180 degree scenario. • Small proportion occurred at commercial assesses - entering (180 degree) exiting (90 degree). • Occurred during daylight hours and clear weather conditions. • 90 degree scenario occurred in light traffic densities - 180 degree scenario occurred in full range of densities. • Older drivers over-represented [(25 percent >70 years of age), (50 percent >55 years of age)]. • Drivers in the 35-54 year age group appeared to be involved as a result of an inappropriate traffic scanning technique. • Younger drivers (<35 years) were also over-represented and appeared to be involved as a result of completing perfunctory traffic checks. • Accepted crash responsibility.
2. Accepted Inadequate Gap To Other Vehicle 3.3 Percent of UDA Sample	• Driver noted presence of other vehicle, but misjudged the distance to that vehicle or the approach velocity of that vehicle. • 90 and 180 degree approach trajectory scenarios identified. • Primarily left turn across path of approaching vehicle. Small portion of 90 degree scenario drivers initiated a right turn into the path of the approaching vehicle. • Occurred at intersections controlled by a stop sign - 90 degree scenario. • Occurred at intersections controlled by a traffic signal - 180 degree scenario. • Occurred during daylight hours and clear weather conditions. • 90 degree scenario occurred in light traffic densities - 180 degree scenario occurred in full range of traffic densities. • Younger drivers (<35 years) were over-represented in 90 degree scenario (86 percent) - associated with aggressive driving traits. • Older drivers were over-represented in 180 degree scenario with 21 percent exceeding age 70 and 42 percent exceeding age 55. • Older male and younger female drivers shifted crash responsibility to the other driver.
3. Turned With Obstructed View 2.3 Percent of UDA Sample	• Intervening non-contact vehicle blocked subject drivers view of other crash-involved vehicle. • 90 and 180 degree approach trajectory scenarios identified. • Subject driver initiated left turn across path of other vehicle. • Occurred at intersections controlled by a stop sign - 90 degree scenario. • Occurred at intersections controlled by a traffic signal - 180 degree scenario. • Occurred during daylight hours, in clear weather conditions, and in moderate to heavy traffic densities. • Younger drivers (<35 years) were over-represented in 90 degree scenario (56 percent) with no evidence of aggressive driving. • Older drivers were over-represented in 180 degree scenario with 46 percent exceeding the age of 55 and 23 percent exceeding the age of 70. • Older male drivers and female drivers tended to shift crash responsibility to the other driver.
4. Driver Inattention /TCD Violation 2.3 Percent of UDA Sample	• Subject driver was inattentive to the driving task and violated TCD. • 90 and 180 degree approach trajectory scenarios identified. • Subject driver either violated a TCD and struck a left turning vehicle or violated a TCD, turnd left, and was struck by the other crash-involved vehicle. • Most TCD violations involved traffic signals (85 percent), occurred during daylight hours, in clear weather conditions, and during a range of traffic densities. • Inattention mechanisms were varied and included looking for street signs (7.1 percent), conversing with passengers (7.1 percent), and focusing on internal thought processes (28.6 percent). • Younger males drivers (<35 years) were over-represented (42.9 percent) as were males in general (85 percent).

Table 4-5
Single Driver, Roadside Departure With Traction Loss Crashes
(Problem Types 1-3)

Crash Type/ Problem Type	Key Characteristics
Excessive Vehicle Speed 2.3 Percent of UDA Sample	• Subject driver was typically approaching a curve (76.5 percent) while exceeding the speed limit by more than 24 km/h (15 mph). As a result of this travel speed, vehicle exited the roadway. • Most of the crashes occurred on local or collector roadways (64.7 percent) during periods of darkness (58.8 percent) and during clear weather (88.2 percent) • Younger males (<35 years) were over-represented (65.4 percent) with males less than 20 years of age comprising 46.2 percnet of the sample. • Most drivers attempted to shift crash responsibility to a variety of design characteristics or roadway condition factors.
DUI/DWI With Excessive Vehicle Speed 1.6 Percent of UDA Sample	• All of the subject drivers were classified as DUI or DWI. • These drivers were typically approaching a curve (76.5 percent) while exceeding the speed limit by more than 24 km/h (15 mph) - 53 percent. • As a result of the alcohol and vehicle speed factors, the subject drivers lost directional control and exited the roadway. • Most of the crashes occurred on local or collector roadways (64.7 percent) during periods of darkness (76.5 percent) and during clear weather conditions (88.2 percent). • Younger drivers (<35 years) were over-represented (58.8 percent) in the age distribution. • Most drivers attempted to shift crash responsibility to roadway design characteristics, roadway condition factors, or visibility limitations.
DUI/DWI Crashes 1.6 Percent of UDA Sample	• With the exception of the vehicle speed factor, all other aspects of this problem type either duplicated or paralleled characteristics in the preceding problem type.

Table 4-6
Single Driver, Roadside Departure Without Traction Loss Crashes (Problem Types 1-3)

Crash Type/ Problem Type	Key Characteristics
Driver Fatigue 1.7 Percent of UDA Sample	• Subject driver fell asleep departing the roadway to the left or right. • Drivers were typically completing short duration local trips. • Crashes typically occurred during the hours of darkness (56.3 percent) with the most of the night crashes occurring between 2 am and 5 am. • All of the crashes that occurred in daylight hours involved workers coming home from work or traveling to work. All of these drivers reported sleep deprivation in the preceding 24 hour period. • Younger males (<35 years) were over-represented in the age distribution (68.9 percent). • All of the subject drivers admitted falling asleep and did not attempt to shift crash responsibility.
Driver Inattention 1.6 Percent of UDA Sample	• Subject driver became inattentive and allowed the vehicle to drift off the roadway to the left or right • Crashes typically occurred during daylight hours, in clear weather conditions, and during periods of light traffic densities. • Inattention mechanisms included adjusting radio/reaching into ash tray (28.6 percent), conversing with passengers (14.3 percent), checking baby passenger (7.1 percent), reaching into purse (14.3 percent), and retrieving/lighting cigarette (7.1 percent). • Younger female drivers (<35 years) were over-represented in the age distribution (42.9 percent). • Most drivers in this crash type did not attempt to shift crash responsibility.
DUI/DWI Crashes 1.5 Percent of UDA Sample	• Subject driver exited the roadway as a result of a DUI/DWI circumstance. • Most of the crashes occurred on local or collector roadways during periods of darkness with the highest proportion occurring between midnight and 5 am (53.6 percent). • Crashes were often associated with vehicle speed. Specifically, the driver was exceeding the speed limit in 50.0 percent of these crashes. • Younger male drivers (<35 years) were over-represented (42.9 percent) as were male drivers between the ages of 35-54 (35.7 percent). • Drivers typically did not admit to consuming alcoholic beverages prior to crash occurrence.

Table 4-7
Intersecting Paths, Straight Paths Crashes
(Problem Types 1-3)

Crash Type/ Problem Type	Key Characteristics
Looked, Did Not See 1.6 Percent of UDA Sample	• All crashes occurred at intersection locations where the subject vehicle was controlled by a stop sign. • Approach trajectories were initially separated by 90 degrees. • Both drivers intended to proceed straight through the intersection. • The other crash-involved vehicle was typically approaching from the subject driver's right (71.4 percent). The subject driver did not see this vehicle and accelerated into the intersection. • Older drivers were over-represented with 35.7 percent of the drivers exceeding the age of 70 and 42.8 percent exceeding the age of 55. • Drivers between 35 and 54 years of age appeared to be involved as a result of using inappropriate traffic scanning techniques. Younger drivers (<35 years) were involved as a result of performing perfunctory traffic checks. • Drivers did not attempt to shift crash responsibility.
Driver Inattention/TSC Violation 1.3 Percent of UDA Sample	• All crashes occurred at intersection locations that were typically controlled by traffic signals (80 percent). • Approach trajectories of involved vehicles were initially separated by 90 degrees. • Due to inattention to the driving task, subject driver violated TCD and entered intersection. • Crashes occurred during daylight hours and clear weather conditions. • Inattention mechanisms included looking for street address (10.0 percent), hanging up cell phone (10.0 percent), conversing with passenger (10.0 percent), and focusing on internal thought processes (20.0 percent). • All of the drivers in the sample were less than 35 years of age. • Drivers did not attempt to shift crash responsibility.
Crossed With Obstructed View 1.2 Percent of UDA Sample	• All crashes occurred at intersection locations where the subject vehicle's direction of travel was controlled by a stop sign. • Approach trajectories of involved vehicles were initially separated by 90 degrees. • Other vehicle was most frequently approaching from the subject driver's right (57 percent). • Subject driver's view of approaching vehicle was blocked by intervening vehicle. • All crashes occurred during daylight hours and during periods of moderate to moderately heavy traffic densities. • Sample size was limited, but males in the 35-54 year age group appeared to be over-represented. • Drivers did not attempt to shift crash responsibility.

Table 4-8
Same Trafficway, Opposite Direction Crashes
(Problem Types 1-3)

Crash Type/ Problem Type	Key Characteristics
1. Driver Inattention 0.9 Percent of UDA Sample	• Trajectories of involved vehicles were initially 180 degrees opposed. • The subject driver became inattentive to the driving task and allowed the subject vehicle to drift into the opposing traffic lane. • The subject vehicle most frequently struck the side of the other vehicle (36.4 percent) or was struck in the side by the other vehicle (33.3 percent). The remaining crashes were either head-on configurations or off-set frontal configurations. • Most crashes occurred during daylight hours and clear weather conditions (87.5 percent) and during periods of light traffic densities. • Inattention mechanisms included reaching for tools on seat (9.1 percent), conversing with passengers (9.1 percent), checking delivery log, (9.1 percent), retrieving object from left floor pan (9.1 percent), reading magazine (9.1 percent), and focusing on internal thought processes (9.1 percent). • Younger drivers (<35 years) were over-represented in the age distribution (70 percent). • More than half of the drivers attempted to shift crash responsibility.
2. Lost Directional Control 0.9 Percent of UDA Sample	• The subject driver lost directional control while traversing a wet or icy surface and crossed into the opposing travel lane. • Most of the drivers were traveling within the speed limit (92.9 percent), however, the travel speed was inappropriate for given weather/road surface conditions. • The most frequent impact configurations were front to side (42.9 percent), off-set frontal (35.7 percent), and head-on (14.3 percent). • Younger female drivers (<35 years) were over-represented (38.5 percent) as were male drivers between the age of 35 and 54 (30.8 percent). • Most drivers accepted crash responsibility.
3. Excessive Vehicle Speed 0.8 Percent of UDA Sample	• Subject drivers lost directional control while traveling on dry surfaces as a result of excessive vehicle speed. • Subject vehicles crossed into opposing travel lanes and were involved in head-on or off-set frontal impact configurations. • Clinical sample size was insufficient to establish the range of situational characteristics. All of the drivers in the sample, however, were less than 35 years of age.

Table 4-9
Other, Miscellaneous Crashes
(Problem Types 1-3)

Crash Type/ Problem Type	Key Characteristics
1. Excessive Speed 0.5 Percent of UDA Sample	• Subject vehicles were involved in a wide array of unusual impact configurations. • The common thread tying these crashes together was involvement of the subject vehicle due to excessive speed. • The clinical sample size was insufficient to establish the range of situational characteristics or demographic characteristics.
2. Following Too Closely 0.4 Percent of UDA Sample	• Subject vehicles were involved in a wide array of unusual impact configurations. • The subject vehicle's crash involvement could be traced to following too closely behind a lead vehicle. • The clinical sample size was insufficient to establish the range of situational characteristics or demographic characteristics.
3. Sudden Deceleration 0.4 Percent of UDA Sample	• Subject vehicles were lead vehicles that decelerated suddenly due to a non-contact vehicle crossing its intended travel path. • Sudden deceleration steering/braking inputs resulted in a misalignment between the lead and following vehicles such that a nominal rear end crash configuration was changed to a front to side impact configuration. • The clinical sample size was insufficient to establish the range of situational characteristics or demographic characteristics.

SECTION 5
COUNTERMEASURE ASSESSMENT/APPLICATION

The focus of this effort was to identify countermeasures in the education/training/law enforcement areas. Given the nature of the crash problem types identified in this effort, however, it is important to recognize that some of the "best" long term solutions are associated with technology-based countermeasures emerging from the intelligent transportation systems (ITS) field. The project staff has elected to identify a limited range of these technology-based countermeasures to ensure that complete coverage is provided for each identified problem type. Education/training/law enforcement countermeasures are addressed in Section 5.1 and technology-based countermeasures are addressed in Section 5.2.

5.1 Education/Training/Law Enforcement Countermeasures

Recommended countermeasures for the 23 crash problem types discussed in Section 4 are summarized in Table 5-1. While all of the identified problem types could be addressed through either education or training countermeasures, Table 5-1 prioritizes countermeasures on the basis of which countermeasure type is likely to be most successful. For example, seven of the 23 identified problem types involve driver inattention as the primary factor associated with crash occurrence. This factor can be most effectively addressed, in the near term, though an education countermeasure that has a public information campaign as its central focus. Specifically, the general public should be informed of the relative size of this factor in the crash population, the crash types that result from this factor, relevant situational factors, and the specific types of inattention mechanisms that lead to crash occurrence. Inattention is a pervasive problem among all age groups of both genders. Relatively few of the crash-involved drivers in this sample appeared to be aware that removing attention from the driving task for even brief periods could result in crash involvement. Similarly, focusing on internal thoughts was noted in each of the identified problem types. This would be very difficult to detect because the drivers were typically looking forward and may have appeared to be attentive to other drivers/witnesses. Following crash occurrence, most of the drivers who were focusing on internal thoughts expressed an increased awareness of the relative risk associated with this inattention mechanism. A public information campaign focusing on these types of issues would increase the awareness levels of non-crash involved drivers.

"The looked, did not see", "Accepted inadequate gap to other vehicle", and "Turned/crossed with obstructed view" problems can be most effectively addressed, in the near term, with training countermeasures that focus on appropriate traffic scanning/checking techniques. The perceptual difficulties associated with older drivers in these problem types, however, could probably be most effectively addressed through low level public information campaigns specifically targeted to this group.

The remaining problem types are best suited to enhanced law enforcement countermeasures. The relatively strong association between DUI/DWI crashes and vehicle speed factors should be stressed in law enforcement countermeasure applications.

Table 5-1
Education/Training/Law Enforcement Countermeasures

Crash Type/Problem Type	Problem Size (%)	Countermeasure Type		
		Education	Training	Law Enforcement
Crash Type 3: Same Direction, Rear End				
Problem Type 1: Driver Inattention-Mid Range Travel Speeds	5.6	X		
Problem Type 2: Driver Inattention-Low Range Travel Speeds	2.5	X		
Problem Type 3: Driver Inattention-High Range Travel Speeds	2.4	X		
Problem Type 4: Following Too Closely	2.4		X	X
Crash Type 4: Turn, Merge, Path Encroachment				
Problem Type 1: Looked, Did Not See	4.1		X	
Problem Type 2: Accepted Inadequate Gap	3.3		X	
Problem Type 3: Turned With Obstructed View	2.3		X	
Problem Type 4: Driver Inattention/TCD Violation	2.3	X		
Crash Type 2: Single Driver, Roadside Departure With Traction Loss				
Problem Type 1: Excessive Vehicle Speed	2.3			X
Problem Type 2: DUI/DWI With Excessive Vehicle Speed	1.6			X
Problem Type 3: DUI/DWI	1.6			X
Crash Type 1: Single Driver, Roadside Departure Without Traction Loss				
Problem Type 1: Driver Fatigue	1.7	X		
Problem Type 2: Driver Inattention	1.6	X		
Problem Type 3: DUI/DWI	1.5			X
Crash Type 6: Intersecting Paths, Straight Paths				
Problem Type 1: Looked, Did Not See	1.6		X	
Problem Type 2: Driver Inattention/TCD	1.3	X		
Violation	1.2		X	
Problem Type 3: Crossed With Obstructed View				
Crash Type 5: Same Trafficway, Opposite Direction				
Problem Type 1: Driver Inattention	0.9	X		
Problem Type 2: Lost Directional Control	0.9		X	
Problem Type 3: Excessive Vehicle Speed	0.8			X
Crash Type 7: Other/Miscellaneous				
Problem Type 1: Excessive Vehicle Speed	0.5			X
Problem Type 2: Following Too Closely	0.4		X	X
Problem Type 3: Sudden Deceleration	0.4		X	
Total	**43.2**			

5.2 Technology-Based Countermeasures

Technology-based countermeasures that are likely to provide highly efficient solutions to the crash problem types identified in this report are summarized in Table 5-2. It must be stressed, however, that the systems indicated in Table 5-2 are either currently in development or are undergoing product refinement/engineering evaluations and are unlikely to be available in sufficient quantities, in the near term, to appreciably diminish the relative magnitude of any given problem type. These solutions should be viewed as long term applications that will provide efficient solutions in a 5-15 year time frame.

Rear end crash avoidance systems (including headway detection units and smart cruise control units) will be applicable to all of the problem types identified in crash type 3 (Rear End Crashes) as well as a relatively high proportion of the crashes contained in problem types 2 and 3 in crash type 7 (Other/Miscellaneous Crashes). Intersection collision avoidance systems will be applicable to all of the problem types identified in crash type 4 (Turn, Merge, Path Encroachment) and in crash type 6 (Intersecting Paths, Straight Paths). Lane keeping systems, on the other hand, will be applicable to all of the problem types identified in crash type 1 (Single Driver, Roadside Departure Without Traffic Loss) as well as crashes in problem type 1 of crash type 5 (Same Trafficway, Opposite Direction).

Table 5-2
Technology-Based Countermeasures

Crash Type/Problem Type	Problem Size (%)	Countermeasure Type: Rear End Crash Avoidance Systems	Countermeasure Type: Intersection Collision Avoidance Systems	Countermeasure Type: Lane Keeping Systems
Crash Type 3: Same Direction, Rear End				
Problem Type 1: Driver Inattention-Mid Range Travel Speeds	5.6	X		
Problem Type 2: Driver Inattention-Low Range Travel Speeds	2.5	X		
Problem Type 3: Driver Inattention-High Range Travel Speeds	2.4	X		
Problem Type 4: Following Too Closely	2.4	X		
Crash Type 4: Turn, Merge, Path Encroachment				
Problem Type 1: Looked, Did Not See	4.1		X	
Problem Type 2: Accepted Inadequate Gap	3.3		X	
Problem Type 3: Turned With Obstructed View	2.3		X	
Problem Type 4: Driver Inattention/TCD Violation	2.3		X	
Crash Type 2: Single Driver, Roadside Departure With Traction Loss				
Problem Type 1: Excessive Vehicle Speed	2.3			
Problem Type 2: DUI/DWI With Excessive Vehicle Speed	1.6			
Problem Type 3: DUI/DWI	1.6			
Crash Type 1: Single Driver, Roadside Departure Without Traction Loss				
Problem Type 1: Driver Fatigue	1.7			X
Problem Type 2: Driver Inattention	1.6			X
Problem Type 3: DUI/DWI	1.5			X
Crash Type 6: Intersecting Paths, Straight Paths				
Problem Type 1: Looked, Did Not See	1.6		X	
Problem Type 2: Driver Inattention/TCD Violation	1.3		X	
Problem Type 3: Crossed With Obstructed View	1.2		X	
Crash Type 5: Same Trafficway, Opposite Direction				
Problem Type 1: Driver Inattention	0.9			X
Problem Type 2: Lost Directional Control	0.9			
Problem Type 3: Excessive Vehicle Speed	0.8			
Crash Type 7: Other/Miscellaneous				
Problem Type 1: Excessive Vehicle Speed	0.5			
Problem Type 2: Following Too Closely	0.4	X		
Problem Type 3: Sudden Deceleration	0.4	X		
Total	**43.2**			

SECTION 6
CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations derived from this effort are presented in the subsections below. Additional discussion of major issues identified in the analysis sequence is also provided.

6.1 Conclusions

Major conclusions may be summarized as follows:

- The UDA database was a rich and interesting data set. As indicated in Section 3.1, however, study data for this effort was collected at only 4 of the 24 NASS sites for a period of 13 months. The resulting data sample was skewed and was not representative of the national crash population. Therefore, the specific size estimates of problem types identified in this effort must be viewed as suspect. This circumstance does not imply that study results are invalid. The project staff, in fact, is confident that problem types identified in this effort would retain their relative order of importance in a larger statistically representative sample. Characteristics of these problem types would also remain relatively stable in a larger statistically representative data set.

- There were a number of interesting patterns in the 78 UDA variables coded by NASS Researchers for this effort. For example, in the risk/influence of roadway, weather, and traffic condition variables (six variable sequence) the proportion of drivers indicating that there was increased risk associated with these conditions was relatively small (e.g., roadway conditions - 12.9 percent, weather conditions - 8.5 percent, traffic conditions - 7.1 percent). Only a portion of those drivers who recognized that there was an increased risk associated with these factors, believed that these factors influenced their own driving performance and, therefore, altered their driving pattern (e.g., roadway conditions - 71.3 percent, weather conditions - 82.4 percent, traffic conditions - 67.6 percent). A clinical review of cases where the drivers reported that there was no influence of the increased risk on their driving performance, found that there was a relatively high incidence rate of retrospective recognition of increased risk. There were also a number of drivers who believed that other drivers were behaving inappropriately or who believed that there was no association between the increased risk and crash occurrence.

- Approximately 12.6 percent of the drivers in this sample indicated that other drivers involved in the crash were driving aggressively. This result most be interpreted cautiously for the following reasons:

  + For this effort, the aggressive driving variable only addressed multi-vehicle crashes. This variable was not relevant to single vehicle crashes and those drivers were not questioned with respect to their own driving behavior.

  + Approximately 26 percent of the drivers who indicated that other drivers were driving aggressively were assessed as having primary responsibility for crash occurrence. A similar proportion of the drivers assessed as being aggressive were assessed by the project staff as either not contributing to crash causation (typical designation) or as being less responsible than the driver who made the assessment. Clearly, a significant rate of "blame shifting" had occurred.

+ A clinical review of the cases with these designations indicated that many of the assessments were made on the basis of the assessing driver's perception of crash events as opposed to the intent of the offending driver. For example, these were a number of crashes that involved inattentive drivers who violated traffic signals. The inattentive drivers were typically assessed as driving aggressively even though there was no intent by the offending driver to violate the traffic signal. Similar patterns were noted in crashes involving perceptual errors or decision errors. This finding has serious implications for survey results. Specifically, survey results are likely to overstate the incidence rate of aggressive driving unless a check mechanism (such as using a matched pair technique that includes both the witness and offending drivers) is incorporated to prevent misinterpretation of driver intent.

- Approximately 23 percent of the drivers in this sample reported that they were focused on a non-involved person, object, or event prior to the start of the collision course. Subsequent analyses indicated that most of these drivers were inattentive to the driving task and that the inattention was directly related to crash occurrence.

- Approximately 5.3 percent of the drivers in the sample reported less than one month of experience with respect to driving the crash-involved vehicle. This experience level factor was not causally related to crashes in the sample.

- A significant proportion of the drivers in the sample reported visual (25.4 percent). Visual impairments, particularly impairments reported by drivers exceeding the age of 55, were related to perceptual error crash problem types in the sample.

- Approximately 6.7 percent of the drivers in the sample reported that they were fatigued prior to the crash and an additional 2.0 percent reported that they were feeling ill prior to the crash. A very high proportion of these conditions were causally related to crash occurrence.

- Causal assessments were completed for 96.5 percent of the drivers in the unweighted sample. The pattern of assignments may be summarized as follows:

  + Driver inattention was the most dominant component of the causal factor pattern. Inattention was noted as the sole causal factor for 16.7 percent of the drivers who contributed to crash causation, was assigned as the primary causal factor in combination with other contributory factors for 5.2 percent of the drivers, and was assigned as a contributory factor for 0.8 percent of the drivers. Thus, the total sample contribution of the inattention factor was 22.7 percent.

- Vehicle speed factors were assigned at the primary level to 10.6 percent of the drivers who contributed to crash causation. The total sample contribution of this factor was 18.7 percent.

- DUI/DWI conditions were the sole causal factor for 6 percent of the drivers, were assigned as the primary causal factor in combination with other contributory factors for 11.1 percent of the drivers, and were assigned as a contributory factor for an additional 1.1 percent of the drivers. Thus, the total sample contribution of alcohol consumption factors was 18.2 percent.

- Perceptual errors in the form of looked, did not see (8.9 percent) and accepted inadequate gap to other vehicle (6.1 percent) scenarios were assigned at a primary level for 15 percent of the drivers who contributed to crash causation.

- Decision errors in the form of attempted to turn with an obstructed view (3.3 percent) and attempted to cross with an obstructed view (1.4 percent) scenarios were assigned at a primary level to 4.7 percent of the drivers who contributed to crash causation. The total sample contribution of this factor was 10.1 percent.

- Driver fatigue (4.4 percent) and driver incapacitation (2 percent) factors were assigned at a primary level to 6.4 percent of the drivers who contributed to crash causation.

• Unsafe driving actions (UDAs) were assigned to 732 of the 1284 drivers in the unweighted sample. All of these drivers were assigned a primary UDA (most relevant to crash causation), 531 were also assigned a first contributory UDA, and 219 drivers were assigned a second contributory UDA. Thus, the total number of UDAs assigned to the 732 drivers who committed UDAs was 1,482. The most frequently assigned primary UDAs were driver inattention (22.9 percent) followed by DUI/DWI (16.7 percent) and exceeded speed limit (11.6 percent). The most frequently assigned first contributory UDAs were failure to yield the right-of-way (21.4 percent) followed by exceeded the speed limit (15.5 percent) and turning in close proximity (9 percent). Second contributory UDAs included failure to yield the right-of-way (46.5 percent), exceeded the speed limit 15.9 percent), and drifting to the right side (12.9 percent).

• A multivariate analysis sequence which focused on six key variables (i.e., crash cause, BAC test result, primary behavior source, necessary UDA, travel speed, and first UDA in sequence) and a set of more general variables (i.e., driver age, sex, road surface condition, lighting, and roadway profile) was used to identify unique sets of crash problem types within a series of seven crash types. This sequence was very effective with respect to identifying specific case groups which comprised individual problem types. These case groups were subsequently clinically reviewed to determine problem type descriptions and associated characteristics. A total of 23 problem types were subsequently described in Section 4. Major points with respect to these problem types may be summarized as follows:

+ Driver inattention was the central focus of seven of the 23 problem types identified in Section 4. Combined, these problem types represented 16.6 percent of the UDA sample. This finding indicated that driver inattention was a pervasive factor in sample crashes. Younger drivers (<35 years) were over-represented in six of the seven identified problem types.

+ Perceptual errors were the central focus of three of the problem types identified in Section 4. Combined, these problem types represented 9.0 percent of the UDA sample. Older drivers (>55 years) were over-represented in four of the five scenarios identified within these problem types. The proportion of drivers exceeding 70 years of age in these scenarios was particularly revealing (i.e., ranged from 21 percent to 35 percent). Younger drivers (<35 years) were over-represented in the remaining scenario and the involvement of these drivers appeared to be related to completing perfunctory checks for approaching traffic.

+ Decision errors were the central focus of two of the problem types which represented 3.5 percent of the UDA sample. Older drivers (>55 years) were over-represented in one of the three scenarios associated with these problem types.

+ Excessive vehicle speed factors were the central focus of three of the problem types which represented 3.6 percent of the UDA sample. Younger drivers (<35 years) were over-represented in all three problem types.

+ Combined, these four groups of problem types accounted for 15 of the 23 identified problem types and 32.7 percent of the UDA sample.

6.2 Recommendations

Major recommendations deriving from this effort may be summarized as follows:

- Results of this study indicate that drivers tend to classify the behavior of other drivers on the basis of perceived outcome rather than intent. Therefore, surveys of driver behavior conducted in the future should incorporate a check mechanism to ensure that the incidence rate of aggressive driving is not overstated.

- Driver inattention was a pervasive factor in four of the seven crash types examined in this effort. This factor should receive high priority with respect to countermeasure application. The most effective short term approach would be to initiate an education countermeasure with a multi-media public information campaign as its central focus.

- Perceptual and decision error problems associated with older drivers should also be addressed. Given the aging status of the general population, these problem types are likely to continue increasing in size and relative prominence. Countermeasure applications include training programs and low level public information campaigns targeted to this age group.

- The analysis approach developed for this effort was highly effective and should be extended to a larger and statistically representative sample to map the entire crash population. It is estimated that the minimum required sample size would be a one year sample from the complete NASS system.

SECTION 7
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APPENDIX A

COMPARISON OF UDA AND INDIANA TRI-LEVEL CAUSAL ANALYSES

COMPARISON OF UDA AND INDIANA TRI-LEVEL CAUSAL ANALYSES

In this section, UDA causal analysis results are compared with Indiana Tri-Level analysis results. There are several factors to be considered in reviewing comparison results as follows:

- The focus of the Indiana Tri-Level study was identification of all factors related to crash occurrence. In contrast, the focus of the UDA study was identification of problem driving behaviors and identification of situational factors/characteristics associated with these behaviors. The more limited research objective of the UDA study was likely to result in an underreporting of environmental and vehicle factors as compared to the Tri-Level study or other more global studies of causation factors.

- A significant portion of the vehicle related factors in the Tri-Level study were related to braking system deficiencies (30.8 percent). The specific deficiencies noted in that study (e.g., gross failures, side-to-side imbalances, premature lock-up, etc.) occur at much lower frequency levels in the more advanced braking systems installed in vehicles manufactured in the 1990s.

- The UDA study did not utilize the certain, probable, and possible levels to describe causal assignments . In general, however, UDA causal assignments were most directly comparable to the probable level assignments made by the on-site teams in the Tri-Level study.

With these points in mind, a comparison of human, environment, and vehicle causal factors assigned in these two studies is provided in Figure A-1. As was anticipated, there was a pronounced disparity in the assigned levels of environment and vehicle factors in the two studies. While the levels of disparity shown were primarily related to the more limited research objectives of the UDA study, improvements in vehicle system designs may have also contributed to the very low level of vehicle factors noted in the UDA study.

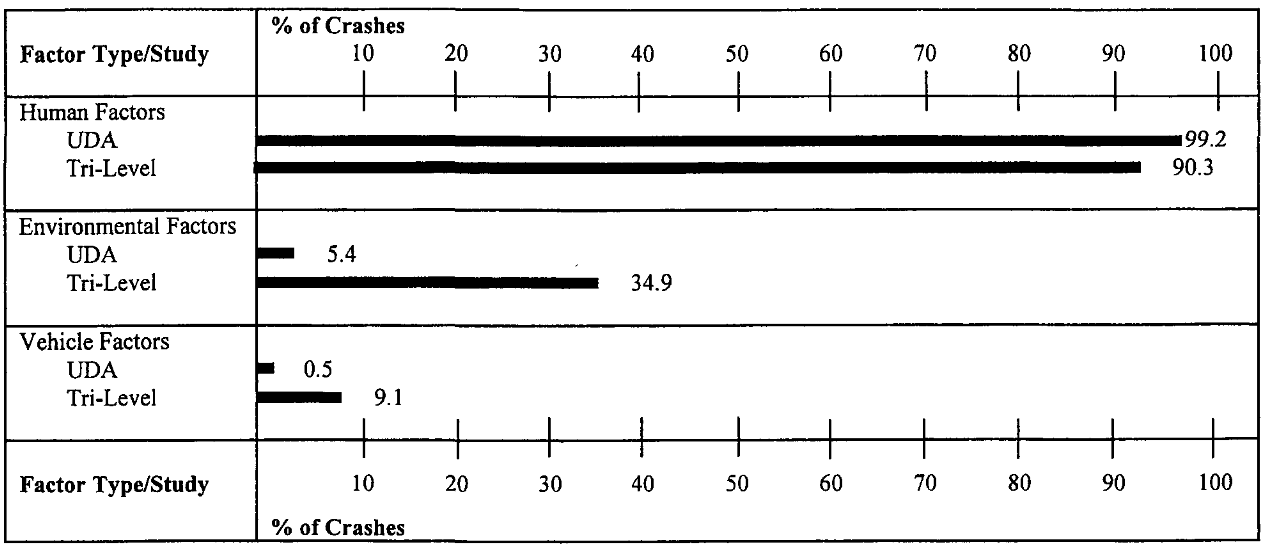

Figure A-1: Comparison of UDA/Tri-Level Assignments of Human, Environment, and Vehicle Factors

A comparison of the six most frequently assigned human-related causal factors in the two studies is provided in Figure A-2. [NOTE: The UDA incidence rates shown in Figure A-2 are slightly higher than the incidence rated shown in Figure 3-1. This occurs as a result of converting the UDA incidence rates from the proportion of drivers contributing to crash causation base used in Figure 3-1 to the proportion of crashes base used in the Tri-Level study and Figure A-2]. The upper portion of Figure A-2 provides a comparison of the four causal groups that were among the six most frequently assigned causal factors in both studies. The mid portion of the figure provides a comparison of two causal factors that were part of the six most frequently assigned causal factors in the UDA study, but that did not appear in the six most frequently assigned causal factors in the Tri-Level study. Finally, the lower portion of the figure provides a comparison of two causal factors that were part of the six most frequently assigned causal factors in the Tri-Level study, but that did not appear in a similar distribution for the UDA study. Major findings may be summarized as follows:

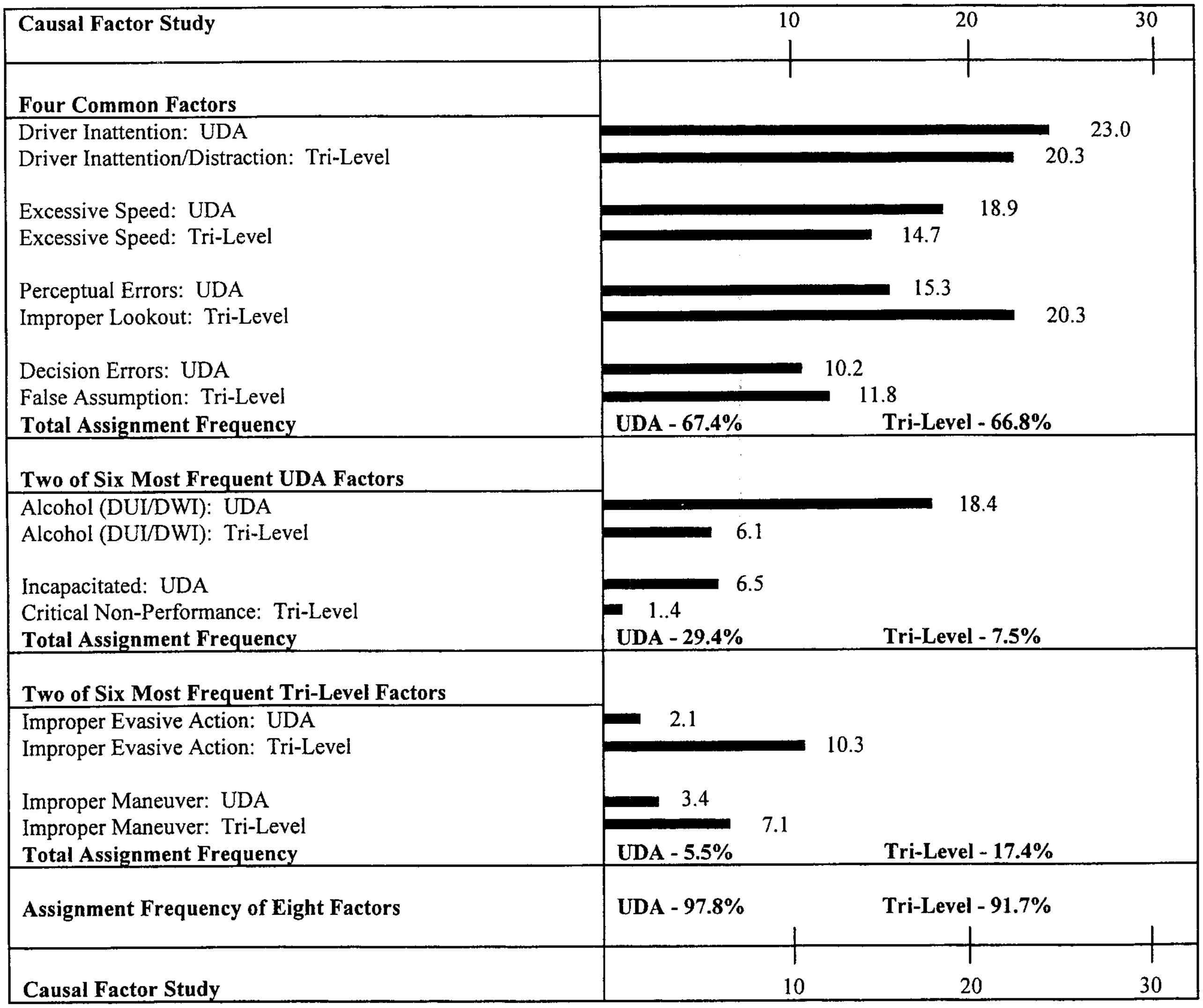

Figure A-2: Comparison of Six Most Frequent UDA Causal Assignments With Six Most Frequent Tri-Level Causal Assignments

Four Common Causal Factor Groups

- The driver inattention category, as defined in the UDA study, was comprised of the driver inattention and driver distraction categories as defined in the Tri-Level study. This factor was assigned to 23.0 percent of the crashes in the UDA study and 20.3 percent of the crashes in the Tri-Level study.

- The excessive speed category was assigned to 18.9 percent of the crashes in the UDA study and 14.7 percent of the crashes in the Tri-Level study.

- The UDA perceptual error category (15.3 percent) was directly comparable to the Tri-Level improper lookout category (20.3 percent). Both category labels were somewhat arbitrary in nature. It is also interesting to note that both studies found an over-representation of older drivers in this category.

- The UDA decision error category (10.1 percent) was directly comparable to Tri-Level false assumption category (11.8 percent).

- In general, these four common factors demonstrated a remarkable degree of consistency over time. Specifically, these factors were assigned to 67.4 percent of the UDA crashes and 66.8 percent of the Tri-Level crashes.

UDA Alcohol (DUI/DWI) and Incapacitated Factors

- The alcohol related designation was assigned to 18.4 percent of the UDA crashes and 6.1 percent of the Tri-Level crashes. As stated in the Tri-Level report, that study experienced a very high incidence rate of property damage only crashes. The report authors believed that this property damage incidence rate accounted for the pronounced level of underreporting of alcohol related crashes.

- The UDA incapacitated category (comprised of drivers who fell asleep or experienced a heart attack, seizure, or blackout) was assigned to 6.5 percent of the UDA crashes and was comparable to the Tri-Level critical non-performance category which was assigned to 1.4 percent of the Tri-Level crashes. The UDA rate is consistent with other causal analyses completed with NASS data. The relatively low rate reported in the Tri-Level study may again be related to the high incidence of property damage only crashes in that study.

Tri-Level Improper Evasive Action and Improper Maneuver Factors

- The improper evasive action category was assigned to 10.3 percent of the Tri-Level crashes and 2.1 percent of the UDA crashes.

- The improper maneuver category was assigned to 7.1 percent of the Tri-Level crashes and 3.4 percent of the UDA crashes.

- The disparity level in the assignment frequencies for these categories appeared to be associated with the classification scheme used to designate alcohol-related crashes in the UDA study. In this effort, these behaviors were assumed to be part of the alcohol designation. Specifically, the only additional factors that were routinely recorded in alcohol-related crashes in the UDA study were excessive vehicle speed and TCD violations. A clinical review of a sample of UDA alcohol-related crashes indicated that if these factors were added to the alcohol designation, the UDA incidence rate for improper evasive action would increase by a factor of two to three times and the incidence rate for improper maneuver would nearly double in size.

APPENDIX B

SUMMARY TABLES FOR MULTI-VARIATE ANALYSES

Table B-1
Relative Involvement Levels of Five Key Variables and Six General Variables
Single Driver – Right or Left Road Departure or Forward Impact (Not Traction Loss) NASS Type 1: (A & B Except 02 & 07)

Profile Variable	Highest Percentage	Highest Cell Factor*	Most Over-Represented	Over-Rep Factor	Most Under Represented	Under Rep Factor
Crash Cause	Perceptual/ Cognitive Failure	0.45	Driver Vehicle Control Failure	3.67	Excess Speed	0.14
Blood Alcohol Test Result	BAC = 0	0.50	BAC = .05 - .09%	2.10	BAC = 0	0.50
Primary Behavior Source	Attention	1.13	Motor Skills	6.05	Perception	0.37
Necessary Unsafe Driving Act	Impaired Judgment, Other	2.29	Directional Control	4.95	Proximity	**
Travel Speed (km/h)	49 - 72	3.00	49 - 72	3.00	Stopped	0.00
1st Unsafe Driving Act in Sequence	Exceeding speed limit by 10-15 mph	2.36	DUI	3.00	Turning in Close Proximity	**
Driver Age	21 - 34	1.32	21 - 34	1.32	55 – 69	0.45
Driver Sex	Male	1.54	Male	1.54	Female	0.67
Lighting Condition	Dark/Lighted	3.32	Dawn/Dusk	4.48	Day	0.14
Surface Condition	Dry	1.16	Dry	1.16	Slippery	0.82
Roadway Alignment	Straight	0.41	Right Curving	2.05	Straight	0.41
Roadway Profile	Uphill	1.82	Uphill	1.82	Crest/Sag	0.14

* Relative involvement index for response level with highest frequency.

** Relative involvement index is undefined by considered a minimum because cell has 0 observations.

Table B-2
Relative Involvement Levels of Five Key Variables and Six General Variables
Single Driver, Traction Loss, Right or Left Road Departure (NASS Type I: A-02 & B-07)

Profile Variable	Highest Percentage	Highest Cell Factor*	Most Over-Represented	Over-Rep Factor	Most Under Represented	Under Rep Factor
Crash Cause	Excessive Speed	6.69	Excessive Speed	6.69	Perceptual/Cognitive	0.14
Blood Alcohol Test Result	BAC = 0	0.45	BAC = .10 - .14%	4.48	BAC = 0	0.45
Primary Behavior Source	Decision	3.67	Decision	3.67	Perception	0.00
Necessary Unsafe Driving Act	Speed Control	9.03	Speed Control	9.03	Proximity	**
Travel Speed (km/h)	> 96	13.46	> 96	13.46	Stopped	0.05
1st Unsafe Driving Act in Sequence	Exceeding speed limit by 10-15 mph	4.06	DUI	4.48	Turn in close Proximity	**
Driver Age	< 21	2.20	< 21	2.20	70 and older	0.02
Driver Sex	Male	3.67	Male	3.67	Female	0.37
Lighting Condition	Day	0.37	Dark	3.00	Day	0.37
Surface Condition	Dry	0.37	Slippery	3.32	Dry	0.37
Roadway Alignment	Straight	0.41	Left Curving	2.72	Straight	0.41
Roadway Profile	Level	0.67	Downhill	1.42	Crest/Sag	**

* Relative involvement index for response level with highest frequency.

** Relative involvement index is undefined by considered a minimum because cell has 0 observations.

Table B-3
Relative Involvement Levels of Five Key Variables and Six General Variables
Same Trafficway, Same Direction, Rear End & Forward Impact (NASS Type II: D & E)

Profile Variable	Highest Percentage	Highest Cell Factor*	Most Over-Represented	Over-Rep Factor	Most Under Represented	Under Rep Factor
Crash Cause	Perceptual/Cognitive Failure	14.48	Perceptual/Cognitive Failure	14.88	Vehicle Environment or Road Condition	0.01
Blood Alcohol Test Result	BAC = 15% & higher	1.43	BAC = .10 - .14%	29.96	BAC = 10 - .14%	**
Primary Behavior Source	Attention	20.09	Attention	20.09	Motor Skills	**
Necessary Unsafe Driving Act	Impaired Judgment	29.96	Impaired Judgment	29.96	Directional Control	**
Travel Speed (km/h)	Stopped	1.46	Stopped	1.46	> 96	0.37
1st Unsafe Driving Act in Sequence	Inattention	6.69	Inattention	6.69	Turn in close Proximity	**
Driver Age	35 - 54	1.65	35 - 54	1.65	50 - 69	0.14
Driver Sex	Female	1.34	Female	1.34	Male	0.74
Lighting Condition	Day	5.47	Day	5.47	Dark/Lighted	0.14
Surface Condition	Dry	2.10	Dry	2.10	Slippery	0.50
Roadway Alignment	Straight	1.17	Straight	1.17	Right Curving	0.82
Roadway Profile	Level	1.15	Downhill	1.25	Crest/Sag	**

* Relative involvement index for response level with highest frequency.
** Relative involvement index is undefined by considered a minimum because cell has 0 observations.

Table B-4
Relative Involvement Levels of Five Key Variables and Six General Variables
Turn, Merge, Path Encroachment (NASS Type II: F), **(NASS Type IV: J & K)

Profile Variable	Highest Percentage	Highest Cell Factor*	Most Over-Represented	Over-Rep Factor	Most Under Represented	Under Rep Factor
Crash Cause	Perceptual/Cognitive Failure	1.95	Inappropriate Maneuver	2.01	Driver Vehicle Control Failure	0.00
Blood Alcohol Test Result	BAC = 0	29.96	BAC = 0	29.96	BAC = 01 - .04%	**
Primary Behavior Source	Decision	1.39	Perception	3.32	Attention	0.37
Necessary Unsafe Driving Act	Proximity	4.06	Proximity	4.06	Presenting an Obstacle	**
Travel Speed (km/h)	49 - 72	0.90	1 - 24	1.92	> 96	0.14
1st Unsafe Driving Act in Sequence	Rare Mix	1.32	Turn in close Proximity	4.48	DUI	0.05
Driver Age	21 - 34	1.00	55 - 69	1.95	< 21	0.14
Driver Sex	Male	0.90	Female	1.06	Male	0.90
Lighting Condition	Day	0.82	Dark/Lighted	1.62	Dawn/Dusk	0.37
Surface Condition	Dry	0.82	Slippery	1.17	Dry	0.82
Roadway Alignment	Straight	1.05	Left Curving	1.06	Right Curving	0.82
Roadway Profile	Level	1.63	Crest/Sag	2.72	Downhill	0.55

* Relative involvement index for response level with highest frequency.
** Relative involvement index is undefined by considered a minimum because cell has 0 observations.

Table B-5
Relative Involvement Levels of Five Key Variables and Six General Variables
Same Trafficway, Opposite Direction-Head-On, Forward Impact, Sideswipe Angle (NASS Type III: G, H, I)

Profile Variable	Highest Percentage	Highest Cell Factor*	Most Over-Represented	Over-Rep Factor	Most Under Represented	Under Rep Factor
Crash Cause	Alcohol/Drug Impairment	7.39	Vehicle, Environment, Road Condition	8.17	Perceptual/Cognitive Failure	0.14
Blood Alcohol Test Result	BAC = .15% or Higher	8.17	BAC = .15% or Higher	8.17	BAC = 0	0.14
Primary Behavior Source	Decision	4.95	Decision	4.95	Perception	0.05
Necessary Unsafe Driving Act	Speed Control	4.95	Speed Control	4.95	Presenting an Obstacle	**
Travel Speed (km/h)	25 - 48	5.47	25 - 48	5.47	Stopped	0.05
1st Unsafe Driving Act in Sequence	Rare Mix	1.55	DWI	14.88	Turning in Close Proximity	**
Driver Age	35 - 54	2.03	35 - 54	2.03	< 21	0.37
Driver Sex	Male	1.67	Male	1.67	Female	0.61
Lighting Condition	Day	2.08	Day	2.08	Dark/Lighted	0.41
Surface Condition	Dry	0.37	Slippery	3.32	Dry	0.37
Roadway Alignment	Straight	0.37	Right Curving	4.06	Straight	0.37
Roadway Profile	Downhill	2.56	Downhill	2.56	Level	0.14

* Relative involvement index for response level with highest frequency.

** Relative involvement index is undefined by considered a minimum because cell has 0 observations.

Table B-6
Relative Involvement Levels of Five Key Variables and Six General Variables
Intersecting Paths –Straight Paths (NASS Type V: K)

Profile Variable	Highest Percentage	Highest Cell Factor*	Most Over-Represented	Over-Rep Factor	Most Under Represented	Under Rep Factor
Crash Cause	Perceptual/Cognitive Failure	1.00	Alcohol/Drug Impairment	1.75	Excessive Speed	0.02
Blood Alcohol Test Result	BAC = .15% or Higher	4.95	BAC = .15% or Higher	4.95	BAC = .01 - .04%	**
Primary Behavior Source	Perception	3.32	Perception	3.32	Decision	0.61
Necessary Unsafe Driving Act	Impaired Judgment	0.50	Illegal Act	3.67	Directional Control Failure	**
Travel Speed (km/h)	49 - 72	2.12	49 - 72	2.12	> 96	**
1st Unsafe Driving Act in Sequence	Rare Mix	2.36	DWI	3.32	Turning in Close Proximity	0.05
Driver Age	21 - 34	1.35	55 - 69	1.49	70 and Older	0.61
Driver Sex	Male	0.82	Female	1.26	Male	0.82
Lighting Condition	Day	3.00	Day	3.00	Dark	0.14
Surface Condition	Dry	4.48	Dry	4.48	Slippery	0.14
Roadway Alignment	Straight	1.70	Straight	1.70	Left Curving	0.37
Roadway Profile	Level	0.74	Uphill	1.79	Level	0.74

* Relative involvement index for response level with highest frequency.
** Relative involvement index is undefined by considered a minimum because cell has 0 observations.

Table B-7
Relative Involvement Levels of Five Key Variables and Six General Variables
Miscellaneous – Braking, Etc. (NASS Type VI: M)

Profile Variable	Highest Percentage	Highest Cell Factor*	Most Over-Represented	Over-Rep Factor	Most Under Represented	Under Rep Factor
Crash Cause	Driver Vehicle Control Failure	27.11	Driver Vehicle Control Failure	27.11	Vehicle, Environment, or Roadway Condition	**
Blood Alcohol Test Result	BAC = 0	**	BAC = 0	**	BAC = 0	**
Primary Behavior Source	Decision	29.96	Decision	29.96	Attention	0.05
Necessary Unsafe Driving Act	Impaired Judgment	1.9	Presenting an Obstacle	6.69	Directional Control Failure	**
Travel Speed (km/h)	Stopped	2.29	73 - 96	4.48	1 - 24	0.05
1st Unsafe Driving Act in Sequence	Rare Mix	121.51	Rare Mix	121.51	Turning in Close Proximity	**
Driver Age	21 - 34	8.17	21 - 34	8.17	70 and Older	0.02
Driver Sex	Female	4.06	Female	4.06	Male	0.37
Lighting Condition	Day	0.45	Dark	3.32	Day	0.45
Surface Condition	Dry	0.74	Slippery	1.34	Dry	0.74
Roadway Alignment	Straight	5.47	Straight	5.47	Left Curving	0.05
Roadway Profile	Uphill	1.88	Uphill	1.88	Crest/Sag	0.05

* Relative involvement index for response level with highest frequency.
** Relative involvement index is undefined by considered a minimum because cell has 0 observations.

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