The Relative Frequency of Unsafe Driving Acts in Serious Traffic Crashes

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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 TRAFFIC-WAY, OPPOSITE DIRECTION (Inattention, Speed) - 2.6%, and BACKING, OTHER, MISCELLANEOUS, ETC. (Following Too Closely, Speed) - 1.3%

A more detailed description of study methods is provided in the Final Report submitted for this effort. The final report also provides a full description of all analysis results.

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Unsafe driving acts, driver behavioral errors, crash problem types, causal factors, countermeasures

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THE RELATIVE FREQUENCY OF UNSAFE DRIVING ACTS IN SERIOUS TRAFFIC CRASHES

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THE RELATIVE FREQUENCY OF UNSAFE DRIVING ACTS IN SERIOUS TRAFFIC CRASHES

SUMMARY OF IMPORTANT FINDINGS

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 at 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 provided 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 were:

• **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%**
• **INCAPACITATION (e.g. fell asleep)**	**6.4%**

Problem types in terms of crash configuration and specific behavioral errors were also identified. The following seven crash problem types, when associated with specific behavioral errors, 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 TRAFFIC-WAY, OPPOSITE DIRECTION (Inattention, Speed)**	**2.6%**
• **BACKING, OTHER, MISCELLANEOUS, ETC. (Following Too Closely, Speed)**	**1.3%**

Countermeasures were identified and recommended in the following areas in order to deal with these driver behaviors and unsafe driving acts:

- **EDUCATION & TRAINING** – for driver inattention factors, gap acceptance
- **LAW ENFORCEMENT** – to reduce excessive speed, following too closely, and driving while impaired
- **TECHNOLOGY BASED REAR END CRASH AVOIDANCE SYSTEMS** – in development as part of the Intelligent Transportation Systems (ITS) initiative to compensate for driver inattention and following too closely
- **TECHNOLOGY BASED INTERSECTION COLLISION AVOIDANCE SYSTEMS** – part of ITS to compensate for driver errors at intersections
- **TECHNOLOGY BASED LANE KEEPING SYSTEMS** – part of ITS to prevent lane encroachment and roadside departure crashes

There were certain limitations to the data. While the sample was reasonably representative of serious crashes involving passenger cars that occurred in this country during that time period, the 723 crashes were not nationally representative because they were selected from only 4 of 24 NASS sites. Also, while the inter-rater reliability for many of the causal assessments was as high as one can expect for studies of this kind, the determination of causal factors still relied upon investigator judgment and clinical assessment.

This study confirms other research showing that driver inattention, driver impairment, unsafe vehicle speeds, and driver fatigue are important factors in serious crashes. It also provides unique insight into driver information failures and unsafe driving acts that lead to crashes under certain specified conditions.

THE RELATIVE FREQUENCY OF UNSAFE DRIVING ACTS IN SERIOUS TRAFFIC CRASHES

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% of the crashes investigated. In that study, anywhere from 12 to 34% of the crashes involved environmental factors (such as slick roads) while between 4 and 13% 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 National Highway Traffic Safety Administration (NHTSA) commissioned a study by Veridian Engineering, Inc. to accomplish the following objectives:

(1) Determine the specific driver behaviors that lead to crashes and the situational driver and vehicle characteristics associated with these behaviors.
(2) Classify behaviorally caused crashes into "problem types" which contain common sets of characteristics.
(3) Develop a ranking of "problem types" based upon their relative frequency of occurrence.
(4) Describe potential countermeasures appropriate for each identified problem type.

The goal of this research effort was to determine the relative frequency of unsafe driving acts (UDAs) in serious crashes and then recommend countermeasures that have the potential to substantially reduce these types of crashes.

Methods

The approach selected by Veridian Engineering to meet the objectives of the study involved the development and refinement of a crash causation clinical assessment methodology, the selection of a data source, the determination of necessary crash-related data, site selection, and data analysis techniques.

Clinical Assessment

A clinical analysis sequence was developed in order to determine the causes of crashes investigated and the specific unsafe driving acts or behavioral errors that occurred and contributed to the crash. The clinical analysis sequence was comprised of eleven steps:

1. Assess crash participants statements.
2. Examine physical evidence patterns generated during the crash sequence.
3. Verify accuracy of available data and resolve discrepancies.
4. Verify crash type.
5. Assess pre-existing conditions.
6. Assess critical event.
7. Evaluate crash cause.
8. Evaluate driver behavior (safe/unsafe).
9. Specify UDA.
10. Determine intentionality of UDA.
11. Determine behavior source of UDA.

A schematic representation of the clinical analysis sequence is provided in Figure 1.

Previous experience indicated that most of the data required to successfully execute steps 1-7 was available in standard case reports provided by the National Automotive Sampling System (NASS) Crashworthiness Data System (CDS). It was also apparent, however, that additional data collection would be required to provide an adequate basis for executing steps 8-11 of this analysis sequence. This additional information related to 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.

Data Sources

Since the data necessary for steps 1-7 of the clinical assessment were already available in the NASS, and there was a desire to attain a fairly representative sample of serious crashes in the U.S., a decision was made to integrate the data collection activity into the NASS program as a special study.

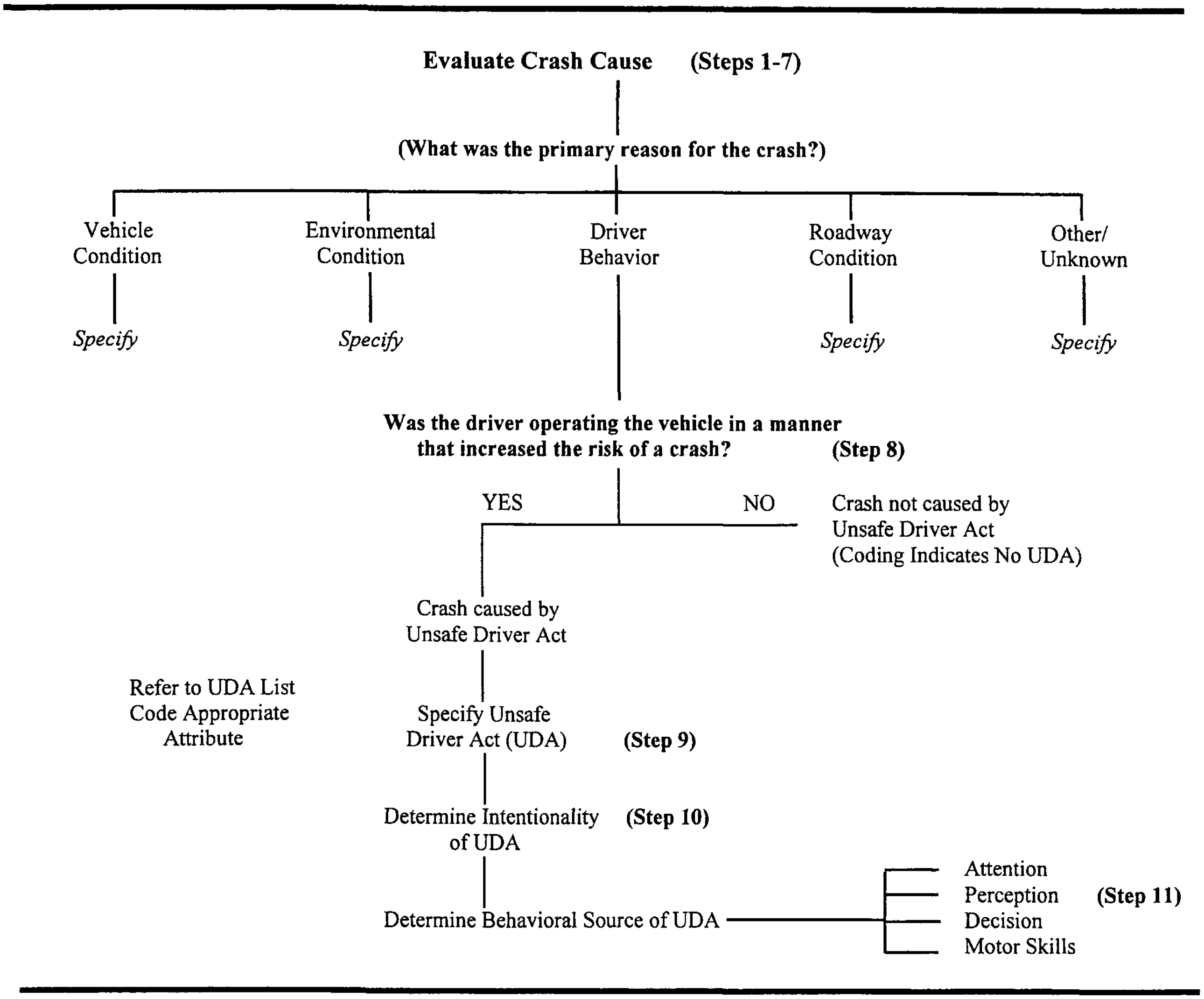


Figure 1: Schematic Depiction of Clinical Analysis Sequence

Field Data Collection

Field data were collected in the following manner:

- *Case Selection* – Cases were selected in accordance with the NASS 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.

- *Vehicle Documentation* – Vehicles were documented in accordance with the NASS vehicle documentation protocol. A smaller number of exterior vehicle photographs were submitted with the UDA case report and interior vehicle documentation forms were omitted from the package. Obvious vehicle failures were recorded.

- *Occupant Injury Documentation* – Occupant injury levels were documented in accordance with the standard NASS protocols.

- *Driver Interviews* – The project staff developed a UDA form which summarized UDA data for each driver involved in the crash. While most of the variables contained in the UDA form were also present in a driver interview form, the driver was not intended to be the sole source for the UDA form responses. The intent of this form was to provide the most accurate assessment available for each driver in the crash sequence. Therefore, field investigation personnel were instructed to incorporate findings from other interviews conducted for the crash and from their field investigation of the crash sequence.

Data Processing

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

- *UDA Form Variables* – A total of 78 UDA Form variables were incorporated into the database. These variables were coded by the NASS Researchers following certain clinical assessment rules.

- *UDA Variables Coded By Project Staff* – A total of 13 UDA variables were coded by the project staff for each crash-involved vehicle using the clinical assessment technique. These variables added the following information to the database:

    - Primary crash cause
    - Nature of crash causation factor
    - Assessment of the 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 travel and impact speeds
    - Nature of speed estimates

Site Selection

It was considered important to select a limited number of sites to ensure that 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 in the NASS. A total of four PSU sites meeting the above criteria were selected to participate in this effort. The final sites were:

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

Data collection at each of the four NASS sites was initiated on April 8, 1996, for crashes occurring on or after April 1, 1996. Data collection ended on April 30, 1997. A total of 723 crash cases involving 1284 vehicles was collected during this period.

Data Analysis

All relevant data were computerized and analyzed using the SAS statistical package. Initially, univariate analyses were performed to determine relative frequencies of the various unsafe driving acts (UDAs), driver behavioral errors, and crash types. In addition, multivariate analyses were performed to determine relationships between the UDAs, driver behavioral errors and crash circumstances. Emphasis was placed on identifying the most important driver demographic and behavioral characteristics and crash situation descriptions associated with each of a set of crash types. This analysis produced a series of profiles of the driver's actions, attributes and crash conditions.

For each crash type, the relative involvement for each value of each profile variable was calculated (excluding missing and unknown values). For each level of the profile 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:

$I_r = 1n\{T_{Br}/CT_{BR})/(T_r/CT_r)\}$, where

$CT_{Br} = T_B - T_{Br}$
$CT_r = T - T_r$

	Crash Type			
Levels of Profile Variable	**Type A**	**Type B**	**Continued Types**	**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 59 variables for each of the crash types. These 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.

Data Limitations

The interpretation of the findings presented in this report was based on unweighted data rather than on national crash estimates. This approach was implemented due to certain data limitations, as follows:

- The data were obtained from only four of the twenty-four National Automotive Sampling System (NASS) sites, consequently the results of the study were not representative of the nation as a whole and may not generalize to the population of all crashes. In addition, 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 sampling weights account for these uneven sampling probabilities, and the 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. Because the sample was not nationally representative, it was not appropriate to use the available NASS weights to expand the sample to national estimates for each studied crash type configuration and associated combination of crash factors. The approach taken in this study was to tilt all estimates towards severe crashes. Not using weights resulted in a bias relative to national distributions, but accorded more importance to severe crashes than to less severe crashes.

- A related limitation of the study sample was that it included only a relatively small number of crashes (723) and drivers (1,284). The small sample size further limited 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. It should be noted that the crash configurations had sample sizes ranging between 121 and 389, enabling either a detailed look at a few events (combinations of one or two crash factors) or a coarse-grained look at many events (combinations of 3 or more factors).

- An additional limitation was that the variable "BAC Test Result" was rarely available in the CDS data, limiting the use of that variable to reporting estimates of alcohol involvement.

- It is also important to note, although the staff making the clinical 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, were open to question. Veridian Engineering firmly believes that this 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 the assessments and consistent findings have been documented over extended time intervals.

Results

Causal Factors. Causal assessments were completed for 1239 (96.5 percent) of the drivers in the sample. There was insufficient data to complete causal assessments for 45 of the 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 causal 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. The most frequently assigned causal factor groups are described below and shown in Figure 2.

- **DRIVER INATTENTION.** The most dominant component of the causal factor pattern was driver inattention. As defined for this effort, driver inattention indicated a lack of focus on the required field of view (typically forward). This definition encompassed both of the driver inattention and driver distraction categories as defined in the earlier Indiana Tri-Level study (Treat, et al, 1979). 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. This factor was also cited as a contributory factor in combination with other primary factors for 0.8 percent of the drivers contributing to causation.

- **VEHICLE SPEED.** The second largest component of the causal factor pattern was the vehicle speed factor. These assignments typically reflected circumstances in which the driver was exceeding the speed limit and the absolute vehicle velocity contributed to crash causation. It should be noted, however, that this causal factor was assigned in a small number of crashes where the vehicle's travel speed was at or below the posted speed limit. In these situations, the travel speed was inappropriate for prevailing weather/roadway conditions and contributed to a pre-crash loss of vehicle control (i.e., too fast for conditions).

  Vehicle speed was assigned as the sole causal factor for 6.8 percent of the drivers who contributed to crash causation and was assigned as the primary factor in combination with other contributory 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.

- **ALCOHOL IMPAIRMENT.** Alcohol impairment was the third largest component of the causal factor pattern. Driving while impaired by alcohol was the sole causal factor for 6.0 percent of the drivers who contributed to crash causation and was noted as the primary factor in combination with other contributory factors for 11.1 percent of the drivers who contributed to causation. In addition, alcohol impairment was cited as a contributory factor in combination with other primary factors for 1.1 percent of the drivers.

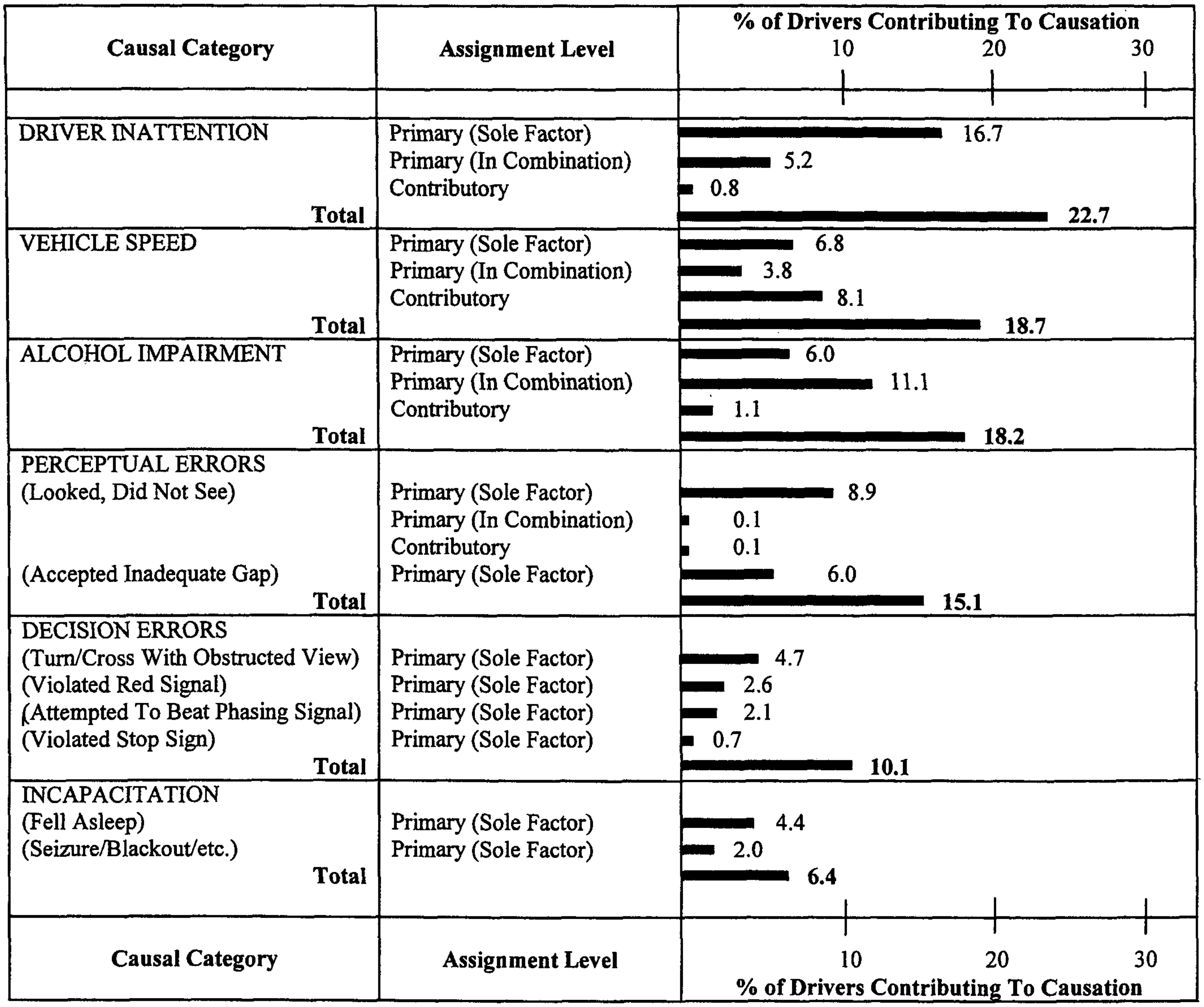
- **PERCEPTUAL ERRORS.** The fourth most frequently assigned causal factor involved perceptual errors associated with intersection crashes. Two specific scenarios were noteworthy: (1) The subject driver checked for approaching traffic, did not see the other crash-involved vehicle (e.g., looked, did not see), and then attempted to cross or turn at the intersection. This factor was noted as the sole causation mechanism for 8.9 percent of the drivers who contributed to crash causation. (2) The driver checked for approaching 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 6.0 percent of the drivers who contributed to causation.

- **DECISION ERRORS.** The primary scenario in this group involved subject drivers who attempted to turn or cross with an obstructed view (4.7 percent). While these situations typically reflected intersection crashes, there were a number of collisions which occurred at non-intersection locations (e.g., driver attempted to cross the roadway from a private/commercial driveway or attempted to turn into/exit a private/commercial driveway).

  Additional causal factor types in this category included (1) violated a red traffic signal (2.6 percent), (2) attempted to beat a phasing signal (2.1 percent), and (3) violated a stop sign (0.7 percent). The total contribution of this category was 10.1 percent with all of the assignments occurring as primary/sole assignments.

- **INCAPACITATION.** Drivers who fell asleep (4.4 percent) or experienced a seizure/heart attack/blackout (2.0 percent) also contributed to the causal factor pattern. All of the assignments in this category were made as primary/sole assignments (i.e., no contributory factors noted).

  These six causal factor groups were assigned as primary (sole) factors for 60.9 percent of the drivers contributing to crash causation. These same factors were assigned as primary factors in combination with other contributing factors for an additional 20.2 percent of the drivers who contributed to crash causation. Thus, as primary assignments, these factors were assigned to 81.1 percent of the drivers who contributed to causation.



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

Figure 2: Six Most frequently Assigned Causal Factor Groups

Crash Problem Types

In this multivariate analysis, important driver demographic/behavioral characteristics and crash situation descriptors associated with seven crash types were identified. The process involved eight major steps:

1. Produced and reviewed frequency distributions for each of the 203 variables contained in the combined NASS CDS/UDA data file.

2. Selected a set of 59 "Pattern" variables containing information useful for describing crashes in terms of UDAs 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 Occupant Assessment Form - 2

3. Recoded selected pattern variables, combining response levels to simplify and improve the analysis.

4. Recoded NASS crash types (provided in Figure 3) to simplify and improve the analysis. Crash types were redefined into seven classes with operational differences that were likely to be associated with driver behavior/performance as follows:

    - Crash Type 1 - Single Driver, Right or Left Roadside Departure Without Traction Loss [NASS Types I: A (except 02), I: B (except 07), and I:C].

    - Crash Type 2 - Single Driver, Right or Left Roadside Departure With Traction Loss (NASS Types I: A-02 and I: B-07).

    - Crash Type 3 - Same Direction, Rear End (NASS Type II: D).

    - Crash Type 4 - Turn/Merge/Path Encroachment (NASS Types II: F and IV: J and K).

    - Crash Type 5 - Same Trafficway, Opposite Direction (NASS Type III: G, H, and I).

    - Crash Type 6 - Intersecting Paths, Straight Paths (NASS Type V: L).

    - Crash Type 7 - Other, Miscellaneous, Backing, Etc. (NASS Type VI: M).

    - NASS Crash Type II: E did not occur in the UDA data file.

5. Determined unweighted frequencies for each of the 59 pattern variables, treating each driver/vehicle as a unit of analysis. Cross tabulations of unweighted observations of each pattern variable with crash type were then constructed.

6. Calculated a relative involvement index to assess the over-and-under representation of each profile variable within each crash type. Tables were prepared showing the frequency, percentage, and relative involvement in six of the 59 pattern variables within the seven defined crash types.

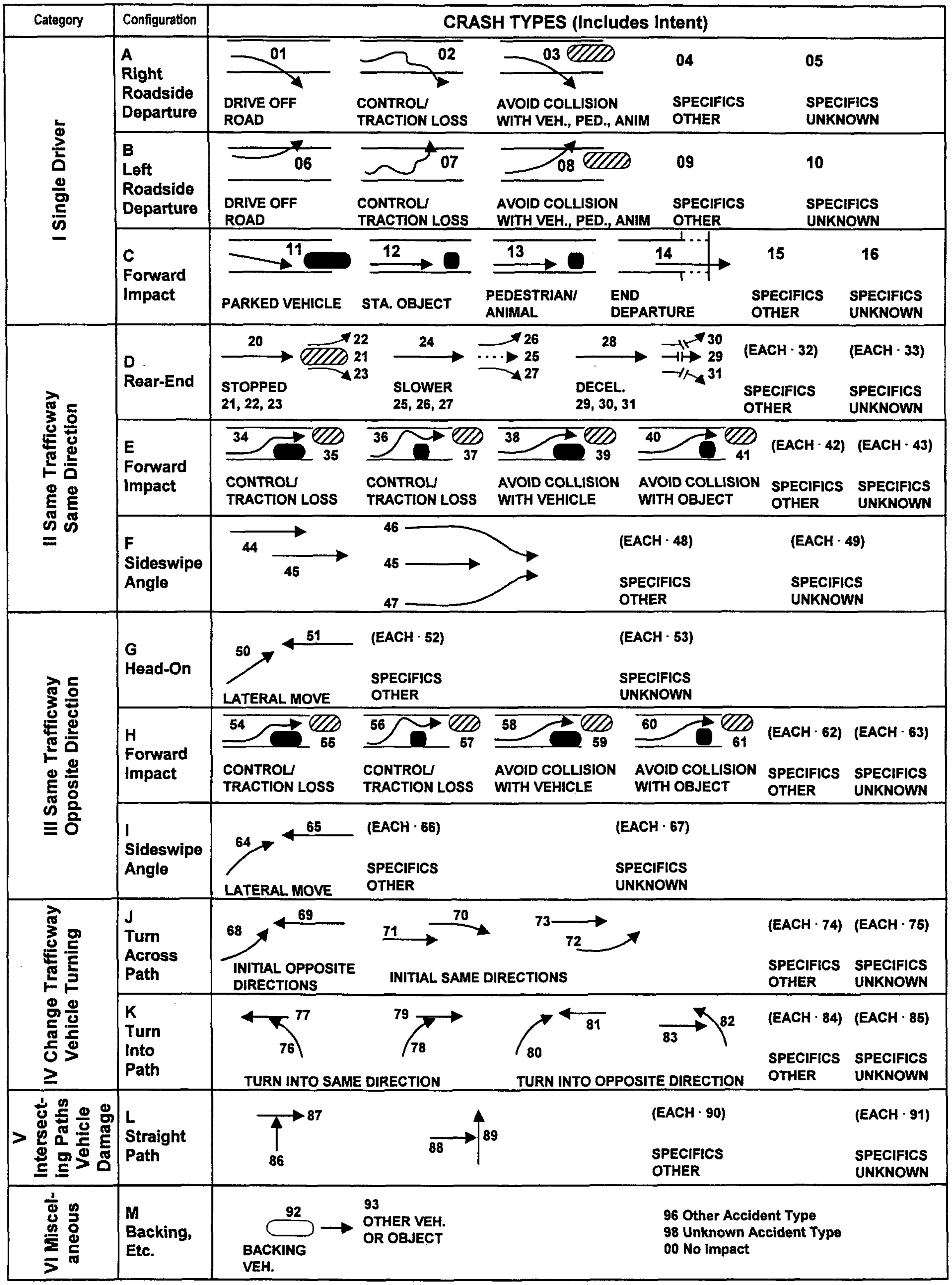


Figure 3: Crash Types as Identified in the NASS Program.

7. Selected a limited set of six "key" profile variables (from the original set of 59 pattern variables) to characterize crash scenarios within crash types. The key 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 including driver age, sex road surface condition, and lighting was also examined to further characterize specific scenario types.

8. Determined the most frequent scenarios within each crash. In general, it was noted that combinations of four of the six key variables noted in the preceding step resulted in the most homogenous and distinctive scenario groupings. Specifically, BAC test result and travel speed were excluded from the cross-tabulations. For Crash Type 3: Same Direction; Rear End crashes, however, it was necessary to include the travel speed variable to achieve adequate distinction between the scenario types.

A prioritized listing of crash problem types identified by this analysis sequence is provided in Table 1. 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 1 contributed to more than two-thirds of the UDA sample crashes.

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

Key characteristics of crash problem types are summarized in Tables 2 through 8. The presentation sequence is as follows:

Table No.	**Crash Type**	**Problem Type**	**% of UDA Sample**
2	Same Direction, Rear End	1-4	12.9
3	Turn, Merge, Path Encroachment	1-4	12.0
4	Single Driver, Roadside Departure With Traction Loss	1-3	5.5
5	Single Driver, Roadside Departure Without Traction Loss	1-3	4.8
6	Intersecting Paths, Straight Paths	1-3	4.1
7	Same Trafficway, Opposite Direction	1-3	2.6
8	Other, Miscellaneous	1-3	1.3
		Total	**43.2**

Table 2
Same Direction, Rear End Crashes (Problem Types 1-4)

Crash Problem Type	Key Characteristics
1. 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 signs (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.
2. 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), 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.
3. Driver Inattention - High Range Travel Speeds ***2.4 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 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.
4. 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 the lead vehicle.

Table 3
Turn, Merge, Path Encroachment Crashes (Problem Types 1-4)

Crash 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 accesses - 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) over-represented in 90 degree scenario (86 percent) - associated with aggressive driving traits. • Older drivers 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.
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) 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 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, turned 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 male drivers (<35 years) were over-represented (42.9 percent) as were males in general (85 percent).

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

Crash Problem Type	Key Characteristics
1. 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 percent of the sample. • Most drivers attempted to shift crash responsibility to a variety of design characteristics or roadway condition factors.
2. 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 shift crash responsibility to roadway design characteristics, roadway condition factors, or visibility limitations.
3. 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 5
Single Driver, Roadside Departure Without Traction Loss Crashes
(Problem Types 1-3)

Crash Problem Type	Key Characteristics
1. 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.
2. 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.
3. 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 6
Intersecting Paths, Straight Paths Crashes
(Problem Types 1-3)

Crash Problem Type	Key Characteristics
1. 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.
2. Driver Inattention/ TCS 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.
3. 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 7
Same Trafficway, Opposite Direction Crashes
(Problem Types 1-3)

Crash 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 the drivers in the sample, however, were less than 35 years of age.

Table 8
Other, Miscellaneous Crashes
(Problem Types 1-3)

Crash 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.

There were several other interesting findings as a result of these analyses. Some of these are described below.

- Despite the fact that 732 drivers committed some behavioral error or unsafe driving act, only 418 drivers (57 percent) were charged with any violation by the police. Of the drivers receiving citations from the police, 18 percent were for failure to yield, 17 percent for driving while impaired, 10 percent for violating stop signs or traffic signals, 7 percent for reckless driving, and 4 percent for speeding violations.

- Almost one-third of the drivers in the sample (29 percent) indicated that they were unaware of the impending collision and did not recognize any need for evasive action.

- Close to one-third of the turning/intersection crashes (32 percent) occurred at locations where there were no traffic control devices reflecting the large number of cases where drivers were turning into private driveways or commercial accesses.

- Approximately 79 percent of the primary unsafe driving acts reflected a deliberate intent of the driver to engage in that action. Most of the unintentional acts were associated with "driver inattention" and "looked but did not see" behavioral errors.

- The source of the driver behavioral errors in these crashes was distributed as follows:

Driver Decision	59 percent
Driver Inattention	27 percent
Driver Perception	12 percent
Driver Motor Skills	2 percent

Recommendations For Countermeasures

Recommendations for countermeasures to reduce specific crash types fall into three major areas: Education/Training, Law Enforcement, and Technology-Based. While virtually all of the identified problem types could be addressed through either education or training countermeasures, Table 9 prioritizes countermeasures on the basis for 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 though an education countermeasure that has a public information campaign as a central focus. The general public should be informed of the relative size of this problem in the crash population, the crash types that result from inattention, 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 or witnesses. Following the crash occurrence, most of the drivers who were focusing on internal thoughts expressed in increased awareness of the relative risk associated with this attention problem. A public information campaign focussing 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 could be most effectively addressed, in the near term, with driver training countermeasures that focus on appropriate traffic scanning/checking techniques. These training techniques should be incorporated into all driver education courses for new drivers. The perceptual difficulties associated with older drivers in these problems types 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 alcohol impairment and vehicle speed factors should be stressed in law enforcement countermeasure applications.

Table 9
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 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		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**			

Technology-based countermeasures are very likely to provide highly efficient solutions to the crash problem types identified in this report. It must be stressed, however, that the systems indicated in Table 10 are either currently in development or are undergoing product refinement/engineering evaluations and are unlikely to be available 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 of 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 (Intersection 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 Traction Loss) as well as crashes in problem type 1 of crash type 5 (Same Trafficway, Opposite Direction).

Table 10
Technology-Based Countermeasures

Crash Type/Problem Type	**Problem Size (%)**	**Countermeasure Type**		
		Rear End Crash Avoidance Systems	**Intersection Collision Avoidance Systems**	**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**			

Appendix
Comparison of UDA and Indiana Tri-Level Causal Analyses

In this section, the UDA causal analysis results are compared with the Indiana Tri-Level analysis results (Treat, et al, 1979). There are several factors to be considered in reviewing comparison results:

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

A comparison of human, environment, and vehicle causal factors assigned in these two studies is provided in Figure 4. 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 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.

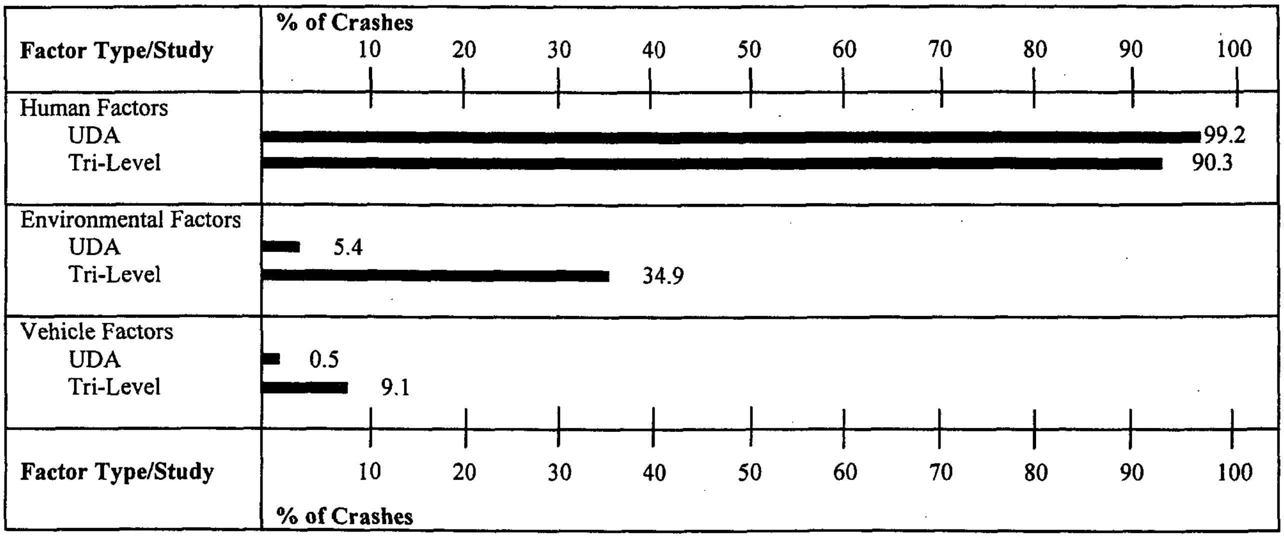


Figure 4: Comparison of UDA/Tri-Level Assignments of Human, Environment, and Vehicle Factors

A comparison of the six most frequently assigned human-related causal factors in the two studies is provided in Figure 5. The UDA incidence rates are converted from the proportion of drivers contributing to the proportion of crashes used in the Tri-Level study. The upper portion of Figure 5 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:

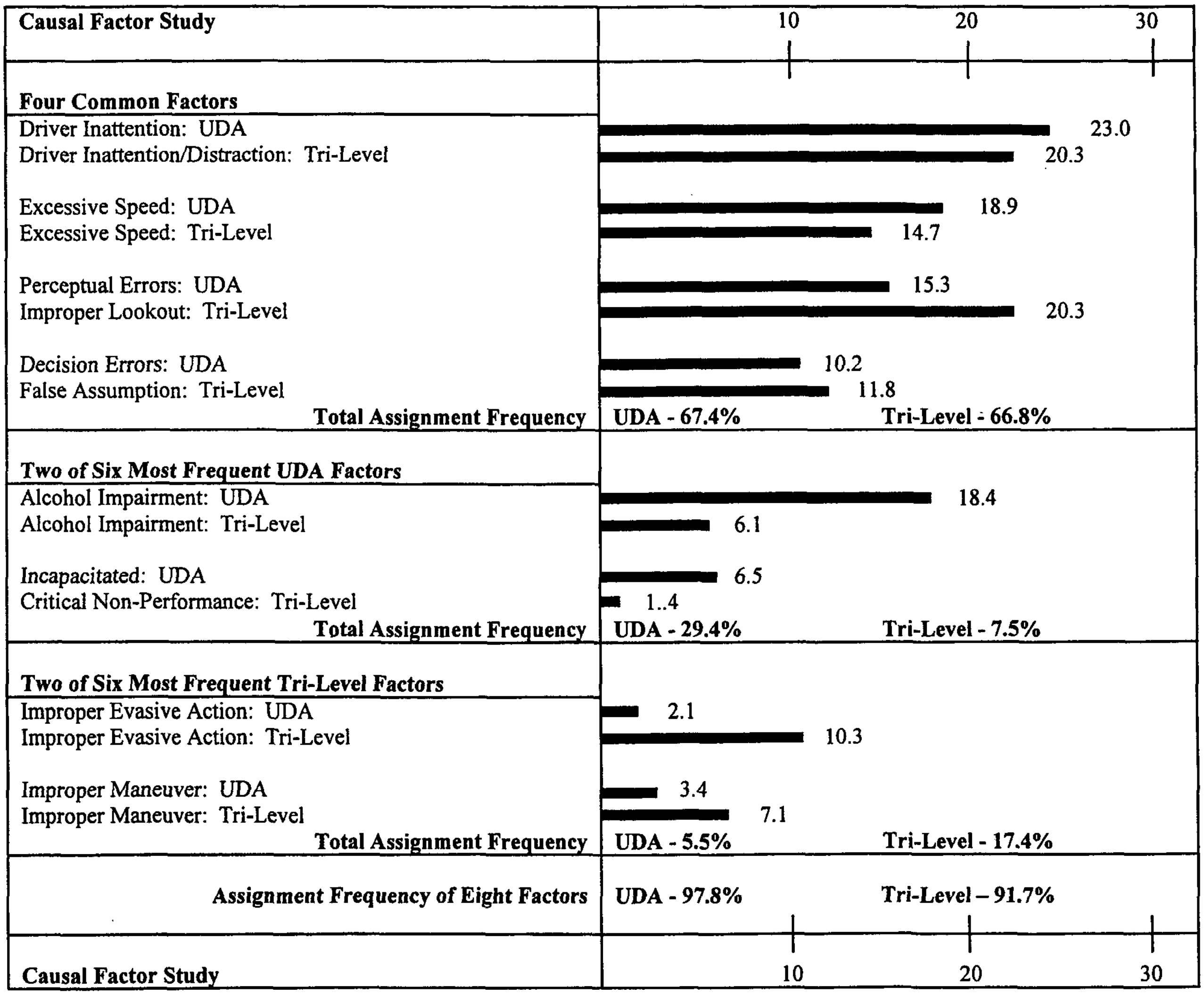


Figure 5: Comparison of Six Most Frequent UDA Causal Assignments With Six Most Frequent Tri-Level Causal Assignments

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 Impairment and Incapacitation Factors

- The alcohol impairment factor was assigned to 18.4 percent of the UDA crashes and only 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 large property damage incidence rate accounted for the relatively low level of alcohol related crashes. On the other hand, the UDA study had an overrepresentation of serious injury crashes. Other studies of injury crashes (Terhune and Fell, 1981) show alcohol involvement at about 20 percent.

- The UDA incapacitation 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 traffic control device 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.

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