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The Relationship Between Private and Commercial Vehicle Driver Records and Accidents in Michigan

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THE RELATIONSHIP BETWEEN PRIVATE AND COMMERCIAL VEHICLE DRIVER RECORDS AND ACCIDENTS IN MICHIGAN

By

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Robert E. Maki, D.P.A.

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The primary objective of this study was to determine whether previous accidents and citations are reliable predictors of future tractor-trailer heavy truck accidents in Michigan. In addition, the background material on accident trends shows how heavy truck safety policy was formed at the Michigan Department of Transportation.

Historically, accident prediction models have been able to explain only small portions of the accident experience. More recent studies have tended to show that previous citation and accident experience were good predictors of commercial vehicle accidents. Most studies have suffered from an admitted lack of exposure data and incomplete accident statistics.

Through the use of induced exposure techniques or the "innocent victim" concept, a research design was constructed to minimize the influence of unknown exposure and data voids. A large accident data base was assembled with all reported accidents in Michigan for the years 1982 to 1987. This database included driver histories from the Michigan Department of State and drew upon the computing and analysis power of the Michigan Department of Transportation's

Unisys A-15 computer and the Michigan Dimensional Analysis Surveillance (MIDAS) system.

The researcher concluded that previous accident experience is not a reliable predictor of future tractor-trailer accidents. There appears to be little or no relationship between the type of vehicle involved in an accident, whether it is private or commercial, and subsequent commercial accident experience. Previous citations and driver age appear to be possible predictors of future heavy truck accidents. No single large group of drivers emerged as a target for intensive training or enforcement efforts. These conclusions, however, depend on validation of the induced exposure concept used.

Recommendations for future research include a driver survey to validate the innocent victim concept and a methodology to evaluate the Commercial Motor Vehicle Act of 1986.

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Robert E. Maki

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CHAPTER I

INTRODUCTION

The focus of this dissertation is on driver citation and accident histories as predictors of commercial vehicle accident experience. To promote increased understanding of truck safety issues nationally and specifically in Michigan, the researcher has drawn together numerous sources of information. The study includes the pertinent laws, regulations, and accident trends. This information was analyzed to better define current truck safety issues, especially in the context of the major truck issues of commercial driver licensing, allowable size and weight, accident prediction, and other environmental and economic factors. The scope of this research is limited to truck safety policy and commercial vehicle licensing policy.

A major concern is a review of truck accident trends in Michigan. These trends, with appropriate evaluation of contributing factors, should provide the needed answer as to the extent of the truck safety "problem." The actual research design then seeks to reveal root causes of any problems found, possible solutions to those problems, and a policy model.

The purpose of this dissertation is to analyze and summarize the vast amount of often-conflicting data, to document government policy action noting where appropriate countermeasures are being

formulated, and to isolate those areas in which further research is needed.

The Policy Issues

Large truck safety issues have received much attention from government, insurance companies, and academia during the past several years. Trucks continue to grow in size and weight, seemingly without limits, even while the passenger cars in the population become smaller in size. Collisions between cars and trucks are often tragic, and there continues to be much public interest in reducing the carnage on the nation's highways by enacting policies that place restrictions on the trucking industry.

It is extremely difficult to fashion additional highway safety policies as they relate to large trucks. The needed data are often lacking, the issues are often clouded by sensational pleas on both sides, and there is no clear understanding of the real "problem."

The purpose of this paper is to address the truck safety issue in a rational manner, segregating safety and licensing policy as much as possible from the closely associated problems of pavement damage, environmental concerns, and transportation revenue equity. While concentrating on the causes and possible remedies for large truck accidents, however, the economic effects on the industry and government for any associated policy countermeasures must also be addressed.

The tasks before us are truly difficult, not the least of which is wading through the existing research data on the subject to extract meaningful contributions. After years of research and first-hand experience with enforcement personnel, policy analysts, legislators, and state government officials, this writer is convinced that documentation of the nebulous "problem" remains incomplete and that the root causes of any documented large truck safety problems remain elusive. There exist no good policy model and insufficient data to guide decision making. These issues must be resolved soon because the trucking industry is continuing to increase its market share at the expense of rail traffic, and the industry also continues to seek the use of larger and larger trucks for reasons of economy. State legislatures often respond favorably to the trucking lobby because their economic data appear stronger than the less convincing data put forth by the safety advocates.

In addition to the search for root causes of large truck accidents and the associated licensing policy model, this research effort will also make a contribution by providing a synthesis of past research studies and a summary of the major truck safety issues.

After examining several areas of current research emphasis, the area of commercial licensing policy surfaced as one needing additional attention, specifically regarding the validity of using prior violations and accident experience to predict truck accidents.

The examination of current research and policy issues also revealed that when large truck safety is discussed, most participants envision large tractor-trailer combinations, but the data usually contain statistics from trucks that exceed 26,000 pounds gross vehicle weight (GVW) or even accidents involving 10,000-pound GVW single units rather than the 80,000-pound GVW semi tractor-trailer vehicles assumed to be the topic of discussion. This research is restricted to semi tractor-trailer combinations. The effects of pickups, vans, delivery vehicles, and other straight trucks are, thereby, minimized.

There is a need for improved licensing policy as the following discussion demonstrates. The research question is: Can large truck accident involvement be predicted, based on prior driver accident experience or citations?

The researcher hopes to show whether such a relationship exists, using a novel technique for minimizing the effects of unequal exposure and by using the powerful data-processing capability of the Michigan Department of Transportation's Unisys A-15 mainframe computer and the vast data resources of the Michigan Department of State and the State Police.

Further, in this introductory chapter, the reasons for selecting this topic are presented in more depth. Other current research, primarily at the Michigan Department of Transportation (MDOT), Michigan State University, and the University of Michigan Transportation Research Institute, are also discussed.

Later chapters develop the context of the truck safety issues in Michigan and also discuss the state's policy initiatives. The policy issues and accident trends are discussed at length in Chapter II.

A literature review is presented in Chapter III, which is segmented into three distinct areas of interest: general truck safety issues, previous research, and innocent victim concepts.

In Chapter IV the writer develops the research methodology and discusses formal hypotheses, models, and the key concepts pertaining to the research. Research methods are described with the aid of a flow chart. Data sources, file descriptions, and the file merge process are detailed.

Chapter V provides a general discussion of preliminary results, analysis, and statistical testing.

Finally, the summary and conclusions are presented in Chapter VI. A case is also made here concerning the need for future research and for an exposure survey.

Focusing the Research

So much research has been concentrated on truck safety in recent years that care was taken not to duplicate current efforts, especially in Michigan. A brief review of related research is appropriate well in advance of the literature review to support the selection of this specific research focus.

The University of Michigan Transportation Research Institute (UMTRI) has long been recognized as a leader in heavy truck research, from the perspectives of both operations and safety. During the past 25 years, UMTRI staff have generated hundreds of contributions to the body of knowledge primarily through research papers, contract reports, journal articles, dissertations, and conference presentations in the following areas: accident data and systems analysis, accidents, occupant injuries and protection, biomechanics, emergency medical services, human characteristics, alcohol and drugs, driver vehicle systems, vehicle dynamics, roads and traffic, highway safety program management, law and policy analysis, and transportation systems.

More recently, Michigan State University has devoted more research effort to analysis of truck safety issues and associated research. In 1985, the University of Michigan and Michigan State University entered into a joint research effort sponsored by the Michigan Office of Highway Safety Planning (OHSP) to resolve several truck-safety-related issues, primarily associated with establishing exposure measures for the various classifications of trucks. As chairman of the Truck Safety Subcommittee with MDOT, the researcher had significant input in guiding this effort.

The research was aimed at testing 12 hypotheses:

1. Trucks are under-involved with respect to total accidents (need to define trucks).

2. Trucks are over-involved in casualty accidents when compared to total accidents (i.e., they cause much more severity).

3. Privately owned trucks are causing more of a problem than major fleet trucks.

4. Younger, inexperienced drivers are over-represented in the accident picture (training versus time behind the wheel).

5. Casualty accidents are over-represented on designated green routes.

6. Super-heavy trucks (GWV > 80,000 pounds) are over-represented in casualty accidents.

7. Trucks are over-involved in single-vehicle casualty accidents.

8. Trucks are over-represented in nighttime casualty accidents.

9. Most accidents happen at the end of the logged journey.

10. Accident data being collected for trucks need to be improved.

11. There are differential accident involvement rates for various truck/truck-trailer combination types based on roadway geometrics.

12. There are differential accident involvement rates for various truck/truck-trailer combination types based on overall length and width of the combination.

A final comprehensive report is not available on the total research results, but the above was presented to show why the

research that is the topic of this dissertation was aimed away from topics that were under study by others. The major Michigan university research was aimed at actually measuring exposure in testing the 12 hypotheses, whereas the focus of this dissertation research was on using a surrogate-induced exposure concept to determine whether previous accident and citation experience could be used to predict commercial vehicle accident involvement.

In 1988, the University of Michigan took on the initiative to establish the Great Lakes Center for Truck Transportation Research (GLCTTR) as a result of a provision in the Surface Transportation and Uniform Relocation Assistance Act of 1987 (23 U.S.C. § 101 et seq.). The Act authorized the U.S. Department of Transportation (USDOT) to establish a university-based transportation center in each of the 10 federal regions.

The GLCTTR represents a consortium of six universities: the University of Michigan, Michigan Technological University, Wayne State University, Michigan State University, Northwestern University, and Central State University of Ohio. The purpose of the center is defined as follows in the Proposal (University of Michigan, 1988):

> The purpose of the Great Lakes Center for Truck Transportation Research is to establish a national resource for science-based understanding on all aspects of truck transportation and those aspects of bus transportation where trucks and buses face similar vehicular, driver, and infrastructure issues. The very existence of the Center is to recognize and address the crucial role of truck transportation in our national economy and the complex system of problems posed in both the public and private

> sectors by this generic mode of transportation. The Center's cadre of experts are to engage the priority research needs in this field, yielding new knowledge, techniques, and perspectives on the issues while also training students and the professional community on the developing technologies. The developed information and accessible resources of the Center, plus the message it speaks on the nature of the issues, should enable other researchers, industry practitioners and government officials to appreciate the broad systems aspects of truck transportation problems. (p. 7)

Within this framework of ongoing research, this writer sought to review policy, to evaluate the reliability of previous citations and accidents as predictors of future commercial vehicle accidents, and to build a model for policy evaluation in the future.

Summary

In the preceding pages, a case was made for the purpose and focus of this research. The major policy issues were introduced, and a chapter outline for the dissertation was presented.

CHAPTER II

THE CONTEXT OF TRUCK SAFETY ISSUES

Governmental Policy

Much, perhaps too much, has been written on the subject of large truck safety policy over the past few years. The related literature has been reviewed extensively and organized here using the following format. Michigan truck safety policy and accident research are discussed first and then melded with national policy issues in a general discussion. A section on federal regulations is then presented, as well as a section on driver licensing qualifications. Discussion of deregulation issues, both state and national, follows. The formal literature review is presented in Chapter III. That review concludes with an extensive evaluation of similar research conducted at the University of North Carolina, which leads into the methodology for this research in Michigan.

A report intended to provide background material on the trucking industry in Michigan and to establish an agenda for future department activities was released by the Michigan Department of Transportation in May 1986. This report culminated several months of increased activity in all sectors of the department on truck safety issues. Proposed actions were listed, and recommendations pertinent to the focus of this study were as follows:

Departmental Interest. The department recognizes the importance of truck transportation and will strengthen its involvement in truck transportation issues through an improved data base and analytical capability, expanded inter- and intradepartmental communication, state and federal legislative monitoring, and development of a cooperative working relationship with truck companies and industry representatives.

State Involvement in the Trucking Industry. Responsibility for trucking activities is dispersed among a number of state agencies, including the departments of State Police, Commerce, State, Treasury, and Transportation. An Interagency Truck Work Group, with representation from each department, has recently been established to coordinate truck issues. This group is chaired by MDOT. The department will utilize this organization to address and resolve truck issues involving the several state departments.

Truck Deregulation Impacts. There has been an ongoing debate as to whether deregulation would reduce transportation services and/or increase prices for persons and businesses located in rural areas or smaller communities. The department will periodically survey shippers to determine service or rate changes or other problems being encountered with truck services.

Michigan Truck Standards. Michigan currently allows 102" wide trucks on most trunklines with a 50' limitation for semi-trailers or two 28.5' twin trailers. Legislation has been introduced to increase semi-trailer length to 53', similar to that allowed in several other states. Michigan allows 164,000 pound trucks (with proper axle spacing). This is the highest weight allowed in the country with most states having an 80,000 pound limit. The next highest state to Michigan allows 117,000 pounds.

Commercial Traffic. The department will undertake a special review of major commercial corridors to determine if previous forecasts, plans, and strategies are consistent with trends. The department will work more closely with the Department of State Police regarding safety inspections, hours of service log inspections, overweight vehicle enforcement and other safety related issues.

Truck Safety Studies. The MDOT has held discussions with the Department of State relative to possible changes in driver licensing procedures. In addition, the department recently contracted with the University of Michigan Transportation Research Institute to examine the safety issues associated with

> 53' trucks and to compare Michigan truck accident experience with national truck accident experience. These and other studies will be carefully reviewed by the Department to determine causal factors for accidents and a basis for improvements. (p. 11)

The Interagency Truck Committee continued to formulate proposed policies and actions and issued a report in May 1987. The Committee found that truck accidents had increased by 65% during the period from 1982 through 1985 and made the following recommendations:

1. Implement the Commercial Motor Vehicle Safety Act of 1986.
2. Increase fines for truck safety violations.
3. Work toward stricter local court enforcement.
4. Develop a pilot program to identify truck owners and dimensions.
5. Increase the tanker inspection fee.
6. Develop an improved truck accident data base.
7. Include truck information in driver education programs.
8. Update the Motor Vehicle Code.
9. Provide additional MPSC enforcement authority.
10. Recommend 12 month mandatory truck inspection program.
11. Implement corrective actions at high truck accident locations.
12. Evaluate mandatory use of tachographs.
13. Cover all loads where spillage could occur.
14. Expand 22" bumper height requirement to other trucks.
15. Restrict trucks to the two right lanes on freeways of three or more lanes.
16. Review the need for additional Motor Carrier Division enforcement personnel.

17. Require registration of all for-hire trucks and private fleets.

18. Develop truck safety funding sources.

19. Retain 55 mph maximum speed limit for trucks. (p. 1)

The Truck Safety "Problem"

Truck accidents are increasing rapidly in Michigan according to the Interagency Truck Committee (1987) and other truck safety proponents. Table 1 demonstrates the significant increase in truck-related accidents during the 3-year period between 1982 and 1985. Truck travel during this period, however, increased by only 15%.

Table 1

Truck-Related Accident Increase, 1982-1985

	Accidents		Accident Change	Travel Change
	1982	1985		
Trucks	12,900	21,300	+65%	+15%
Cars	282,000	365,800	+30%	+11%

In general, increases in Michigan truck accidents are following regional and national trends. In fact, a report by Campbell, Carsten, and Schultz (1986) of the University of Michigan Transportation Research Institute (UMTRI) showed that heavy truck

accident increases were somewhat less for Michigan than for Ohio, Indiana, and the nation.

The causes of the increase are not completely understood, although the competitive pressure of deregulation is commonly assumed to be a major factor. This may cause truckers to drive faster and run longer hours. Less vehicle maintenance may also be occurring because of insufficient revenues. This is supported by the fact that increasing numbers of trucks are being removed from service after police inspections. In general, the principal causes of truck accidents are commonly accepted to be (a) drivers who are inexperienced, or have poor driving records; (b) drivers operating too many hours or driving too fast; (c) trucking companies or shippers who encourage violation of laws; (d) inadequate truck maintenance; (e) increasing auto and truck traffic; and (f) truck configurations and loading.

Accidents are increasing at an unacceptable rate. There is no single cause or easy solution. It will require a comprehensive package of actions to address the problem.

As noted earlier, current research efforts endorsed by the MDOT and the Office of Highway Safety Planning are concentrated on the joint Michigan State University/University of Michigan Heavy Truck Safety Project. The work plan for the joint research by Campbell and Lyles (1986) focused on the following issues:

> The research program will be pursued jointly by the Statistical Research Group of the University of Michigan Transportation

> Research Institute (UMTRI) and the Department of Civil and Environmental Engineering of Michigan State University (MSU). While the efforts by each group will largely be independent, there will be considerable interaction and actual convergence at several points. It should be noted that the interests and expertise of the two groups are somewhat different--MSU's interest is focused on the interactions between vehicles and the roadway environment, and on handling accident data and various associated files maintained by, for example, the Michigan Departments of State Police (MSP) and Transportation (MDOT). UMTRI's interest stems from its continuing work in vehicle dynamics and an extension of their effort with, for example, the Fatal Accident Reporting System (FARS) data. While the bases for involvement are different, the interests converge on the need to develop differential accident rates for various types of trucks and truck-trailer combinations. (p. 1)

Not only do the federal and state governments and the trucking industry have an interest in these issues, but so do the insurance companies. An extensive study was published by AAA Michigan in December 1986 that included the following recommendations:

1. The State of Michigan should immediately take steps to comply with recently enacted federal truck and bus driver license regulations even though implementation is not mandated until 1992.

2. The state should emphasize the driving skills needed to safely mix passenger vehicles and heavy trucks in all Michigan high school driver education classes. In addition, the Michigan Department of State should review its written license tests and the booklet "What Every Driver Must Know" to be sure this skill is stressed.

3. Michigan's Legislature and the U.S. Bureau of Motor Carrier Safety should require tachographs in all heavy trucks to record speed, driving time and other information. (A tachograph is a tamper-resistant device that records information on speed, distance traveled, driving time and rest periods. Many major U.S. carriers of hazardous materials have used them for 20 years, according to the Insurance Institute for Highway Safety.) These devices should operate continuously and automatically. In order to prevent tampering, they should indicate when the case containing the record sheet is opened. Until tachographs are in every heavy truck, both the U.S. Bureau of Motor

Carrier Safety and the Michigan State Police Motor Carrier Division should inspect driver log books more rigorously. (Log books are diaries of the start and end of trips, miles driven and stops made.)

4. Despite increasing need, the size of the Michigan State Police Motor Carrier Division has not increased since 1982. However, federal funds are available to increase that division's size. As a matter of fact, a training class of 26, supported by these funds, is already under way. If sufficient federal funds are unavailable to allow the State Police to inspect every heavy truck at least yearly and to ticket trucks that litter, Michigan's Legislature should provide funds by increasing truck taxes.

5. Michigan's Legislature should establish more costly minimum fines for certain truck violations, including overloading, vehicle defects, speeding and improperly maintained log books. (pp. 1-4)

Heavy truck accident issues are extremely controversial. At a meeting of the Michigan Industrial Traffic League in June 1987 in Lansing, Michigan, Philip Haseltine (1987), Deputy Assistant Secretary for Policy and International Affairs for the Federal Department of Transportation argued that highway safety is not placed in jeopardy by heavy vehicles. His presentation included the following statements:

> A great deal of new safety information has been generated by the critics. And that raw data <u>also</u> offers some disturbing numbers. According to this evidence, there was a 24 percent increase in trucking accidents between 1983 and 1985 along with a 4.3 percent increase in fatalities over roughly the same period. This information is accurate, but hardly complete. Truck fatalities and <u>reported</u> accidents did increase, but with economic deregulation came a very significant rise in trucking activity (vehicle miles traveled), and, therefore, a greater exposure to risk. It was this increased exposure that resulted in the higher accident and fatality levels during these years.
>
> An index compiled by Americans for Safe and Competitive Trucking (a coalition of shippers, carriers, manufacturers, consumer advocates and public interest groups) shows a <u>decline</u>

in injury and fatality rates per vehicle mile traveled (VMT). This index--measured against a 1974 base of 100--reveals a drop in injuries, from 101 in 1981 to 79 in 1985. And, according to this study, the fatality index plummeted from 111 to 82 over the same period. Supporting these numbers are the results of studies conducted by the Department of Transportation which also show a significant decrease in fatalities per VMT since the enactment of deregulatory reforms in 1980, from 6.51 that year to 5.72 in 1985.

Accident statistics reported by the Federal Highway Administration within DOT are also revealing. As you may know, interstate carriers are required to report an accident if it results in a fatality, an injury or property damage over a certain dollar amount. Between 1973 and 1985, the damage amount that triggered an accident report was $2,000. Retaining this $2,000 figure for over a decade distorted the reporting data. An accident that caused $1,000 in damage during 1975 would not have required reporting, but that same accident ten years later ended up as a statistic due to inflation. This situation contributed appreciably to the increases in reported accidents. Accordingly, the Department has begun indexing the property damage reporting threshold. It was set at $4,200 for 1986. DOT also studied the distorting effect inflation had on past truck accident data. Accident reports were disaggregated and the property damage accidents isolated, eliminating those that would not have been listed if the threshold had been indexed throughout the reporting period. Using a pre-deregulation base year of 1978, it was discovered that the highest accident year was 1979--before passage of the Motor Carrier Act--and improvement has been shown every year since that time. If we go further and look at reported accidents per 100 million VMT, the rate has fallen by 24 percent since 1978.

While all of this indicates that there is no hard evidence of a direct correlation between deregulation and a deterioration of trucking safety--in fact, a strong case can be made otherwise--the record still calls for improvement. (pp. 10-12)

Michigan Department of Transportation
Interagency Truck Committee

J. L. Roach (personal communication, October 27, 1988), Manager, Freight Transportation Planning Section of MDOT, and

R. F. Tuttle, Sr. (personal communication, October 28, 1988), Supervisor of the Motor Carrier Unit, provided reliable information on past and current MDOT truck transportation policy. They indicated that the Michigan Department of Transportation is supportive of rail, water, and truck transport modes. Each plays a vital role in providing freight transportation services throughout Michigan. The department takes a comprehensive view toward freight planning and program development and assists shippers and local communities to meet their needs in the most appropriate manner. At times, this may involve substitution of one mode for another. An example is departmental assistance to shippers who must switch to truck service when rail services are discontinued.

The trucking industry represents an essential component of Michigan's transportation service system. As such, the Michigan Department of Transportation has a vital interest in assuring that truck transportation services are provided in a manner consistent with the needs of Michigan shippers and citizens.

The Michigan Department of Transportation recognized the importance of truck transportation and strengthened its involvement in truck transportation issues through an improved data base and analytical capability, expanded inter- and intra-departmental communication, state and federal legislative monitoring, and development of a cooperative working relationship with truck companies and industry representatives. This has enabled the department to respond in a coordinated and knowledgeable manner to

the variety of trucking issues that arise. The Bureau of Transportation Planning serves as the principal clearinghouse for truck-related issues and information.

Roach (personal communication, October 27, 1988) and Tuttle (personal communication, October 28, 1988) further defined evolving issues relating to truck transportation, which include:

1. Truck safety concerns associated with an increasing number of truck accidents. Truck accidents in Michigan increased by 65% during the 1982-1985 period. Truck travel during this period increased by only 15% (1982 accidents 12,900; 1985 accidents 21,300).

2. Truck rates and adequacy of services in a deregulated transportation environment. The federal Motor Carrier Act of 1980 (49 U.S.C. 10101 et seq.) deregulated Interstate Commerce. This deregulated environment has led to a large number of trucking companies going out of business. Many of these companies served all or part of Michigan.

3. Truck taxation equity questions relating to whether large trucks pay their proportionate share of highway costs. Diesel fuel discount of 6 cents in Michigan makes truck transport attractive.

4. Highway design and capacity issues given increasing truck traffic volumes. Safety is an issue for 53-foot semitrailers with regard to intersection geometry because of the turning radius needed. Long combination vehicles on highways with high average

daily traffic volumes are concerns especially due to longer passing sight distance needed on two-lane roads and merge problems on freeways.

5. Truck transportation roles vis-a-vis other transport modes. Railroad abandonments increase the need for trucking. Railroads have abandoned 2,100 miles of track in Michigan since 1960. In the past 3.5 years, 150 miles, in 25 segments, have been abandoned. Truck combinations of up to 11 axles and 164,000 pounds GVW create stiff competition with railroads for traffic.

6. Truck program concerns associated with a complex and fragmented national system. The National Governor's Association is working with the states to streamline bureaucracy. The issues include (a) internal registration plan, (b) base state fuel plan, (c) one-stop shop operation, and (d) registration of interstate operating authority.

In the area of guiding truck safety policy, Roach (personal communication, October 27, 1988) and Tuttle (personal communication, October 28, 1988) pointed to the involvement of the Freight Planning Section of the Bureau of Transportation Planning in mid-1985 in responding to questions raised by the State Transportation Commission on trucking issues in Michigan. The Freight Planning Section chaired and was heavily involved in the development of a Vital Innovative Performance (VIP) award-winning study published in May 1986, entitled A Background Report on Truck Safety, Revenue and Taxation, Truck Services and Highway Facilities (MDOT, 1986). This

author chaired the Safety Subcommittee in that effort, representing the Bureau of Highways of MDOT.

According to W. T. Lebel (personal communication, November 16, 1988), current Traffic and Safety Division, Bureau of Highways representative on the MDOT Truck Committee, the past truck concerns of the Bureau were primarily of an operational or structural nature. Design considerations of intersection radii or "throat" opening adequacy drew much attention, as did median width and directional cross-over design. In terms of structure, the engineers have held that marginal incremental pavement damage will result with super-heavy trucks, which can weigh as much as 164,000 pounds, if the weight is distributed over a number of axles (11 maximum without special permit) so that individual wheel loadings are kept at acceptable levels.

The Bureau of Highways also is responsible for designating which roadways are to comprise the "green route." The following description and map (Figure 1) from A Background Report on Truck Safety, Revenue and Taxation, Truck Services and Highway Facilities (MDOT, 1986) detail the commercial truck routes in the state at that time:

> The Michigan route system initially began as an identification of all weather truck routes and evolved into a hierarchical system specifying weight limitations on all state trunklines. The Michigan truck route system segments state trunklines into categories based on weight and width allowances for the standard five axle truck configuration. (Michigan's 1984 Truck Operators' Map is depicted in Figure 1.) Michigan's "green" routes (Band 1), which also comprise the National Network

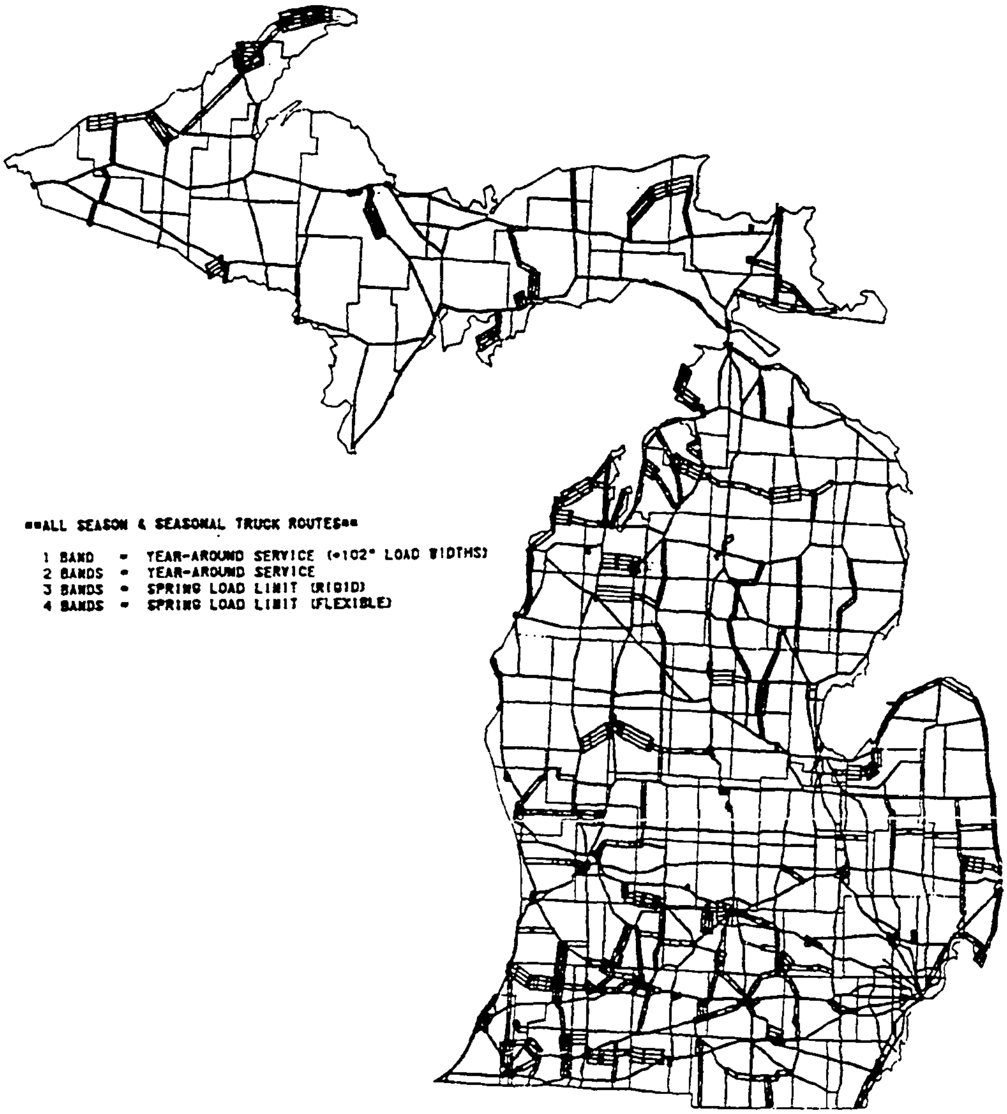

Figure 1. Michigan "Green" Truck Routes.

Source: Michigan Department of Transportation. (1986, May). <u>A background report on truck safety, revenue and taxation, truck services and highway facilities</u>. Lansing: Author, p. 16.
Adapted by permission, Michigan Department of Transportation.

system, allow for an 80,000 lb. Gross Vehicle Weight (GVW) for standard 5-axle configuration, and up to 102" wide trailers. The "black" (Band 2) routes allow for a 73,280 lb. GVW and 96" width. With additional properly spaced axles, loads of 164,000 lb. are allowed. Both the green and black systems have no seasonal load limitations. The remainder of the trunkline system (shown as solid and dotted red on the truck map; Bands 3 and 4) are seasonal routes which are subject to spring load limitations. The seasonal routes, when not restricted, allow for 73,280 lb. GVW and 96" wide trailers.

On the "green" (federally designated system), there is no overall length limit for a truck tractor and semi combination; however, the trailer cannot exceed 50 feet. For a tractor and two trailers the overall limit is 59 feet for the black and red routes; there is no overall length limit for two trailers (each limited to 28 feet) on the green routes. (p. 15)

Criteria used for including roads in the designated network are (a) safety record; (b) current or anticipated safety problems; (c) alternate routing; (d) route classification; (e) lane widths; (f) sight distance; (g) severity and lengths of grade; (h) shoulder widths; (i) narrow bridge, clearance, and load limits; (j) intersection geometrics; and (k) structural adequacy of the pavement.

Other traditional Bureau of Highways concerns are crash-worthiness of hardware, guardrail and barrier heights, and length of yellow intervals on traffic signals. More recently, other issues have surfaced, such as the increasing size differential between larger trucks and smaller cars, transportation of hazardous materials, and public safety concerns, especially in depressed free-ways, tunnels, and bridge plazas.

The Department of Transportation continues to be more involved with trucks and truck safety. Initial efforts were put forth within

the Freight Transportation Planning Section of the Bureau of Transportation Planning. This section was multimodal, consisting of units in the area of rail and marine. Due to the increasing staff time requirements for trucking issues, the Freight Section was officially reorganized on August 7, 1986, creating units in the areas of rail and truck as well as a specialist position in the marine area. This reorganization has enhanced the ability of the section to concentrate resources on each mode and the issues within these modes.

Soon after its creation, the Motor Carrier Unit, headed by R. F. Tuttle, became a member of the Interagency Truck Committee. This committee generated the report entitled Truck Safety in Michigan: Background and Proposed Actions (Interagency Truck Committee, 1987). The 19 recommendations made by the committee were all adopted by the State Transportation Commission. Many of these recommendations were present in the truck safety legislation package of 1988.

The Motor Carrier Unit is the lead unit for the various state departments working with the National Governor's Association Task Force on the implementation of one-stop shop operations. The Interagency Truck Committee, in turn, created a One-Stop Shopping Subcommittee. That subcommittee generated A Proposal to Streamline the Administration of Commercial Truck Licensing and Registration in Michigan (MDOT, 1987).

In September 1988, the responsibility for weigh stations was transferred from the Highway Bureau to the Bureau of Transportation Planning, Freight Planning Section. The use of truck weigh stations constitutes the principal weight-enforcement method in Michigan. Weight enforcement and safety enforcement are strongly linked. The Motor Carrier Unit of the State Police is responsible for this dual enforcement, and weigh stations provide a logical starting point for a plan of action. The unit has become the focal point for trucking activities within the Department of Transportation and for coordination of truck-related issues for the other five state departments involved in trucking.

Tuttle (personal communication, October 28, 1988) indicated that truck activities and truck safety in Michigan are emotional issues. The work done by the Motor Carrier Unit is intended to have an effect on lives saved and property damage curtailed, and to provide Michigan with a strong and safe trucking industry. Identifying the causes of the increase in truck accidents and taking a leadership role in organizing state-level efforts on trucking issues represent the mission of the Motor Carrier Unit.

Tuttle (personal communication, October 28, 1988) addressed the future direction of the Motor Carrier Unit, which can best be identified by some of the projects proposed to be undertaken in the future:

1. Weigh station consultant study.
2. Trucker handbook.

3. Truck registration information--central data base.

4. Equipment register for Michigan trucks.

5. Freight rate studies--analysis of rail/truck cost.

6. Regional conference on dimensional concerns: (a) kingpin settings, (b) weight allowances, and (c) one-stop shop issues (trip permits).

7. Weigh-in motion--coordinate with Motor Carrier Unit.

8. CMVSA 86--monitor and coordinate activities for the MDOT.

9. Interagency Truck Committee (Motor Carrier Unit coordinate and schedule minimum bi-monthly meeting).

10. Travel Demand Identification Project: (a) origin/designation studies--industries, (b) truck types--visual counts, (c) conduct axle/weight/truck-type studies, and (d) production locations--computerized and printable on maps.

Organizational relationships are shown in Figure 2, provided by Roach (personal communication, October 27, 1988). He indicated that MDOT input into the 1988 Truck Safety Package included the following recommendations, all of which were adopted in the eventual legislation:

1. Implement the federal Commercial Motor Vehicle Safety Act of 1986 (49 U.S.C. § 2101 et seq.): (a) new licensing standards, (b) single drivers license, (c) road tests for drivers, and (d) tougher penalties for violations.

2. Increase overweight and civil fines.

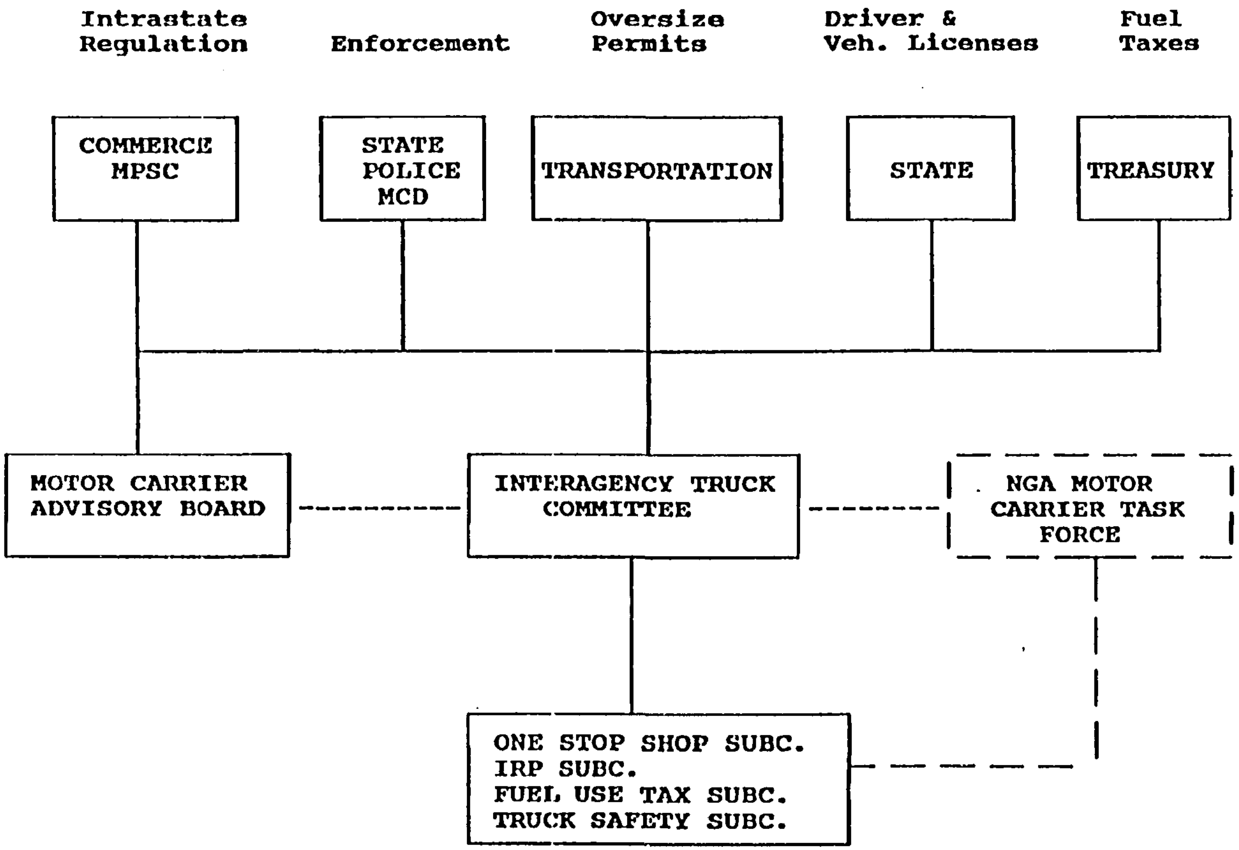

Figure 2. State of Michigan Motor Carrier Organizational Relationships.

3. Improve truck identification.
4. Cover all loads.
5. Require 22-inch rear bumpers.
6. Restrict trucks to driving in right-hand lanes.
7. Increase truck-driver education.
8. Increase State Police enforcement.
9. Increase registration fees for new safety-related revenue.

In addition, the legislature thought that truck safety was such an important issue that Public Act 348 of 1988 created a special truck safety fund and the Michigan Truck Safety Commission.

The Commercial Motor Vehicle Safety Act of 1986

The Commercial Motor Vehicle Safety Act of 1986 was necessitated by weak laws in 19 states, where any person licensed to drive an automobile could also legally drive a tractor-trailer or a bus. No special training or special license was required. There was also a concern that too many drivers were operating motor vehicles that they might not be qualified to drive.

Multiple driver licenses pose another serious problem. Some commercial drivers avoid possible license suspension or revocation for traffic law violations by holding driver licenses in more than one state, thus spreading their convictions among several licenses.

Title XII of the Commercial Motor Vehicle Safety Act of 1986 enacted by Congress on October 18, 1986, addresses these problems. The Act makes it illegal for an operator of a commercial truck or

bus to have more than one driver license. It also requires the U.S. Secretary of Transportation to develop uniform standards for testing and licensing operators of vehicles over 26,000 pounds gross vehicle weight rating (GVWR). The Act establishes sanctions for states that do not implement the uniform national standards by September 30, 1993. Furthermore, it makes provisions for the Secretary--in cooperation with the states--to develop a clearinghouse to aid the states in implementing the one-license requirement, and to record the issuance of a commercial driver license. In addition, the Act stipulates operator disqualifications and provides for financial grants to assist states in implementing the testing and licensing standards.

Deregulation

The federal Motor Carrier Act of 1980 eliminated most federal requirements for truck rate and route authority. This affected interstate trucking; intrastate trucking is still regulated by the Michigan Public Service Commission. Approval of this state agency is required for new service and rate structure requests for movement of intrastate goods. Deregulation resulted from a growing belief in the U.S. Congress that competition could control the availability and cost of transportation services.

There have been several <u>post hoc propter hoc</u> attempts to link deregulation with degradation of truck safety. No conclusive

evidence has yet been uncovered to prove that deregulation has had a dramatic effect on highway safety. Those who argue that a definite detrimental link exists between deregulation and safety point to the loss of thousands of veteran drivers forced out of the market by economic competition and replaced by lower-paid, inexperienced drivers. Economic pressures further forced these new drivers, many of whom were owner-operators, to cut costs through deferred maintenance, long hours, speeding, overloading, and risk-taking.

The argument certainly is plausible, but statistical data are not readily available due to irregularities in accident reporting among states. In addition, the USDOT has raised the dollar amount of a property-damage accident that requires reporting, and the numbers of cars and trucks in the population have both increased significantly. Even the fact that safety inspectors have identified a higher number of mechanically unsafe trucks is no indication because the enforcement efforts themselves have increased.

Driver Licensing Policy

According to the Handbook for Chauffeur License and Classified Endorsements (Michigan Department of State, 1986), in Michigan one is required to have a chauffeur license if driving any kind of motor vehicle used as a public or common carrier of persons or property or if the main purpose of the job is driving for pay, carrying passengers or merchandise for pay, or driving a school bus. In addition, a class 3 endorsement is required for a school bus driver.

A class 1 endorsement is required if operating a single vehicle weighing more than 24,000 pounds GVW, and a class 2 endorsement is required if operating a combination of vehicles weighing more than 24,000 pounds GVW. Class 2 includes class 1 but not class 3.

Applicants for class 2 endorsements required for the operating of trucks covered in this research must be at least 18 years of age and pass a written test, a vision test, and a road test if acceptable proof of experience or training in operating classified vehicles is not provided.

An original classified endorsement will not be issued if the applicant has been charged with one or more points in the preceding 2 years, has had a suspended or revoked license during the past 36 months, or has been convicted of a 6-point violation in any vehicle or an impaired driving violation (4 points) in a classified vehicle in the previous 24 months.

The Commercial Motor Vehicle Safety Act of 1986 requires that, effective July 1, 1987, only one license be held except in a few rare instances where states require more than one. In addition, the law requires the DOT to establish minimum federal standards for testing commercial drivers effective no later than April 1, 1992. Complete state compliance is expected by September 30, 1993.

Accident Trends

In this analysis the researcher attempted to determine causal factors for the recent increase in truck-related accidents in

Michigan and to provide other insight into truck accident issues. Among such possible factors are deregulation, the Surface Transportation Assistance Act of 1982 (23 U.S.C. § 101 et seq.), and longer semitrailer lengths.

The road and street network in Michigan consists of 110,000 miles, including the state trunkline system (which totals 9,500 miles). Although the MDOT is concerned with the total transportation system on all roads, some of the data presented here refer specifically to trunklines; more detailed data are available on these routes. Data were obtained from the Michigan Department of State Police (MSP) through the MDOT in the form of computerized accident files, printed summaries, and graphs. In addition, driver records were made available by the Department of State.

Responsibility for regulation and enforcement falls on several agencies, primarily the Motor Carrier Unit of the MSP. Recently, the MDOT has taken a leadership role in a cooperative effort among departments to address truck safety, revenue, and taxation issues as discussed previously.

Comparisons in this analysis that refer to changes in percentages may be more meaningful than changes in the raw number of accidents. Changes in accident counts by themselves are less meaningful because (a) changes in the number of truck-involved accidents would be due in part to changes in the exposure of trucks, and accurate truck-exposure data were not available for this

analysis; and (b) corrections were made in the Michigan Accident Location Index (MALI), so the data were not consistent during the period as they relate to the state trunkline highway system, as used for accident-analysis purposes. Any errors introduced, however, should be slight.

For this analysis, the following terms are used:

Truck. Refers to a vehicle coded either as code 8 (Stake or Dump Truck, Step Van, Motor Home) or code 9 (Truck Tractor [Semi] or Road Tractor) in the State Police Accident Master. Pickup and Panel Trucks are not included in this definition.

Single unit. Refers to a vehicle coded as code 8 or code 9 with no trailer.

Single-bottom. Refers to a vehicle coded as code 9 with a single trailer.

Double-bottom. Refers to a vehicle coded as code 8 with a single trailer or as code 9 with two trailers.

Car. Refers to any other motorized vehicle, including pickup and panel trucks and motorcycles.

Truck-only accident. Refers to an accident in which the only vehicle, or all vehicles, involved were trucks (as defined above).

Car/truck accident. Refers to an accident in which at least one truck and one car were involved.

Car-only accident. Refers to an accident in which no trucks were involved. It could be either a single- vehicle or a multi-vehicle accident.

For this analysis, statewide (trunkline and nontrunkline combined) accident records for the period January 1, 1979, through December 31, 1988, were used.

Changes in the frequency of truck-involved accidents may be due to such factors as deregulation, increased size and weight, volume of both trucks and cars, age of vehicles, driver qualifications, and driver economic euphoria. The classic definition of a truck accident in and of itself causes bias in that all collisions of a truck with another vehicle are ascribed to the truck. Under this definition, trucks can be expected to be involved in more collisions than would be expected from their population alone. For example, if the population was 90% cars and 10% trucks and the probability of collision was the same for all vehicles, the expected distribution of two-vehicle accidents would be 81% (.9 x .9) car and car, 18% (.9 x .1 + .1 x . 9) car and truck, and 1% (.1 x .1) truck and truck. Thus, if the truck, with 10% of the population, was found to be involved in 19% of all two-vehicle accidents, that fact should be neither surprising nor condemnatory to trucks.

Overall Trends

The 3.6% increase in total accidents from 1985 to 1986 somewhat tempered the 15% increase from 1984 to 1985 and the 11% increase from 1983 to 1984. Total statewide accidents in 1986, 1987, and 1988 (nearly 400,000) surpassed the total for 1978, the last year before the annual accident counts began to decrease, as shown in

Figure 3. The increase in large-truck-involved accidents, however, was greater: 21% between 1983 and 1984, 29% between 1984 and 1985, and 10% between 1985 and 1986, before the 7.9% decrease between 1986 and 1987.

Statewide truck and nontruck accident trends by month for the period 1980-1988 are shown in Figures 4 and 5. Large truck (10,000 pound GVW or greater) accident trends are shown in Figures 6 and 7.

The total trunkline accident increase was primarily in property-damage-only accidents. In the 6 years before 1985, the percentage of statewide accidents that resulted in a fatality or a personal injury stayed constant at about 30.5%. In 1985, that percentage dropped to 27.9%, and in 1986 it dipped to 27.2%. The severity incidence of injury or fatality of large-truck-involved accidents had a similar decrease.

Trunkline accident experience paralleled the statewide trends until 1987, as shown in Table 2.

Table 2

Truck Accident Increases, 1983-1986

	1983-1984 % Increase	1984-1985 % Increase	1985-1986 % Increase	1985 Count	1986 Count
Total	17	15	3.2	139,947	144,407
Truck-involved accidents	22	25	7.5	11,702	12,578

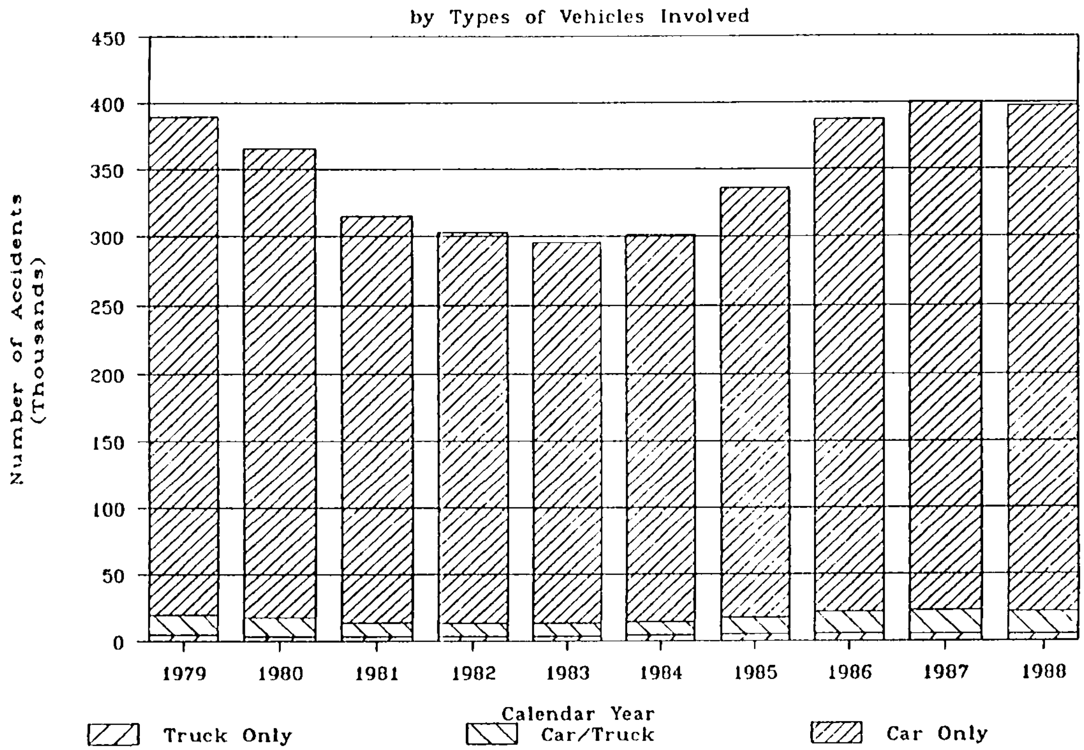

Figure 3. Michigan Statewide Traffic Accidents.

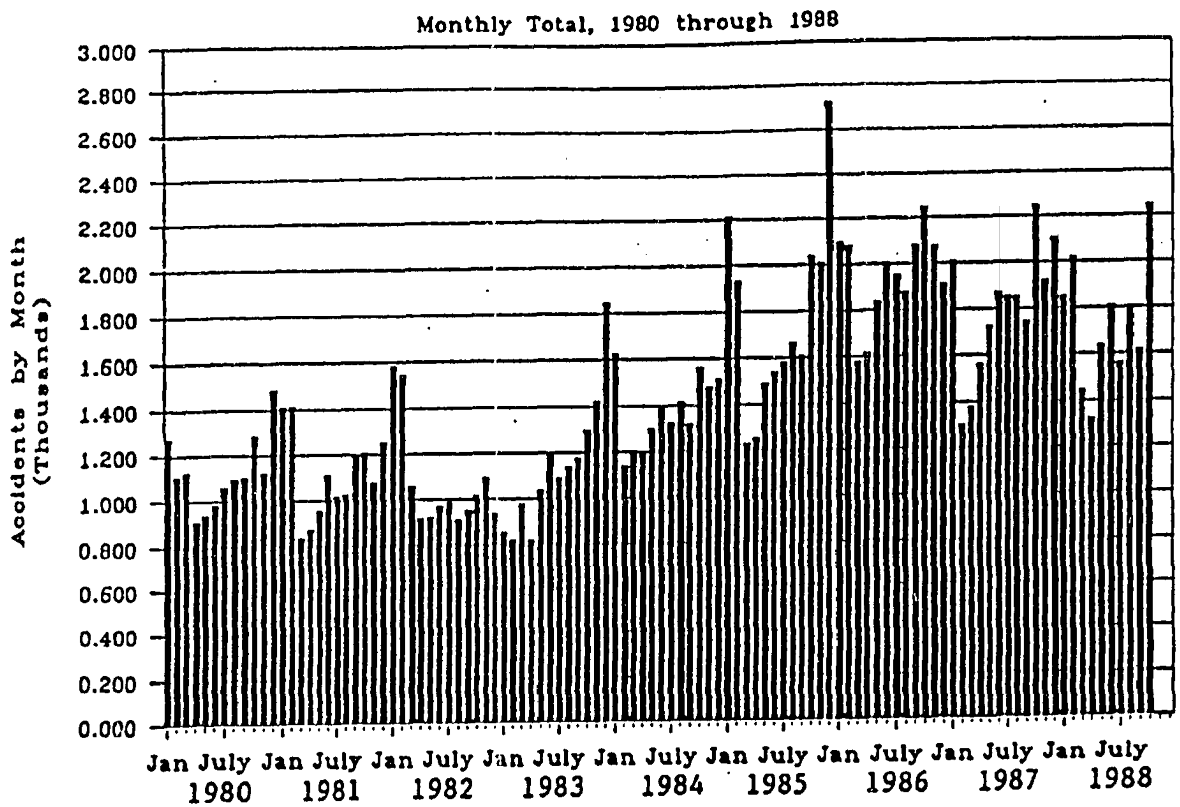

Figure 4. Michigan Truck-Related Accidents (Monthly Total, 1980 Through 1988).

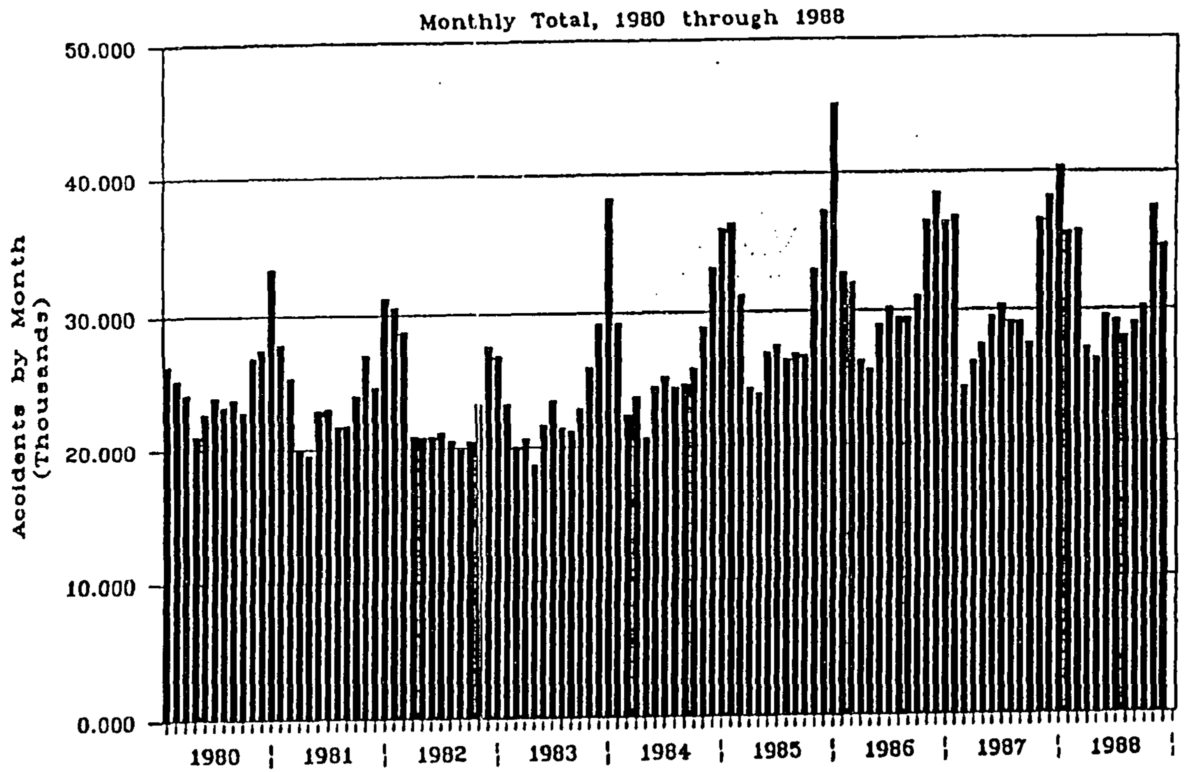

Figure 5. Michigan Nontruck Accidents (Monthly Total, 1980 Through 1988).

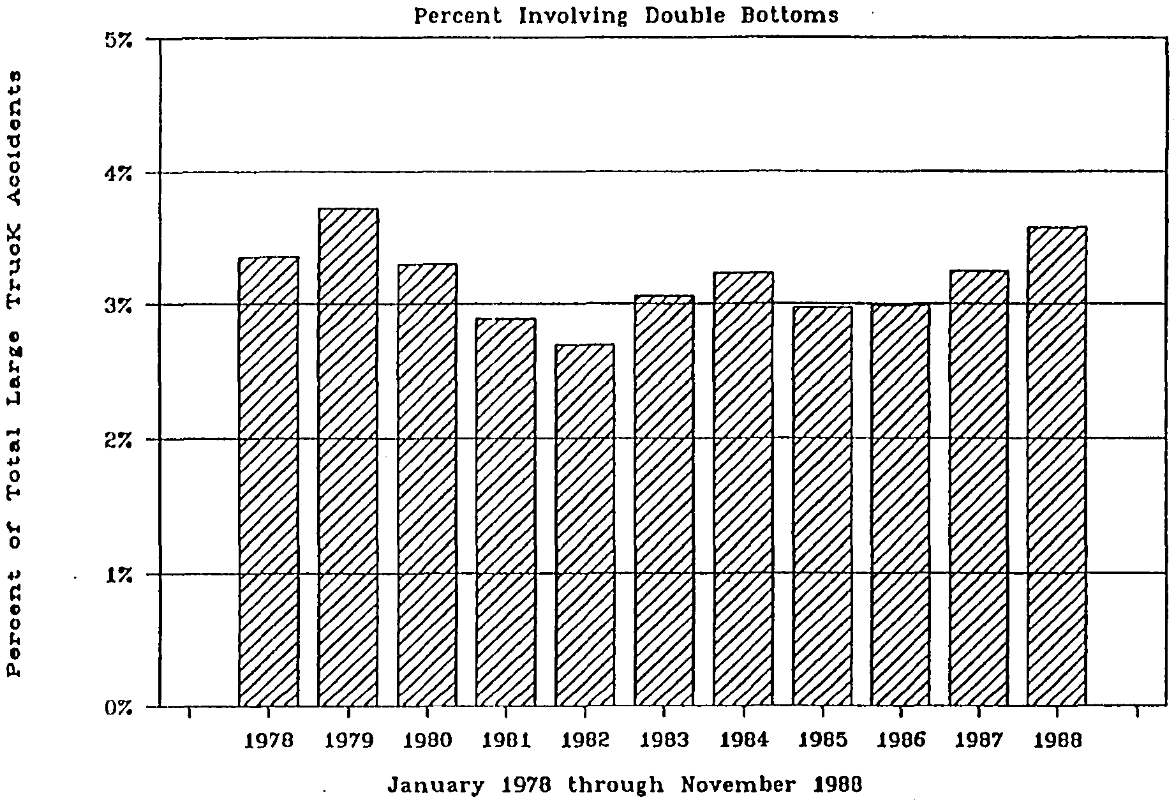

Figure 6. Michigan Large Truck Accidents (Percentage Involving Double Bottoms).

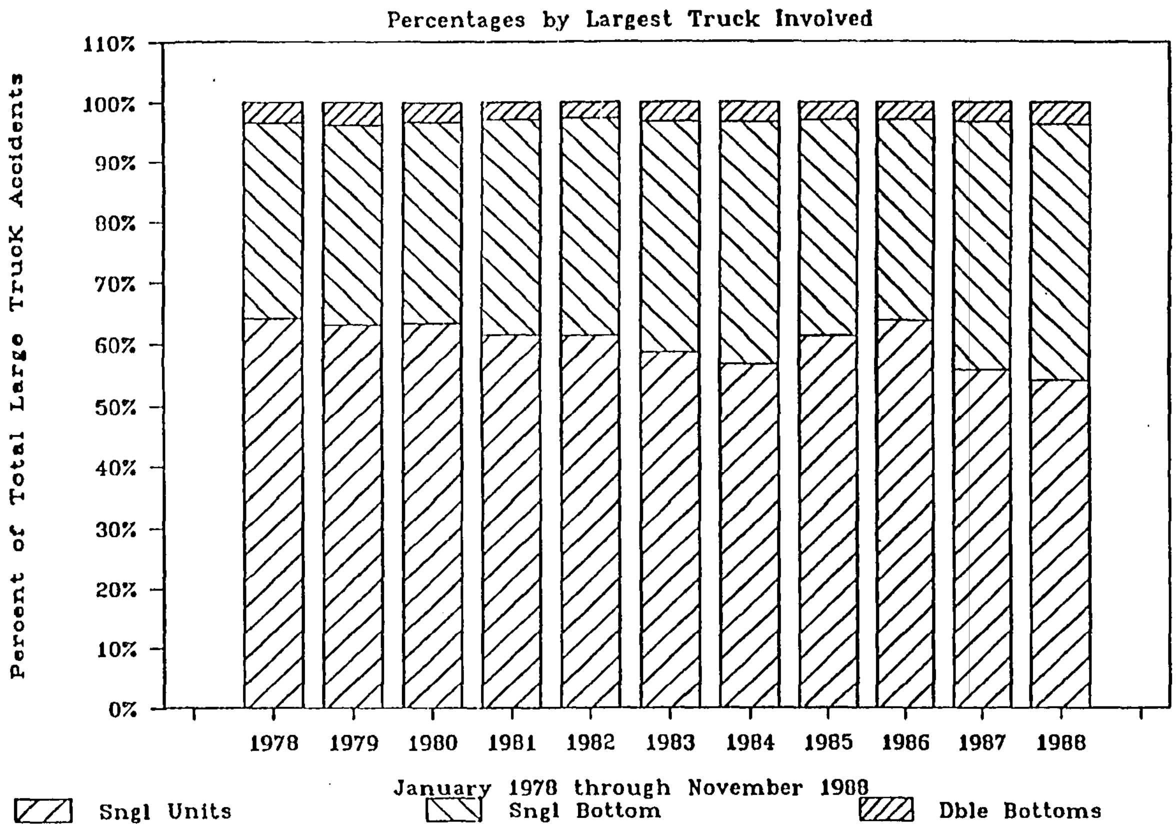

Figure 7. Michigan Large Truck Accidents (Percentages by Largest Truck Involved).

Then, in 1987, the following occurred (see Table 3).

Table 3

Truck Accident Increase, 1986-1987

	1986-1987 % Increase	1987 Count
Total	0.8	145,600
Truck-involved accidents	-7.9	11,588

Severity trends were as shown in Table 4 (percentage injury or fatal).

Table 4

Severity Trends, 1984-1987

	1984	1985	1986	1987
Total	31.1	28.7	27.5	27.3
Truck-involved accidents	27.4	26.3	25.8	26.1

Rates

The MDOT Bureau of Transportation Planning reported a 4% annual increase in travel for 1984-1985 for all vehicles, with commercial travel remaining at 9% of the total. Sales of fuel increased 7% for cars and 6.5% for trucks from 1984 to 1985. The Bureau of

Transportation Planning recognizes that there are problems in estimating exposure information for various configurations of trucks and is now intensifying its research efforts in this area. Increases in travel between 1985 and 1986 were estimated at 3.2% and between 1986 and 1987 at 7.2%. It does not appear that changes in volume alone can account for the fluctuations in accidents; the preliminary indication is that accident rates have increased. Some reasons are presented in the following section, but the cause of much of this increase remains unknown.

Snowy or Icy Pavement Surface

The most apparent increase during 1984 and 1985 was in accidents occurring on snowy or icy pavement; almost two-thirds of the increase in trunkline accidents from 1984 to 1985 was in this category. The number of icy-pavement accidents (27,923) and their percentage of the total (23%) were the highest in 10 years. For comparison, in the previous 9 years, icy-pavement accidents accounted for between 13.3% and 19.6% of the total. This increase was greater for property-damage accidents than for injury-producing accidents. Truck-involved trunkline accidents on snowy or icy surfaces increased by 127% and accounted for 21.7% of the total truck-involved accidents.

The number of accidents that occurred when it was snowing almost doubled, from 11,000 in 1984 to 21,000 in 1985, which

indicates that there may have been more snowfall, possibly during peak-volume periods, in 1985. Climatological information for Michigan shows a 40% increase in precipitation in the winter months between calendar years 1984 and 1985. Over the same period, the statewide use of de-icing salt increased by 50%, from 296,000 to 443,000 tons. However, in 1986 the snow/icy surface accidents returned to normal level, about 13% of the total.

Truck Types

A truck-involved accident, as defined here, is one in which at least one of the vehicles was larger than a pickup or step van, and 10,000 pounds GVW or larger, as recorded by the investigating officer. (A standard of 26,000 pounds to define a large truck is being adopted nationally, so care must be taken with definitions.)

This definition of a truck is further divided into three classes: single unit (dump trucks, stake trucks, delivery trucks, and such); single-bottom (truck-tractor and single trailer); and double-bottom (truck-tractor and two trailers or a single-unit with a trailer).

The increase in truck-involved trunkline accidents in 1985 and 1986 occurred mostly with single-unit trucks as tabulated in Table 5.

Accidents involving single trailer combinations, the major focus of most studies, did not increase between 1985 and 1986, but in 1987 this type of accident apparently increased 11%, while there

was a 23% decrease in single-unit truck accidents. Coding changes that more correctly attributed single-trailer accidents rather than "bob-tails," and classified them as single-trailer units, are believed to be the cause of the 11% increase. Double-bottom trucks continue to make up only a small percentage of the total accident figure.

Table 5

Accidents by Truck Type, 1984-1987

	1984 Count	1985 Count	% Increase	1986 Count	% Increase	1987 Count	% Increase
Single unit	4,378	5,979	37	6,811	14	5,235	-23
Single bottom	4,564	5,243	12	5,248	0	5,845	11
Double bottom	395	482	22	519	8	408	- 2

Summary of Accident Trends Analysis

Accident causation is a complex phenomenon that involves several variables, primarily associated with the driver, vehicle, roadway, and environment. Much attention has been given to the vehicle, with many studies devoted to the effect of increasing truck weight and length as primary contributors to accident increases. These studies are discussed in the next chapter.

Trucks have long governed the structural and geometric criteria for highway design in an attempt to minimize the roadway contribution to accident causation.

In this brief review of accident trends, the environmental factors of weather and snowy or icy surfaces were examined as major contributors to accidents. Although not proven here, the decrease in severity of accidents may be due to increased use of seatbelts. Other environmental factors such as the deregulation of 1980 and the Surface Transportation Assistance Act of 1982, allowing larger trucks, also presumably affected the trends in, as yet, undefined proportions.

Some argue that the driver is the single most important factor, and studies have shown that as many as 95% of truck accidents are attributed to the driver. Licensing requirements for commercial drivers will continue to be a major issue. The current federal legislation pertaining to truck driver licensing represents an important step toward greater safety but will take a long period to implement and has many loopholes. Improved criteria are needed for determining who should be licensed to drive large trucks, and this study should shed light on that effort.

The Michigan Dimensional Accident Surveillance System

The Michigan Dimensional Accident Surveillance (MIDAS) system is a successful research effort that could contribute further to

policy decisions through analysis of data from combined driver records and existing data. It has long used combined accident, geometric, and environmental data to provide improved information for decision making regarding the spending of scarce highway safety funds. Concepts from MIDAS were used to analyze several years of truck accident data. The original work plan for MIDAS in the mid-1970s envisioned that driver records would add a significant contribution to the safety policy and resource-allocation process. However, this last phase of MIDAS has not been implemented due to lack of resources for the effort in light of other pressing safety priorities. This is discussed in greater detail later.

Summary

In this chapter, governmental policy issues were identified and discussed. Background material on the evolution of policy at the MDOT was presented. Historical accident data were examined to assist in explaining why the truck-safety policy makers were encouraged to take action. Arguments were presented from various perspectives on the issues of deregulation and licensing policy.

CHAPTER III

LITERATURE REVIEW

The review of literature begins with a general discussion of research efforts and then focuses on the primary interest of this research--using previous accident experience as a predictor. The last part of the chapter is devoted to examination of induced exposure or "innocent victim" applications in the literature.

In a review of accident research involving truck size and weight, Freitas (1982) concluded that available research on large truck safety is not always congruent. Conflicting results involve different sizes of trucks. The quality of data generally is poor. Freitas stated that these problems must be addressed so that these productive trucks can be operated safely on the nation's highways.

The Insurance Institute for Highway Safety (1985) reported that nearly 4,500 people die each year from injuries in crashes involving big trucks. More than a million big trucks operate in the United States. The report further stated that only 15% of truck drivers involved in accidents had any formal commercial driver education. Proposed solutions to the highway safety problem posed by large trucks included a federal certification system with special qualifications for drivers of big trucks and an automated National Driver Register to determine driver licensing and histories in other states.

Congress directed the National Research Council to determine the effects of the Surface Transportation Act of 1982, which mandated that states permit double trailers and larger single trailers on certain routes. Its eventual recommendations included "stricter requirements for these drivers, including a single national license with uniform standards, stricter enforcement of time limits, appropriate physical qualifications, required driving performance monitoring, and training requirements" (Transportation Research Board, 1986, p. 209).

A comprehensive study involving 1,816 accidents sponsored by the Federal Highway Administration (FHWA) found there was no significant difference in the accident rates of trucks, nontrucks, and the total traffic stream (Vallette, McGee, Sanders, & Enger, 1981). Among other findings, the researchers concluded that truck drivers under age 20 have the highest accident rate, followed by those in the 20 to 29 and over-60 age groups. Eleven percent of all trucks involved in accidents had vehicle defects of one kind or another that usually precipitated the accident. Defective brakes accounted for 38% of the vehicle-defect accidents. Other findings were that drivers with more commercial experience had low accident-involvement rates and that doubles had higher rates than singles.

Subsequent research by Glauz and Harwood (1985) discredited the above-mentioned FHWA research, which came to be known as the Bio Technology, Inc., Study:

> Most researchers have found little if any difference in their respective accident rates. The major exception is a large, widely quoted study conducted by Bio Technology, Inc., for the Federal Highway Administration. It concluded, among other things, that doubles have significantly higher accident rates than do singles. The research reported in this paper consisted of a thorough review of all aspects of that study, with particular emphasis on the structure and contents of the three major data bases used. These included data on 2,112 large truck accident involvements, vehicle classification count data taken at 78 sites, and driver and truck data (including size and weight) on more than 32,000 trucks. It was found that the conclusions drawn by Bio Technology, Inc., regarding doubles versus singles, as well as most of the other major conclusions, are not supported by the data bases. Although the accident data base may be useful to other researchers, if used with care, the two data bases needed to estimate exposure are totally inaccurate, and results derived therefrom are probably meaningless. (p. 17)

Several other authors have noted inconsistencies in various other findings. For example, Chira-Chavala and Cleveland (1985) noted the following sources of incompatibility:

> Most studies only examined a special population of trucks (i.e., from certain companies, states, or regions of the country). Often, the selection of the samples was not necessarily random; thus, it is difficult to use or extrapolate their findings at the national level; and, methods of analyzing accident rates, t-tests, and/or analysis of variance in which one or two variables were investigated at a time, have shortcomings. One of these is the implicit assumption that these tests were carried out for "homogeneous" populations. That is, there were no other significant "confounding" factors at play. Such an assumption, when not met, gives rise to "Simpson's Paradox" and, therefore, model misspecification and possible incorrect findings. (p. 56)

These researchers concluded, based on discrete multivariate analysis, that most doubles and singles showed higher accident-involvement rates than straight trucks. Further, they recommended that schemes aimed at increasing driver experience in operating

combination vehicles, particularly doubles, be encouraged (Chira-Chavala & Cleveland, 1985).

A report entitled Large Truck Accident Causation (Eichler, Robertson, & Toth, 1982), prepared by the National Highway Safety Administration in cooperation with the Federal Highway Administration for the Senate Committee on Appropriations, included the following recommendations:

> To undertake a comprehensive data collection and analysis of large (greater than 10,000 pounds GVW), medium (10,000 to 26,000 pounds GVW), and heavy (greater than 26,000 pounds GVW) truck accidents. This undertaking should be done in cooperation with other Federal agencies, State transportation or highway departments, truck manufacturers, operators and carriers, labor organizations, associations, police officials, accident investigators and researchers, insurance companies, and other interested and affected parties. Such report shall identify truck accident causative factors and include recommendations so that effective countermeasures to prevent accidents and injuries, both to their occupants and those of other vehicles, can be defined. (pp. 1-2)

These measures were called for, based on accident data cited in the report.

> In 1979-1980, large trucks were involved in 5.7 percent of all traffic accidents and 11.8 percent of all fatal accidents reported to police. It is estimated that during these years, 44 accidents involving large trucks occurred every hour each day of the year and one out of every nine persons killed on the nation's roadways was the victim of a large truck accident. Data for 1981 show that 5,779 persons died in accidents involving large trucks (FARS data, NASS data, 1979-1981). (Eichler et al., 1982, p. 2)

In a discussion paper prepared for the AAA Foundation for Traffic Safety, Baker (1985) concluded that structural changes resulting from deregulation have produced a threatening combination of aging equipment and underpaid, unqualified, and overworked

drivers. Stringent licensing procedures, including demonstrated ability to handle specific equipment, were recommended, as were increased inspection, identification and elimination of "hours of service" violators, and overall length limits of 60 feet.

The National Highway Safety Advisory Committee on Commercial Vehicle Safety (U.S. Department of Transportation, 1985) recommended that:

> Truck driver training and licensing will have to be more tailored to the operating requirements of commercial trucks in use; the National Driver Register must come on line as quickly as possible so that states and trucking companies can use this system to remove unsafe drivers; government must develop accident data for specific types of trucks if program efforts are to become more effective in reducing accidents; states should be encouraged to introduce more effective roadside safety inspections; and, all states should be encouraged to adopt the critical items inspection practice of the Commercial Vehicle Safety Alliance. (p. 1)

Specific Related Research

Freitas (1986) summarized the federal role in large truck safety research. Project 1U was undertaken in response to a need for better information on the safety implications of increased truck size and weight.

Project 1U began in 1975 and included "The Effect of Truck Size and Weight on Accident Experience and Traffic Operations" (commonly called the Biotech Study). Other major topics were "The Effect of Truck Size on Driver Behavior," "Motorists' Attitude Towards Large Trucks," "Influence of Size and Weight Variables on the Stability

and Control Properties of Heavy Trucks," and "Simulation of Cargo Shifting Effects of Vehicle Handling." Other portions of Project 1U involved truck splash and spray, runaway trucks on steep downgrades, truck stopping, sight distance, and offtracking.

Other studies at that time involved geometric features at interchanges, truck tractive power criteria, operation of larger trucks on roads and streets with restrictive geometry, techniques for improving the dynamic ability of multitrailer combination vehicles, safety criteria for a multitrailer truck highway network, and development of a large truck safety data needs study plan. With the possible exception of the last noted research area, detailed analysis of driver records for crash prediction of large trucks was not in the federal research plan.

Chira-Chavala and Cleveland (1985) concluded, based on discrete-multivariate analysis, that most doubles and singles showed higher accident-involvement rates than straight trucks. The authors encouraged schemes aimed at increasing driver experience in operating combination vehicles, and they recognized a strong need to improve truck-exposure data.

O'Day and Kostyniuk (1985) concluded from an urban truck accident model that an increase in the proportion of large trucks will lead to an increase in injuries and fatalities. They saw improved roadway design and engineering as the main solutions to avoid the impending increases.

In an analysis of 8 years of accident data in Michigan (1970-1977), Atabak and Khasnobis (1980) concluded that there was no significant difference in the overall accident rates of trucks versus nontrucks but that truck-tractor combinations have a higher fatal accident rate than nontrucks. Exposure was estimated from published average statistics and travel trends.

A more recent study by Campbell, Blower, Gattis, and Wolfe (1988), using an adjusted-rate method to account for travel differences, concluded that the risk of fatal accident involvement would be greater for doubles and for singles weighing more than 65,000 pounds _if_ their travel patterns were comparable to that of all large trucks. Data were obtained from two UMTRI surveys: the Trucks Involved in Fatal Accidents (TIFA) and the National Truck Trip Information Survey (NTTIS). The primary study objective was to demonstrate the potential use of such data to increase understanding of large truck accidents.

Lund (1984) reviewed various studies on crash prediction from driver records and concluded that predictive accuracy for individuals remains low; the best predictive variables could explain only 10% to 15% of the variation. He found that _groups_ of drivers with elevated crash risk could be identified but that these severely deviant drivers made up such a small segment of the problem that preventing them from driving would have little effect on the crash picture. The most effective way that license revocation or

suspension programs affect the total accident problem may be as a deterrent to other drivers.

A summary of previous research in the area of crash prediction is found in a study by Mitter and Vilardo (1984):

> Another interesting result is the value of r^2, the proportion of variance explained, obtained for these models. Although neither equation shows strong explanatory power in absolute terms, these results are substantially higher than the results reported by other researchers working toward the prediction of drivers' accident involvement, especially for the heavy truck group. In a study of truck drivers employed by several commercial carriers, Levonian et al. attempted to predict recorded accidents and recorded violations using multiple regression models with non-driving independent variables, including cognitive, visual and psycho-motor test results, personal characteristics and medical and personality factors. Although they obtained statistically significant results, the highest r^2 they reported was .077, which they considered to be low. In an effort to predict accident involvement using multiple regression models, from driver record data only, Coppin and Peck report the highest r^2 obtained from the several models they investigated to be .0459. When this same study was expanded to include biographical data as well as driver record data, the best result was r^2 = .0514. In a very recent study, Miller and Schuster used many different regression models to predict current and previous driving behavior, employing driver record data and driver attitude survey scale scores as independent variables. The best results obtained were in the range r^2 = .08 to .10. Miller and Schuster's work was confined to individuals who were not professional drivers, and their results can be loosely compared to the "other" group in this report. The work of Coppin, McBride and Peck used a simple random sample of all California drivers with valid records. Both of these previous studies used many independent variables, as compared with the relatively few variables employed in this study.
>
> One explanation for the difference between prior research and this report may be that the data from NASS used for this analysis were confined to accident-involved drivers who may comprise a discrete subset of accident-prone individuals. Another consideration in this connection is that, in the NASS data, the circumstances under which prior violations were charged is not known, i.e., a driver with a prior accident may have been charged with an infraction associated with that

accident. However, the authors believe that by singling out homogeneous subpopulations, the usefulness of efforts to predict accident involvement will be enhanced.

The ability to identify and control high risk drivers, especially heavy truck drivers, is of great interest to the U.S. Department of Transportation, the insurance industry, and the trucking industry. The viability of driver's record data in this context is important because data collection and analysis is vastly simplified. If the results of this study can be validated by replication and improved upon by more refined analyses, the modeling of accident involvement for certain groups of drivers holds great promise as the basis for countermeasure development. (pp. 119-120)

Researchers have long held that accident proneness, if it does exist, accounts for only a small proportion of the total crash picture. Forbes (1939) found that the accident-prone driver contributes not more than 3% or 4% of the traffic-accident problem.

Peck and Kuan (1982) summarized accident-risk-prediction research as follows:

Although a number of correlates of individual accident liability have been found, it would be incorrect to conclude that the majority of accidents are caused by a small number of "accident-prone" drivers or that individual accident involvement (and accident losses) can be predicted with a high degree of precision. Several large scale studies have documented the fact that the majority of accidents in any time period involve drivers with average or good prior driving records. It has also been pointed out that the statistical nature of driver accident frequencies makes it impossible to accurately predict which individuals will and will not be involved in accidents. For example, Peck et al. (1971), using a Poisson fitting technique developed independently by Newbold (1927) and Cobb (1940), reported that even an infallible prediction battery could not predict more than 15 percent of the variance in the three year accident frequencies of the California male driving population. There is obviously a substantial amount of luck or chance in determining accident involvement because of the complex chain of interactive events that determine a given accident occurrence. A very negligent driver may not become accident-involved for long periods through pure luck, whereas a safe driver may have the

> misfortune of being victimized by some other driver's carelessness. All of the factors operate to suppress our ability to predict accurately the accident involvement frequencies of individual drivers. A more detailed schematic representation of the accident generation process can be found in Peck (1976).
>
> Despite the preceding limitations, certain drivers are more likely than others to be involved in accidents, and it is possible to incorporate these correlations into formulas for: (1) predicting the likelihood that a driver with given characteristics will be accident-involved, and (2) accurately estimating the number of accidents of any large group of drivers. (p. 372)

Michiels and Schneider (1984) found in analyzing traffic offenders in Geneva, Switzerland, that of drivers who committed three or more offenses in 2 years, only 62% would actually commit one other offense in the next 2-year period.

Although it has been shown that predicting individual accident involvement or offenses based on driver records is not normally feasible, most states have licensing policies aimed at restricting licenses based on past driver records. Furtado, Saenz, and Eskin (1983) recommended postlicensing control of heavy vehicle drivers in California by providing earlier sanctions against heavy vehicle operators who are negligent. Prima facie negligent operation is defined by the number of points resulting from traffic convictions.

The recommendations in California stemmed in part from earlier work by Waller and Li (1979). The authors summarized their main ideas in the following manner:

> In the process of conducting the project, it became evident that many of the key questions regarding the safety of heavy trucks cannot be adequately answered on the basis of available data. Nevertheless, there is no question that there is growing

> concern as to whether our current practices are adequate to ensure an acceptable level of safety performance. Heavy trucks are disproportionately represented in fatal crashes, and their overrepresentation has been increasing in recent years.
>
> The findings indicate that at the present time there is inadequate information as to exactly what should be included in a licensing program. However, in the absence of proven technology, the recommendations for licensure are based on input from the literature review, the data analyses, interviews with motor carrier safety supervisors, and the many contacts and discussions with persons representing other areas of expertise regarding licensing and monitoring of drivers of heavy trucks.
>
> In summary, there appear to be major shortcomings in current procedures for licensing and monitoring drivers of heavy trucks. Not only do many state programs need upgrading but also there is a critical need for an effective records system that will provide accurate and complete information on driver performance. Although a federal license for drivers of heavy trucks could potentially alleviate some safety problems, the evidence indicates that a coordinated state system, supported by federal standards with enforceable sanctions and by an interstate identification file, would be far more effective and less costly to implement and maintain. (pp. v-vii)

In a more recent report, also by the University of North Carolina Highway Safety Research Center (HSRC), Geissinger, Waller, Stewart, Rodgman, and Reinfurt (1986) helped to direct research that was similar in its focus to this study, especially in addressing the admitted shortcomings of the research regarding exposure. On the basis of its literature review, the results of the study, and the suggestion of an expert panel, the HSRC made 13 recommendations. The research study examined both the relationship between a driver's record in his or her private vehicle and that person's record in a large truck, with the purpose of being able to determine the extent

to which violations or crashes incurred in private driving were related to commercial violations and crashes.

Geissinger et al. (1986) cautioned that a major reservation about the findings was that the completeness of records was not known and that multiple licensing posed significant problems in analyzing the data. Another concern was that an estimate of exposure for truck drivers was not easily available. An admittedly crude method of exposure based on responses for North Carolina drivers regarding estimated annual miles driven was used in the study.

Records of commercial vehicle drivers from North Carolina and Washington were analyzed using chi-square techniques to measure the association between prior and subsequent driving records, and linear regression models were used to determine predictability. Geissinger et al. (1986) concluded that:

> The findings clearly show that there is a relationship between the record in the private vehicle and that incurred in subsequent employment related driving. In addition, findings indicate that estimated annual mileage and driver age are related to subsequent crashes but these relationships are not as strong as that between prior driving record and number of subsequent crashes. Generally, the driving record in the truck is a better predictor than either the record in the private vehicle or the total record, including both private and commercial driving. (p. vi)

The next question is whether there are research designs that minimize the effects of lack of good exposure information, the effects of multiple licenses, and the possible lack of complete

records. The methodology described in Chapter IV was designed to deal with these questions.

The Concept of Innocent Victim (Induced Exposure)

Lack of exposure data was a major concern in this research design. Drivers may have more accidents and citations merely due to having more logged miles. Selection of the samples for comparison must account for possible differences in exposure.

Waller, Reinfurt, Freeman, and Imroy (1973) concluded that it was not possible to disprove the induced exposure concept on the basis of their research. Yet Waller made no attempt through secondary analysis to apply these concepts to the more recent research on heavy truck driver licensing (Geissinger et al., 1986; Waller & Li, 1979). Waller et al. noted that in 1964 Thorpe proposed a method for determining risk based on the following assumption:

> 1. Single-vehicle accidents are caused entirely by attributes of the driver-vehicle combination concerned.
>
> 2. Collision accidents are caused by the first two vehicles to hit. In each such collision, there will be a "responsible" and a "not responsible" driver-vehicle combination.
>
> 3. The relative likelihood of a driver-vehicle combination being the "responsible" combination in a collision accident will be the same as the relative likelihood of that combination being involved in a single-vehicle accident.
>
> 4. The likelihood of any particular driver-vehicle combination being "innocently" involved in a collision accident will be the likelihood of meeting that combination on the road (i.e., will constitute the exposure distribution). (p. 2)

Lyles, Lighthizer, and Stamatiadis (1988) found the quasi-induced (innocent victim) method for determining exposure quite promising in their reexamination performed for presentation at the January 1989 Transportation Research Board Conference. This method, developed in the 1960s, was also previously used successfully by Kuroda at Michigan State University in 1984 and is discussed later in this section.

The conclusions drawn by Lyles et al. (1988) are directly applicable to this study:

> If it is assumed that in many accidents there is a driver who is "at-fault" (driver-1) and one who is an "innocent victim" (driver-2), it has been argued that the characteristics of driver-2 (e.g., sex, age, type of vehicle driven) constitute a random sample of the characteristics of driver/vehicle combinations on the road at the time of the accident. That is, the characteristics of driver-2 are implicit measures of "exposure." Subsequently, it can be argued that the ratio of the proportions of driver-1s and driver-2s with stated characteristics, the involvement ratio (IR) is a measure of the "relative risk" associated with that characteristic. If IR is greater than one, then that characteristic is disproportionately represented in accident causation. For example, if the proportion of males who are driver-1 is higher than the propor-tion of males who are driver-2, then males are disproportionately more likely to cause accidents--the magnitude of IR indicates, within reason, how disproportionate the effect is.
>
> While the concept of using the IRs as a measure of those driver, vehicle, and roadway characteristics which are most related to accident risk is not particularly new, validation of the technique has been lacking. The effort reported here is a first step in such a validation. For relatively simple circumstances (e.g., sex of drivers), it has been demonstrated that the characteristics of driver-2 appear to be reasonably good measures of exposure. This conclusion is based on comparisons of the distributions of driver-2 characteristics involved with different types of driver-1s. For example, on state-numbered routes in Michigan, 61.9 percent of the accidents caused by male driver-1s were with male driver-2s. Likewise, 60.4 percent of the accidents caused by female

> driver-1s were with male driver-2s. The similarity of the distributions of driver-2s provides implicit support that driver-2 is an "innocent victim," a random sample of all those on the road under the specified conditions. (pp. 17-18)

In a separate paper also for presentation at the Transportation Research Board, Lyles and Stamatiadis (1988) stated:

> The analysis of truck accidents presented here has not been comprehensive but rather directed to an initial application of a quasi-induced exposure method to the analysis of truck accidents. In this sense, the work is clearly "in progress," and comments, both of a theoretical and empirical nature are encouraged. The approach itself appears to have at least some merit. At the most general level, the results of the analysis are not different from those reported elsewhere--larger trucks seem to be over-represented (relative to their exposure) in two-vehicle accidents. Further, there is relative consistency "within" the application--it appears reasonable to assume that driver-2 characteristics (as defined here) constitute a random sample of driver/vehicle combinations on the highway under specified conditions.
>
> This assertion of validity comes from the general agreement in the distributions of driver-2 characteristics. At the same time, variations in these distributions, when compared on the basis of vehicle type, lend themselves to an explanation of the "truck safety problem" that is different from what "conventional wisdom" might suggest. That is, that passenger vehicle-truck involvements are not especially over-represented in the data--rather the general over-representation of trucks in two-vehicle accidents results from truck-truck interactions. (As indicated earlier, this statement is not meant to minimize the clear problems of severity associated with passenger vehicle-truck accidents, rather it is addressed solely to the relative involvement rate.)
>
> There are also problems with attaching statistical significance to, for example, the values of IR which have not been addressed here. Further, it is clear from the work here and elsewhere, that the row percentages are relatively unstable given the relatively small cell sample sizes as are the calculated IRs. This point notwithstanding, the trends in terms of which vehicle types contributed to relative over- and under-involvement were quite consistent.
>
> Further work is being done on both the application of this technique to truck-involved accidents and development of a

> better theoretical base. Still further work is being done on assessing the validity of driver-2 characteristics per se--i.e., comparing selected driver-2 characteristics derived from accident data with field observations of the same characteristics. (pp. 21-23)

Bowman and Hummer (1988) concluded the induced exposure methods section of their literature-review summary with this observation:

> It is interesting to consider the possibility that the apparent reluctance of traffic engineering professionals to use quasi-induced exposure estimates may be due to preconceived, and incorrect ideas of exposure, resulting from erroneous traditional exposure methods. In fact, the failure of induced exposure methods to gain increased acceptance among traffic engineering professionals may be because their results did not agree with the more common and possibly erroneous traditional results. Better estimates of the accuracy of induced exposure may be obtained by analyzing the induced exposure in conjunction with variables that have more reliability than those obtained from counts of traffic stream components. For example, comparing estimates of driver characteristics such as age and sex from induced exposure methods, with relatively accurate demographic estimates, may yield a better estimate of the applicability of induced exposure than a comparison of induced exposure results and traditional exposure methods such as vehicle miles traveled. (pp. 29-30)

Kuroda, Maleck, and Taylor (1984) used the "innocent victim" approach to account for unknown exposure in an earlier study of accidents by vehicle size. Although this was not the first use of nonviolators in accidents to estimate relative populations, it is the most far-reaching application; that is, it used the most accidents. That study used Michigan data, encompassed the MIDAS model, and was performed by Michigan State University staff.

The research was undertaken by Michigan State University through a contract managed by this writer with a report prepared by Kuroda et al. (1984), edited by this writer, and formally delivered

to the MDOT. The following analysis includes portions of that effort.

The critical data link that relates vehicle characteristics, accidents, and geometry is the vehicle identification number (VIN), available in Michigan accident data for the years 1981 to present. VINDICATOR 83, obtained from the Highway Loss Data Institute, decodes the VIN. This computer system decodes and analyzes VINs for 12 domestic and 33 foreign makes of passenger cars, as well as vans, light trucks, and multipurpose vehicles for the 1967 to 1983 model years.

In this first research effort, VINDICATOR was used mainly to determine in which of seven weight or wheelbase classes to place the vehicle. This effort can be expanded to perform analysis of specific makes and models.

A measure of exposure of different-size vehicles was also critical to this study. A surrogate exposure approach based on two hypotheses was used:

1. The likelihood of an automobile being an object (the second vehicle) of an accident is proportional to its exposure.

2. The likelihood of any automobile being the object of an accident is equal if the exposure is the same.

The data support these hypotheses, and the surrogate approach is a useful tool for exposure estimates. This is somewhat similar to the induced or indirect exposure approach used by others with varying degrees of success.

In 1982, slightly more than 100,000 accidents occurred on the state trunkline system. Only accidents involving at least one passenger car were analyzed. Processing by VINDICATOR provided a data base of 51,740 automobiles identified as Vehicle #1 and 32,284 identified as Vehicle #2.

Instructions for completing the State of Michigan Official Traffic Accident Report (UD-10), issued by the Department of State Police, state that the reporting section for Vehicle #1 is to be used for the motor vehicle and driver most responsible for causing the accident. If the reports are properly completed, the second vehicle is often an innocent victim. A detailed discussion of the validity of designating Vehicle #1 as the violator is presented at the end of the File Merge Process section.

If the hypotheses hold, the number of Vehicles #2 should be proportional to the exposure of any class of vehicle. One would expect that for total accidents, if the type or size of vehicle is not a factor, the ratio of actual involvement to expected involvement (based on the number of Vehicle #2 accidents) should be near 1.0 for all seven classes used, based on curb weight.

This surrogate exposure approach is compared to the traditional exposure method (registration percentage information from a sample county) in Figures 8 and 9.

When examining all of the accidents, the surrogate approach appears far superior to the registration information method. The

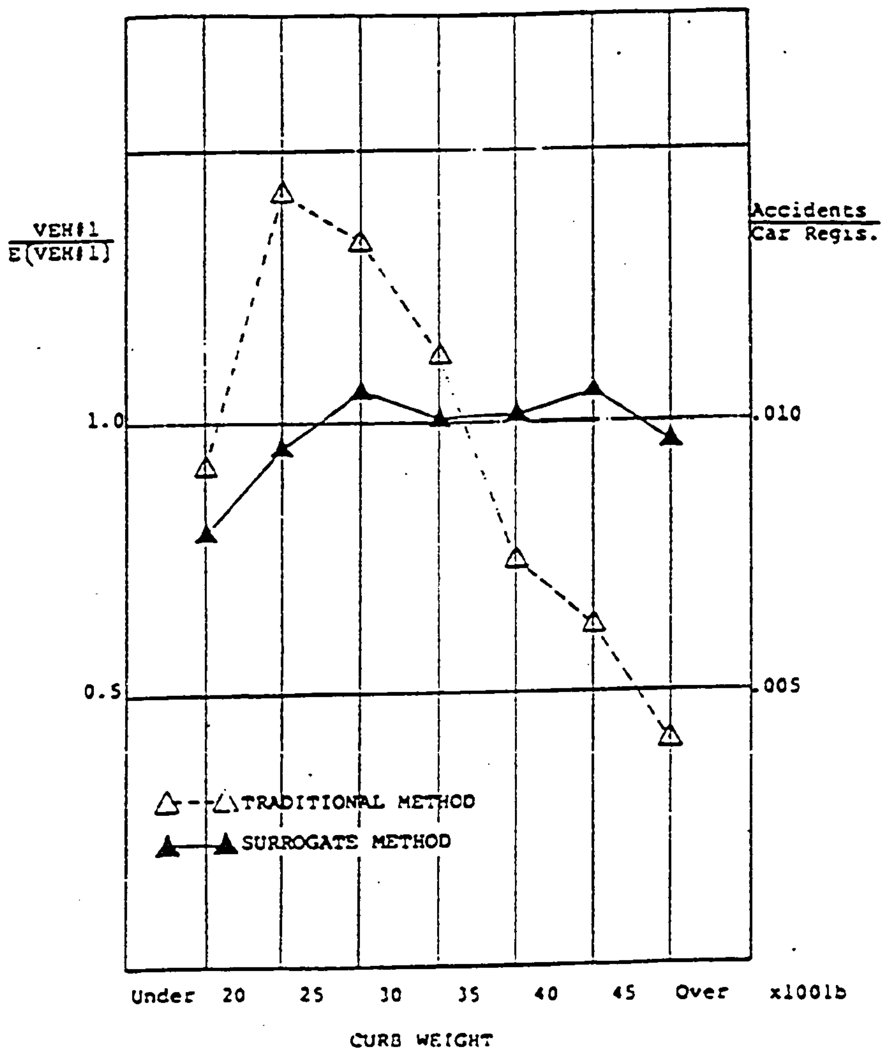

Figure 8. Exposure Method (Kuroda, Maleck, & Taylor, 1984).

Source: Kuroda, K., Maleck, T. L., & Taylor, W. C. (1984). <u>The relationship of vehicle characteristics, highway geometry, and traffic accidents</u>. East Lansing: Michigan State University, p. 53.

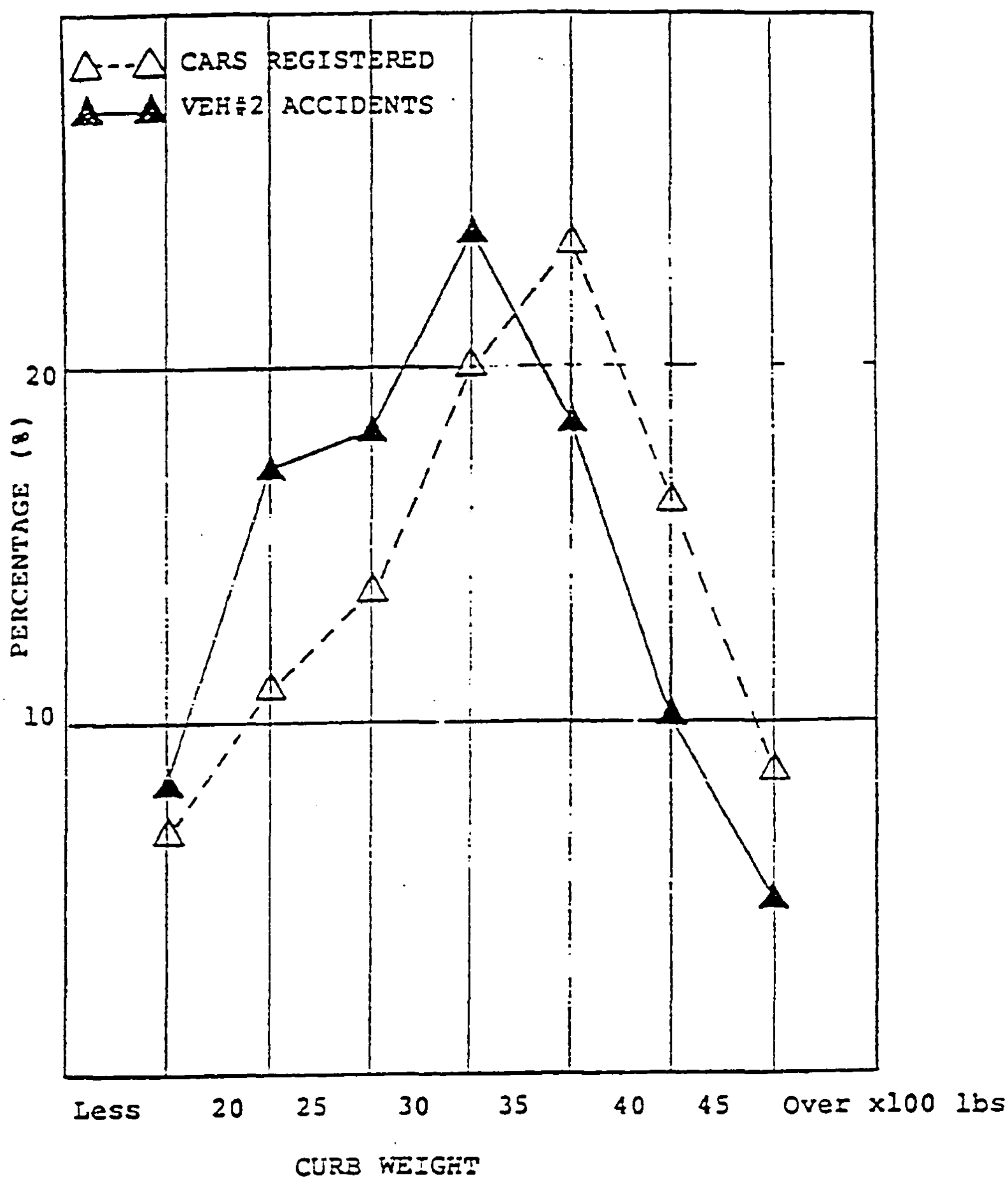

Figure 9. Difference Between Exposure Measures (Kuroda, Maleck, & Taylor, 1984).

Source: Kuroda, K., Maleck, T. L., & Taylor, W. C. (1984). <u>The relationship of vehicle characteristics, highway geometry, and traffic accidents</u>. East Lansing: Michigan State University, p. 51.

values plotted are the ratios of the observed frequency of Vehicle #1 accidents divided by the expected frequency based on assumed exposure. A distinct lateral shift is noted in Figure 9, which can be explained by either smaller vehicles having a higher exposure or being more likely to be hit.

If the risk of an automobile being involved as Vehicle #2 is not related to size, the distribution by size should be similar for different types of accidents. Figure 10 bears out this expectation.

The ratios of the actual to expected number of accidents for the seven curb-weight classes using this surrogate approach were examined for hundreds of possible relationships. One of the more interesting ones will be discussed here with the caveat that more research is needed to determine other factors affecting these relationships, such as driver and vehicle age and driver characteristics. Figure 11 illustrates the comparison of sex of the driver and size of vehicle. It appears that there is little difference between the expected and actual accident frequencies of male versus female drivers when exposure is considered.

Summary

A review of the literature showed that there has been continued disagreement on the scope of the "problem" regarding heavy truck safety. Although it was generally accepted that singles and doubles showed higher overall accident rates than straight trucks, Michigan

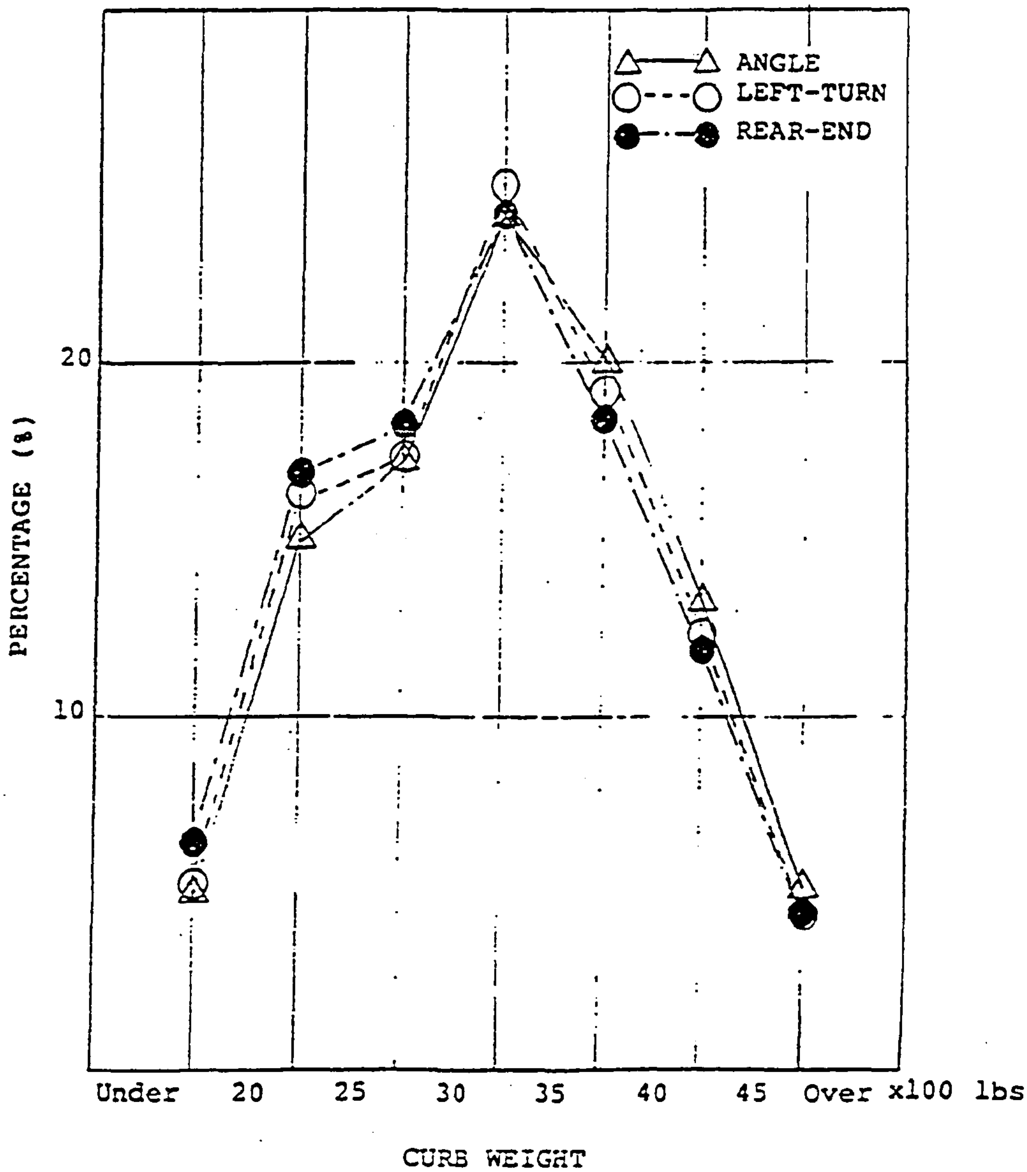

Figure 10. Population Distribution #2 (Kuroda, Maleck, & Taylor, 1984).

Source: Kuroda, K., Maleck, T. L., & Taylor, W. C. (1984). The relationship of vehicle characteristics, highway geometry, and traffic accidents. East Lansing: Michigan State University, p. 55.

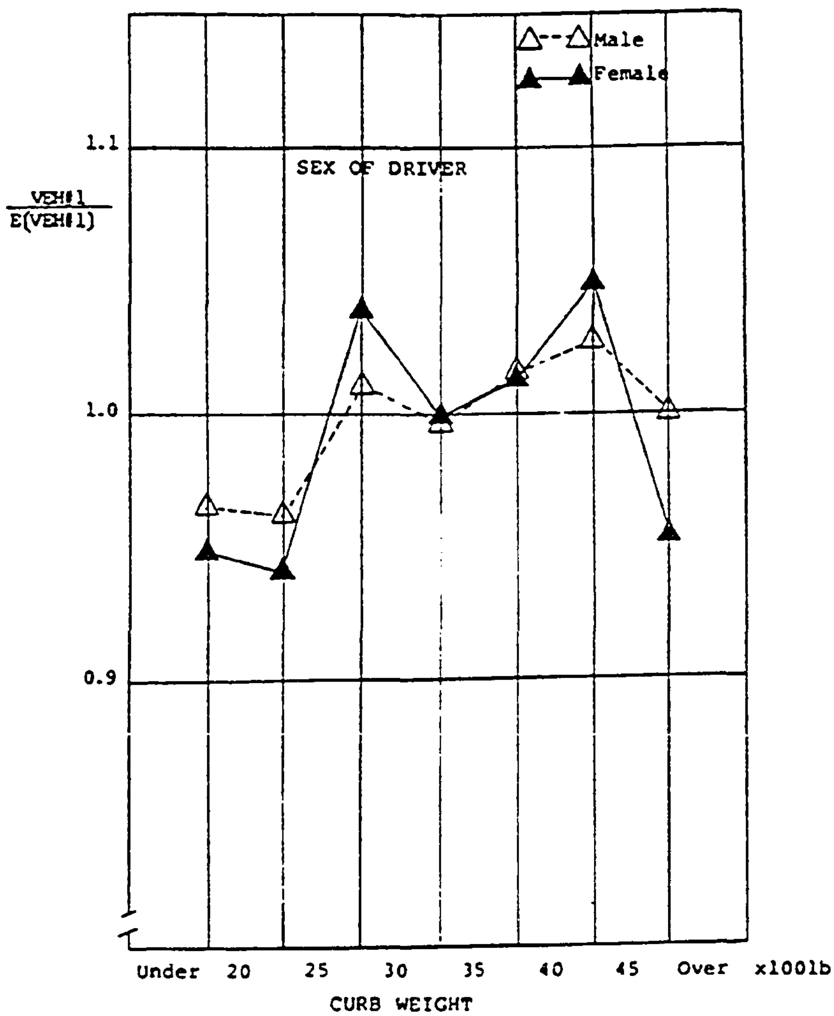

Figure 11. Accidents by Sex of Driver (Kuroda, Maleck, & Taylor, 1984).

Source: Kuroda, K., Maleck, T. L., & Taylor, W. C. (1984). <u>The relationship of vehicle characteristics, highway geometry, and traffic accidents</u>. East Lansing: Michigan State University, p. 126.

data showed this to be true only for fatal accidents. There was also consensus that more detailed data gathering by policing agencies was needed. In addition, most researchers concluded that increased driver training and experience were needed for those driving singles and doubles.

There appears to be a void in current research on the driver and on prediction. The lone exception is the 1986 North Carolina Highway Safety Research Center study (Geissinger et al., 1986), which admitted concern regarding exposure and completeness of data.

The older studies on accident prediction generally concluded that severely deviant drivers make up a very small proportion of the population. The predictive equations based on prior driving history are very weak and can predict only a small portion of the accidents. The literature indicated that previous research on crash prediction has concluded that prediction capabilities for individuals remain low. However, prediction efforts may be enhanced by singling out homogeneous subpopulations.

Most current researchers view measures of exposure as problems. The use of induced exposure or the innocent victim concept is gaining popularity among some researchers. Lack of more widespread acceptance of such a method may be due to preconceived or incorrect ideas about exposure or accident rates in general.

CHAPTER IV

METHODOLOGY

The methodology introduced here was designed to determine the causes of heavy truck accidents, provide an evaluation of policy, and build a model for future analysis. It was adopted to minimize the effects of factors that may have distorted the previous research results.

The primary focus of this research was to determine whether a driver's accident or citation experience in a private vehicle (nonheavy truck) as well as in a heavy truck is a good predictor of accident experience in a commercial vehicle (heavy truck). The recent research effort at the University of North Carolina Highway Safety Research Center (HSRC) (Geissinger et al., 1986) attempted to demonstrate the relationship and was marginally successful. The main focus of the HSRC study was on the value of the personal driver record for predicting future performance in a truck. The study included a literature review, data analysis, and a review of findings by an expert panel. Driver history files from Washington and North Carolina comprised the majority of the data base. Among conclusions reached was that there was a clear relationship between the prior private vehicle accident record and that of the truck but that previous truck driver record was the best predictor of future truck accidents. Driver age, annual mileage, and total previous

accident experience were associated with future driver performance but were not as strong predictors as truck accident history. The authors warned that the findings should be treated with caution due to lack of knowledge or completeness of data.

The research design can be improved on, and powerful analysis tools available only in the case of Michigan data should provide for more reliable results. If a strong relationship can be quantified and relationships clearly defined, the use of private vehicle accident experience can be used as a qualification in licensing heavy truck drivers. The HSRC study was unable to reach this conclusion due to the inadequacy of its data base.

Several obstacles confront researchers in this area. Among the most formidable are:

1. Gaining access to driver records with accidents and citations.

2. Gaining access to accident data detailed enough to isolate contributing variables.

3. Linking driver records and accident data.

4. Determining the type of vehicle involved in an accident (heavy truck or car) from available data.

5. Selecting an unbiased sample for study.

6. Designing a study that minimizes effects of absence of reliable exposure data.

7. Designing a study that minimizes the effects of multiple driver licenses.

8. Analyzing enough data so that even obscure relationships between variables are discovered.

9. Arriving at statistically significant results on which to base policy recommendations without trepidation.

This section details how many of these obstacles were overcome, and the flow chart in Figure 12 graphically demonstrates the overall process. In summary, the process involved obtaining tapes of driver information data from the Department of State, which included citation information, and matching those data with accident data, originally provided by Michigan State Police and available at the MDOT. The match was accomplished through driver license number or accident report number. The matched file was divided in half for a predictor generator set and test set. The 1986-1987 accident data were used to determine innocent victims and violators, and then the 1982-1985 accident data were used to test for differences between the two groups. Several of the other facets of the research designed to eliminate or overcome research problems will become clearer as the remainder of the methodology unfolds. However, there are two issues that must be fully understood before progressing further in discussing the research methodology. These are the issues of exposure and multiple licenses.

Vehicle miles of travel have long been accepted as the best measure of exposure in analyzing traffic accidents. However, obtaining such data for particular analysis purposes is often

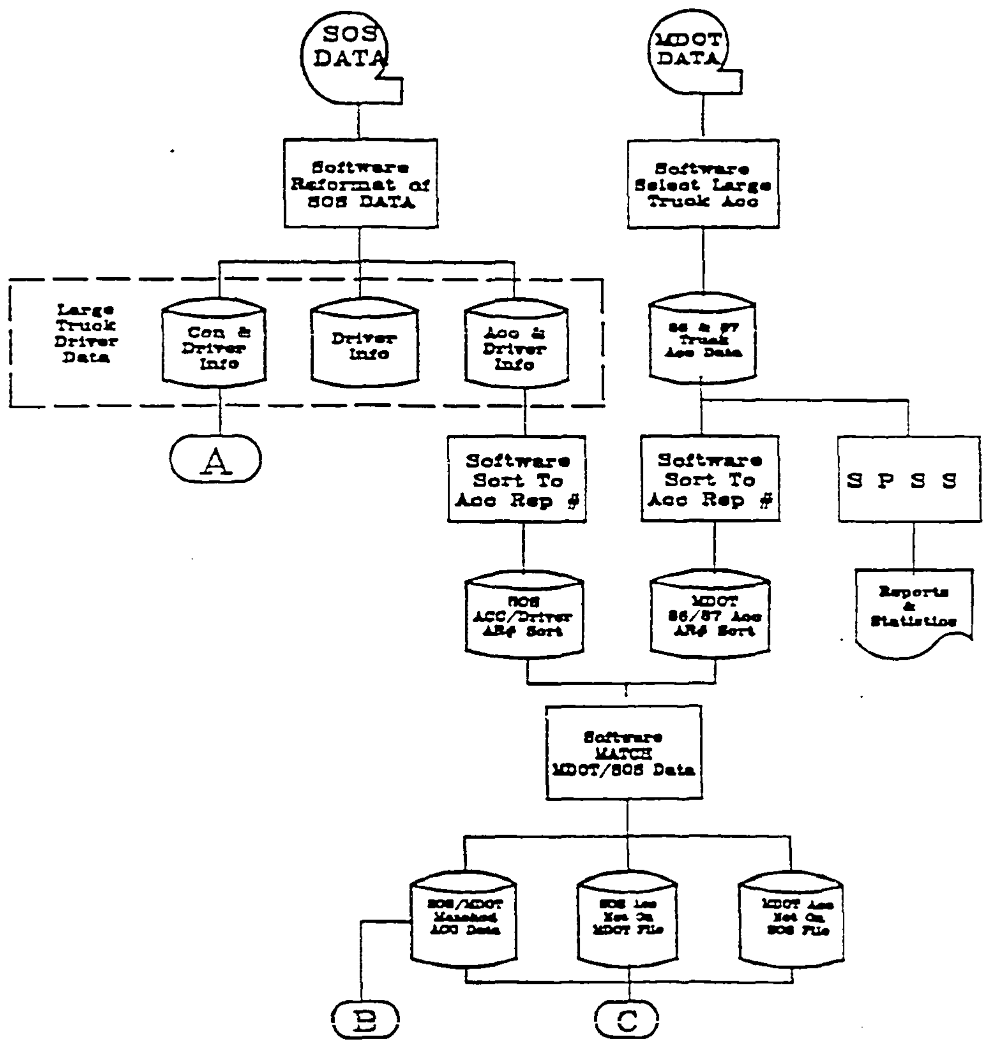

Figure 12. Data-Processing Flowchart.

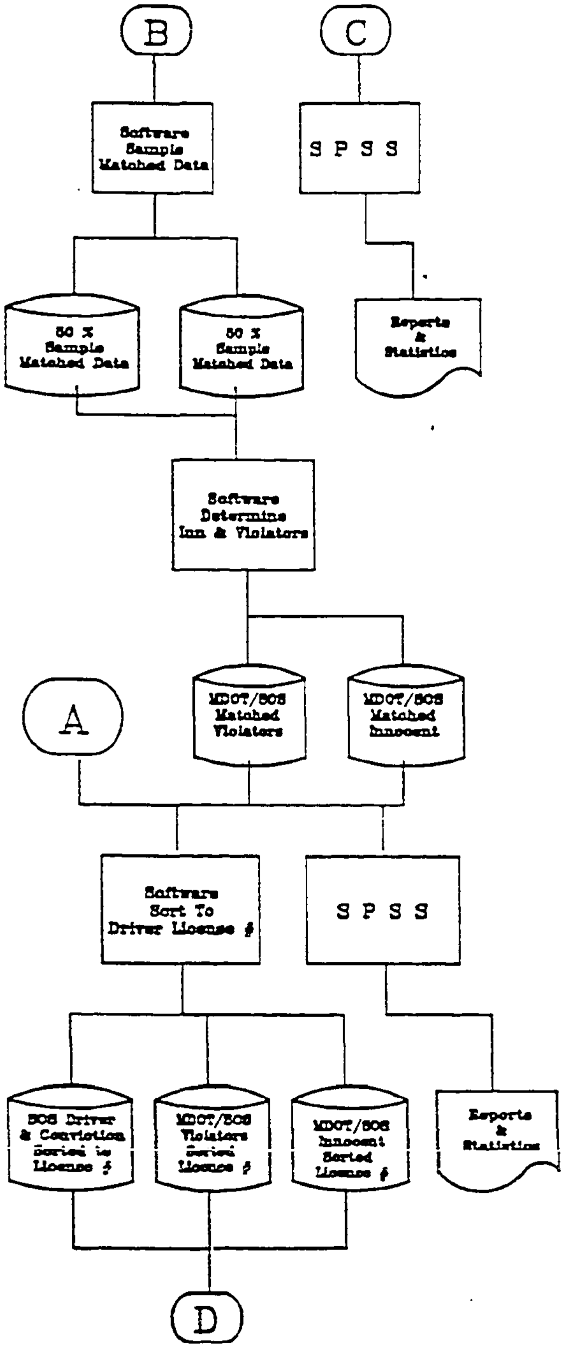

Figure 12--Continued

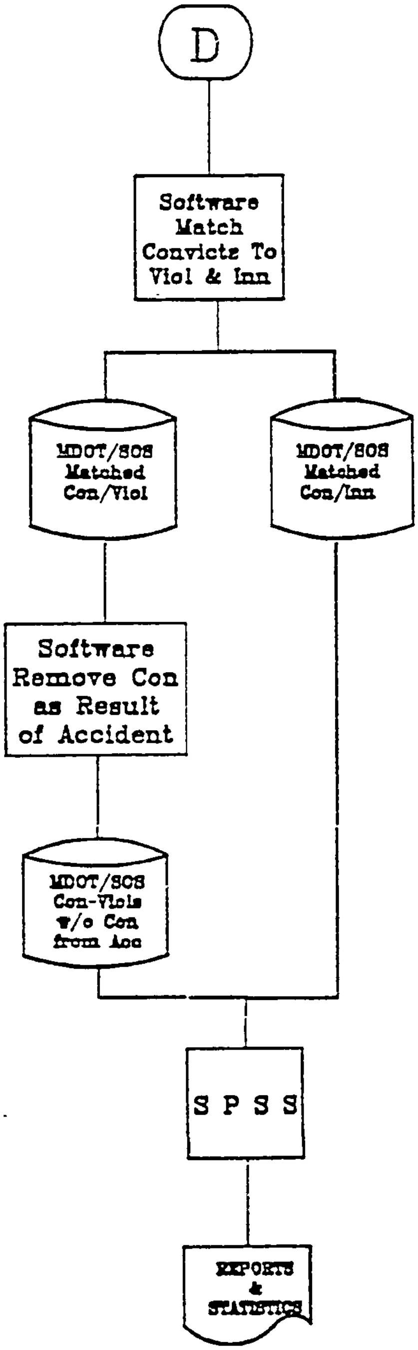

Figure 12--Continued

difficult, if not impossible. For instance, traffic surveys on the highway network allow estimates of total vehicle miles of travel (VMT) changes from year to year, and samples of the commercial proportion of travel may allow gross measurement of commercial VMT. But these data are of little value in attempting to analyze individual or group driver accident or citation histories because their relative exposure is unknown. Researchers may compare citation histories of drivers involved in accidents with histories of all licensed drivers and conclude that citation histories can be used to predict accidents because accident-involved drivers have significantly more citations. However, there is no way of knowing the exposure of either group. Just because an individual has a license, there is no guarantee that he or she will exercise the use of the license. If a person has an accident, at least the researcher can be reasonably sure that the individual has exercised the use of the license and has some exposure.

The problem then becomes one of finding groups of drivers to compare who are known to be driving, and who have known exposure, even though their relative exposure may not be certain. This is why the induced exposure or innocent victim concept, as discussed previously in the literature review and expanded further later in this chapter, is vital. These drivers are selected from a population of truck drivers who have been involved in accidents and, therefore, have some exposure, and are exercising their license to

drive tractor-trailers. A meaningful comparison with violators is then possible because it is known that the innocent victim had a certain amount of exposure rather than allowing a license to go unused.

Another apparent major obstacle that has been alleviated, based on recent federal research results and inspection of the Michigan accident data, is that of multiple driver licenses from different states. Edwards and Benkowski (1989) reported that the vast majority of truckers (78%) limited themselves to possessing only one valid license each.

Any error in this study's research design, introduced by this factor, should be minimal, since the data show that over 85% of the drivers are Michigan residents and, of the remaining 15%, the majority are of unknown residence. Two basic data sources were merged through the Michigan Dimensional Analysis Surveillance (MIDAS) system as a further means of overcoming any residual problems that might have been caused by multiple driver licenses from different states.

Using Michigan trunkline accident data for 1986 and 1987, a 50% sample of tractor-trailer drivers who were not at fault in accidents was compared with a 50% sample of drivers who were found to be at fault. The accident (A) and citation (C) histories for the two groups, innocent victims (IV) and violators (V), were compared to see if there was a statistically significant difference in the frequency of private vehicle and commercial vehicle accidents and

citations between the samples. Of course, the accident and the related citation that caused the selection for the at-fault sample were not included in the comparison.

The null hypothesis H_0 can be expressed as:

$$H_0: \quad A_{IV} = A_V; \quad C_{IV} = C_V$$

The alternative (research) hypothesis is:

$$H_1: \quad A_{IV} < A_V; \quad C_{IV} < C_V$$

The sample size was not dependent on available computing capabilities, but it was large enough to satisfy all statistical thresholds. The objective was to use as much of the available population as possible within limits of data availability and time, and to take full advantage of the MDOT's Unisys A-15 made available for this research. With the large sample size, the effects of varying exposure should be minimized. The research design used 50% of the population for the years studied so that any significant relationships found could then be tested against the remaining 50% of the data.

By using a large sample approaching the population size, more acceptance can be expected of any conclusions reached through the analysis. The two-sample _t_-test of means will be used at the 99% level of confidence, alpha = .01. This should minimize the error of rejecting the null hypothesis when it is, in fact, true.

Conclusions reached in this study may affect driver licensing policies; hence, error cannot be tolerated.

Should significant relationships be found, the next step in the research process will be to build a model for predicting heavy truck collisions based on drivers' previous accident and citation experience as well as other factors such as age of driver, type of vehicle, weather conditions, presence of drugs or alcohol, and other as yet undefined variables. Stepwise multiple regression analysis will be used primarily to produce the model, but an interaction-detection model may be needed to isolate key variables. The model will be built with the 50% sample 1982-1985 data and tested against the other half of the population.

Induced exposure or "innocent victim" concepts have direct application to this study. If a sample of truck drivers is selected from a group of innocent victims involved in accidents, their relative exposure should be reflected in the fact that they were operating a vehicle and thus exposed to involvement in accidents. The higher the exposure, the more likely they will be selected. A similar argument can be made for the "violators." If the violators are really more predisposed to an accident than the innocent victims, they should be overrepresented with respect to exposure; they should have higher accident rates or fewer miles. If the at-fault driver sample selected in this manner actually has less exposure, any error will be in assuming a worse driving record with less exposure. In that regard, the study is conservative. If we

reject H_0, in spite of less exposure, the effect of possible less exposure is negated.

The two samples, innocent victims and violators, will have to be tested for homogeneity so far as truck size, driver age, and other factors are concerned so that reasonable certainty can be assured that the accident experience is the only discriminating factor.

If a question of exposure between the two groups is still not resolved, a short questionnaire could be sent to a sample from both groups as well as a sample of those Class 2 endorsed drivers who fall into neither group to determine relative exposure. Since the reliability of such a survey can be questioned and the trouble and expense may be inordinate, the exposure survey is recommended for further research since it is beyond the realm of this research effort.

The Michigan Dimensional Accident Surveillance (MIDAS) System

The development of the MIDAS system began in the 1970s. The following discussion was prepared with the assistance of the Traffic and Safety Division of MDOT responsible for the MIDAS program.

In its first phase, MIDAS concentrated on obtaining high-accident listings based on injury-producing accidents. Roadway segments were analyzed in uniform 0.2-mile lengths, categorized

according to the geometric conditions at the beginning of each segment.

In its second phase, MIDAS was expanded to include property-damage-only accidents and variable segment lengths: segments thus are now defined by their categories and extend until one of the data items changes. The site-specific accident report package was developed in this phase.

MIDAS is being developed to provide accident-analysis information in three forms:

1. It identifies locations that have abnormally high numbers of accidents compared to similar locations on the state trunkline system, using an objective, statistically sound procedure.

2. It gathers together all available information about any particular location and presents that information to the investigator in a package of tables and charts.

3. In the future, it will enable the investigator to predict the number of accidents that would occur if the conditions at a location were changed.

MIDAS is being developed by the Technical Services Unit, Traffic and Safety Division of the MDOT, with computer programming and statistical analysis assistance from the MDOT Engineering and Scientific Data Center. Since 1979, MIDAS development was funded, in part, by a grant from the National Highway Traffic Safety Administration, administered by Michigan's Office of Highway Safety Planning. This federal funding, however, is no longer available.

MIDAS development is now in its third phase. Various versions of the high-accident lists have been tested, several are in use, and the techniques are being refined. The site-specific package of reports is operational; it will, however, be continually reevaluated and revised as necessary. Preliminary predictor equations have been developed, but only to test the theory.

When the predictor portion of MIDAS is completed, the investigator will be able to predict what the accident experience would be if a location's design or operations were changed so that the location would fall within another peer group. The theory is that a number of design and operational combinations could be tested, with the one having the lowest number of predicted accidents being the one that would, in fact, have the lowest number if that treatment were applied. The predicted accident count would be used only to compare alternate treatments and would not necessarily precisely predict the actual number of accidents. This phase of the MIDAS system requires very accurate information concerning the roadway geometry and operations to develop accurate predictor equations.

In Michigan, all accident records are kept by the Department of State Police, which uses the Michigan Accident Locating Index (MALI) system to add location information on the computer accident record. The MDOT obtains a copy of the accident files for its own uses, including their analysis by MIDAS. Roadway geometric information

was obtained from the MDOT Photolog system. The initial data were gathered in 1977 and improved in 1979. The data were recollected in 1982 to update and expand the files. Horizontal alignment information was obtained from the MDOT right-of-way books. Traffic-volume information was obtained from the MDOT Transportation Planning Bureau's "Trunkline Vehicle Miles" file. Structure information was taken from the MDOT Design Division's Structure Inventory.

MIDAS's development has been hampered by the fact that the reference information used by the various files was often incompatible, making it difficult and time consuming to match the location information from the different data sources.

MIDAS's need for data from a number of different sources has highlighted the need for a department-wide data network that will cross-reference the files from a number of different sources. The MDOT is now in the process of developing such a data network, which will simplify the maintenance of MIDAS. MIDAS's development has also reemphasized the long-recognized need for a major overhaul of MALI; that effort is under way.

The system will eventually be expanded to include other types of data not currently being used, such as driver and vehicle characteristics and guardrail and traffic control device inventories. The research included in this dissertation will be incorporated into the MIDAS system expansion.

The research approach being evaluated in this study is intended to better isolate the contributing factors in heavy truck accidents. It uses the 7 years of trunkline truck accident data, combined with the geometric and environmental information available from MIDAS, along with driver records. Important software used in this study was drawn from the Statistical Package for the Social Sciences (SPSS).

Stepwise Multiple Regression

The SPSS package includes multiple regression, which permits the user to solve a sequence of one or more multiple linear regression problems by stepwise application of the least-square method. At each step in the analysis, a variable is added or removed, which results in the greatest reduction in the error sum of squares. Stepwise regression is a variation of multiple regression, which provides a means of choosing that combination of variables that yields the best prediction possible with the fewest independent variables.

A report is produced at each step as a variable is brought into or removed from the regression equation. The report provides the regression coefficient, standard error of regression coefficient, and F-to-remove for each variable in the regression at this step. The partial correlation coefficient, tolerance, and F-to-enter for every variable not in the equation at this step are also provided. The report provides the multiple correlation coefficient, the

standard error of estimate, and an analysis of variance summary table.

The significance of variables already in the regression equation may change as new variables are entered. The significance of the variables currently in the equation is also measured by the *F*-statistic. If *F* is too small, the variable is deleted from the equation.

Research Methods

The basic data needs and analysis requirements are listed below, followed by a brief chronology of data-acquisition actions and merging procedures. Abbreviated file descriptions are then given, with examples and more detail provided in Appendix A.

In summary, the research involved comparing driver histories of tractor-trailer drivers at fault in accidents over a 2-year period with driver histories of tractor-trailer drivers with similar opportunity for accidents (exposure). The necessary data include accident and citation histories for drivers maintained by the Department of State, as well as accident data compiled by the Department of State Police and maintained by the Department of Transportation.

A large-capacity mainframe computer capable of analyzing the entire population of accidents rather than samples was desirable, which would thus reduce errors and add credibility to the research.

Access to the computer proved a formidable obstacle, as did obtaining the needed skilled technical staff time to conduct the file manipulation, merging, and output generation.

The research design was chosen to minimize problems associated with multiple licensing and lack of reliable exposure data. An alternating driver survey methodology was proposed for future research efforts.

Driver Records

In January 1988, the Bureau of Information Systems for the Secretary of State approved release of driver histories for Michigan licensed drivers with Class 2 or Class 3 endorsements. They recognized the potential benefit to the Secretary of State and other Michigan departments through the contribution to accident reduction and incentive to complete the link between accidents, roadway data, vehicle characteristics, and driver information.

This approval was contingent on assurances of data confidentiality regarding names, Accident Report (AR) numbers, and personal information. These data were provided on magnetic tape and transferred to disk storage on the MDOT mainframe computer, a Unisys A-15. The file contained 7 years of driver histories for nearly 150,000 Class 2 and Class 3 endorsed drivers during the period 1981-1987.

The main file was then segregated into two files, one for citations and the other for accidents, each by driver. These files,

in and of themselves, are fruitful sources of descriptive statistical data. These statistics and the process used to meld the data follow a brief discussion of MDOT accident data.

Accident Data

Michigan law requires that reports of accidents be forwarded to the Director of the Department of State Police on forms that it provides. Such reports are not to be used in court, but the information can be used as statistical data on the number and causes of accidents. These reports also provide the basis for traffic legislation, enforcement, engineering, education, driver licensing, and public information pursuant to Section 624, Act 300, Public Acts of 1949.

The UD-10 form is provided to all local police agencies in Michigan. It includes information on the accident location, conditions, driver, circumstances, vehicles, and a written and graphic description of the accident. Compilation of statewide accident data is a complex task, requiring large expenditures by the State Police, even though the process is automated to a large extent. A delay of 6 months to receive data is not uncommon. The MDOT receives data monthly from the State Police and updates its files. The data are in the form of 252-character records that the MDOT transforms to various reporting formats through several programs, including SPSS.

File Merge Process

Department of State driver records consist of header records and trailers. The header record has driver information such as name, license number, address, license type, and other pertinent information. The trailers may be citation records, which have such information as the conviction type, date, and vehicle, or accident records, which include the data, severity, police department, and accident report number. These files are described more fully in Appendix A.

To facilitate handling of these unmanageably large files, the driver file was segregated into two files, one for accidents and one for citations. Both files contain the header, which means that the total storage space is increased, but this disadvantage is more than offset by the greater efficiency gained in file manipulation with smaller files.

To analyze the driver history/accident-prediction relationships in detail, it is necessary to append the accident data from the MDOT accident file to the driver header rather than rely on the limited accident information or the Department of State driver file. The research objectives are more directly reached in this manner because MDOT accident record files can be trimmed through a computer-select process so that only tractor-trailer accidents and the drivers therein are matched to the driver file. This match was accomplished in this study by using the year of accident and the Accident Report

number common to both files. The matched numbers can then be checked against the Department of State file to make sure that the correct numbers of matches actually occur.

The combined file was then split into two files, one for model building and one for testing. At the time that initial matches were attempted in spring 1988, the 1985 and 1986 data were used because the full year 1987 data were not yet available. By combining data over a 2-year period, the effects of yearly time series trends or other yearly fluctuations were minimized and a 4-year history of accidents and citations, 1981 through 1984, remained available for testing and model building. When the 1987 data became available, the 2 years 1986-1987 were used for the driver/accident sample and the preceding 4 years of data for testing and prediction.

The 50% combined file was then categorized by violator (V) and innocent victim (IV). As previously discussed, the violator or the driver most responsible is to be coded as vehicle 1 in multiple-vehicle accidents according to State Police instructions to all local police agencies filling out a UD-10 (see Appendix B). Only multiple-vehicle accidents were used in this analysis. Single-vehicle accidents accounted for 22.4% of truck-involved accidents in 1986. Although they are important, single-vehicle accidents were not used here because of concern that the data would be less reliable if there was no opportunity for a violator and an innocent victim in each accident. Furthermore, single-vehicle accidents may

have attributes that would mask or cloud the relationships that may be isolated by analyzing multiple-vehicle accidents separately.

There were 16,016 total multiple-vehicle accidents involving at least one large truck in the 2-year period, 1986-1987. Of these, 9,290 accidents matched with the Department of State driver file. The reason for inability to match was investigated, and the cause was that either driver 1 or driver 2 was from a bordering state or residence was unknown. Only Michigan-licensed drivers and Michigan accidents were used in this analysis.

The matching accidents were randomly split into approximately 50% test and control groups, 4,826 in the test set and 4,454 in the control set. Of the 4,826, there were 2,716 violators and only 1,711 innocent victims, in part because unless driver 2 was clearly an innocent victim, the accident was thrown out. That is, if driver 2 was thought to have contributed to the accident in any way, the accident report was not used in the analysis. Accuracy of police officer coding was relied on entirely because it was not feasible to review each report manually.

Further, the distribution of the number of truck accidents in the 2-year period, by driver, is as shown in Table 6. When the incidence of multiple accidents in the 2-year period is accounted for, there are 1,666 innocent victims and 2,609 violators to be used in analysis of previous years' accident experience to develop predictors. The distribution for the preceding 4 years is shown in Table 7.

Table 6

Truck Accident Distribution, 1986-1987

Innocent Victims	Violators
1 driver had 3 accidents	5 drivers had 3 accidents
43 drivers had 2 accidents	97 drivers had 2 accidents
1,622 drivers had 1 accident	2,507 drivers had 1 accident

Table 7

Truck Accident Distribution, 1982-1985

Innocent Victims	Violators
515 total truck accidents	750 truck accidents
	1 driver had 8 accidents
5 drivers had 4 accidents	5 drivers had 4 accidents
13 drivers had 3 accidents	21 drivers had 3 accidents
72 drivers had 2 accidents	110 drivers had 2 accidents
312 drivers had 1 accident	439 drivers had 1 accident
1,264 drivers had 0 accidents	2,033 drivers had 0 accidents

Previous investigations over a 10-year period by the writer concluded that the accuracy of coding the violator as vehicle 1 was about 85%. There appears to be little bias to the 15% when this

does not occur and the officer errs. It should be noted that, in pedestrian accidents, the pedestrian data are given in the place of vehicle 1. To be more certain that the violator file contained true violators, the information was checked against the hazardous action code to be sure that vehicle 2 did not have a hazardous action. If the form showed that vehicle 2 had a hazardous action, the report was removed from further analysis. In this manner, a file of true violators and innocent victims in tractor-trailer accidents for 1986-1987 was obtained.

Mercer's Method of Investigation

This issue was researched in depth by Mercer (1986). The conclusion reached after a study of 139,947 accidents was: "A person analyzing multiple-vehicle traffic accident information can rely on the 'Driver 1 is Violator' convention with at least 85 percent confidence" (p. 5). Mercer explained his procedure as follows:

> The 1985 Trunkline Accident Master (139,947 accidents) was used in this investigation. This file contains 38 percent of all 1985 traffic accidents in Michigan. The accident file can be further divided according to the type of unit given as Vehicle 2:

Vehicle 2 Type	No. Accidents	Percent
No Second Unit	38,593	27.6%
Motor Vehicle	99,181	70.9%
Pedestrian	1,178	0.8%
Pedalcycle	995	0.7%

> The reliability of the "Driver 1 is Violator" convention is measured by grouping the Multiple-Vehicle accidents into a 2-by-2 table, according to whether Driver 1 and Driver 2 were assigned hazardous action codes:

1985 Trunkline Multiple-Vehicle Accidents

Hazardous Action by Driver 1?	Hazardous Action by Driver 2?		
	No	Yes	Total
No	(A) 4,465	(C) 11,253	15,718
(Percent)	4.5%	11.3%	15.8%
Yes	(B) 77,632	(D) 5,831	83,563
(Percent)	78.3%	5.9%	84.2%
Total	82,097	17,084	99,181
(Percent)	82.8%	17.2%	100.0%

Percent Driver 1 Violator in Single-HA Accidents: 87.3% (E)

The accidents in Cell (B) exactly fit the convention: Driver 1 was assigned a hazardous action and Driver 2 was not. The accidents in Cell (C) are exactly opposite of the convention. For the accidents in Cell (A) neither driver was assigned a hazardous action and in Cell (D) both were. There is no way to determine if the investigating officers chose one of the drivers in the Cell (A) or Cell (D) accidents as the most responsible.

Two values are used to measure the reliability of the convention. The first is the percent in Cell (B) and the other is the percent in which Driver 1 was assigned the hazardous action when there was exactly one hazardous action. This is calculated by dividing Cell (B) by the sum of Cell (B) and Cell (C) [shown as (E) above]. (pp. 2-3)

To assure that the tractor-trailer accident subset of total accidents did not deviate significantly from Mercer's (1986) analysis, Table 8 was constructed, using all multiple-vehicle accidents in which at least one vehicle was a tractor-trailer combination. Analysis of more than 16,000 such accidents shows that the driver of vehicle 1 was the most responsible for these accidents where only one hazardous action was noted in 90% of the cases, thus

confirming designation of the vehicle 1 driver as the violator in the truck accident analysis.

Table 8

1986 and 1987 Tractor-Trailer Multiple-Vehicle Accidents

Hazardous Action by Driver 1?	Hazardous Action by Driver 2?		
	No	Yes	Total
No	(A) 1,103	(C) 1,389	2,492
(Percent)	6.9%	8.7%	15.5%
Yes	(B) 12,383	(D) 1,143	13,526
(Percent)	77.3%	7.1%	84.4%
Total	13,486	2,532	16,018
(Percent)	84.2%	15.8%	100.0%

Percent Driver 1 Violator in Single-HA Accidents: 89.9% (E).

Summary

As a result of this methodology, the effects of multiple licenses, unmeasured exposure, and often unreliable accident data and incomplete driver records have been minimized. By using recent data to isolate the sample violators and innocent victims, the same sample can be used to test the validity of the results with data for future years as they become available. The large number of drivers used in the study should aid in obtaining statistically significant results. If it was found that vehicle 2 had a hazardous action, the report was removed from further analysis.

CHAPTER V

ANALYSIS

After the 1986-1987 truck accident file was randomly split to provide approximately equal model-building and control sets, 4,275 drivers were identified and matched with their accident and citation histories: 1,666 innocent victims and 2,609 violators. A larger file of violators exists, partially because the driver 2 candidates for innocent victim status were screened to be sure that they were, indeed, innocents and did not contribute to the accident. It should be noted that the vehicle 1 file was larger for other unexplained reasons that are subject to future research, as noted later.

Recall that we are seeking to reject H_0: $C_{IV} = C_V$ and H_0: $A_{IV} = A_V$.

During 1986-1987, 714 of the 1,666 innocent victims had a history totaling 1,277 citations for an average of .766 citations/ driver. Of the 2,609 violators, 1,296 had at least one citation with a total of 2,361 for an average of .904 citations/ driver. If only the drivers with citations are considered, however, the average citations per driver is 1.788 for innocent victims and 1.821 for violators. The distributions are shown in Tables 9 and 10 and graphically in Figures 13 and 14.

Examination of the types of citations showed no obvious difference between the files. Speeding-related citations amounted

to 55% of the total for the innocent victims and 54.6% for the violators. This is discussed in more detail later in this chapter.

Table 9

Citations Including Drivers With Zero Citations for 1986-1987

Number of Citations	Innocent Victims	Total Citations	Violators	Total Citations
0	952	--	1,313	--
1	407	407	689	689
2	183	366	350	700
3	61	183	136	408
4	29	116	65	260
5	13	65	38	190
6	13	78	16	96
7	5	35	1	7
8	1	8	0	0
9	1	9	0	0
10	1	10	0	0
11	0	0	1	11
Total	1,666	1,277	2,609	2,361

Table 10

Citations for 1986-1987

Number of Citations	Innocent Victims	Total Citations	Violators	Total Citations
1	407	407	689	689
2	183	366	350	700
3	61	183	136	408
4	29	116	65	260
5	13	65	38	190
6	13	78	16	96
7	5	35	1	7
8	1	8	0	0
9	1	9	0	0
10	1	10	0	0
11	0	0	1	11
Total	714	1,277	1,296	2,361

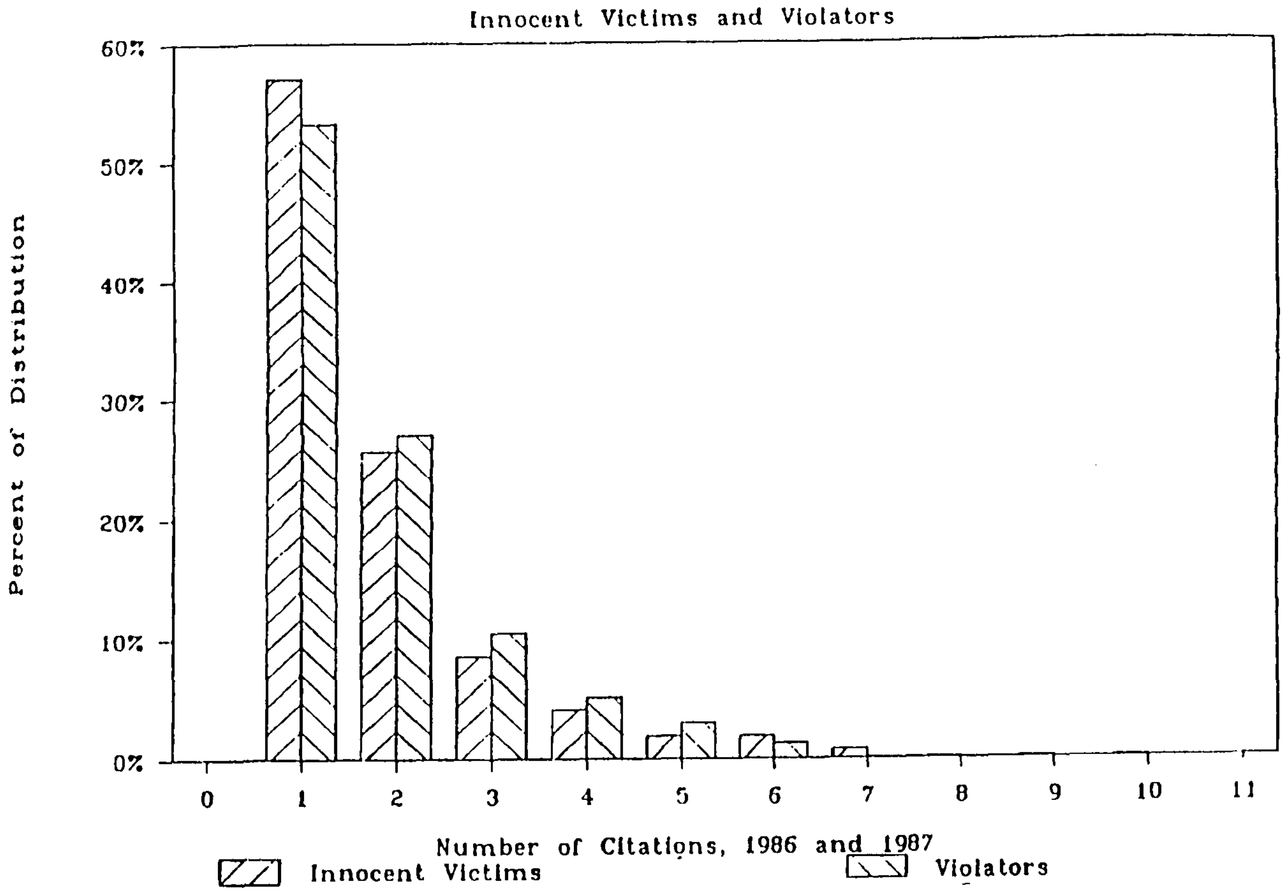

Figure 13. Citation History Bar Graph, 1986 and 1987.

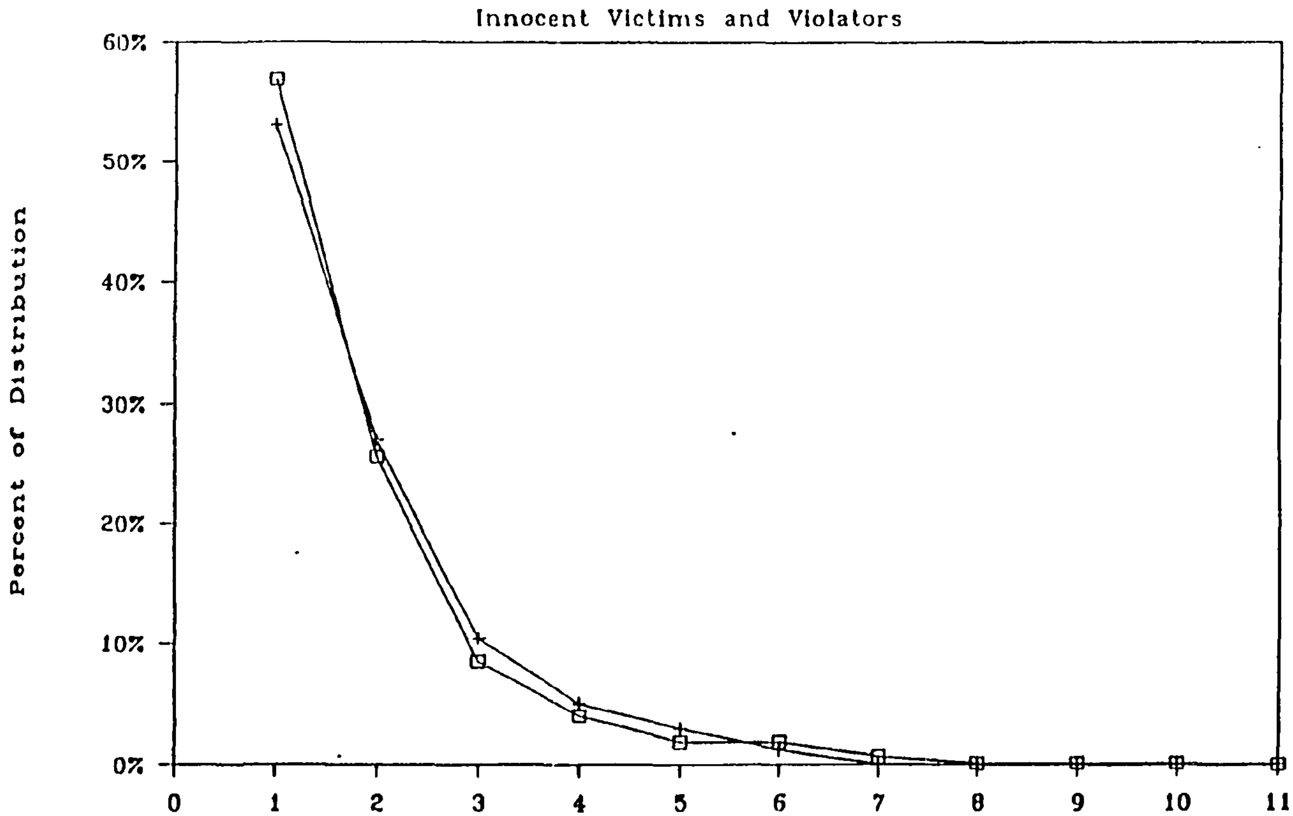

Figure 14. Citation History Line Graph, 1986 and 1987.

The citation history for the 3-year period 1982-1985 is shown in Table 11 and 12. The figures are shown graphically in Figures 15 and 16. Table 11 includes only those drivers who had at least one citation because the analysis techniques originally used precluded determining those who had no citations. Once it was recognized that it was crucial to the analysis to determine how many drivers had zero citations, the analysis process was revised to count those with no citations (or no accidents). Since the data were already available for those with one or more citations, both sets of data are shown.

If the drivers experiencing no citations are included, the distributions appear as represented in Table 12. The average citation experience is 1.32 for the innocent victims and 1.57 for the violators.

The *t*-test of means, the simplest meaningful statistical test, was used to test the difference between the two samples.

$\underline{N}_1$ = 1,668 $\qquad$ $\underline{N}_2$ = 2.609

$\underline{\bar{X}}_1$ = 1.3195 $\qquad$ $\underline{\bar{X}}_2$ = 1.5696

St. dev.$_1$ = 1.6260 $\qquad$ St. dev.$_2$ = 1.8131

Variance$_1$ = 2.6459 $\qquad$ Variance$_2$ = 3.2874

.01 level of significance, one-tailed test

$$\underline{t} = \frac{(\underline{\bar{X}}_1 - \underline{\bar{X}}_2) - (\mu_1 - \mu_2)}{\hat{\sigma}\ \underline{\bar{X}}_1 - \underline{\bar{X}}_2}$$

assume $\mu_1 = \mu_2$

Table 11

Citation History, 1982-1985

Number of Citations	Innocent Victims	Total Citations	Violators	Total Citations
1	432	432	659	659
2	260	520	427	854
3	146	438	281	843
4	67	68	141	564
5	49	245	98	490
6	22	132	38	228
7	9	63	23	161
8	5	40	10	80
9	2	18	7	63
10	2	20	9	90
11	1	11	0	0
12	0	0	3	36
13	0	0	1	13
14	1	14	1	14
Total	966	2,201	1,698	4,095
	Avg. per IV	2.2098	Avg. per V	2.4117
	St. dev.	1.5695	St. dev.	1.7397

Table 12

Citation History Including Drivers With Zero Citations, 1982-1985

Number of Citations	Innocent Victims	Total Citations	Violators	Total Citations
0	672	0	911	--
1	432	432	659	659
2	260	520	427	854
3	146	438	281	843
4	67	68	141	564
5	49	245	98	490
6	22	132	38	228
7	9	63	23	161
8	5	40	10	80
9	2	18	7	63
10	2	20	9	90
11	1	11	0	0
12	0	0	3	36
13	0	0	1	13
14	1	14	1	14
Total	1,666	2,201	2,609	4,095
	Avg. per IV	1.319	Avg. per V	1.569
	St. dev.	1.569	St. dev.	1.813
	Variance	2.640	Variance	3.287

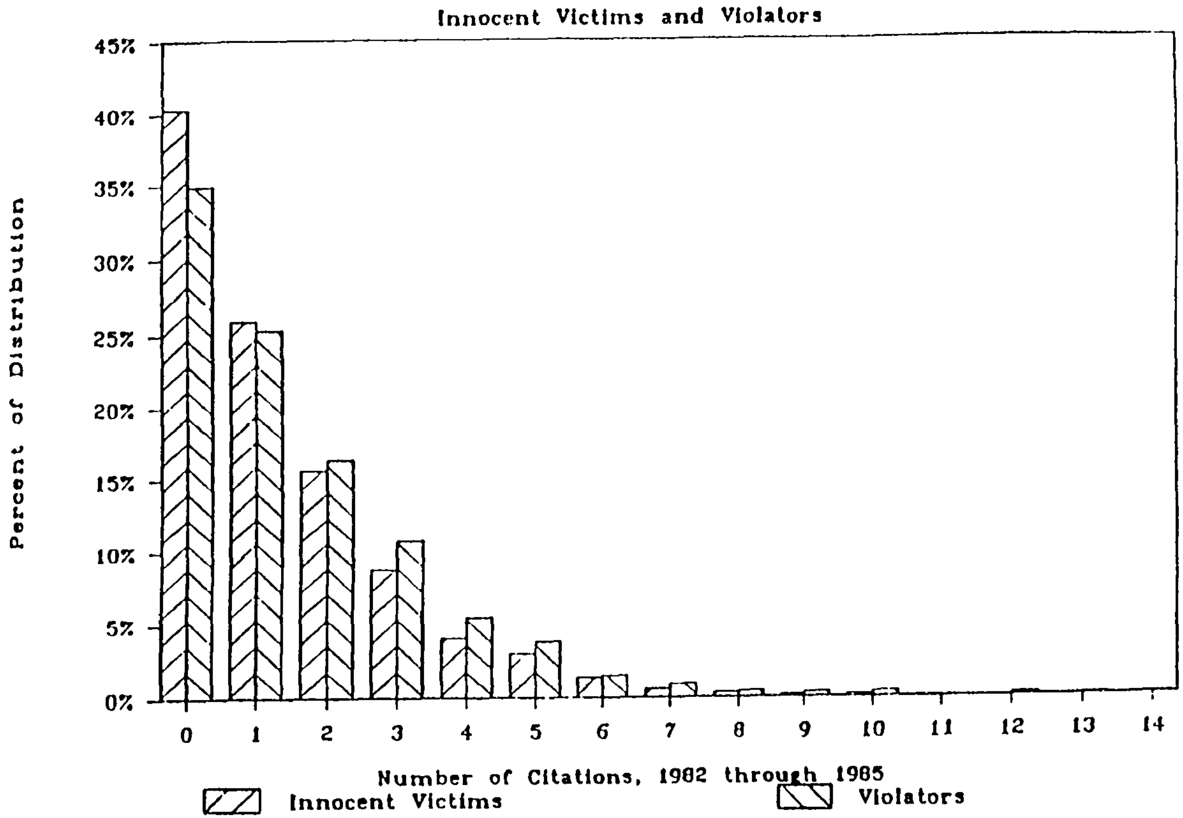

Figure 15. Citation History Bar Graph, 1982 Through 1985.

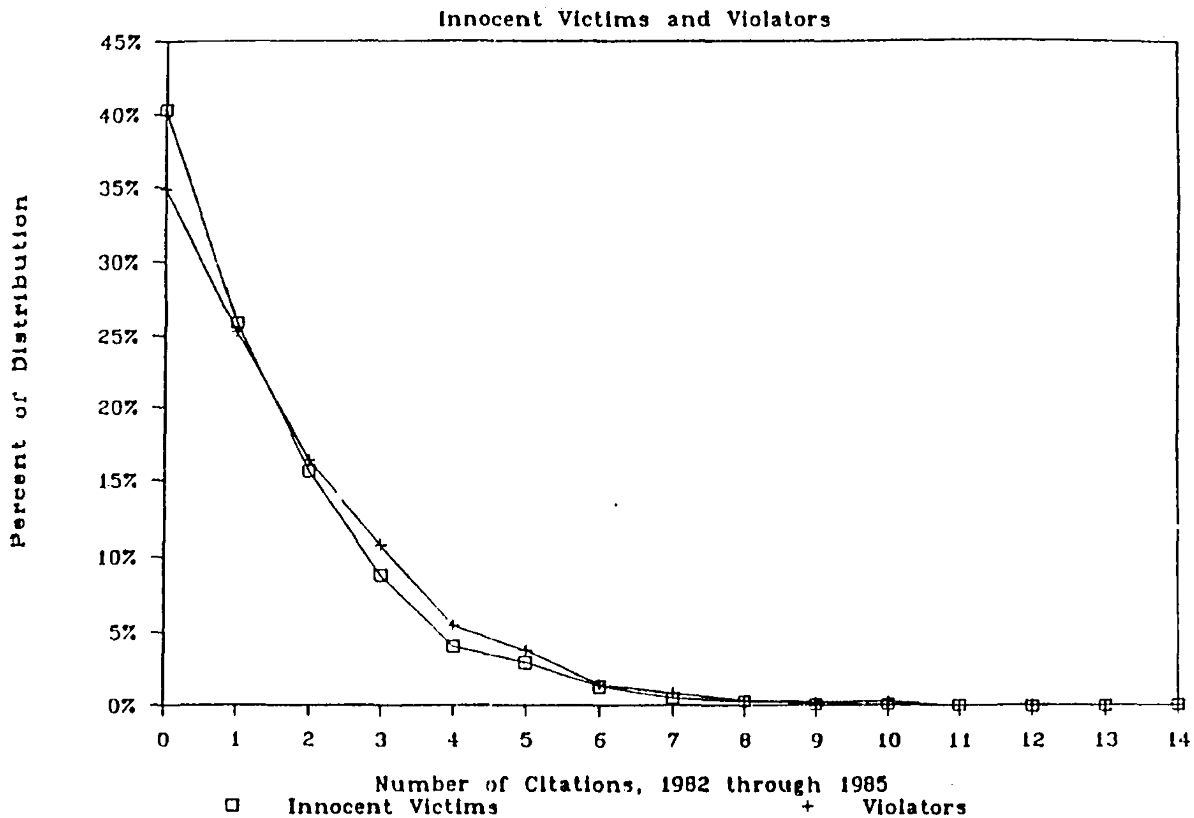

Figure 16. Citation History Line Graph, 1982 Through 1985.

$$\underline{t} = \frac{\bar{X}_1 - \bar{X}_2}{\hat{\sigma}\ \bar{X}_1 - \bar{X}_2}$$

$$\hat{\sigma}\ \bar{X}_1 - \bar{X}_2 = \sqrt{\frac{N_1\ S_1^2 + N_2\ N_2^2}{N_1 + N_2 - 2}} \quad \sqrt{\frac{N_1 + N_2}{N_1\ N_2}}$$

$$= \sqrt{\frac{(1,668)\ (2.6459) + (2,609)\ (3.2874)}{4,275}} \quad \sqrt{\frac{4,277}{4,351,812}} = .054$$

$$\underline{t} = \frac{1.3195 - 1.5696}{.054} = -4.63$$

Because the calculated $\underline{t}$ is greater than $\underline{t}$ (.01, ∞), 4.63 > 2.576, H_0 is rejected in favor of H_1. There is a significant difference in the mean number of citations, $A_{IV} < A_V$. If the assumption of equal variances is not valid, an alternative method for computing $\sigma\ \bar{X}_1 - \bar{X}_2$ is needed.

$$\sigma\ \bar{X}_1 - \bar{X}_2 = \sqrt{\frac{S_1^2}{+ N_1 - 1} + \frac{S_2^2}{+ N_2 - 1}}$$

$$\sqrt{\frac{2.6459}{1,667} + \frac{3.2874}{2,608}}$$

$$= .0533 = .054 \text{ computed earlier}$$

$$\underline{t} = \frac{1.3195 - 1.5696}{.054} = -4.63$$

An alternative method would have been to use the *F*-test to determine equal variance. Given the large *N*s as are present in this research design, the assumptions regarding equal or unequal variance are not meaningful. In addition, with the large *N*s, the normality assumption can be relaxed. In this case, because the computed *t*-value exceeds the table values, H_0 is rejected and we conclude that there is a significant difference in the number of citations between the innocent victims and violators, with the violators having more.

Citation types and frequencies for the two groups are shown in Table 13. Preliminary review shows that some benefit may be realized by grouping the citations by severity and testing the difference between groups. Detailed statistical analysis could be performed, but it does not appear that citation type will contribute to accident predictability. Note that the innocent victims actually appear to have a larger proportion of speeding-related citations. The violators appear to have more of the severe types of citations, such as felonious driving and blood alcohol of .10 or more, but the absolute frequencies are very low. Nearly 60% of citations involved speeding. Other particularly noteworthy items from the table are that operating under the influence of alcohol citations were only 1% of the total and that all improper load violations were only 2.5% of the total.

Previous accident experience was evaluated between the two groups with the following results. If all drivers from the

Table 13

Citations for 1982-1985

Category Label	Code	Violators		Innocent Victims	
		Absolute Freq.	Relative Freq. (%)	Absolute Freq.	Relative Freq. (%)
Felony/auto used	3	2	--	--	--
Felonious driving	4	1	0.0		
Unlawful blood alcohol level (.10)	5	13	0.3	3	0.1
Operating under influence of liquor	7	28	0.7	15	0.7
Fail stop or identify after P.D. acc.	10	4	0.1	4	0.2
Reckless driving	11	6	0.1	7	0.3
Drove w/o proper license or endorsement	15	51	1.2	34	1.5
Violation of basic speed law	16	152	3.7	84	3.8
Failure to drive minimum speed	17	--	--	1	0.0
Speed	18	1,172	28.6	600	27.3
Energy speed xxx/xx/55	19	1,017	24.8	600	27.3
Drag racing	20	1	0.0	2	0.1
Careless driving	22	71	1.7	39	1.8
Operated while impaired	23	88	2.1	68	3.1
Disobey traffic control device	25	38	0.9	28	1.3
Disobey policeman signal	26	2	0.0	--	--
Improper crossing-divided highway	27	5	0.1	6	0.3
Fleeing and eluding officer	28	2	0.0	2	0.1
Failed to yield	30	85	2.1	33	1.5
Failed to stop leaving alley/private drive	37	12	0.3	4	0.2
Following too closely	39	23	0.6	12	0.5
Failed to signal and/or observe	40	35	0.9	16	0.7

Table 13--Continued

Category Label	Code	Violators		Innocent Victims	
		Absolute Freq.	Relative Freq. (%)	Absolute Freq.	Relative Freq. (%)
Prohibited turn	44	112	2.7	63	2.9
Improper turn	45	45	1.1	28	1.3
Drove wrong way on one-way street	46	22	0.5	6	0.3
Improper lane use	47	32	0.8	29	1.3
Drove left of center	48	23	0.6	4	0.2
Improper use of lights	51	11	0.3	4	0.2
Improper size, load, or towing	65	101	2.5	55	2.5
Obstructed vision or control	66	8	0.2	1	0.0
Unlawful rider on motorcycle/moped	68	1	0.0	--	--
Drove while license expired	70	46	1.1	27	1.2
No valid license in possession	71	118	2.9	45	2.0
Drove while license suspended, etc.	74	80	2.0	52	2.4
Violation of license restrictions	77	1	0.0	--	--
Drove without corrective lens	79	4	0.1	1	0.0
Violation of restricted license	81	4	0.1	4	0.2
Disobeyed traffic signal	84	323	7.9	164	7.5
Failed to stop for school bus	87	4	0.1	3	0.1
Disobeyed stop sign	88	114	2.8	59	2.7
Improper passing	89	29	0.7	20	0.9
Unlawful use or display of license	90	1	0.0	3	0.1
No proof of insurance	96	208	5.1	75	3.4
Total		4,095	100.0	2,201	100.0

1986-1987 sample of violators and innocent victims are analyzed, the violators averaged .814 (2,125/2,609) total accidents/driver for the period 1982-1985, and the innocent victims averaged .76 (1,269/ 1,666) for the same period. Table 14 shows the distribution of total accidents for only those drivers who had at least one accident.

If the number of innocent victims and violators who had zero accidents is accounted for, the distribution appears as in Table 15.

Again, applying the t-test of means:

$$N_1 = 1{,}666 \qquad N_2 = 2{,}609$$

$$\bar{X}_1 = .761 \qquad \bar{X}_2 = .814$$

$$\text{Variance}_1 = .948 \qquad \text{Variance}_2 = .946$$

.01 level of significance, one-tailed test

$$t = 1.757 < t\ (.01,\ \ ) = 2.326$$

Because the computed t is less than the table t at .01 with ∞ df, H_0: $A_{IV} = A_V$ cannot be rejected and we conclude that there is no difference in the mean accident experience between the 1986-1987 innocent victims and the violators for the period 1982-1985. If only 1982-1985 tractor-trailer truck accidents are analyzed, the distribution is as shown in Table 16. The figures are shown graphically in Figures 17 and 18.

If drivers who had zero accidents are included, the distribution would be as shown in Table 17. The average incidence of truck accidents for the innocent victims was .309 (515/1,666) and for the violators, .287 (750/2,609). (See also Figures 19 and 20.)

Table 14

1982-1985 Total Accidents Using 1986-1987 Innocent Victims and Violators

Number of Accidents	Innocent Victims	Distrib. Percent	Total Accidents	Violators	Distrib. Percent	Total Accidents
1	493	61.39	493	846	62.57	847
2	200	24.91	400	331	24.48	662
3	77	9.59	231	117	8.65	351
4	24	2.99	96	36	2.66	144
5	7	0.87	35	16	1.18	80
6	0	0.00	0	3	0.22	18
7	2	0.25	14	2	0.15	14
8	0	0.00	0	0	0.00	0
9	0	0.00	0	1	0.07	9
Total	803	100.00	1,269	1,352	100.00	2,125
		Avg. per IV	1.5803		Avg. per V	1.5717
		St. dev.	0.8202		St. dev.	0.7974

Table 15

1982-1985 Total Accidents Using 1986-1987 Innocent Victims and Violators
Including Drivers With Zero Violations

Number of Accidents	Innocent Victims	Distrib. Percent	Total Accidents	Violators	Distrib. Percent	Total Accidents
0	863	51.80	--	1,257	48.25	--
1	493	29.59	493	846	32.43	847
2	200	12.00	400	331	12.69	662
3	77	4.62	231	117	4.48	351
4	24	1.44	96	36	1.38	144
5	7	0.42	35	16	0.61	80
6	0	0.00	0	3	0.11	18
7	2	0.12	14	2	0.07	14
8	0	0.00	0	0	0.00	0
9	0	0.00	0	1	0.04	9
Total	1,666	100.00	1,269	1,352	100.00	2,125
		Avg. per IV	0.761		Avg. per V	0.814
		St. dev.	0.974		St. dev.	0.973
		Variance	0.948		Variance	0.946

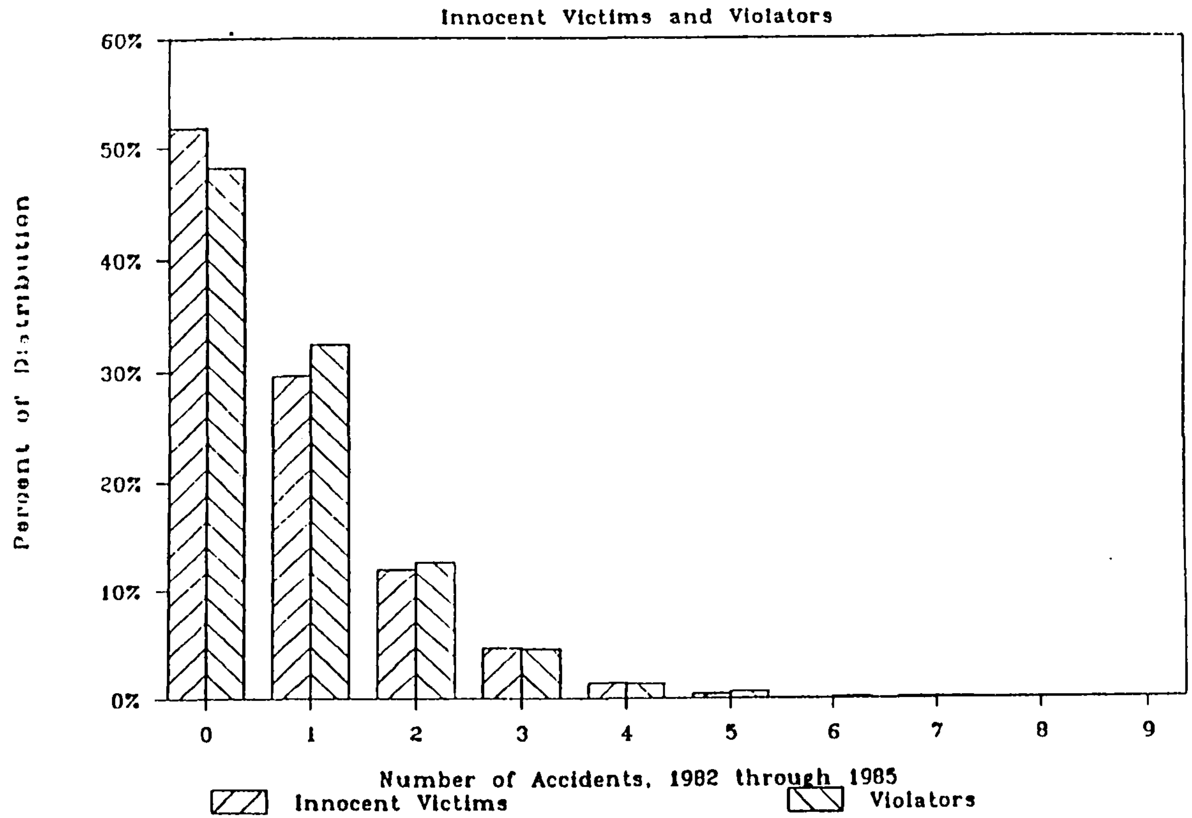

Figure 17. Total Accidents Bar Graph, 1982 Through 1985.

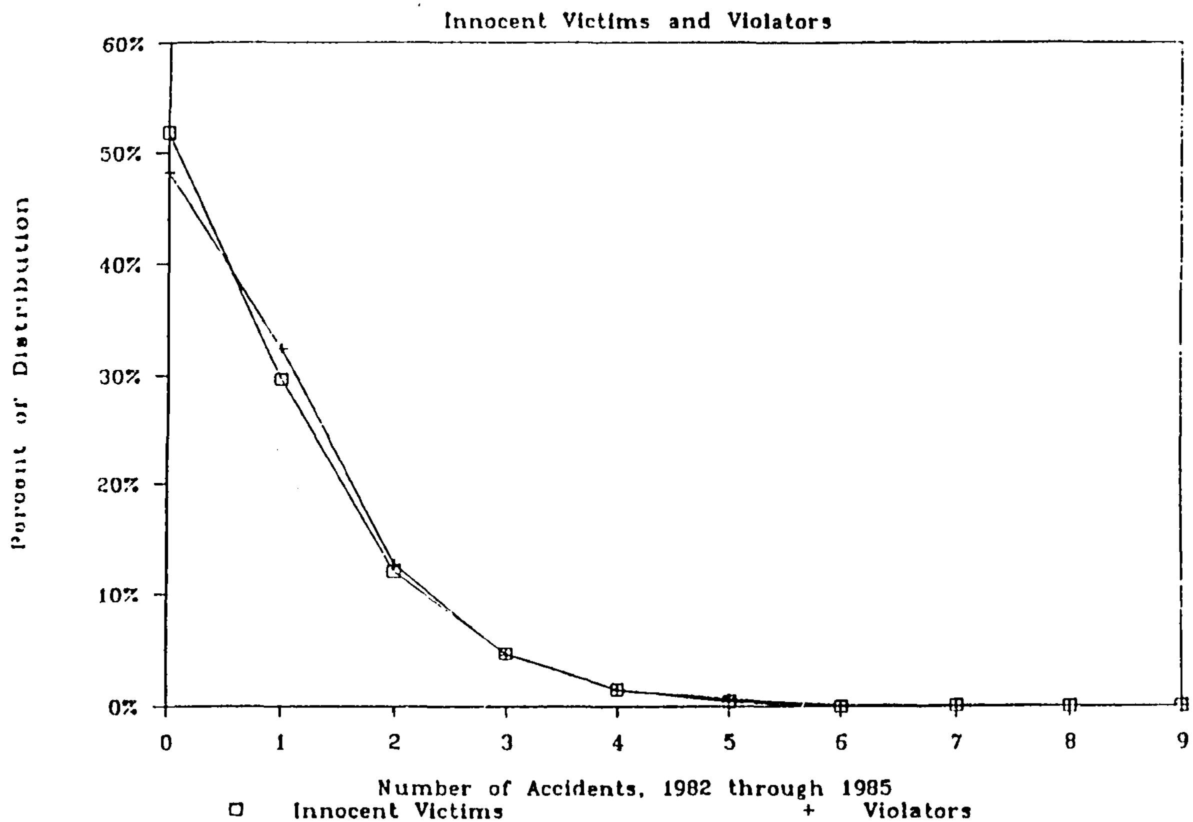

Figure 18. Total Accidents Line Graph, 1982 Through 1985.

Table 16

1982-1985 Truck Accidents

Number of Accidents	Innocent Victims	Distrib. Percent	Total Accidents	Violators	Distrib. Percent	Total Accidents
1	312	77.61	312	439	76.22	439
2	72	17.91	144	110	19.10	220
3	13	3.23	39	21	3.65	63
4	5	1.24	20	5	0.87	20
5	0	0.00	0	0	0.00	0
6	0	0.00	0	0	0.00	0
7	0	0.00	0	0	0.00	0
8	0	0.00	0	1	0.17	8
Total	402	100.00	1,269	1,352	100.00	2,125
		Avg. per IV	1.2811		Avg. per V	1.3021
		St. dev.	0.5850		St. dev.	0.6399

Table 17

Truck Accidents, 1982-1985, Including Drivers with Zero Accidents

Number of Accidents	Innocent Victims	Distrib. Percent	Total Accidents	Violators	Distrib. Percent	Total Accidents
0	1,264	75.87	--	2,033	77.92	--
1	312	18.72	312	439	16.82	439
2	72	4.32	144	110	4.21	220
3	13	0.78	39	21	0.80	63
4	5	0.30	20	5	0.19	20
5	0	0.00	0	0	0.00	0
6	0	0.00	0	0	0.00	0
7	0	0.00	0	0	0.00	0
8	0	0.00	0	1	0.04	8
Total	1,666	100.00	515	2,609	100.00	750
		Avg. per IV	0.309		Avg. per V	0.287
		St. dev.	0.618		St. dev.	0.598
		Variance	0.383		Variance	0.358

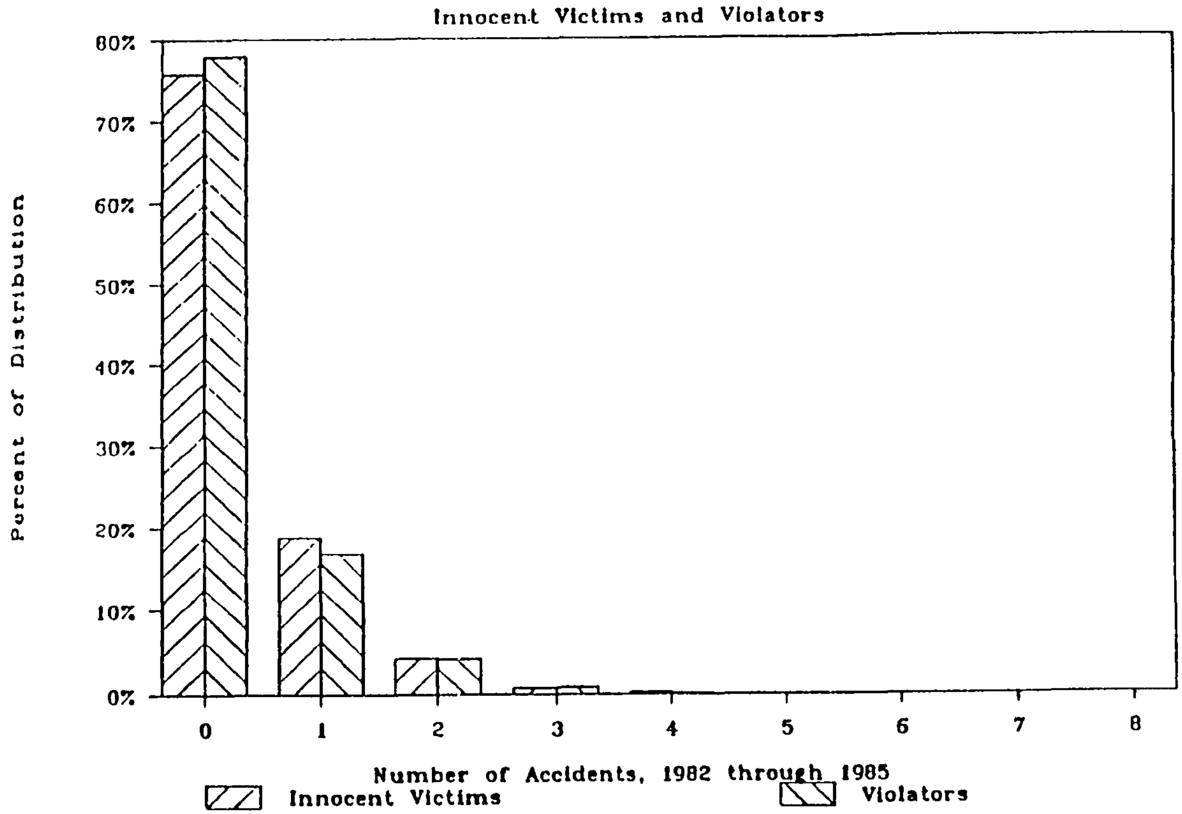

Figure 19. Truck Accidents Bar Graph, 1982 Through 1985.

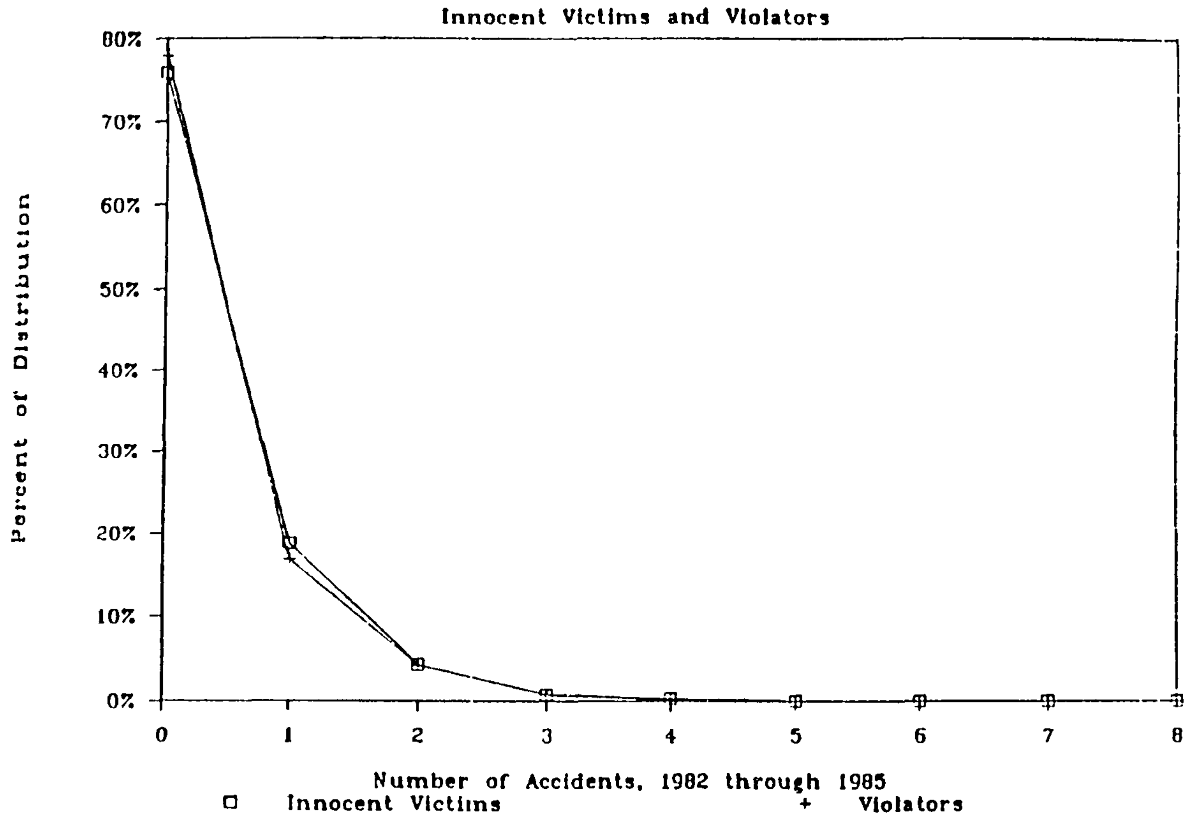

Figure 20. Truck Accidents Line Graph, 1982 Through 1985.

Applying the $\underline{t}$-test to these data:

$\underline{N}_1 = 1,666$ $\quad\quad$ $\underline{N}_2 = 2,609$

$\bar{X}_1 = .309$ $\quad\quad$ $\bar{X}_2 = .287$

$\text{Variance}_1 = .383$ $\quad\quad$ $\text{Variance}_2 = .358$

.01 level of significance, one-tailed test

$\underline{t} = 1.17 < \underline{t}\ (.01, \infty) = 2.326$

Because the computed $\underline{t}$ is less than the table $\underline{t}$ at .01 with ∞ df, H_0: $A_{IV} = A_V$ cannot be rejected and we conclude that there is no difference in the average truck accident experience between the 1986-1987 innocent victims and violators for the 1982-1985 period.

It should be noted here that the selection of alpha = .01 for significance testing is a major factor in the decision process. On page 79 the level of confidence was stated with justification. The test statistic should be established in advance of evaluating the data. The .01 level was selected to minimize Type I error, rejecting H_0 when H_0 is true. The actual implication is the acceptance of H_1, of course. In designing against Type I error the opportunity for Type II error, accepting H_0 when it is, in fact, false, increases.

In the previous example, if alpha = .05 had been selected, H_0 would have been rejected for total accidents and a significant difference would have been the conclusion. This level of significance would have increased the probability of error, however. Note that a one-tailed test was selected to take advantage of the information that violators will be worse drivers than the innocent

victims. This has the effect of increasing the alpha level to .02 compared to a two-tailed test. Further, note that for the truck accident comparison, the innocent victims actually had a higher mean rate so the one-tailed test in this case is open to criticism.

One then may question whether these comparisons are important even if they are statistically significant. With the large Ns in this research, most differences will be statistically significant at high alpha levels. The reader should be aware of this here and as the chi-square tests are discussed.

Although no real significant difference can be shown between the accident experience of the violators or innocent victims for the 1982-1985 period, more investigation relative to vehicle type or violator status was conducted to see whether patterns could be detected. Table 18 shows the breakdown of previous (1982-1985) accident experience for the innocent victims and violators (1986-1987) by type of vehicle and whether they were innocent victims or violators during the 1982-1985 period.

This type of information lends itself well to analysis through use of contingency tables with the chi-square statistic. Through this method, one can test whether the various proportions in each group are associated or not. The null hypothesis is that the two classifications are independent; that is, the probability that an observation falls in a particular row or column is not affected by the row or column to which it belongs. If the null hypothesis is rejected, the two variables are said to be dependent or correlated.

Table 18

Accident Experience by Type of Vehicle, 1982-1985

IV — 1,269

	V	IV
Percent	(57.9)	(40.3)
Number	758	511

V 758:

TT	SU	PUP	PC	O
408	60	90	163	47
(53.8)	(6.6)	(11.9)	(21.5)	(6.2)

IV 511:

TT	SU	PUP	PC	O
237	37	67	161	19
(46.4)	(7.2)	(13.1)	(29.5)	(3.7)

V — 2,125

	V	IV
Percent	(64.1)	(35.9)
Number	1,363	762

V 1,363:

TT	SU	PUP	PC	O
642	91	193	344	93
(47.1)	(6.7)	(14.2)	(25.2)	(6.8)

IV 762:

TT	SU	PP	PC	O
306	35	115	268	38
(40.2)	(4.6)	(15.1)	(35.2)	(5.6)

Legend. TT = Tractor/trailer; SU = Single unit; PUP = Pickup, panel; PC = Passenger car;

O = other; (00.0) = Percent

First, a 2 x 2 table was tested to see whether the likelihood of being an innocent victim or a violator in the 1982-1985 period is independent or whether the driver was an innocent victim or a violator in the 1986-1987 period. From Table 18, a contingency table was formulated (see Table 19).

Table 19

2 x 2 Contingency Table

	1986-1987		
	Innocent Victim	Violator	Total
1985 violator	758	1,363	2,121
1985 innocent victim	511	762	1,273
Total	1,269	2,125	3,394

$$\chi^2 = \Sigma \frac{(\text{Observed}_{ij} - \text{Expected}_{ij})^2}{\text{Expected}_{ij}} \quad \text{where } E_{ij} = \frac{R_i C_j}{n}$$

$$\chi^2 = \frac{(35)^2}{793} + \frac{(35)^2}{1,328} + \frac{(36)^2}{476} + \frac{(35)^2}{797} = 6.57$$

The computed chi-square of 6.57 is less than the table chi-square (.01, 1) of 6.63. Hence the hypothesis of independence can not be rejected, and we cannot conclude that being a 1982-1985 violator or innocent victim is dependent on the 1986-1987 classification.

Another contingency table was developed to determine whether there is a correlation with vehicle type. The results of comparing

1982-1985 violators who were innocent victims in 1986-1987 with 1982-1985 violators who were violators in 1986-1987 are shown in Table 20.

Table 20

Comparison by Type of Vehicle, 1982-1985 Violators

	TT	SU	PUP	PC	O	Total
Violator-violator	642	91	193	344	93	1,363
Innocent victim-violator	408	50	90	163	47	758
Total	1,050	141	283	507	140	2,121

Legend. TT = Tractor/trailer; SU = Single unit; PUP = Pickup, panel; PC = Passenger car; O = other

The computed chi-square of 9.50 is less than the table chi-square (.01, 4) of 13.28, so the hypothesis of independence cannot be rejected. There is no reason to believe that the proportions of accidents by vehicle type are dependent on the two groups of 1982-1985 violators.

A similar analysis performed on the 1982-1985 innocent victim data showed the following when the types of vehicles involved were compared (see Table 21).

Table 21

Comparison by Type of Vehicle, 1982-1985 Innocent Victims

	TT	SU	PUP	PC	0	Total
Violator-innocent victim	306	35	115	268	38	762
Innocent victim-innocent victim	237	37	67	161	19	521
Total	543	72	182	429	57	1,283

Legend. TT = Tractor/trailer; SU = Single unit; PUP = Pickup, panel; PC = Passenger car; O = other

The calculated chi-square of 10.29 again is less than the table value. We again conclude that the proportion of accidents by vehicle type is not dependent on the grouping of innocent victims, or at least that there is not enough evidence to support the conclusion that a relationship exists.

Another way of testing the data is to determine whether the two accident distributions are independent using the chi-square statistic. The null hypothesis again is that the two classifications are independent--that is, in the case here, that the probability that an observation falls in a particular column is not affected by the particular row to which it belongs. If the null hypothesis is rejected, the two variables are said to be correlated.

The computed chi-square is far below the table value of chi-square (.01, 8) = 20.1 for both the total accident experience (Table 22) and truck accident experience (Table 23) for 1982-1985, so it appears that the accident experience does not depend on whether the driver was an innocent victim or a violator. The hypothesis of independence cannot be rejected.

Caution should be used in stating conclusions from this test, and statisticians advise never to accept the null hypothesis solely on this test. However, after examination of the data through the several tests conducted here, it can be concluded that there is no meaningful difference between the distribution of accidents themselves.

Table 22

Contingency Table for Total Accidents, 1982-1985

	Number of Accidents										Total
	0	1	2	3	4	5	6	7	8	9	
Innocent victims	863	493	200	77	24	7	0	2	0	0	1,666
Violators	1,257	846	331	117	36	16	3	2	0	1	2,609
Total	2,120	1,339	531	194	60	23	3	4	0	1	4,275

$$\chi^2 = \Sigma = \frac{(O - E)^2}{E} = 10.23$$

Table 23

Contingency Table for Truck Accidents, 1982-1985

	Number of Accidents 0	1	2	3	4	5	6	7	8	9	Total
Innocent victims	1,264	312	72	13	5	0	0	0	0	0	1,666
Violators	2,033	439	110	21	5	0	0	0	0	0	2,609
Total	3,297	751	182	34	10	0	0	0	0	0	4,275

$$\chi^2 = \Sigma \frac{(O - E)^2}{E} = 2.97$$

In cases in which the sample size is moderately large and the events are rare, the Poisson distribution is a good approximation. The data appear to fit a Poisson distribution and goodness-of-fit tests are in order, especially considering the implications of randomness or chance with which Poisson distribution has commonly been associated.

The function is given by:

$$p\ (x;m) = \frac{e^{-m}m^x}{x!}, \qquad x = 0, 1, 2, 3 \ldots$$

where m = mean (and variance).

Although the mean and variance are not equal in our data, they are reasonably close for the distributions where the drivers having zero accidents are indicated.

The chi-square goodness-of-fit test is used to determine whether the observed frequencies match or fit the theoretical frequencies. For the distribution of innocent victim accidents in Table 22, the chi-square calculation is as shown in Table 24.

Table 24

Chi-Square Calculation for Innocent Victim Accidents, 1982-1985

	0	1	2	3	4	5	6	7	8
P	.467	.355	.135	.04	.0066	.0010	.00013	.000014	.999
E	778	591	224	57	11	1.66	.22	.0	1,663
O	864	493	200	71	24	7	0	2	1,666
O-E	85	-98	-24	20	13	5.34	-.78	2	--

m = .761

$$\chi^2 = \Sigma \frac{(O - E)^2}{E} = 9.28 + 16.25 + 2.57 + 7.01 + 15.4 + 14.25 = 61.3$$

The calculated chi-square is 61.3, which is much greater than the table value of chi-square (.01, 7) = 18.5. There is not a good fit. Similar results were obtained when testing the violators in Table 11; calculated chi-square = 106 >>> chi-square (.01, 9) = 21.7.

Analysis of the distributions in Table 23, which include only truck accidents, resulted in no better matches and still no statistical fits using chi-square, although the expected and observed values for the number of drivers with zero accidents agreed with the expected values within 5%.

The age of drivers with citations is the last attribute to be tested. Whether age is a factor in itself or merely a surrogate for training or experience has yet to be determined. Review of the grouped data in Table 25 and the statistical analysis reveals that a significant difference in age does exist, with the innocent victims being older than the violators. Whether this difference is meaningful is another matter. Note that current law requires a driver to have reached the age of 21 years to operate the types of vehicles (tractor-trailers) being analyzed here in interstate commerce. Michigan law requires the age of 18, except 21 is the minimum age for hazardous cargo. For insurance and other reasons, companies often require driver ages higher than the legal minimum.

Summary

The 1986-1987 truck accident file was randomly split, yielding analysis and control sets. The analysis set was further divided into violators and innocent victims for testing the differences in means for numbers of citations and accidents for the period 1982 through 1985. Significant differences between means were found only for mean number of citations and driver age.

Table 25

Ages of Innocent Victims and Violators, 1982-1985

Driver Age	Innocent Victims	Percent	Violators	Percent
19.5	2	0.12	5	0.09
22.0	33	2.81	115	2.50
25.0	170	12.01	492	7.72
27.5	218	8.91	365	9.90
29.5	182	9.55	391	8.27
31.5	200	10.23	419	9.08
33.5	168	7.77	318	7.63
35.5	149	6.74	276	6.77
37.5	142	5.96	244	6.45
39.5	113	4.74	194	5.13
41.5	112	5.08	208	5.09
43.5	119	4.42	181	5.40
45.5	99	3.44	141	4.50
47.5	96	2.76	113	4.36
49.5	78	2.37	97	3.54
51.5	77	2.64	108	3.50
53.5	61	2.15	88	2.77
55.5	51	1.78	73	2.32
57.5	47	1.71	70	2.13
59.5	29	1.64	67	1.32

Table 25--Continued

Driver Age	Innocent Victims	Percent	Violators	Percent
61.5	31	1.73	71	1.41
63.5	13	0.76	31	0.59
65.5	6	0.39	16	0.27
67.5	3	0.17	7	0.14
69.5	3	0.12	5	0.14
Total	2,202	100.00	4,095	100.00
	Avg. per IV	38.2191	Avg. per V	36.7736
	St. dev.	10.1961	St. dev.	10.4288

$$\underline{t} = \frac{\bar{X}_1 - \bar{X}_2}{\hat{\sigma}_{\bar{X}_1 - \bar{X}_2}} = \frac{1.44}{.27} = 5.333$$

$\underline{t}\ (.01, \infty) = 2.576$

Contingency tables were developed to test for correlation between whether violators in one year tend to be violators in other years and also for independence between violators and innocent victims regarding reliable type. Goodness-of-fit tests were run between the accident distributions and also with a Poisson distribution. The innocent victim and violator distributions fit each other well, but neither fits a Poisson.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This dissertation has focused on determining whether previous accidents and citations are reliable predictors of future tractor-trailer heavy truck accidents in Michigan. Background material was presented that showed how heavy truck safety policy was formed at the Michigan Department of Transportation.

Summary

The critical policy issues here are allowable truck size and weight, safety, license requirements, deregulation, and research needs. Understanding these issues requires that they be placed in an appropriate context.

A model relating pertinent variables to accidents is needed. Clearer definition of what is meant by "truck-related" accidents and restricting the analysis to tractor-trailer heavy trucks will help in formulating effective policy. Truck accidents increased dramatically in the mid-1980s, but so did truck vehicle miles of travel. An accurate assessment of relative truck involvement is not possible unless exposure is known or a surrogate measure is used, as is done in this research. The research design also minimized the effects of other data voids and the possibility of multiple driver licenses distorting the results.

In addition to constructing a model to assist in identifying the root causes of large truck accidents, this dissertation has made a contribution by providing a synthesis of past research studies and an extensive definition of major truck safety issues.

Several past actions and recommendations are of particular importance in understanding what has happened and why. Through personal communication with key MDOT staff members and through document research, background material on the evolution of policy was presented. Overall, the MDOT has been very responsive to the issue, but it is clear that more data need to be generated in the area.

In light of these issues, events, and prior recommendations, the research problem is defined in this dissertation as whether there is a need for improved licensing policy. Much research is ongoing in several areas of truck safety by major universities and government. However, there appeared to be a void in recent research on the licensing policy issue. The focus here is thus on driver records as predictors of accidents.

Heavy truck safety issues are extremely controversial, and there is not universal agreement on what needs to be done. The Interagency Truck Work Group chaired by the MDOT was established in the 1980s to coordinate truck issues because the trucking industry represents an essential component of the transportation service system. Truck safety was deemed such a important issue that Public

Act 348 of 1988 created a special truck safety fund and the Michigan Truck Safety Commission.

At the federal level, the Commercial Motor Vehicle Safety Act of 1986 was a response to many needs, especially multiple licenses and lack of qualification requirements in many states. The Act established sanctions for states that do not implement the uniform national standards by September 30, 1993.

The federal Motor Carrier Act of 1980 eliminated most federal requirements for truck rate and route authority, and further deregulation is planned. Although there have been several attempts to link deregulation with degradation of safety, no conclusive evidence has been put forth.

Accident trends analyzed over several years show major increases in large truck accidents: 21% between 1983 and 1984, 29% between 1984 and 1985, and 10% between 1985 and 1986. A decrease of 7.9% from 1986 to 1987 helped to offset this trend. These changes cannot be explained totally by increases in travel alone, but it should be noted that total accident experience for cars also has been on an upward trend. The term "truck accident" may itself be misleading. It must be realized that in most instances passenger cars are involved but the accident is still termed a truck accident. There is thus a certain definitional bias that enters in. If collisions were entirely random, the expected percentage of truck accidents would be 19% even if trucks accounted for only 10% of the vehicle miles of travel ($[.1 \times .9] + [.9 \times .1] + [.1 \times .1] = .19$).

The anticipated results in this dissertation consisted of models to predict heavy truck accidents, specifically tractor-trailer accidents. These models were based on a very large accident data set provided to the MDOT by the Michigan State Police and extensive driver histories provided by the Department of State. These data were processed on the MDOT Unisys A-15 mainframe computer. Significant results were anticipated as a result of using induced exposure techniques and accident analysis techniques unique to the MDOT, in conjunction with the MIDAS system. By using such a new research approach, it was hoped that the problems of lack of exposure data, multiple licenses, and incomplete data would be overcome. The products of the research, in addition to the construction of predictive models, were expected to be a framework for future research and an evaluation of the Commercial Motor Vehicle Safety Act of 1986.

The three-part literature review concentrated on national and state-sponsored research on truck policy, predictive models, and induced exposure. The relationship between such prior results and the findings in this study is discussed later.

Limitations of the Data

Several caveats are in order regarding results and conclusions from this study. The data are from Michigan only and may suffer from regional or other biases not accounted for in the research

design. Furthermore, the focus has been primarily on tractor-trailer accidents and may not apply to all trucks or all truck drivers. Perhaps the most fundamental concern regarding the research relates to the use of the induced exposure measure. This method should be validated, as recommended later in this chapter, before many conclusions can be supported.

Findings

The analysis in this study has shown that there was a significant difference in the ages of drivers who were violators and those who were innocent victims. The violators' average age was 36.77 years, while the average for the innocent victims was 38.22 years. This factor alone will be of some value in building a stronger model. For instance, nearly 15% of the violators were age 26 or below, compared to only 9.3% of the innocent victims. Such research results will be particularly valuable to policy makers in the near future as pressure builds to relax age restrictions due to a shortage of large commercial vehicle drivers. (The minimum age is now 18 years in Michigan and 21 years for interstate travel.)

A significant difference in the mean number of citations was found, with the violators having an average of 1.569 citations in the 4-year period, 1982-1985, and the innocent victims having an average of 1.319 citations. The primary contributor to this difference was the large proportion of innocent victims having zero citations, 40.34%, as opposed to 34.91% of the violators.

No significant difference was found between the accident experiences of the two groups, and further accident comparison between groups is not warranted. It would, however, be beneficial to review here and discuss the 1986-1987 truck accident data in general (see Appendix C), especially in light of current governmental policy priorities (as discussed in Chapter II).

Nearly 50% of all multiple vehicle tractor-trailer collisions in the 2-year period involved a rear-end-type accident (rear end straight, rear end left turn, rear end right turn, or rear end driveway). If only state trunkline accidents are considered, this figure jumps to over 60%. In about one-half of these rear-end accidents, the tractor-trailer was the striking vehicle; in the other half, it was the vehicle struck. Current policy initiatives calling for front brakes on tractors and improved rear underride protection on trailers appear warranted.

During these 2 years, 214 people were killed. This represents less than 7% of the total highway fatalities for the period. This information from the large truck accident data for 1986-1987 should assist in putting tractor-trailer truck accidents in a more appropriate and less emotional policy perspective.

Of the more than 20,000 tractor-trailer accidents that did occur in the 2-year period, only 584 (2.9%) were coded as having defective equipment. Many of the passenger cars involved had defective equipment and contributed to this percentage. The heavy

emphasis now placed on vehicle inspection is thus certainly questionable, although inspection supporters will doubtless argue that the percentage would be much higher if the inspection program were not in effect.

In comparing the severity of accidents when a tractor-trailer is vehicle 1 and when it is vehicle 2, the percentage of "fatals" is three times higher when tractor-trailers are coded as vehicle 2. The difference is 48 (0.5% of 9,234) versus 102 (1.5% of 6,909). Based on the fact that vehicle 1 should be coded to the driver most heavily contributing to the accident, it appears that large trucks are at fault in a disproportionately low percentage of fatals.

It does not appear that previous accident experience is an indicator of future heavy truck accident involvement. For their part, previous citation experience and driver age may be predictors. This tends to add some credibility to the value of the "point system" of driver license revocation and the merits of issuing citations in general. However, the practice of insurance companies setting rates based on past accidents as predictors has an extremely weak foundation according to this research.

The research objectives have been substantially achieved. The stated purpose of this dissertation was to summarize and analyze the relevant data, document government policy in response to the issues, and isolate areas in which further research is needed. Further, this research has shown that previous accident experience should not be used as a predictor of future accident involvement in commercial

vehicles. Because age and citations were the only possible predictors found, the results did not support exhaustive model-building efforts.

There is considerable consistency between the findings in this study and the previous research discussed in the literature chapter. The need for more accurate measures of exposure is widely acknowledged. The low predictive accuracy of past models was confirmed in the current research. Accident proneness was not thoroughly researched here, but the distribution of accident data would tend to support the contention that if accident proneness does exist, it accounts for a very small fraction of accidents. This was suggested by Forbes (1939) more than 50 years ago.

The most recent major effort found in the literature review with objectives and methodology similar to those of the present study is the analysis conducted by Geissinger et al. (1986) at the University of North Carolina Highway Safety Research Center. They used data from North Carolina and Washington. They found that there was a relationship between the driver's record in his or her private vehicle and that incurred in employment-related driving. The prior record in the commercial vehicle was a better predictor. These predictors were better than simply using age or mileage driven. However, the authors concluded that the relationships established generally will not lead to the identification of large groups of drivers having a high likelihood of poor commercial driving.

Further, the authors admitted to questions of reliability due to incomplete data and lack of good exposure information.

The findings here somewhat contradict those from the Geissinger et al. (1986) study. Previous accident experience was not found to be a predictor, and citations and age now appear to be predictors. Previous accident experience in a tractor-trailer was no different for the violator group than for the innocent victims. On the whole, accidents were shown to be more of a random event than predictable by any criterion other than chance.

The key element that separates this effort from previous studies is the use of induced exposure or innocent victim concepts in the truck accident analysis process. Verification for using this surrogate technique will not be complete and the results herein will probably not be fully accepted until a survey confirms this measure of exposure. The writer has proposed this to the MDOT, and included the research topic in a recent Request for Proposals to major Michigan universities. (The Research Problem Statement is included in Appendix D.) Although rather straightforward now that the violators and innocent victims have been defined, this effort is beyond the scope of this dissertation. Brief questionnaires in letter or post card form can be sent to both violators and innocent victims without endangering the confidentiality of the data. All that is required is that a reasonable sample of the questionnaires be returned and the responses sorted by group. It is desirable to know the approximate mileage driven in a tractor-trailer and other

vehicles for the years 1982 through 1989. The exposure question will then be answered.

The questionnaire could be expanded to ask questions about when and how much training was obtained and about the driver's experience with specific types of heavy trucks.

The methodology employed in this research allows the MDOT to continue to add data to evaluate the conclusions reached here. The 1986-1987 samples of violators and innocent victims should remain relatively stable for the next several years, thus enabling the MDOT continually to add data each year as they become available. This approach permits a flexible research design that incorporates the more conventional methods of establishing a base condition. It also allows the researcher to look forward and make predictions rather than merely looking backward as was done in this research. If the violator and innocent victim samples had been selected based on 1982-1983 data, the samples would likely have been of less validity for future research because fewer of the selected drivers would actually have the expected exposure due to considerations such as retirement.

Regardless of the arguments made for an acceptable surrogate for the actual measured miles driven by the groups compared here, there will always be questions as to the true differences in rates between the violators and the innocent victims unless a validation survey is conducted.

Recommendations

A driver response survey is needed. The resulting exposure data are vital to future MDOT truck safety research efforts. Exposure information from a sample of violators, innocent victims, and drivers in neither group could now be used to test the arguments in this research. Furthermore, if the exposure issue can be resolved, a number of important comparisons can be made to provide the data needed for a truly effective heavy truck policy. Such comparisons include vehicle type, roadway type and condition, route, driver attributes, number of violations, and previous accident experience. The MDOT would benefit greatly from the additional explanatory power that researchers would possess if only the exposure question can be resolved.

Based on the accident data generated in this study, further research is needed to determine answers to the following questions. Do truck drivers fail to compensate for the poor stopping characteristics of large trucks and allow more headway where needed? Should the rear ends of trailers have clearer definition or improved brake-light systems to reduce the incidence of rear-end collisions?

The accident data also show that more research is needed on the true effect of the vehicle inspection program.

In response to the conclusion of an earlier study by AAA Michigan (1986) that large trucks are at fault in a disproportionately low number of fatal accidents, more research is

needed to determine whether this is, in fact, true. Or, instead, is it that the policing agencies tend to assign fault to the small vehicle in the accident, whose driver is the fatality in nearly all collisions of this type? Only five of the fatalities in the 2-year period studied here were in large trucks.

The value of merging driver records into the MIDAS system has been demonstrated here. The MDOT should resurrect the long-dormant MIDAS expansion project in order to include this valuable component.

Additional research efforts to define the accident distribution are warranted. Although the data do not fit a Poisson distribution well, it appears that by using the variance and the mean in the equation to estimate proportions, an accurate predictive formula for the number of drivers having a given number of accidents holds promise. The data will likely fit a negative-binomial distribution.

This data base can also be used to evaluate the effect of the Commercial Motor Vehicle Act of 1986. According to the Michigan Department of State (1989), the goals of the federal law are to:

> Provide uniform commercial licenses nationwide; prevent drivers from having multiple licenses; improve driver testing, both written and road testing; ensure driver fitness through minimum physical standards; and impose strong penalties for poor performance and alcohol and drug abuse. (p. 1)

The research base in this dissertation is therefore timely, and the exposure validation, if conducted soon, will also fit well into the schedule for evaluating the Act.

The Commercial Motor Vehicle Act was signed on October 27, 1986, while the single license rule went into effect on July 1,

1987. However, Michigan did not begin commercial driver license testing and licensing in compliance until October 1, 1989. All drivers will be tested by April 1, 1992. Complete state compliance is expected by September 30, 1993. Because a considerable amount of "grandfathering" is expected in the skills test area (as much as 95% by some estimates), a very detailed and complete research design is needed to evaluate effect.

Although the law applies to vehicles over 26,000 pounds and trailers over 10,000 pounds, the tractor-trailer data included in this dissertation should prove useful in evaluating the effect on this important segment of the population and in guiding future policy decisions.

This study has provided a rigorous attempt at predicting tractor-trailer accidents in Michigan. Even with 7 years of data, a carefully prepared research design, and the computing power of a massive state-of-the-art computer, correlations and predictive equations could not be generated. This leads to a final recommendation. To make optimum use of the analysis tools described here, more accurate data must be captured. Only then can policy analysts provide decision makers with the critical facts that are needed to enact rational, equitable, and responsible heavy truck safety policies and thus assure the safest possible surface transportation system for all the motorists of Michigan.

Appendix A

Tape File Layout

MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

TAPE FILE LAYOUT

LAYOUT NUMBER: DR120T
FILE NAME(External Label:) MDR Master
PREPARED BY: J. Pixley
FILE ID(Internal Label): MDRMAST

PAGE 1 of 11
DATE 3/28/83

CHARACTERS PER RECORD 48-210
RECORDS PER BLOCK

IF VARIABLE LENGTH RECORDS -
CHARACTERS PER BLOCK 8000

RECORD NAME: Header Record

SIZE: 210

FIELD NAME	START POS	LENGTH	CLASS AN	N	A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0210B
Indicator	6	1	X			X		
Driver License Number	7	13	X					
License Issued (0-6)	20	1		X		X		
License Class Endorsement (0-5)	21	1		X		X		
License Type (Ɓ,C,D,Ø,R)	22	1			X	X		
License Extension (Ɓ or E)	23	1			X	X		
License TIP (0 = none, 1 = TIP)	24	1		X		X		
License Restriction	25	1		X		X		
Issue Date	26	6		X			MMDDYY	
Branch Number (Exam Station)	32	4	X			X		
Expiration Year	36	2		X			YY	
Original License Date	38	6		X			MMDDYY	
Probation Code (Ɓ or P)	44	1			X	X		
End of Probation Date	45	6		X			MMDDYY	
Probation Pre-Notice Code	51	1		X		X		
Sex (M or F)	52	1			X	X		
Birthdate	53	6		X			MMDDYY	
Name (First, Middle, Last)	59	36	X					
(Continued)								

TAPE CHARACTERISTICS
9 TRACK
ODD PARITY

DENSITY (BPI)
1600
6250

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

T A P E F I L E L A Y O U T (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: Header Record (Continued)

PAGE 2 of 11
DATE 3/28/83
SIZE

FIELD NAME	START POS	LENGTH	CLASS AN	N	A	CODED FIELD	FORMAT	CON VALUE
Name Char Count	95	2		X				
Street	97	36	X					
Street Char Count	133	2		X				
City	135	19	X					
City Code (If present)	154	3		X		X		
City Char Count (If no city code)	157	2		X				
State	159	2		X		X		
Zip Code	161	5		X				
County	166	2		X		X		
Microfilm #1	168	5	X					
Microfilm #2 (Backup)	173	5	X					
School Number	178	3	X			X		
Print Batches	181	4	X					
Posting Date (Julian)	185	5		X			YYDDD	
Last Conviction Date (Julian)	190	5		X			YYDDD	
Address Change Date (_ulian)	195	5		X			YYDDD	
Last Activity Code	200	1	X			X		
Registration Notice Sent	201	1		X		X		
Renewal Select Code (Print Tape)	202	1			X	X		
Out-of-state State Code	203	2			X	X		
Filler	205	6			X			Blank

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

T A P E F I L E L A Y O U T (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: Dummy Header

PAGE 3 of 11
DATE 11/1/81
SIZE: 210

FIELD NAME	START POS	LENGTH	CLASS AN	CLASS N	CLASS A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0210B
Indicator	6	1	X					
Old Driver License Number	7	13	X					
Filler	20	32			X			Blank
Sex	52	1			X			JorK
Old Birthdate	53	6		X			MMDDYY	
Old Name (First, Middle, Last)	59	36	X					
Old Name Char Count	95	2		X				
New Name (First, Middle, Last)	97	36	X					
New Name Char Count	133	2		X				
New Driver License Number	135	13	X					
New Birthdate	148	6		X			MMDDYY	
Filler	154	14			X			Blank
Microfilm #	168	5	X					
Filler	173	8			X			Blank
Print Batches	181	4	X					
Posting Date (Julian)	185	5		X			YYDDD	
Filler	190	21			X			Blank

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

TAPE FILE LAYOUT (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: Address History

PAGE 4 of 11
DATE 11/1/81
SIZE: 48

FIELD NAME	START POS	LENGTH	CLASS AN	N	A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0048H
Indicator	6	1	X					
Change Date 1	7	6		X			MMDDYY	
Microfilm #1	13	5	X					
Change Date 2	18	6		X			MMDDYY	
Microfilm #2	24	5	X					
Change Date 3	29	6		X			MMDDYY	
Microfilm #3	35	5	X					
Posting Date (Julian)	40	5		X			YYDDD	
Filler	45	4			X			Blank

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

TAPE FILE LAYOUT (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: Previous Name or Alias

PAGE 5 of 11
DATE 11/1/81
SIZE: 78

FIELD NAME	START POS	LENGTH	CLASS AN	N	A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					J7 0078K
Indicator	6	1	X					
Previous Name or Alias (Fir, Mid, Last)	7	36	X					
Name Char Count	43	2		X				
Old Drivers License Number	45	13	X					
Old Birthdate	58	6		X			MMDDYY	
Microfilm #	64	5	X					
Posting Date (Julian)	69	5		X			YYDDD	
Filler	74	5			X			Blank

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

TAPE FILE LAYOUT (continued)

LAYOUT NUMBER: DR120T — PAGE 6 of 11
FILE NAME: MDR Master — DATE 11/1/81
PREPARED BY: J. Pixley
RECORD NAME: Special Restriction — SIZE: 54

FIELD NAME	START POS	LENGTH	CLASS AN	CLASS N	CLASS A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0054L
Indicator	6	1	X					
Restriction Codes (6 2-posit. codes)	7	12	X			X		
Restriction Description	19	28	X					
Description Char Count	47	2		X				
Posting Date (Julian)	49	5		X			YYDDD	
Filler	54	1			X			Blank

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

T A P E   F I L E   L A Y O U T   (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: Conviction

PAGE 7 of 11
DATE 3/28/83
SIZE 66

FIELD NAME	START POS	LENGTH	CLASS AN	N	A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0066M
Indicator (Purge)	6	1	X					
Conviction Date	7	6		X			MMDDYY	
Arrest Date	13	6		X			MMDDYY	
Microfilm #	19	5	X					
Court	24	20	X					
Court Code (If present)	44	3	X			X		
Court Char Count (If no court code)	47	2		X				
Type of Court Code	49	1			X	X		
Offense Code (2N + 1b̸ or A for Attempted)	50	3	X			X		
Speed (Going for 3/Limit for 2)	53	5	X					
Same Incident/Late Recd/Bond Forfeiture	58	1	X			X		
Type of Vehicle	59	2	X			X		
Posting Date (Julian)	61	5		X			YYDDD	
Print Tape New Indicator	66	1		X				

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

T A P E F I L E L A Y O U T (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: FAC/FCJ/FCPV Record

PAGE 8 of 11
DATE 3/28/83
SIZE 84

FIELD NAME	START POS	LENGTH	CLASS AN	CLASS N	CLASS A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					00840
Indicator	6	1	X					
Suspension Date	7	6		X			MMDDYY	
Arrest Date	13	6		X			MMDDYY	
Court Date or Court File Number *	19	7	X					
Suspension Microfilm #	26	5	X					
Termination Microfilm #	31	5	X					
Court	36	20	X					
Court Code (If present)	56	3	X			X		
Court Char Count (If no court code)	59	2		X				
Type of Court Code	61	1			X	X		
Offense Code (2N + 1b or A for Attempted)	62	3	X			X		
Speed (Going for 3/Limit for 2)	65	5	X					
Termination Date	70	6		X			MMDDYY	
FAC or FCJ Code	76	1		X		X		
Posting Date (Julian)	77	5		X			YYDDD	
Filler	82	3			X			Blank
* Court Date will have "*" in position 1, followed by MMDDYY; If not "*", field will be 7 position court file number.								

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

T A P E   F I L E   L A Y O U T (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: Accident

PAGE 9 of 11
DATE 11/1/81
SIZE: 66

FIELD NAME	START POS	LENGTH	CLASS AN	CLASS N	CLASS A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0066S
Indicator	6	1	X					
Accident Date	7	6		X			MMDDYY	
Counts (Vehicles, Injured, Killed)	13	6		X				
Report Number	19	6		X				
Police Department	25	24	X					
Department Code (If present)	49	3	X			X		
Department Char Count (If no dept code)	52	2		X				
Coded Items	54	8	X			X		
Posting Date (Julian)	62	5		X			YYDDD	

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

T A P E F I L E L A Y O U T (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixley
RECORD NAME: Action

PAGE 10 of 11
DATE 3/28/83
SIZE 90

FIELD NAME	START POS	LENGTH	CLASS AN	N	A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0090V
Indicator (Purge)	6	1	X					
Occurrance Date (A-date)	7	6		X			MMDDYY	
Action-Type Code	13	4		X		X		
Microfilm #	17	5	X					
From Date (B-date)	22	6		X			MMDDYY	
Thru Date (C-date)	28	6		X			MMDDYY	
Reason Codes	34	12	X			X		
E-field (App #, FR Case #, Court, Points)*	46	10	X					
Lifted Date (D-date)	56	6		X			MMDDYY	
Original Action Date (F-date)	62	6		X			MMDDYY	
G-field (Analyst**, Hearing Off. or Judge***)	68	14	X			X		
Posting Date (Julian)	82	5		X			YYDDD	
Print Tape New Indicator	87	1		X				
Filler	88	3			X			Blank

* On Referrals and Warning Letters, pos. 1-3 contain class code if 12+ points; 9-10 contain points at time of action.

** pos. 1-2 contain county; 3-6 contain analyst; 7-8 contain alcohol referral; 9 contains passed or failed road test; 10 contains points considered.

*** pos. 1-4 contain county & hearing officer or judge, 5-6 contain previous action type; 7-8 contain previous action reason; 9-10 contain second previous action reason; 11 contains previous DI/DLAD code.

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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MICHIGAN DEPARTMENT OF STATE
DATA PROCESSING CENTER

T A P E F I L E L A Y O U T (continued)

LAYOUT NUMBER: DR120T
FILE NAME: MDR Master
PREPARED BY: J. Pixlev
RECORD NAME: Action Description

PAGE 11 of 11
DATE 11/1/81
SIZE: 48

FIELD NAME	START POS	LENGTH	CLASS AN	N	A	CODED FIELD	FORMAT	CON VALUE
Record Count & Identification	1	5	X					0048W
Indicator	6	1	X					
Action Description *	7	32	X					
Description Char Count	39	2		X				
Count (# of Action Desc Records)	41	2		X				
Posting Date (Julian)	43	5		X			YYDDD	
Filler	48	1			X			Blank
* Description Record 02 may contain up to 16 two-position numeric reason codes.								

CODED FIELD: X = STANDARD CODE
Y = SPECIAL CODE (attached)

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```
SPSS BATCH SYSTEM

BURROUGHS LARGE SYSTEMS SPSS RELEASE 8.0, LEVEL 728.02.23.24.00

DEFAULT SPACE ALLOCATION..    ALLOWS FOR..    50 TRANSFORMATIONS
WORKSPACE      17500 WORDS                   400 RECODE VALUES + LAG VARIABLES
TRANSPACE       2500 WORDS                   600 IF/COMPUTE OPERATIONS

PAGESIZE       80

RUN NAME       CREATION OF SPSS SYSTEMS FILE FROM ACCIDENT MASTER
COMMENT     ____________________________________________________________
COMMENT
COMMENT     This SPSS Data File will create a "Systems" File of the
COMMENT     252-Character Trunkline Accident Master.  The Systems file
COMMENT     is to be saved, for use in later SPSS runs.
COMMENT
COMMENT     Only limited data for Vehicle 3 are used, in order to fit
COMMENT     the full trunkline system into one file.
COMMENT
COMMENT     All Variable and Value labels are retained in the Systems
COMMENT     file.
COMMENT
COMMENT     Donald J. Mercer                           August 28, 1986
COMMENT          Revised, DJM                       September 11, 1987
COMMENT          Revised, DJM                            June 23, 1988
COMMENT     ____________________________________________________________
COMMENT
FILE NAME      ACCM87  1987 Trunkline Accident Master

VARIABLE LIST  DIST, CS, MP, AREATYPE, AREACODE, WEEKDAY, HOUR, MONTH,
               DAY, YEAR, COUNTY, CITY, RTECLASS, RTENUM, WEATHER,
               LIGHTING, SURFACE, DEFECT, AINJ, BINJ, CINJ, TCONTROL,
               SPCLTAG, ACCTYPE, NUMVEH, POPULATN, OINJ,
               V1SUB, V1MAKE, V1AGE, V1RES, V1SEX, V1INJ, V1INT, V1HAZACT,
               V1CIRCUM, V1VISOBS, V1DIR, V1DRINK, V1OBJHIT,
               V1STUATN, V1TYPE, V1IMPACT, V1COND, V1TRAILR,
               UNIT1, V1TRUCK,
               V2SUB, V2MAKE, V2AGE, V2RES, V2SEX, V2INJ, V2INT, V2HAZACT,
               V2CIRCUM, V2VISOBS, V2DIR, V2DRINK, V2OBJHIT,
               V2STUATN, V2TYPE, V2IMPACT, V2COND, V2TRAILR,
               UNIT2, V2TRUCK,
               V3SUB, V3INJ, V3HAZACT, V3TYPE, V3TRAILR, UNIT3, V3TRUCK,
               SEVERITY, FATALS, TOTINJ, TOTOCC, ACCLOC, POLICE

INPUT FORMAT   FIXED (F2.0, F5.0, F5.3, F1.0, F2.0, F1.0, 6F2.0,
               F1.0, F3.0, 7F1.0, X,2F2.0, F3.0, 4X,F2.0, 2X,F1.0, T83,
               F2.0, 2(3F2.0,3F1.0,3F2.0,X,3F1.0,F2.0,F1.0,F2.0,5F1.0),
               T143,F2.0, T151,F1.0, T154,F2.0, T165,F2.0, T169,3F1.0,
               T181,F4.0,T181, 2F2.0, X,F2.0,F1.0, T252,F1.0)


ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE   FORMAT   RECORD    COLUMNS
```

CREATION OF SPSS SYSTEMS FILE FROM ACCIDENT MASTER

DIST	F 2. 0	1	1-	2
CS	F 5. 0	1	3-	7
MP	F 5. 3	1	8-	12
AREATYPE	F 1. 0	1	13-	13
AREACODE	F 2. 0	1	14-	15
WEEKDAY	F 1. 0	1	16-	16
HOUR	F 2. 0	1	17-	18
MONTH	F 2. 0	1	19-	20
DAY	F 2. 0	1	21-	22
YEAR	F 2. 0	1	23-	24
COUNTY	F 2. 0	1	25-	26
CITY	F 2. 0	1	27-	28
RTECLASS	F 1. 0	1	29-	29
RTENUM	F 3. 0	1	30-	32
WEATHER	F 1. 0	1	33-	33
LIGHTING	F 1. 0	1	34-	34
SURFACE	F 1. 0	1	35-	35
DEFECT	F 1. 0	1	36-	36
AINJ	F 1. 0	1	37-	37
BINJ	F 1. 0	1	38-	38
CINJ	F 1. 0	1	39-	39
TCONTROL	F 2. 0	1	41-	42
SPCLTAG	F 2. 0	1	43-	44
ACCTYPE	F 3. 0	1	45-	47
NUMVEH	F 2. 0	1	52-	53
POPULATN	F 1. 0	1	56-	56
OINJ	F 2. 0	1	83-	84
V1SUB	F 2. 0	1	85-	86
V1MAKE	F 2. 0	1	87-	88
V1AGE	F 2. 0	1	89-	90
V1RES	F 1. 0	1	91-	91
V1SEX	F 1. 0	1	92-	92
V1INJ	F 1. 0	1	93-	93
V1INT	F 2. 0	1	94-	95
V1HAZACT	F 2. 0	1	96-	97
V1CIRCUM	F 2. 0	1	98-	99
V1VISOBS	F 1. 0	1	101-	101
V1DIR	F 1. 0	1	102-	102
V1DRINK	F 1. 0	1	103-	103
V1OBJHIT	F 2. 0	1	104-	105
V1STUATN	F 1. 0	1	106-	106
V1TYPE	F 2. 0	1	107-	108
V1IMPACT	F 1. 0	1	109-	109
V1COND	F 1. 0	1	110-	110
V1TRAILR	F 1. 0	1	111-	111
UNIT1	F 1. 0	1	112-	112
V1TRUCK	F 1. 0	1	113-	113
V2SUB	F 2. 0	1	114-	115
V2MAKE	F 2. 0	1	116-	117
V2AGE	F 2. 0	1	118-	119
V2RES	F 1. 0	1	120-	120
V2SEX	F 1. 0	1	121-	121
V2INJ	F 1. 0	1	122-	122
V2INT	F 2. 0	1	123-	124
V2HAZACT	F 2. 0	1	125-	126
V2CIRCUM	F 2. 0	1	127-	128
V2VISOBS	F 1. 0	1	130-	130
V2DIR	F 1. 0	1	131-	131
V2DRINK	F 1. 0	1	132-	132
V2OBJHIT	F 2. 0	1	133-	134
V2STUATN	F 1. 0	1	135-	135
V2TYPE	F 2. 0	1	136-	137
V2IMPACT	F 1. 0	1	138-	138
V2COND	F 1. 0	1	139-	139
V2TRAILR	F 1. 0	1	140-	140
UNIT2	F 1. 0	1	141-	141
V2TRUCK	F 1. 0	1	142-	142
V3SUB	F 2. 0	1	143-	144
V3INJ	F 1. 0	1	151-	151
V3HAZACT	F 2. 0	1	154-	155
V3TYPE	F 2. 0	1	165-	166
V3TRAILR	F 1. 0	1	169-	169

CREATION OF SPSS SYSTEMS FILE FROM ACCIDENT MASTER

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE	FORMAT	RECORD	COLUMNS
UNIT3	F 1. 0	1	170- 170
V3TRUCK	F 1. 0	1	171- 171
SEVERITY	F 4. 0	1	181- 184
FATALS	F 2. 0	1	181- 182
TOTINJ	F 2. 0	1	183- 184
TOTOCC	F 2. 0	1	186- 187
ACCLOC	F 1. 0	1	188- 188
POLICE	F 1. 0	1	252- 252

THE INPUT FORMAT PROVIDES FOR 80 VARIABLES. 80 WILL BE READ
IT PROVIDES FOR 1 RECORDS ('CARDS') PER CASE. A MAXIMUM OF 252 'COLUMNS' ARE USED ON A RECORD.

```
VAR LABELS       DIST      District /
                 CS        Control Section /
                 COUNTY    State Police County Code /
                 RTECLASS  Route Class /
                 RTENUM    Route Number /
                 DEFECT    Road Defect /
                 AINJ      No. of A [Incapacitating] Injuries /
                 BINJ      No. of B [Non-Incapacitating] Injuries /
                 CINJ      No. of C [Possible] Injuries /
                 TCONTROL  Traffic Control /
                 SPCLTAG   Special Tag /
                 ACCTYPE   Accident Type /
                 NUMVEH    Number of Vehicles Involved /
                 POPULATN  Population /
                 OINJ      No. of Uninjured Persons /
                 ACCTYPE   Accident Type /
                 V1SUB     Vehicle 1 Type Subscript /
                 V1MAKE    Vehicle 1 Make /
                 V1AGE     Driver 1 Age /
                 V1RES     Driver 1 Residence /
                 V1SEX     Driver 1 Sex /
                 V1INJ     Driver 1 Degree of Injury /
                 V1INT     Driver 1 Intent /
                 V1HAZACT  Driver 1 Hazardous Action /
                 V1CIRCUM  Vehicle 1 Contributing Circumstance /
                 V1VISOBS  Driver 1 Visual Obstruction /
                 V1DIR     Vehicle 1 Direction of Travel /
                 V1DRINK   Driver 1 Drinking\Drugs Usage /
                 V1OBJHIT  Vehicle 1 Object Hit /
                 V1STUATN  Vehicle 1 Situation /
                 V1TYPE    Vehicle 1 Type /
                 V1IMPACT  Vehicle 1 Point of Impact /
                 V1COND    Vehicle 1 Condition /
                 V1TRAILR  Vehicle 1 Trailer /
                 UNIT1     Traffic Unit 1 Type /
                 V1TRUCK   Vehicle 1 Truck Type Code/
                 V2SUB     Vehicle 2 Type Subscript /
                 V2MAKE    Vehicle 2 Make /
                 V2AGE     Driver 2 Age /
                 V2RES     Driver 2 Residence /
                 V2SEX     Driver 2 Sex /
                 V2INJ     Driver 2 Degree of Injury /
                 V2INT     Driver 2 Intent /
                 V2HAZACT  Driver 2 Hazardous Action /
                 V2CIRCUM  Vehicle 2 Contributing Circumstance /
                 V2VISOBS  Driver 2 Visual Obstruction /
                 V2DIR     Vehicle 2 Direction of Travel /
                 V2DRINK   Driver 2 Drinking\Drugs Usage /
                 V2OBJHIT  Vehicle 2 Object Hit /
                 V2STUATN  Vehicle 2 Situation /
                 V2TYPE    Vehicle 2 Type /
                 V2IMPACT  Vehicle 2 Point of Impact /
                 V2COND    Vehicle 2 Condition /
                 V2TRAILR  Vehicle 2 Trailer /
                 UNIT2     Traffic Unit 2 Type /
                 V2TRUCK   Vehicle 2 Truck Type Code/
                 V3SUB     Vehicle 3 Type Subscript /
                 V3INJ     Driver 3 Degree of Injury /
                 V3HAZACT  Driver 3 Hazardous Action /
                 V3TYPE    Vehicle 3 Type /
```

CREATION OF SPSS SYSTEMS FILE FROM ACCIDENT MASTER

```
                V3TRAILR Vehicle 3 Trailer /
                UNIT3    Traffic Unit 3 Type /
                V3TRUCK  Vehicle 3 Truck Type Code/
                FATALS   Number of Persons Killed /
                TOTINJ   Number of Non-Fatal Injured Persons /
                TOTOCC   Number of Persons in Accident /
                ACCLOC   Location of Accident /
                POLICE   Agency Investigating Accident /

VALUE LABELS    DIST     (1) Crystal Falls     (2) Newberry
                         (3) Cadillac          (4) Alpena
                         (5) Grand Rapids      (6) Saginaw
                         (7) Kalamazoo         (8) Jackson
                         (9) Metro
VALUE LABELS    AREATYPE (1)I'Change Area (2)ISection Area (3)Midblock/
VALUE LABELS    AREACODE (00) No Ramp¦In Isect  (01) <100' N I'Sect
                         (02) <100' NE I'Sect   (03) <100' E I'Sect
                         (04) <100' SE I'Sect   (05) <100' S I'Sect
                         (06) On Decl¦<100' SW  (07) On Accl¦<100' W
                         (08) <100' NW I'Sect
                         (10) Exit to C-D Road  (15) Entr frm C-D Road
                         (21) Off Ramp @ Main   (22) Off Ramp Between
                         (23) Off Ramp @ X-Rd   (24) On Ramp  @ X-Rd
                         (25) On Ramp Between   (26) On Ramp  @ Main
                         (31) Off Loop @ Main   (32) Off Loop Bewteen
                         (33) Off Loop @ X-Rd   (34) On Loop  @ X-Rd
                         (35) On Loop Between   (36) On Loop  @ Main
                         (41) Exit -- Lv Main   (42) Exit -- On Ramp
                         (43) Exit -- Ent X-Rd  (44) Entr -- Lv X-Rd
                         (45) Entr -- On Ramp   (46) Entr -- Ent Main
                         (47) Exit to RestArea  (48) In Rest Area
                         (49) Entr frmRestArea  (50) Exit to Scales
                         (51) In      Scales    (52) Entr ftm Scales
                         (53) Exit to Other     (54) Entr frm Other
                         (55) Within  Other
                         (56) Commrcl Driveway  (57) Private Driveway
                         (58) Factory Driveway  (59) RR Cross @ Grade
                         (60) School  Driveway  (61) Public  Driveway
                         (71) Enter   Crossovr  (72) Within  Crossovr
                         (73) Leave   Crossovr
                         (75) Left    Shoulder  (76) Right   Shoulder
                         (78) Lt Turn Flare     (79) Rt Turn Flare
                         (80) On Cut- off Decl  (81) On Cut- off
                         (82) Leave   Cutoff    (83) TurnChnl @ X-Rd
                         (84) On Turn Channel   (85) TurnChnl @ Main
                         (91) TurnLoop @ Main   (92) On Turn  Loop
                         (93) TurnLoop @ X-Rd
                         (98) Intersctn on Ramp (99) Other \ Unknown
VALUE LABELS    WEEKDAY (1) Sunday  (2) Monday  (3) Tuesday  (4) Wednesday
                        (5) Thursday  (6) Friday  (7) Saturday /
VALUE LABELS    HOUR    (01) Midnite- 1 am  (02) 1 - 2 am (03) 2 - 3 am
                        (04) 3 - 4 am       (05) 4 - 5 am (06) 5 - 6 am
                        (07) 6 - 7 am       (08) 7 - 8 am (09) 8 - 9 am
                        (10) 9 -10 am       (11) 10-11 am
                        (12) 11 am  - Noon
                        (13) Noon   - 1 pm  (14) 1 - 2 pm (15) 2 - 3 pm
                        (16) 3 - 4 pm       (17) 4 - 5 pm (18) 5 - 6 pm
                        (19) 6 - 7 pm       (20) 7 - 8 pm (21) 8 - 9 pm
                        (22) 9 -10 pm       (23) 10-11 pm
                        (24) 11 pm  - Midnite (25) Unknown /
VALUE LABELS    MONTH   (01) January  (02) February  (03) March
                        (04) April    (05) May       (06) June
                        (07) July     (08) August    (09) September
                        (10) October  (11) November  (12) December /
VALUE LABELS    COUNTY  (01) Alcona          (02) Alger
                        (03) Allegan         (04) Alpena
                        (05) Antrim          (06) Arenac
                        (07) Baraga          (08) Barry
                        (09) Bay             (10) Benzie
                        (11) Berrien         (12) Branch
                        (13) Calhoun         (14) Cass
                        (15) Charlevoix      (16) Cheboygan
                        (17) Chippewa        (18) Clare
                        (19) Clinton         (20) Crawford
                        (21) Delta           (22) Dickinson
                        (23) Eaton           (24) Emmet
                        (25) Genessee        (26) Gladwin
                        (27) Gogebic         (28) Grand Traverse
```

CREATION OF SPSS SYSTEMS FILE FROM ACCIDENT MASTER

```
                                 (29) Gratiot        (30) Hillsdale
                                 (31) Houghton       (32) Huron
                                 (33) Ingham         (34) Ionia
                                 (35) Iosco          (36) Iron
                                 (37) Isabella       (38) Jackson
                                 (39) Kalamazoo      (40) Kalkaska
                                 (41) Kent           (42) Keweenaw
                                 (43) Lake           (44) Lapeer
                                 (45) Leelanau       (46) Lenawee
                                 (47) Livingston     (48) Luce
                                 (49) Mackinac       (50) Macomb
                                 (51) Manistee       (52) Marquette
                                 (53) Mason          (54) Mecosta
                                 (55) Menominee      (56) Midland
                                 (57) Missaukee      (58) Monroe
                                 (59) Montcalm       (60) Montmorency
                                 (61) Muskegon       (62) Newaygo
                                 (63) Oakland        (64) Oceana
                                 (65) Ogemaw         (66) Ontonagon
                                 (67) Osceola        (68) Oscoda
                                 (69) Ostego         (70) Ottawa
                                 (71) Presque Isle   (72) Roscommon
                                 (73) Saginaw        (74) St. Clair
                                 (75) St. Joseph     (76) Sanilac
                                 (77) Schoolcraft    (78) Shiawassee
                                 (79) Tuscola        (80) Van Buren
                                 (81) Washtenaw      (82) Wayne
                                 (83) Wexford        (86) Mackinac Bridge /
VALUE LABELS    RTECLASS (1) Inter-  state   (2) US Route
                          (3) M Route         (4) I'State BL\BS
                          (5) US Busns Route (6) M Busins Route
                          (7) Connector       (8) Service Drive
                          (9) County\City /
VALUE LABELS   WEATHER    (1) Clear \  Cloudy  (2) Fog
                          (3) Raining          (4) Snowing
                          (5) Other \ Unknown  /
VALUE LABELS   LIGHTING   (1) Daylight          (2) Dawn\Dusk
                          (3) Dark  w\St Lghts (4) Dark No St Lghts
                          (5) Unknown /
VALUE LABELS   SURFACE    (1) Dry  (2) Wet  (3) Snowy or Icy  (4) Unknown /
VALUE LABELS   DEFECT     (1) None              (2) Obstruction
                          (3) Loose   Material (4) Hole Rut or Bump
                          (5) Low\Soft Shldr   (6) Drifting Snow
                          (7) Frosty  Bridge   (8) Slippery When Wet
                          (9) Other \ Unknown /
VALUE LABELS    AINJ, BINJ, CINJ  (9) 9 or More
VALUE LABELS    TCONTROL (01) None              (02) Stop    Sign
                          (03) Stop&Go Signal   (04) Flagman\ Police
                          (05) Flasher\Railroad (06) Yield   Sign
                          (07) School  Speed    (08) No Pass Zone
                          (09) Other   Warning  (10) Other \ Unknown /
VALUE LABELS    SPCLTAG   (01) School  Bus Inv. (02) Schl Bus Assoc.
                          (03) Schl Bus, Other  (04) Deer
                          (05) Deer    Assoc.   (06) Emergncy\Pursuit
                          (07) Danger. Cargo    (08) Constr. Zone
                          (09) Traffic Engrng   (10) None
VALUE LABELS    ACCTYPE   (010) Overturn          (020) Railroad Train
                          (030) Parked  Car       (040) Other   MultiVeh
                          (141) Head On           (342) Sideswip-Passing
                          (543) Sideswip-Meeting  (144) Angle,  Straight
                          (244) Angle,  Turning   (444) Angle,  Driveway
                          (545) Lt Turn, Head On  (645) Lt Turn, Dual
                          (646) Rt Turn, Dual     (147) RearEnd.Straight
                          (345) RearEnd, Lt Turn  (346) RearEnd, Rt Turn
                          (447) RearEnd, Drivewy  (048) Backing
                          (049) Parking           (440) Other   Driveway
                          (050) Pedestrian        (060) Fixed   Object
                          (070) Other   Object    (080) Animal
                          (090) Bicycle           (100) Other   SinglVeh /
VALUE LABELS    POPULATN (1) Township           (2) Under    1,000
                          (3) 1,000 - 2,500      (4) 2,500 - 5,000
                          (5) 5,000 - 10,000     (6) 10,000- 25,000
                          (7) 25,000- 50,000     (8) 50,000- 100,000
                          (9) 100,000-250,000   (10) Over    250,000 /
VALUE LABELS    V1SUB, V2SUB, V3SUB
                          (01) Passengr Car       (02) Truck
                          (03) MtrCycle, Scootr  (04) School    Bus
                          (05) Commercl Bus       (06) Farm      Equipmnt
```

CREATION OF SPSS SYSTEMS FILE FROM ACCIDENT MASTER

```
                                  (07) Constr.  Equipmnt (08) Various\ Unknown
                                  (09) Pedestrn           (10) Bicycle
                                  (11) Other    Vehicle /
VALUE LABELS      V1MAKE, V2MAKE
                                  (01) American Motors     (02) Buick
                                  (03) Cadillac            (04) Chevrolet
                                  (05) Chrylser            (06) Dodge
                                  (07) Ford                (08) Imperial
                                  (09) Jeep                (10) Lincoln
                                  (11) Mercury             (12) Oldsmobile
                                  (13) Plymouth            (14) Pontiac
                                  (15) Volkswagen          (16) GMC
                                  (17) International
                                  (19) Other   Foreign     (20) Other   Domestic
                                  (21) Chevy   Truck       (22) Diamond T. Truck
                                  (23) Dodge   Truck       (24) Federal Truck
                                  (25) Ford    Truck       (26) GMC     Truck
                                  (27) I'natnl Truck       (28) Mack    Truck
                                  (29) Peterblt Truck      (30) Reo     Truck
                                  (31) White   Truck       (32) Jeep    Truck
                                  (40) Other   Truck
                                  (41) MtrCycle            (42) School  Bus
                                  (43) Commercl Bus        (44) Farm    Equipmnt
                                  (45) Road     Constr.    (46) Fire    Equipmnt
                                  (47) Ambulance           (48) Police  Equipmnt
                                  (49) SnowMobile          (50) Other \ Unknown
                                  (51) Pedestrian          (52) Bicycle
                                  (53) Other   Vehicle     (54) Moped
                                  (61) Off-Road Rec Veh.   (62) Go-kart
                                  (71) Mazda               (72) Nisson
                                  (73) Toyota /
VALUE LABELS      V1AGE, V2AGE
                                  (98) 98 years or older  (99) Unknown /
VALUE LABELS      V1RES, V2RES
                                  (1) In County            (2) In State
                                  (3) Borderng State       (4) Driver- less
                                  (5) Other \ Unknown /
VALUE LABELS      V1SEX, V2SEX      (1) Male      (2) Female /
VALUE LABELS      V1INJ, V2INJ, V3INJ
                                  (1) Fatal         (2) Type A
                                  (3) Type B        (4) Type C    (5)Uninjured /
VALUE LABELS      V1INT, V2INT
                          (01) Go       Straight
                          (02) Pass
                          (03) Change   Lanes
                          (04) Turn     Right
                          (05) Turn     Left
                          (06) Make U   Turn
                          (07) Slow or Stopping
                          (08) Starting
                          (09) Enter    Parking
                          (10) Leave    Parking
                          (11) Backing
                          (12) Stopped on Road
                          (13) In       Pursuit
                          (14) Avoid    Object
                          (15) Avoid    Animal
                          (16) Avoid    Pedestrn
                          (17) Lost     Load
                          (18) Avoid    Veh
                          (19) Av. Veh @ Angle
                          (20) Other \ Unknown /
VALUE LABELS      V1HAZACT, V2HAZACT, V3HAZACT
                          (01) None
                          (02) Speed Too Fast
                          (03) Speed Too Slow
                          (04) Fail To Yield
                          (05) Wrong Way
                          (06) Improper Lane Use
                          (07) Improper Turn
                          (08) Improper Backing
                          (09) Follow Too Close
                          (10) Other \ Unknown/
VALUE LABELS      V1CIRCUM, V2CIRCUM
                          (01) DUIL or Drugs      (02) Reckless Driving
                          (03) Ill or  Tired      (04) License  Restrict
                          (05) Obscured Vision    (06) Defective Equip.
                          (07) Shifting Load      (08) None
```

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                         (09) Skidding            (10) Other \ Unknown /
     VALUE LABELS        V1VISOBS, V2VISOBS
                         (1) None                 (2) Obstr in Vehicle
                         (3) Obstr at Scene       (4) Weather Obstr
                         (5) Glare                (6) Other \ Unknown /
     VALUE LABELS        V1DIR, V2DIR
                         (1) North                (2) North   East
                         (3) East                 (4) South   East
                         (5) South                (6) South   West
                         (7) West                 (8) North   West
                         (9) Unknown /
     VALUE LABELS        V1DRINK, V2DRINK
                         (1) Had Been Drinking (2) Not     Drinking
                         (3) Unknown /
     VALUE LABELS        V1OBJHIT, V2OBJHIT
                         (01) None
                         (02) Guard   Rail
                         (03) Highway Sign
                         (04) Utility Pole
                         (05) Culvert
                         (06) Ditch or Embank
                         (07) Pier or Abutment
                         (08) Bridge  Rail
                         (09) Tree
                         (10) Highwy\RR Signal
                         (11) Building
                         (12) Mailbox
                         (13) Fence
                         (14) Island  or Curb
                         (15) Conc Med Barrier
                         (16) Other On-Rd Obj
                         (17) Other Off-Rd Obj
                         (18) Overhead Object
                         (19) Unknown /
     VALUE LABELS        V1STUATN, V2STUATN
                         (1) Rebound from GR
                         (2) Through G'Rail
                         (3) Into     Median
                         (4) Through Median
                         (5) Hit Obj postColl
                         (6) Through T I'sect
                         (7) None
                         (8) Hit and Run /
     VALUE LABELS        V1TYPE, V2TYPE, V3TYPE
                         (01)                     (02) PassengrCar
                         (03)                     (04)
                         (05) Van                 (06) Jeep     Type
                         (07) Pickup \ Panel      (08) SnglUnit Truck
                         (09) Truck   Tractor     (10) Othr\Unk\Non-Veh /
     VALUE LABELS        V1IMPACT, V2IMPACT
                         (0) Rollover             (1) Center  Front
                         (2) Right    Front       (3) Right   Side
                         (4) Right    Rear        (5) Center  Rear
                         (6) Left     Rear        (7) Left    Side
                         (8) Left     Front       (9) Other /
     VALUE LABELS        V1COND, V2COND
                         (1) Disabled Vehicle     (2) Puncture\Blowout
                         (3) Other    Defect      (4) No        Defect
                         (5) Unknown \Non-Veh. /
     VALUE LABELS        V1TRAILR, V2TRAILR, V3TRAILR
                         (1) None                 (2) Utility Trailer
                         (3) Single- Bottom       (4) Double- Bottom
                         (5) House   Trailer      (6) Othr\Unk\Non-Veh /
                         (7) Towed   Vehicle /
     VALUE LABELS        UNIT1, UNIT2, UNIT3
                         (1) Motor   Vehicle      (2) Pedestrn
                         (3) Pedal   Cycle /
     VALUE LABELS        V1TRUCK, V2TRUCK, V3TRUCK
                         (1) Single  Unit         (2) Single- Bottom
                         (3) Double- Bottom       (4) NonTruck /
     VALUE LABELS        SEVERITY
                         (1)Fatal   (2)Personal Injury  (3)Property Damage /
     VALUE LABELS        ACCLOC
                         (1) On Free  Access      (2) Off Free Access
                         (3) On Limit Access      (4) Off Limt Access /
     VALUE LABELS        POLICE
                         (1) State    Police      (2) County   Sheriff
                         (3) Township Police      (4) City\Vil Police /
```

```

RECODE          SEVERITY (0000=3) (0001 THRU 0099=2) (0100 THRU HI=1)
IF              (ACCTYPE EQ 0) ACCTYPE = 100
IF              (POPULATN EQ 0) POPULATN = 10

MISSING VALUES  DIST, CS, RTECLASS, DEFECT, TCONTROL, SPCLTAG,
                ACCLOC, POLICE (0)
MISSING VALUES  V1SUB TO V1TYPE, V1COND, V1TRAILR (0)
MISSING VALUES  V2SUB TO V2TYPE, V2COND, V2TRAILR (0)
MISSING VALUES  V1AGE,   V2AGE  (0,99)

COMMENT          Reset VnTRUCK variable to 1 to 4, depending on type
COMMENT          on type of vehicle.

COMPUTE         V1TRUCK = 4
IF              (V1SUB EQ 0)                                     V1TRUCK = 0
IF              (V1SUB EQ 2 AND V1TYPE EQ 8 AND V1TRAILR NE 4) V1TRUCK = 1
IF              (V1SUB EQ 2 AND V1TYPE EQ 8 AND V1TRAILR EQ 4) V1TRUCK = 3
IF              (V1SUB EQ 2 AND V1TYPE EQ 9 AND V1TRAILR EQ 4) V1TRUCK = 3
IF              (V1SUB EQ 2 AND V1TYPE EQ 9 AND V1TRAILR EQ 6) V1TRUCK = 1
IF              (V1SUB EQ 2 AND V1TYPE EQ 9 AND V1TRUCK  EQ 4) V1TRUCK = 2
COMPUTE         V2TRUCK = 4
IF              (V2SUB EQ 0)                                     V2TRUCK = 0
IF              (V2SUB EQ 2 AND V2TYPE EQ 8 AND V2TRAILR NE 4) V2TRUCK = 1
IF              (V2SUB EQ 2 AND V2TYPE EQ 8 AND V2TRAILR EQ 4) V2TRUCK = 3
IF              (V2SUB EQ 2 AND V2TYPE EQ 9 AND V2TRAILR EQ 4) V2TRUCK = 3
IF              (V2SUB EQ 2 AND V2TYPE EQ 9 AND V2TRAILR EQ 5) V2TRUCK = 1
IF              (V2SUB EQ 2 AND V2TYPE EQ 9 AND V2TRUCK  EQ 4) V2TRUCK = 2
COMPUTE         V3TRUCK = 4
IF              (V3SUB EQ 0)                                     V3TRUCK = 0
IF              (V3SUB EQ 2 AND V3TYPE EQ 8 AND V3TRAILR NE 4) V3TRUCK = 1
IF              (V3SUB EQ 2 AND V3TYPE EQ 8 AND V3TRAILR EQ 4) V3TRUCK = 3
IF              (V3SUB EQ 2 AND V3TYPE EQ 9 AND V3TRAILR EQ 4) V3TRUCK = 3
IF              (V3SUB EQ 2 AND V3TYPE EQ 9 AND V3TRAILR EQ 6) V3TRUCK = 1
IF              (V3SUB EQ 2 AND V3TYPE EQ 9 AND V3TRUCK  EQ 4) V3TRUCK = 2

COMMENT         Reset UNITn variable to 1 to 3, depending of type of unit.

COMPUTE         UNIT1 = 1
IF              (V1SUB EQ 00)  UNIT1 = 0
IF              (V1SUB EQ 09)  UNIT1 = 2
IF              (V1SUB EQ 10)  UNIT1 = 3
COMPUTE         UNIT2 = 1
IF              (V2SUB EQ 00)  UNIT2 = 0
IF              (V2SUB EQ 09)  UNIT2 = 2
IF              (V2SUB EQ 10)  UNIT2 = 3
COMPUTE         UNIT3 = 1
IF              (V3SUB EQ 00)  UNIT3 = 0
IF              (V3SUB EQ 09)  UNIT3 = 2
IF              (V3SUB EQ 10)  UNIT3 = 3

INPUT MEDIUM    DISK
N OF CASES      UNKNOWN

FREQUENCIES     INTEGER = DIST (1,9)
OPTIONS         3

```

FREQUENCIES PROBLEM REQUIRES 55 WORDS OF SPACE

```
READ INPUT FILE

```

AFTER READING 145800 CASES FROM SUBFILE ACCM87 . END OF DATA WAS ENCOUNTERED ON LOGICAL UNIT # 8

Appendix B

Official Traffic Accident Report

Place an "X" on appropriate selection.

ORIGINAL

UD-10 (Rev. 1-78) State of Michigan

OFFICIAL TRAFFIC ACCIDENT REPORT

Department Name | LEIN Number | Department Complaint No.

Accident Location: County Number | City Number | Twp. Number | Day of Week S M T W T F S | Accident Date, Mo/Da/Yr | Time ☐ A.M. ☐ P.M. | DO NOT USE

Name ON | Route No. | Ft. Mi. N S E W | Intersection | Route Nos.

Accident Conditions: WEATHER ☐ Clear, Cloudy ☐ Rain ☐ Fog ☐ Snow | LIGHT ☐ Day ☐ Street Lights ☐ Dawn, Dusk ☐ Dark | ROAD SURFACE ☐ Dry ☐ Snowy, Icy ☐ Wet ☐ Other | TOTAL LANES | ☐ Divided ☐ Limited Access | ☐ ☐ Construction Zone ☐ ☐ Investigated at Scene | Total No. Vehicles

Vehicle Driver No. 1: State | Driver's License | DOB | Hazardous Action Number | Citation Charge | HBD | HN | Test | Helmet

Driver's Name: First M. Last | Address | City | State | Age | Sex | Inj.

Year | Make No. | Type | Trailer | Reg. | Yr/State | VIN Number | Removed to/by

☐ ☐ Haz. Citation ☐ ☐ Other Citation | ☐ ☐ Driver Re-exam ☐ ☐ Vision Obstruct. | ☐ ☐ Vehicle Defect ☐ ☐ Vehicle Drivable | ☐ ☐ Fuel Leakage ☐ ☐ Vehicle Fire | Impact | Severity | Truck Cargo: ☐ ☐ Cargo Spillage Cargo Description | Class

Restraints by occupants pos. | Name | Address | Pos. | Age | Sex | Inj. | Helmet

1 2 3

4 5 6

Total occupants | Local Use/Owner, Phone | Insurance Co. | Agency Address | Injured taken to/by

Driver No. 1

Vehicle Driver No. 2: State | Driver's License | DOB | Hazardous Action Number | Citation Charge | HBD | HN | Test | Helmet

Driver's Name: First M. Last | Address | City | State | Age | Sex | Inj.

Year | Make No. | Type | Trailer | Reg. | Yr/State | VIN Number | Removed to/by

☐ ☐ Haz. Citation ☐ ☐ Other Citation | ☐ ☐ Driver Re-exam ☐ ☐ Vision Obstruct. | ☐ ☐ Vehicle Defect ☐ ☐ Vehicle Drivable | ☐ ☐ Fuel Leakage ☐ ☐ Vehicle Fire | Impact | Severity | Truck Cargo: ☐ ☐ Cargo Spillage Cargo Description | Class

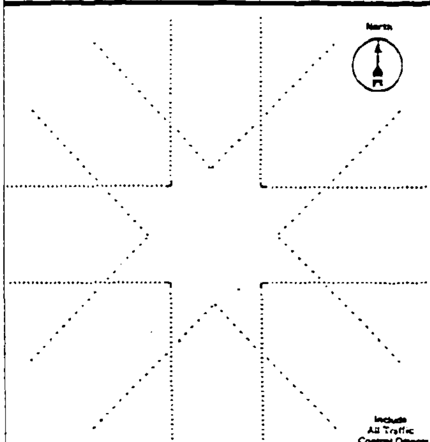
Restraints by occupants pos. | Name | Address | Pos. | Age | Sex | Inj. | Helmet

1 2 3

4 5 6

Total occupants | Local Use/Owner, Phone | Insurance Co. | Agency Address | Injured taken to/by

Driver No. 2



ACCIDENT DESCRIPTION AND REMARKS (*Explain)

Describe all unusual conditions and circumstances

Accident Data | File Class | Department Complaint No.

Date Reported | Time A.M. P.M. | Investigators | Badge No. | Damage Property Other Than Vehicles

Photos by | Complaint Disposition ☐ Open ☐ Closed | Reviewer | Owner | Address

FORWARD COPY TO: Michigan Department of State Police, Safety & Traffic Division 7150 Harris Drive, Lansing, Michigan 48913

This form is prescribed by Director of Department of State Police pursuant to Section 257.622 of Compiled Laws of 1970, as amended.

Area | Pseudo | Time | No. Units | No. Inj. | No. Killed | Residence | Test | Intent | Direction | Obj. Hit | Situation | Cont. Cir. | Residence | Test | Intent | Direction | Obj. Hit | Situation | Cont. Cir. | Road Align | Traffic | Road Loc. | Acc. Type | Where | How | Tags | Road Def. | 1 Veh. Def. | 1 Vision Ob. | 2 Veh. Def. | 2 Vision Ob. | MALI | Coder | File

ACCIDENT LOCATION

DEPARTMENT NAME AND LEIN NUMBER

Department Name	LEIN Number

Enter the Department name and (3 digit) LEIN Number of the Police Department submitting this accident report.

DEPARTMENT COMPLAINT NUMBER

Department Complaint No.

Enter the Department complaint number or other identifying numbers used.

ACCIDENT LOCATION – Use this part of the form to describe where and when the accident occurred.

Accident Location	County Number	City Number	Twp. Number	Day of Week S M T W T F S	Accident Date: Mo/Da/Yr	Time A.M. P.M.		
	Name ON		Route No.		Ft. Mi. N S E W		Intersection	Route Nos.

COUNTY AND CITY OR TOWNSHIP NUMBER

County Number	City Number	Twp. Number

Whenever a motor vehicle accident occurs near a boundary line, whether between two cities, townships, counties, states, or between a city and a rural area, the accident should be allocated to the jurisdiction in which the first event doing damage or injury occurred. The direction of travel of the vehicle(s) involved is immaterial; likewise, the position of the vehicle(s) after the accident is unimportant. If the motor vehicle accident occurs exactly on a boundary line between two political subdivisions, or if information is insufficient to determine where the first event doing damage or injury occurred, refer the case to the state Safety and Traffic Division for final decision on classification.

COUNTY NUMBER [County Number] Enter the County number for the county in which the accident occurred.

CITY OR TOWNSHIP NUMBER [City Number | Twp. Number] Enter the City or Township number for the political jurisdiction in which the accident occurred.

DAY OF WEEK, ACCIDENT DATE AND TIME

DAY OF WEEK [Day of Week S M T W T F S] Enter an "X" on the day of the week on which the accident occurred.

ACCIDENT DATE [Accident Date: Mo/Da/Yr] Enter the date on which the accident occurred.

TIME [Time ☐ A.M. ☐ P.M.] Enter the time (not military) and an "X" in the appropriate box.

OFFICIAL STREET OR HIGHWAY NAME AND ACCIDENT LOCATION MEASUREMENTS

Name ON	Route No.	Ft. Mi. N S E W	Intersection	Route Nos.

Enter the name(s) and identifying number(s) of a street or highway whenever it has an official name and/or number.

Locate all accidents by measurements taken from THE POINT where the projected center lines of the intersecting roadways meet.

a. A location "AT" an intersection will be rare as it ONLY occurs at that point where the center lines of the intersecting roadways meet.

If not at an intersection, give feet or miles and tenths of miles from THE POINT where the center lines of the intersecting roadways meet.

a. Enter an "X" on the "direction" letter indicator as needed. If, however, the roadway runs northeast, southwest, etc., then enter an "X" on two letters.

b. When referencing divided highways always show the direction of travel of the roadway involved, i.e., southbound lane I-75–S I75; northbound lane US-23–N US23.

ACCIDENT CONDITIONS

Accident Conditions	WEATHER	LIGHT	ROAD SURFACE	TOTAL LANES			Total No. Vehicles
	1 Clear, Cloudy 3 Rain	1 Day 3 Street Lights	1 Dry 3 Snowy, Icy		Divided	Y N Construction Zone	
	2 Fog 4 Snow	2 Dawn, Dusk 4 Dark	2 Wet 4 Other	____	Limited Access	Y N Investigated at Scene	____

Use this area to describe some of the general conditions at the time and place of the accident.

WEATHER

WEATHER	
1 Clear, Cloudy	3 Rain
2 Fog	4 Snow

Enter an "X" in the box next to the weather condition which is closest to the weather conditions at the time of the accident.

LIGHT

LIGHT	
1 Day	3 Street Lights
2 Dawn, Dusk	4 Dark

Indicate the light condition prevailing at the time of the accident by entering an "X" on the appropriate box. If the accident occurred during the hours of darkness and the road was equipped with street lights which were on, enter an "X" on the boxes for both "dark" and "street lights".

ROAD SURFACE

ROAD SURFACE	
1 Dry	3 Snowy, Icy
2 Wet	4 Other

Enter an "X" on the box only for the item which applies at the time and location of the accident. When the condition is snowy or icy, it is not necessary to cross out either snowy or icy.

If surface condition contributes adversely to only one vehicle, explain in remarks. If an "X" was entered on the box for "Other," then specify in the Accident Description what condition is observed. "Other" may include: Mud, slush, loose sand or gravel, wet oil, etc.

TOTAL LANES

TOTAL LANES	
____	☐ Divided ☐ Limited Access

Enter total number of lanes, curb to curb less legal parking lanes, occupied or not. Right or left turn flares shall be omitted when determining total lanes. If roadway is a divided roadway, total lanes would be the lanes that were available to that vehicle. For example, on a four lane divided highway, enter 2 for lanes available. Enter an "X" on the appropriate box to indicate whether the roadway is divided or is a limited access roadway.

CONSTRUCTION ZONE

Y N Construction Zone

Enter an "X" on the box marked "Y" if the location of the accident is within a designated or posted construction zone. Otherwise enter an "X" in the box marked "N".

INVESTIGATED AT SCENE

Y N Investigated at Scene

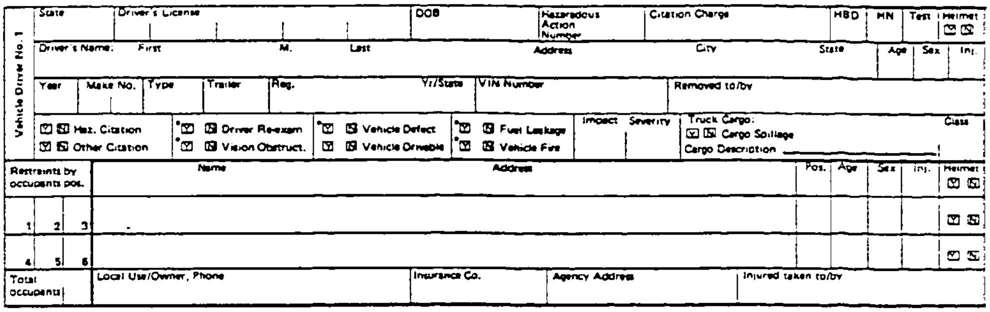
Enter an "X" in the box marked "Y" if the accident was investigated at the scene. Otherwise, enter an "X" in the box marked "N".

TOTAL NUMBER OF VEHICLES

Total No. Vehicles ____

Enter the total number of vehicles directly involved in the accident.

VEHICLE DRIVER NUMBER ONE



Use this section for the motor vehicle and driver, which was most responsible for causing the accident.

OPERATOR'S LICENSE, STATE OF ISSUE [State] Enter the name of the state from which the driver's license was issued. (Does not apply to parked or driverless moving vehicles.)

OPERATOR'S LICENSE NUMBER [Driver's License] Enter the complete operator's license number with special attention to accuracy. (Does not apply to parked or driverless moving vehicles.) Obtain operator's license number by query of Secretary of State if operator has no license on person.

DRIVER'S DATE OF BIRTH [DOB] Enter month, day, year of the driver's birth. (Does not apply to parked or driverless moving vehicles.)

DRIVER'S HAZARDOUS ACTION [Hazardous Action Number] Hazardous Action—This section is used to indicate the circumstances leading up to the accident. Whenever possible, you should indicate the specific action for each pedestrian, bicyclist or driver which contributed most to the accident. This should be done even though it may not be possible to substantiate all recorded information.

Select that action which most closely meets the circumstances of the accident being investigated. Select the hazardous action from the selection on the accident board cover.

HAZARDOUS ACTION CODE. Enter the hazardous action code number for all drivers, pedestrians, bicyclists. If any of these units, do not have a hazardous action, enter a code "0".

0 No hazardous action.
1 Speed too fast.
2 Speed too slow.
3 Failed to yield right-of-way, disregard of traffic control.
4 Drove wrong way.
5 Drove left of center, improper overtaking and passing, improper lane usage.
6 Improper turn, improper or no signal.
7 Improper backing, unsafe start.
8 Following too closely, unable to stop within assured clear distance ahead, failed to use due care and caution.
9 Other or not known.

Exclude catchall offenses – D.U.I.L., careless driving, reckless driving, no operator's license, ran off roadway, asleep, etc. (Catchall offenses usually involve one or more acts. By indicating the specific, the investigating officer will benefit the driver more by telling him specifically what he did wrong that contributed to the cause of the accident.)

CITATION CHARGE [Citation Charge] If a citation is issued, enter the citation description. If more space is needed for additional citations, use REMARKS section.

DRINKING CONDITION [HBD | HN | Test] Complete for each driver, pedestrian, and bicyclist. (Use also for drug conditions.) (Does not apply to parked or driverless moving vehicles.)

HAD BEEN DRINKING (HBD) [HBD] Enter an "X" on this box when in the officer's considered opinion the driver, pedestrian or bicyclist appeared to have been consuming alcoholic beverages, or controlled substances.

HAD NOT BEEN DRINKING (HN) [HN] Enter an "X" in this box when in the officer's considered opinion the driver, pedestrian or bicyclist appeared not to have been consuming alcoholic beverages, or controlled substances.

DRINKING TEST RESULTS (Test) [Test] When any type of chemical test (breath, blood, or urine) is performed to determine the degree of intoxication, enter the results of the test in this box. If not tested or results of tests (chemical or autopsy) are not known, enter one of the following: "N" for no test; "C" for chemical test, results not available; "A" for autopsy, results not available.

DRIVER'S HELMET USE [Helmet: Y N] Enter an "X" in the box marked "Y", when the driver of the vehicle (motorcycle, moped and motor vehicle) was wearing a helmet at the time of the accident. Otherwise, enter an "X" in the box marked "N".

DRIVER NUMBER 1

Driver's Name: First	M.	Last	Address	City	State	Age	Sex	Inj.

DRIVER'S NAME AND ADDRESS

Driver's Name: First	M.	Last	Address	City	State

Enter the full name of each driver. (Does not apply to parked or driverless moving vehicles.) If the driver is licensed, the name should be exactly the same as shown on the operator's or chauffeur's license. However, if the driver's true name is known to be different from that shown on the license, the difference should be explained in the remarks. If the driver is unlicensed, record the first, middle and last name. A married woman's own name should be given, i.e., Mary Jane Smith—not Mrs. Russell R. Smith.

DRIVER'S AGE [Age] Enter the age in terms of years as of the last birthday.

DRIVER'S SEX [Sex] Enter the sex by using the letters "M" or "F".

DRIVER'S DEGREE OF INJURY [Inj.] Enter the injury code in this box.

SEVERITY OF INJURY CODE (Refer to Appendix A for further clarification of severity injury codes.)

- K – FATAL INJURY – Any injury which results in death.
- A – INCAPACITATING INJURY—Any injury other than fatal which prevents normal activities and generally requires hospitalization.
- B – NON-INCAPACITATING INJURY—Any injury not incapacitating but evident to others at the scene.
- C – POSSIBLE INJURY—No visible injury but complaint of pain or momentary unconsciousness.
- O – NO INJURY—No indication of injury.

VEHICLE INFORMATION

Year	Make No.	Type	Trailer	Reg.	Yr/State	VIN Number	Removed to/by

This area is used to identify the vehicle involved and to describe it as closely as possible.

VEHICLE YEAR [Year] Enter the model year of the vehicle as assigned by the manufacturer.

VEHICLE MAKE [Make No.]

VEHICLE TYPE [Type]

PASSENGER CARS

Make
- 00 American Mtrs.
- 01 Buick
- 02 Cadillac
- 03 Chevrolet
- 04 Chrysler
- 05 Dodge
- 06 Ford

Make
- 07 Imperial
- 08 Jeep
- 09 Lincoln
- 10 Mercury
- 11 Oldsmobile
- 12 Plymouth
- 13 Pontiac

Make
- 14 Volkswagen
- 15 G M C
- 16 International
- 17 Not assigned
- 18 Other foreign
- 19 Other domestic

Type
- 0 Passenger car under 1,500 lbs.
- 1 Passenger car 1,500 lbs. to 2,499 lbs.
- 2 Passenger car 2,500 lbs. to 3,500 lbs.
- 3 Passenger car more than 3,500 lbs.
- 4 Carryall
- 5 Jeep type

TRUCKS

Make
- 20 Chevrolet
- 21 Diamond T
- 22 Dodge
- 23 Federal
- 24 Ford

Make
- 25 G M C
- 26 International
- 27 Mack
- 28 Peterbilt
- 29 Reo

Make
- 30 White
- 31 Jeep
- 32 thru 38, not assigned
- 39 Other trucks

Type
- 6 Pickup, panel, or van
- 7 Stake truck, dump, step van, flat bed, motor home, etc.
- 8 Truck tractor (semi)
- 9 Other or not known

SPECIAL VEHICLES

Make
- 40 Motorcycle
- 41 School Bus
- 42 Commercial Bus
- 43 Farm Equipment
- 44 Road Construction Equip.
- 45 Fire Equipment

Make
- 46 Ambulance, Hearse
- 47 Police Equipment
- 48 Snowmobile
- 49 Other or not known
- 50 Off-road Recreational Vehicle
- 51 Go Cart
- 52 Moped

Type
- 0 Passenger car under 1,500 lbs.
- 1 Passenger car 1,500 lbs. to 2,499 lbs.
- 2 Passenger car 2,500 lbs. to 3,500 lbs.
- 3 Passenger car more than 3,500 lbs.
- 4 Carryall
- 5 Jeep type
- 6 Pickup, panel, or van
- 7 Stake truck, dump, step van, flat bed, motor home, etc.
- 8 Truck tractor (semi)
- 9 Other or not known

TRAILERS

- 0 None
- 1 All trailers, except below
- 2 Towed vehicles
- *3 Single bottom semi
- **4 Double bottom combination
- 5 House trailer
- 9 Unknown

SINGLE BOTTOM

DOUBLE BOTTOM

Use the necessary and appropriate codes to fully identify the vehicles involved.

PLEASE NOTE: Passenger Cars start with 00 and extend through 19; Trucks start with 20 and extend through 39; Special Vehicles start with 40 and extend through 52. When a van vehicle is involved, the type will be coded according to the type of registration plates.

VEHICLE TRAILER [Trailer] If a vehicle involved is pulling a trailer, identify the trailer from the list of trailers and enter the code in this box.

VEHICLE REGISTRATION [Reg. Yr/State] Enter the number, year and state of registration from the title.

VEHICLE IDENTIFICATION NUMBER [VIN Number] Enter the vehicle identification (VIN) number from the registration.

VEHICLE REMOVED TO/BY [Removed to/by] Enter the destination of the vehicle if towed and include the name of the wrecker service that removed the vehicle. If driven away or removed by owner or driver, enter this information.

HAZARDOUS CITATION [Y N Haz. Citation] Enter an "X" on box marked "Y" when the driver is cited for a hazardous violation which contributed to the accident. (Speed left of center, disregard stop light or sign, per hazardous action section, or the catchall offenses, careless or reckless driving, D.U.I.L., etc.) Otherwise, enter an "X" in the box marked "N".

OTHER CITATION [Y N Other Citation] Enter an "X" on the box marked "Y" when the driver is cited for a violation which did not contribute to the accident. (No operator's license, no proof of insurance or registration, etc.) Otherwise enter an "X" on the box marked "N".

DRIVER RE-EXAM [Y N Driver Re-exam] Enter an "X" on the box marked "Y" to indicate your recommendation that a driver be re-examined for compentency to operate a motor vehicle. Explain the reason in the "remarks" section. This information shall then be forwarded on a Form OC-88 to the Driver Improvement Section of the Department of State by the investigating department which is recording the accident. If Driver Re-exam is not recommended, enter an "X" on the box marked "N".

VISION OBSTRUCTION [Y N Vision Obstruct.] Enter an "X" on the box marked "Y" if a vision obstruction contributes to the accident. Explain and define the obstruction in the "remarks" section. If vision obstruction is not involved, enter an "X" on the box marked "N".

Whenever a driver's view is obstructed by any condition within the vehicle involving the windshield or windows, etc. Defective glass, frost or steam, rain or snow, dirt, headlight, sun glare, etc., should be indicated. (Packages piled within the car obstructing the driver's view should be included in this section.) In each instance, specify the nature of the obstruction in the "remarks" section.

Buildings, signs, bushes, crops, embankments, parked cars, etc.—When any of these or similar items are involved, then local Road Commision or State Highway Department should be contacted immediately by telephone and then followed by a copy of the accident report so as to correct the condition that may exist.

VEHICLE CONDITION BEFORE AND AFTER ACCIDENT

Y N Vehicle Defect	Y N Fuel Leakage	Impact	Severity	Truck Cargo: Y N Cargo Spillage	Class
Y N Vehicle Drivable	Y N Vehicle Fire			Cargo Description ______	

This area deals with the conditions of the vehicle before and after the accident. Fire and truck cargo deal with the actual or potential damage which may be caused outside of the impact damage.

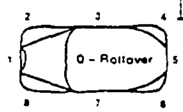
VEHICLE DEFECT [Y N Vehicle Defect] Whenever inspection and/or testing of the vehicle shows that defects in equipment were present at the time of the accident and contributed to the accident. Enter an "X" on the box marked "Y" and explain the defect in the remarks, otherwise enter an "X" on the box marked "N".

VEHICLE DRIVABLE [Y N Vehicle Drivable] Enter an "X" on the box marked "Y" when the vehicle is capable of being driven from the immediate scene of the accident. Otherwise, enter an "X" on the box marked "N".

FUEL LEAKAGE [Y N Fuel Leakage] Enter an "X" on the box marked "Y" where the engine (or auxiliary engine) fuel supply tank, lines, or carburetor, leaked fuel at the accident scene. Otherwise, enter an "X" on the box marked "N". This does not include a truck's cargo after being involved in an accident.

VEHICLE FIRE [Y N Vehicle Fire] Enter an "X" on the box marked "Y" where any part of the vehicle, vehicle attachments, trailer, or cargo caught fire (open flame), before or after impact. Otherwise enter an "X" on the box marked "N".

(Vehicle) IMPACT (Point) [Impact box]



Refer to the vehicle diagram for the appropriate impact number 0 through 8.
Identify the Point of Impact by the position of the FIRST IMPACT ONLY for each vehicle.
In a chain reaction accident, the vehicle in the center shall show Point of Impact on both from (1) and rear (5).
0 indicates a rollover.
Enter the appropriate code in this box.

(Vehicle Damage) SEVERITY

[Severity box]

If there is no damage enter a code Zero (0).
Refer to the "Vehicle Damage Severity Scale Booklet" for damage severity, 1 through 7 as indicated.
Select the degree of severity, 1 being least severe and 7 most severe, for each vehicle.
Enter the appropriate code in the box.
In cases in which vehicles are damaged in more than one area, consider all damage when selecting the appropriate code.

TRUCK CARGO [Truck Cargo: Class / Y N Cargo Spillage / Cargo Description]

This area is used only for truck type vehicles. Enter an "X" on the box marked "Y" when a substantial portion of the Truck Cargo spilled out of the vehicle or trailer or escaped into the air. Otherwise, enter an "X" on the box marked "N". Enter a short description of the cargo being transported, i.e., gasoline, oil, steel, gravel. Enter the cargo code which best describes the cargo being transported.

CLASS OF CARGO CODES

1. Commercial—no cargo.
2. Commercial—flammable or explosive—no cargo.
3. Commercial—flammable or explosive—with cargo.
4. Commercial—general freight—non-bulk.
5. Commercial—general freight—bulk.
6. Non-commercial—(private use, i.e., campers, motor homes, miscellaneous articles and empty.)

RESTRAINT (Use) BY OCCUPANT'S POSITION

Restraints by occupants pos.		
1	2	3
4	5	6

- The numbers 1 through 6 identify occupant positions.
- When an occupant is unbelted on the lap of another, that occupant position restraint code would be "Belt Not Used" (C).
- Do not code restraint information for occupants in buses, motorcycles, snowmobiles, etc.
- When occupant position is unknown, use judgement as to where restraint information should be coded.
- Indicate total occupants for each vehicle.

EXAMPLE:

Restraints by occupants pos.		
D 1	2	E 3
C 4	A 5	B 6

EXAMPLE: There were 5 passengers in this vehicle. The driver's air bag activated (D), the air bag for the passenger in the front seat did not activate (E). In the rear seat the seat belts were not used (C), not available (A), and used (B). In station wagons or like vehicle, the restraint information will not show for passengers in the third seat.

RESTRAINT CODES

Enter the appropriate ALPHA code in the occupant position box.

A. No belt(s) available.
B. Belt(s) used.
C. Belt(s) not used.
D. Air bag activated.
E. Air bag not activated.
F. Restraint failure (bag, belt or child restraint device).
G. Unknown.

TOTAL OCCUPANTS [Total occupants box] Enter the number of occupants in or on this vehicle. This number includes the driver, injured and uninjured persons.

INJURED PASSENGERS

Name	Address	Pos.	Age	Sex	Inj.	Helmet
						Y N
						Y N
						Y N

This area is used to record information on injured passengers.

PERSON'S NAME AND ADDRESS

Name	Address

Enter the full name and address.

PERSON'S POSITION [Pos. box] Enter in the box provided, the seat position code that best describes the occupant's position in the vehicle before the collision. If the codes cannot be used for identifying the seat position of occupants of such vehicles, as commercial and school buses, motorcycles, station wagons, etc., enter a 7 for "OTHER POSITION". If more than one person is occupying a seat position (e.g., child on lap of passenger) use the same code twice or as required. If seat position cannot be determined, enter a 9 for "POSITION UNKNOWN."

Use Vehicle Driver No. 2 section for reporting bicyclist, pedestrian and witness information.

PERSON'S AGE [Age] Enter the person's age in years, as of the last birthday.

PERSON'S SEX [Sex] Enter an "M" or "F" to show the person's sex.

(Person's Degree of) INJURY [Inj.] Enter the code which best describes this person's degree of injury.

SEVERITY OF INJURY CODE

- K – FATAL INJURY—Any injury which results in death.
- A – INCAPACITATING INJURY—Any injury other than fatal which prevents normal activities and generally requires hospitalization.
- B – NON-INCAPACITATING INJURY—Any injury not incapacitating but evident to others at the scene.
- C – POSSIBLE INJURY—No visible injury but complaint of pain or momentary unsciousness.
- O – NO INJURY—No indication of injury.

Refer to Appendix A for further clarification of severity injury code.

HELMET (Use) [Helmet: Y N] Enter an "X" on the box marked "Y" when this person is wearing a helmet. Otherwise enter an "X" in the box marked "N".

LOCAL USE/OWNER, PHONE [Local Use/Owner, Phone] The individual departments may prescribe the use of this area. One use of this area would be to enter the owner's name and phone number when the owner is not the driver.

INSURANCE COMPANY [Insurance Co. | Agency Address] Enter the name and address of the insurance company.

INJURED TAKEN TO/BY [Injured taken to/by] Enter where the injured were taken for treatment and by what ambulance service.

VEHICLE DRIVER NUMBER TWO

Vehicle Driver No. 2	State	Driver's License	DOB	Hazardous Action Number	Citation Charge	HBD	HN	Test / Helmet
	Driver's Name: First	M.	Last	Address	City	State	Age	Sex / Inj.
	Year / Make No. / Type	Trailer	Reg.	Yr/State	VIN Number	Removed to/by		
	Haz. Citation / Other Citation	Driver Re-exam / Vision Obstruct.	Vehicle Defect / Vehicle Drivable	Fuel Leakage / Vehicle Fire	Impact	Severity	Truck Cargo: Cargo Spillage, Cargo Description	Class
Restraints by occupants pos.	Name	Address		Pos.	Age	Sex	Inj.	Helmet
1 2 3								
4 5 6								
Total occupants	Local Use/Owner, Phone	Insurance Co.	Agency Address	Injured taken to/by				

Use this section for pedestrians, bicyclists, and additional motor vehicles.

When this section is used for an additional motor vehicle, follow the instructions for vehicle driver number 1. Witness information may be entered in vehicle driver number 1 or 2.

Each pedestrian or bicyclist requires a complete vehicle and driver section, because the following information is needed:

1. Hazardous Action.
2. Citation Charge.
3. Drinking Condition.
4. Hazardous or Other Citation
5. Vision Obstruction.
6. Name & Address.
7. POS (P–Pedestrian, B–Bicyclist, and W–Witness).
8. Age.
9. Sex.
10. Injury.
11. Helmet.
12. Injury taken to/by.

EXAMPLE: PEDESTRIAN WITH WITNESS

Vehicle Driver No. 2	State	Driver's License	DOB	Hazardous Action Number: 3	Citation Charge: Failed to Yield	HBD	HN: X	Test / Helmet
	Driver's Name: First	M.	Last	Address	City	State	Age	Sex / Inj.
	Year / Make No. / Type	Trailer	Reg.	Yr/State	VIN Number	Removed to/by		
	Haz. Citation (X) / Other Citation (X)	Driver Re-exam / Vision Obstruct. (X)	Vehicle Defect / Vehicle Drivable	Fuel Leakage / Vehicle Fire	Impact	Severity	Truck Cargo: Cargo Spillage, Cargo Description	Class
Restraints by occupants pos.	Name: John Doe	Address: 123 West St. Lansing, Mich		Pos.: P	Age: 18	Sex: M	Inj.: A	Helmet: X
1 2 3	Jane White	321 Blake St. Lansing, Mich		W	28	F	—	
4 5 6								
Total occupants	Local Use/Owner, Phone	Insurance Co.	Agency Address	Injured taken to/by: Mercy Hosp./Lans. FD				

EXAMPLE: BICYCLIST WITH WITNESS

Vehicle Driver No. 2	State	Driver's License	DOB	Hazardous Action Number: 5	Citation Charge: Imp Lane Usage	HBD: X	HN	Test: N / Helmet
	Driver's Name: First	M.	Last	Address	City	State	Age	Sex / Inj.
	Year / Make No. / Type	Trailer	Reg.	Yr/State	VIN Number	Removed to/by		
	Haz. Citation (X) / Other Citation (X)	Driver Re-exam / Vision Obstruct. (X)	Vehicle Defect / Vehicle Drivable	Fuel Leakage / Vehicle Fire	Impact	Severity	Truck Cargo: Cargo Spillage, Cargo Description	Class
Restraints by occupants pos.	Name: John Doe	Address: 123 West St. Lansing, Mich		Pos.: B	Age: 16	Sex: M	Inj.: A	Helmet: X
1 2 3	Bill Black	666 Sage St. Lansing, Mich		W	37	M	—	
4 5 6								
Total occupants	Local Use/Owner, Phone	Insurance Co.	Agency Address	Injured taken to/by: Mercy Hosp./Lans. FD				

EXAMPLE: PARKED VEHICLE

Vehicle Driver No. 2										
State	Driver's License			DOB	Hazardous Action Number	Citation Charge		HBD	HN	Test / Helmet
Driver's Name: First	M.	Last		Address		City	State	Age	Sex	Inj.
Year 71	Make No. 012	Type 4	Trailer 0	Reg. 66F-000/77/Mi	Yr/State	VIN Number 6S1498LD71975	Removed to/by Owner			
Haz. Citation / Other Citation	Driver Re-exam / Vision Obstruct.	Vehicle Defect / Vehicle Drivable	Fuel Leakage / Vehicle Fire	Impact	Severity	Truck Cargo: Cargo Spillage, Cargo Description				Class
Restraints by occupants pos.	Name		Address				Pos.	Age	Sex	Inj. / Helmet
1 2 3										
4 5 6										
Total occupants	Local Use/Owner, Phone: John Doe 283 South Lansing		Insurance Co.: AAA		Agency Address: Lansing Mi		Injured taken to/by			

Enter vehicle identification information.

Enter owner's name, address, insurance company and address in the local use line.

Injured persons in a parked vehicle would be entered in this section.

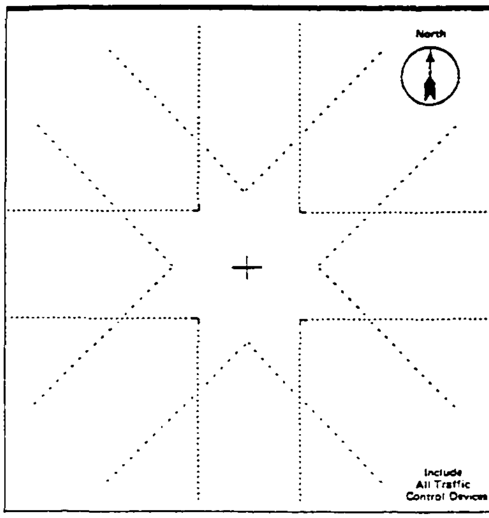
EXAMPLE: TRAIN

Vehicle Driver No. 2										
State	Driver's License			DOB	Hazardous Action Number	Citation Charge		HBD	HN	Test / Helmet
Driver's Name: First	M.	Last		Address		City	State	Age	Sex	Inj.
Year	Make No.	Type	Trailer	Reg.	Yr/State	VIN Number	Removed to/by			
Haz. Citation / Other Citation	Driver Re-exam / Vision Obstruct.	Vehicle Defect / Vehicle Drivable	Fuel Leakage / Vehicle Fire	Impact	Severity	Truck Cargo: Cargo Spillage, Cargo Description				Class
Restraints by occupants pos.	Name: JOHN DOE		Address: 333 DAWN DR. LANSING MICH				Pos. E	Age 49	Sex M	Inj. O / Helmet
1 2 3										
4 5 6										
Total occupants	Local Use/Owner, Phone		Insurance Co.		Agency Address		Injured taken to/by			

E – Engineer

In the Remarks Section, indicate the railroad crossing circumstances. EXAMPLE: Marked crossing with flashing lights, marked crossing with stop sign only and etc.

ACCIDENT DIAGRAM AND DESCRIPTION



ACCIDENT DESCRIPTION AND REMARKS (*Explain)

Describe all unusual conditions and circumstances

DIAGRAM—Always draw the collision scene exactly as you observed it utilizing the Official Michigan Accident Report Symbols template.

1. The diagram section MUST be completed in all cases when the report is submitted even if an attached diagram is submitted or the accident was not investigated at the scene.
2. Select the section of the diagram that most nearly corresponds to the street or highway at the accident scene.
3. Number each vehicle in the diagram to correspond with the previous number assigned on this report. If a double bottom trailer is involved, show both trailers.
4. The diagram shall show the probable position and paths of the vehicles and pedestrians and bicyclists prior to the impact, at the point of impact and final resting place. The basis for this information should be the physical evidence found at the scene and/or information received from witnesses.
5. Use a SOLID LINE to indicate probable paths followed BEFORE the collision or point of impact.
6. Indicate path taken AFTER IMPACT by a BROKEN LINE.
7. Include and identify if present and/or contributing to the accident:

   a. Roadway layout and names or number.
   b. Identify the contact vehicles by number.
   c. Identify non-contact vehicles by letter of the alphabet.
   d. Pedestrians and direction of travel.
   e. Angle of collision.
   f. Objects on or off the roadway.
   g. Vision obstructions, distance from roadway, etc.
   h. Traffic control devices using the template.
   i. Skid marks which indicate the path of the vehicle(s).
   j. Road width and grade.
   k. Unusual or temporary hazardous conditions that contributed to the accident (ice patch, standing water, stones, loose gravel, etc.).
   l. Indicate that a vehicle has overturned, if possible the number of times.
   m. Indicate the probable point of impact.
   n. Possible trafficway design defects. (See Appendix B)

DEPARTMENT OFFICE INFORMATION

Date Reported	Time A.M. P.M.	Investigators	Badge No.
Photos by		Complaint Disposition ☐ Open ☐ Closed	Reviewer

This area is used to enter the department information, relative to this accident.

DATE REPORTED [Date Reported] Enter the date (month, day, year) that this accident was reported to your department.

TIME (Reported) [Time A.M. P.M.] Enter the clock time that this accident was reported to your department. Enter an "X" on "A.M." or "P.M." to show morning or afternoon.

INVESTIGATORS

[Investigators Badge No. /] The investigating officer preparing the report shall sign his name and give his rank and badge number.

PHOTOS (Taken) BY [Photos by] Enter the photographer's name.

COMPLAINT DISPOSITION [Complaint Disposition ☐ Open ☐ Closed] Enter an "X" in the appropriate box to show the status of the accident at the time of submittal.

(Report) REVIEWER [Reviewer] The person reviewing this report will enter his rank and name. By doing so the reviewer certifies that this report is clear and concise.

OTHER DAMAGED PROPERTY

Damage Property Other Than Vehicles	
Owner	Address

When property other than vehicles is damaged, identify the object including domestic animals.

If a motor vehicle strikes an animal other than a domestic animal and harm results only to the animal, the event is not a motor vehicle accident.

Enter the full name and address of the owner of the property damaged.

REPORT FILING INFORMATION

Use of the report filing information is dependant on the individual departments' procedures. Those departments which file their accident reports with the right-hand edge of the report to the top of the drawer, find that this information greatly improves the visual searching for a specific report.

DRIVER NUMBER ONE

Driver No. 1

Enter the last name of driver number one.

DRIVER NUMBER TWO

Driver No. 2

Enter the last name of driver number two.

ACCIDENT DATE

Accident Date

Enter the date (month, day, year) of the accident.

FILE CLASS

File Class

Enter the file class code.

DEPARTMENT COMPLAINT NUMBER

Department Complaint No.

Enter the complaint number for this accident or the number for this report from any other numbering system.

Driver No. 1
Driver No. 2
Accident Date
File Class
Department Complaint No.

DO NOT USE AREA (Shaded)

DO NOT USE

This information is coded by Department of State Police, Safety and Traffic Division for statistical purposes.

Area
Pseudo
Time
No. Units
No. Inj.
No. Killed
Residence
Test
Intent
Direction
Obj. Hit
Situation
Cont. Cir.
Residence
Test
Intent
Direction
Obj. Hit
Situation
Cont. Cir.
Road Align.
Traffic
Road Loc.
Acc. Type
Where
How
Tags
Road Def.
1 Veh. Def.
1 Vision Ob.
2 Veh. Def.
2 Vision Ob.
MALI
Code
File

APPENDIX

APPENDIX A

K–FATAL INJURY is any injury that results in death within twelve months of the motor vehicle traffic accident.

A–INCAPACITATING INJURY is any injury, other than fatal, which prevents the injured person from walking, driving, or normally continuing the activities which he was capable of performing prior to the motor vehicle traffic accident.

INCLUDES: Severe lacerations, broken or distorted limbs, skull fracture, crushed chest, internal injuries, unconscious when taken from the accident scene; unable to leave accident scene without assistance.

EXCLUDES: Momentary unconsciousness.

GENERAL: Determinations are made at the time the injured person leaves the accident scene. It is not necessary to consult with doctors or hospitals unless information is not otherwise available. Apparent condition immediately after the accident does not govern classification because the person may recover from hysteria quickly or may begin to feel the effects of internal or other injuries between the time of the accident and time of leaving the scene.

a. Medical treatment at the accident scene or later makes no difference. What the person does at the scene is important.
b. Hospitalization normally will be required for incapacitating injuries.
c. Duration of the disability after injury makes no difference. Incapacitation is important.
d. Developments after leaving the scene make no difference except in case of death.

B–NON-INCAPACITATING EVIDENT INJURY is any injury, other than fatal and incapacitating, which is evident to any person other than the injured at the scene of the accident.

INCLUDES: Lump on head, abrasion, minor lacerations.

EXCLUDES: Limping (the injury cannot be seen).

EXAMPLE: Pedestrian is unconscious on the ground after accident; his clothes are torn and blood oozes from abrasions; when the ambulance arrives he is conscious, able to give information, and walks around; he goes to the hospital in the ambulance, but is able to sit up in it; there is no evidence that he is incapacitated.

C–POSSIBLE INJURY is any injury reported or claimed which is not a fatal, incapacitating, or non-incapacitating evident injury.

INCLUDES: Momentary unconsciousness. Claim of injuries not evident. Limping, complaint of pain, nausea, hysteria.

GENERAL: Possible injuries are those which are claimed or reported, or indicated by behavior, but not by wounds.

EXAMPLE: Occupant complains of pain but shows no signs of bleeding or other wound; leaves the scene in a taxi to keep an appointment; he dies; this is possible injury when classified at the time of leaving the scene, but should be changed to K upon notice of death.

O–NO INJURY is a situation in which there is no reason to believe that the person received any bodily harm from the motor vehicle traffic accident in which involved.

INCLUDES: Confusion, excitement, anger, internal injuries unknown to the injured until after leaving the accident scene.

APPENDIX B

When the investigating officer feels that engineering or maintenance is a factor in the accident location investigation, this should be included in the "Remarks Section."

Determine which local, county or state road commission is responsible for this maintenance or engineering problem. Notify the responsible commission by telephone and forward a copy of the accident report.

Appendix C

1986 and 1987 Big Truck Accident Printouts

WEEKDAY

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Sunday	1.	569	2.8	2.8	2.8
Monday	2.	3653	17.7	17.7	20.5
Tuesday	3.	3936	19.1	19.1	39.5
Wednesday	4.	3717	18.0	18.0	57.5
Thursday	5.	3725	18.0	18.0	75.6
Friday	6.	3848	18.6	18.6	94.2
Saturday	7.	1197	5.8	5.8	100.0
	TOTAL	20645	100.0	100.0	

MODE 3.000

VALID CASES 20645 MISSING CASES 0

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HOUR

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Midnite- 1 am	1.	327	1.6	1.6	1.6
1 - 2 am	2.	294	1.4	1.4	3.0
2 - 3 am	3.	306	1.5	1.5	4.5
3 - 4 am	4.	251	1.2	1.2	5.7
4 - 5 am	5.	306	1.5	1.5	7.2
5 - 6 am	6.	346	1.7	1.7	8.9
6 - 7 am	7.	629	3.0	3.0	11.9
7 - 8 am	8.	1026	5.0	5.0	16.9
8 - 9 am	9.	1297	6.3	6.3	23.2
9 -10 am	10.	1262	6.1	6.1	29.3
10-11 am	11.	1316	6.4	6.4	35.7
11 am - Noon	12.	1490	7.2	7.2	42.9
Noon - 1 pm	13.	1493	7.2	7.2	50.1
1 - 2 pm	14.	1456	7.1	7.1	57.2
2 - 3 pm	15.	1541	7.5	7.5	64.6
3 - 4 pm	16.	1618	7.8	7.8	72.5
4 - 5 pm	17.	1364	6.6	6.6	79.1
5 - 6 pm	18.	1158	5.6	5.6	84.7
6 - 7 pm	19.	809	3.9	3.9	88.6
7 - 8 pm	20.	638	3.1	3.1	91.7
8 - 9 pm	21.	480	2.3	2.3	94.0
9 -10 pm	22.	435	2.1	2.1	96.1
10-11 pm	23.	379	1.8	1.8	97.9
11 pm - Midnite	24.	389	1.9	1.9	99.8

Unknown	25.	35	0.2	0.2	100.0
	TOTAL	20645	100.0	100.0	

MODE 16.000

VALID CASES 20645 MISSING CASES 0

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MONTH

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
January	1.	2084	10.1	10.1	10.1
February	2.	1682	8.1	8.1	18.2
March	3.	1506	7.3	7.3	25.5
April	4.	1477	7.2	7.2	32.7
May	5.	1547	7.5	7.5	40.2
June	6.	1777	8.6	8.6	48.8
July	7.	1637	7.9	7.9	56.7
August	8.	1547	7.5	7.5	64.2
September	9.	1644	8.0	8.0	72.2
October	10.	1887	9.1	9.1	81.3
November	11.	1925	9.3	9.3	90.6
December	12.	1932	9.4	9.4	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

COUNTY State Police County Code

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Alcona	1.	29	0.1	0.1	0.1
Alger	2.	16	0.1	0.1	0.2
Allegan	3.	204	1.0	1.0	1.2
Alpena	4.	36	0.2	0.2	1.4
Antrim	5.	21	0.1	0.1	1.5
Arenac	6.	44	0.2	0.2	1.7
Baraga	7.	17	0.1	0.1	1.8
Barry	8.	38	0.2	0.2	2.0
Bay	9.	174	0.8	0.8	2.8
Benzie	10.	6	0.0	0.0	2.8
Berrien	11.	553	2.7	2.7	5.5
Branch	12.	125	0.6	0.6	6.1
Calhoun	13.	399	1.9	1.9	8.1
Cass	14.	115	0.6	0.6	8.6
Charlevoix	15.	26	0.1	0.1	8.7
Cheboygan	16.	39	0.2	0.2	8.9
Chippewa	17.	37	0.2	0.2	9.1
Clare	18.	45	0.2	0.2	9.3
Clinton	19.	124	0.6	0.6	9.9
Crawford	20.	31	0.2	0.2	10.1
Delta	21.	93	0.5	0.5	10.5
Dickinson	22.	61	0.3	0.3	10.8
Eaton	23.	223	1.1	1.1	11.9
Emmet	24.	37	0.2	0.2	12.1

Genessee	25.	639	3.1	3.1	15.2
Gladwin	26.	13	0.1	0.1	15.2
Gogebic	27.	26	0.1	0.1	15.4
Grand Traverse	28.	118	0.6	0.6	15.9
Gratiot	29.	64	0.3	0.3	16.2
Hillsdale	30.	74	0.4	0.4	16.6
Houghton	31.	21	0.1	0.1	16.7
Huron	32.	32	0.2	0.2	16.9
Ingham	33.	595	2.9	2.9	19.7
Ionia	34.	144	0.7	0.7	20.4
Iosco	35	36	0.2	0.2	20.6
Iron	36	37	0.2	0.2	20.8
Isabella	37.	45	0.2	0.2	21.0
Jackson	38.	410	2.0	2.0	23.0
Kalamazoo	39	502	2.4	2.4	25.4
Kalkaska	40.	24	0.1	0.1	25.5
Kent	41.	1214	5.9	5.9	31.4
Keweenaw	42.	2	0.0	0.0	31.4
Lake	43.	24	0.1	0.1	31.5
Lapeer	44.	148	0.7	0.7	32.3
Leelanau	45.	7	0.0	0.0	32.3
Lenawee	46.	247	1.2	1.2	33.5
Livingston	47.	310	1.5	1.5	35.0
Luce	48.	16	0.1	0.1	35.1
Mackinac	49.	36	0.2	0.2	35.2
Macomb	50.	1135	5.5	5.5	40.7
Manistee	51.	42	0.2	0.2	40.9

Marquette	52.	98	0.5	0.5	41.4
Mason	53.	74	0.4	0.4	41.8
Mecosta	54.	38	0.2	0.2	42.0
Menominee	55.	85	0.4	0.4	42.4
Midland	56.	77	0.4	0.4	42.8
Missaukee	57.	12	0.1	0.1	42.8
Monroe	58.	472	2.3	2.3	45.1
Montcalm	59.	75	0.4	0.4	45.5
Montmorency	60.	15	0.1	0.1	45.5
Muskegon	61.	187	0.9	0.9	46.4
Newaygo	62.	50	0.2	0.2	46.7
Oakland	63.	2118	10.3	10.3	56.9
Oceana	64.	32	0.2	0.2	57.1
Ogemaw	65.	37	0.2	0.2	57.3
Ontonagon	66.	21	0.1	0.1	57.4
Osceola	67.	57	0.3	0.3	57.7
Oscoda	68.	16	0.1	0.1	57.7
Ostego	69.	52	0.3	0.3	58.0
Ottawa	70.	311	1.5	1.5	59.5
Presque Isle	71.	30	0.1	0.1	59.6
Roscommon	72.	22	0.1	0.1	59.7
Saginaw	73.	385	1.9	1.9	61.6
St. Clair	74.	208	1.0	1.0	62.6
St. Joseph	75.	159	0.8	0.8	63.4
Sanilac	76.	60	0.3	0.3	63.7
Schoolcraft	77.	20	0.1	0.1	63.8
Shiawassee	78.	141	0.7	0.7	64.5

Tuscola	79.	63	0.3	0.3	64.8
Van Buren	80.	191	0.9	0.9	65.7
Washtenaw	81.	765	3.7	3.7	69.4
Wayne	82.	6230	30.2	30.2	99.6
Wexford	83.	90	0.4	0.4	100.0
	TOTAL	20645	100.0	100.0	

MODE 82.000

VALID CASES 20645 MISSING CASES 0

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RTECLASS Route Class

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Interstate	1.	5657	27.4	27.4	27.4
US Route	2.	3077	14.9	14.9	42.3
M Route	3.	4190	20.3	20.3	62.6
I'State BL\BS	4.	404	2.0	2.0	64.6
US Busns Route	5.	246	1.2	1.2	65.7
M Busins Route	6.	13	0.1	0.1	65.8
Connector	7.	42	0.2	0.2	66.0
Service Drive	8.	120	0.6	0.6	66.6
County\City	9.	6896	33.4	33.4	100.0
	TOTAL	20645	100.0	100.0	

MODE 9.000

VALID CASES 20645 MISSING CASES 0

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WEATHER

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Clear \ Cloudy	1.	16370	79.3	79.3	79.3
Fog	2.	198	1.0	1.0	80.3
Raining	3.	2208	10.7	10.7	90.9
Snowing	4.	1836	8.9	8.9	99.8
Other \ Unknown	5.	33	0.2	0.2	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

LIGHTING

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Daylight	1.	15335	74.3	74.3	74.3
Dawn\Dusk	2.	806	3.9	3.9	78.2
Dark w\St Lghts	3.	1115	5.4	5.4	83.6
Dark No St Lghts	4.	3348	16.2	16.2	99.8
Unknown	5.	41	0.2	0.2	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

SURFACE

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Dry	1.	13875	67.2	67.2	67.2
Wet	2.	4201	20.3	20.3	87.6
Snowy or Icy	3.	2495	12.1	12.1	99.6
Unknown	4.	74	0.4	0.4	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

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DEFECT Road Defect

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
None	1.	20514	99.4	99.4	99.4
Obstruction	2.	13	0.1	0.1	99.4
Loose Material	3.	39	0.2	0.2	99.6
Hole Rut or Bump	4.	38	0.2	0.2	99.8
Low\Soft Shldr	5.	8	0.0	0.0	99.8
Drifting Snow	6.	6	0.0	0.0	99.9
Frosty Bridge	7.	11	0.1	0.1	99.9
Slippery When Wet	8.	10	0.0	0.0	100.0
Other \ Unknown	9.	6	0.0	0.0	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

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TCONTROL Traffic Control

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM. FREQ (PCT)
None	1.	13189	63.9	63.9	63.9
Stop Sign	2.	2625	12.7	12.7	76.6
Stop&Go Signal	3.	4390	21.3	21.3	97.9
Flagman\ Police	4.	21	0.1	0.1	98.0
Flasher\Railroad	5.	166	0.8	0.8	98.8
Yield Sign	6.	80	0.4	0.4	99.2
School Speed	7.	4	0.0	0.0	99.2
No Pass Zone	8.	32	0.2	0.2	99.3
Other Warning	9.	39	0.2	0.2	99.5
Other \ Unknown	10.	99	0.5	0.5	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

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SPCLTAG Special Tag

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
School Bus Inv.	1.	36	0.2	0.2	0.2
Schl Bus, Other	3.	26	0.1	0.1	0.3
Deer	4.	598	2.9	2.9	3.2
Deer Assoc.	5.	23	0.1	0.1	3.3
Emergncy\Pursuit	6.	39	0.2	0.2	3.5
Constr. Zone	8.	864	4.2	4.2	7.7
None	10.	19059	92.3	92.3	100.0
	TOTAL	20645	100.0	100.0	

MODE 10.000

VALID CASES 20645 MISSING CASES 0

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04/06/89 FILE - (- CREATED 04/06/89

ACCTYPE Accident Type

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Overturn	10.	475	2.3	2.3	2.3
Railroad Train	20.	17	0.1	0.1	2.4
Parked Car	30.	643	3.1	3.1	5.5
Other MultiVeh	40.	8	0.0	0.0	5.5
Backing	48.	753	3.6	3.6	9.2
Parking	49.	31	0.2	0.2	9.3
Pedestrian	50.	51	0.2	0.2	9.6
Fixed Object	60.	2157	10.4	10.4	20.0
Other Object	70.	109	0.5	0.5	20.6
Animal	80.	620	3.0	3.0	23.6
Bicycle	90.	18	0.1	0.1	23.6
Other SinglVeh	100.	683	3.3	3.3	27.0
Head On	141.	673	3.3	3.3	30.2
Angle, Straight	144.	1024	5.0	5.0	35.2
RearEnd,Straight	147.	7851	38.0	38.0	73.2
Angle, Turning	244.	860	4.2	4.2	77.4
Sideswip-Passing	342.	218	1.1	1.1	78.4
RearEnd, Lt Turn	345.	501	2.4	2.4	80.9
RearEnd, Rt Turn	346.	1051	5.1	5.1	85.9
Other Driveway	440.	294	1.4	1.4	87.4
Angle, Driveway	444.	553	2.7	2.7	90.0
RearEnd, Drivewy	447.	876	4.2	4.2	94.3
Sideswip-Meeting	543.	119	0.6	0.6	94.9
Lt Turn, Head On	545.	324	1.6	1.6	96.4

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Lt Turn, Dual	645.	271	1.3	1.3	97.7
Rt Turn, Dual	646.	465	2.3	2.3	100.0
	TOTAL	20645	100.0	100.0	

MODE 147.000

VALID CASES 20645 MISSING CASES 0

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Frequency Distribution: Coded Variables
04/06/89 FILE - (- CREATED 04/06/89

POPULATN Population

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Township	1.	8100	39.2	39.2	39.2
Under 1,000	2.	136	0.7	0.7	39.9
1,000 - 2,500	3.	457	2.2	2.2	42.1
2,500 - 5,000	4.	581	2.8	2.8	44.9
5,000 - 10,000	5.	622	3.0	3.0	47.9
10,000- 25,000	6.	1469	7.1	7.1	55.0
25,000- 50,000	7.	1722	8.3	8.3	63.4
50,000- 100,000	8.	2207	10.7	10.7	74.1
100,000-250,000	9.	1951	9.5	9.5	83.5
Over 250,000	10.	3400	16.5	16.5	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

SEVERITY

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
Fatal	1.	184	0.9	0.9	0.9
Personal Injury	2.	4668	22.6	22.6	23.5
Property Damage	3.	15793	76.5	76.5	100.0
	TOTAL	20645	100.0	100.0	

MODE 3.000

VALID CASES 20645 MISSING CASES 0

86 & 87 BIG TRUCK ACCIDENTS PAGE 38
Frequency Distribution: Coded Variables
04/06/89 FILE - (- CREATED 04/06/89

ACCLOC Location of Accident

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
On Free Access	1.	12932	62.6	62.6	62.6
Off Free Access	2.	2084	10.1	10.1	72.7
On Limit Access	3.	4634	22.4	22.4	95.2
Off Limt Access	4.	995	4.8	4.8	100.0
	TOTAL	20645	100.0	100.0	

MODE 1.000

VALID CASES 20645 MISSING CASES 0

86 & 87 BIG TRUCK ACCIDENTS PAGE 43
Frequency Distribution: Numeric Variables
04/06/89 FILE - (- CREATED 04/06/89

FATALS Number of Persons Killed

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	0.	20461	99.1	99.1	99.1
	1.	162	0.8	0.8	99.9
	2.	16	0.1	0.1	100.0
	3.	4	0.0	0.0	100.0
	4.	2	0.0	0.0	100.0
	TOTAL	20645	100.0	100.0	

MEAN	0.010	STD ERR	0.001	MEDIAN	0.004
MODE	0.000	STD DEV	0.119	VARIANCE	0.014
KURTOSIS	295.915	SKEWNESS	14.903	RANGE	4.000
MINIMUM	0.000	MAXIMUM	4.000		

VALID CASES 20645 MISSING CASES 0

86 & 87 BIG TRUCK ACCIDENTS PAGE 44
Frequency Distribution: Numeric Variables
04/06/89 FILE - (- CREATED 04/06/89

AINJ No. of A [Incapacitating] Injuries

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	0.	19543	94.7	94.7	94.7
	1.	904	4.4	4.4	99.0
	2.	153	0.7	0.7	99.8
	3.	28	0.1	0.1	99.9
	4.	11	0.1	0.1	100.0
	5.	3	0.0	0.0	100.0
	6.	2	0.0	0.0	100.0
	7.	1	0.0	0.0	100.0
	TOTAL	20645	100.0	100.0	

MEAN	0.066	STD ERR	0.002	MEDIAN	0.028
MODE	0.000	STD DEV	0.315	VARIANCE	0.099
KURTOSIS	66.363	SKEWNESS	6.699	RANGE	7.000
MINIMUM	0.000	MAXIMUM	7.000		

VALID CASES 20645 MISSING CASES 0

Appendix D

Research Problem Statement

RESEARCH PROBLEM STATEMENT

Title: *Techniques to Measure Truck Exposure for Accident Analysis*

Specific Problem Area:

To assess the effect of large trucks in the traffic mix and determine how highway safety and accident analysis are effected by these trucks.

Research Problem Statement:

This department needs to determine how to effectively measure truck exposure in analyzing accidents. There is a lack of agreement among traffic researchers as to what constitutes accident exposure. There is little agreement among researchers on how to incorporate exposure factors in accident analysis. The department has identified that one source of determining accident exposure is to utilize the "innocent victim" concept. Other sources to accomplish this need to be established. Coarse estimates of truck exposure over the highway network are inadequate, as truck exposure, and its effect on accidents, are believed to vary greatly by roadway type.

Objective:

1. To provide a literature search of the problem.
2. To develop an exposure measurement technique for analysis of accident data involving different sizes and operating characteristics of large trucks.
3. To test the procedure.

Deliverables:

1. Analysis of existing research.
2. Determine a methodology for truck exposure:
   a. Use of "innocent victim" concept.
   b. Survey licensed drivers through questionnaire for the amount of truck travel, truck classification, etc.
   c. Conduct vehicle classification counts on sampled roadways, and develop modeling procedures to predict counts for other major routes.
3. Identify and utilize best method; validate procedure.
4. Prepare final report of findings.

Time: 1 Year

Cost: MDOT cost: $45,000

Benefits:

A thorough understanding of risk and exposure for determining truck safety.

Facilities:

Use of MDOT computers, if needed.

Appendix E

Research Protocol Clearance by the Human Subjects Institutional Review Board

WMU

Western Michigan University
Kalamazoo, Michigan 49008-3899

Human Subjects
Institutional Review Board

TO: Robert E. Maki

FROM: Ellen Page-Robin, Chair

RE: Research Protocol

DATE: March 22, 1988

This letter will serve as confirmation that your research protocol, "The Relationship Between Private Vehicle Driver Records and Commercial Vehicle Driver Records in Michigan," has been approved as exempt by the HSIRB.

If you have any further questions, please contact me at 387-2647.

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