NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT **79**

DEVELOPMENT OF IMPROVED METHODS FOR REDUCTION OF TRAFFIC ACCIDENTS

HIGHWAY RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

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DEVELOPMENT OF IMPROVED METHODS FOR REDUCTION OF TRAFFIC ACCIDENTS

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by Highway Planning and Research funds from participating member states of the Association and it receives the full cooperation and support of the Bureau of Public Roads, United States Department of Transportation.

The Highway Research Board of the National Academy of Sciences-National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, non-profit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway departments and by committees of AASHO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are responsibilities of the Academy and its Highway Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

This report is one of a series of reports issued from a continuing research program conducted under a three-way agreement entered into in June 1962 by and among the National Academy of Sciences-National Research Council, the American Association of State Highway Officials, and the U. S. Bureau of Public Roads. Individual fiscal agreements are executed annually by the Academy-Research Council, the Bureau of Public Roads, and participating state highway departments, members of the American Association of State Highway Officials.

This report was prepared by the contracting research agency. It has been reviewed by the appropriate Advisory Panel for clarity, documentation, and fulfillment of the contract. It has been accepted by the Highway Research Board and published in the interest of an effectual dissemination of findings and their application in the formulation of policies, procedures, and practices in the subject problem area.

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FOREWORD

By Staff

Highway Research Board

This report will be of interest to state and city traffic engineers, highway administrators, police administrators, and other safety officials responsible for the management of accident record systems and for the analysis of the accident data contained in these systems. The information provided in this report will enable safety personnel to develop improved accident investigation procedures, records, and statistics which will more accurately reveal accident causation than methods now in use. Recommendations involve an improved centralized accident record system integrated with non-accident data and the use of multi-level accident report schemes. Typical demonstration studies are included to illustrate the feasibility of the proposed system and the techniques required.

The completeness, accuracy, and extent of utilization of accident causation data collected and stored by present accident record systems are unknown. Those responsible for collecting information about accident causes generally have many pressing responsibilities at the scene of an accident. Incorrect information used as a basis for action will inevitably lead to wasted effort and additional accidents. It was with these thoughts in mind that this project was initiated during the winter of 1966.

The objective of the research was to determine and describe the most important methods for using traffic accident information to reduce the likelihood of accidents. The research presents the adequacy, reliability, and utilization of present accident reporting and records; recommends an accident information system that will reveal basic contributing factors of accident causation; presents guidelines for short- and long-range highway improvement programs that will effectively contribute to highway accident reduction; and suggests major areas of need for future accident records research.

Cornell Aeronautical Laboratory in this comprehensive and well-documented study has extensively reviewed the state of the art and the current practices of accident investigation, reporting, and analysis. The report discusses the shortcomings of commonly used accident record systems and recommends specific methods to improve these systems. A multi-level concept of accident investigation is proposed which involves the basic reporting of all accidents, limited investigation of a selected sample of accidents, and intensive investigation of a limited number of accidents. Studies of accident report forms were included in the research, together with suggested methods for improvement.

Pilot studies were performed to demonstrate the benefits which could be obtained from more rigorous analysis of the present data, the additional data which may be collected through intensive investigation of accidents, and the use of specially developed investigation equipment such as a "vectorgraph," a device designed to more accurately record at the accident scene the vehicle path and the angle of departure from the traveled way. As an aid to the practicing engineer an appendix includes several demonstration studies that indicate the type of information that can be obtained by using an improved accident record system study. Examples include tire failure versus vehicle speed, tire failure versus number of plies, frequency of accidents as a function of time since inspection, fatal accident rate by sex, accident involvement according to vehicle manufacturer, and relationships between vehicle exposure and accidents.

Future research could involve the implementation and use of a statewide model accident information system designed in accordance with the concepts advanced in this report.

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The research reported herein was performed by the Transportation Research Department of the Cornell Aeronautical Laboratory. The initial principal investigator, Dr. B. J. Campbell, left the project in its early stage to become Director of the Highway Safety Research Center at the University of North Carolina. Although he was largely responsible for the study design, and the initiation of many of the tasks finally performed, John W. Garrett, Head of the CAL Accident Research Branch, assumed the task of Principal Investigator and performed a large part of the work. He was ably assisted by Dr. Kenneth J. Tharp, Principal Systems Engineer. Statistical studies were performed by Jay Herson, Kenneth Perchonok, and Roger Fargo under the supervision of Dr. Jaakko K. Kihlberg. The section on accident location, and some of the material on data utilization, was prepared by Murray D. Segal, Transportation Consultant. Major contributions also were made by Norris Shoemaker, Richard Braisted, Alexander J. McLean, Donald Hendricks, Mary Ann Bouchard, Frank Sanel, and a number of other CAL personnel who aided in obtaining state cooperation, accident investigation, and a number of other tasks.

Appreciation is extended to the administrators of the highway departments in the 50 states, Puerto Rico, and the District of Columbia, for their cooperation in responding to the survey on accident location and data processing procedures.

Special thanks are extended to the administrators and technical staff in the highway, state police, motor vehicle, and other state organizations in a great many states, who willingly gave of their time to review their organization, operations, and data needs. Special thanks also are extended to the various state and local agencies in Indiana, Ohio, Utah, and Virginia that supplied the data used in this study and cooperated in the investigation of accidents for special topics.

DEVELOPMENT OF IMPROVED METHODS FOR REDUCTION OF TRAFFIC ACCIDENTS

SUMMARY

This report seeks to develop motor vehicle accident investigation procedures, records and statistics that will reveal accident causation more accurately than does the current accident record system. Emphasis is placed on the state system, but the different requirements of local governments are recognized.

An extensive review of the state of the art indicates that accident report forms are geared to operational and regulatory requirements. The accident report form was developed over a period of years to meet the contingencies of day-to-day operations such as driver regulation, vehicle registration, and the scheduling of police patrol activities. Consequently, the data collection forms and procedures do not meet research requirements and the reporting is not complete.

The accident records system represents a mass data analysis problem, but few state agencies employ competent statistically trained personnel. Consequently, statistical interpretation of data is limited, and the significance of summarized data is unclear. Routine state data summaries are tabulations of basic information with little or no cross-tabulation. The summaries would be more useful if selected cross-tabulation, percentage distributions, statistical tests, and written interpretation were provided. In this report, available state data were utilized in studies that demonstrated suggested improvements.

States occasionally publish reports concerning subjects of special interest. The data for these studies may come from the regular accident report form or may be collected especially for the study. Some of the special studies are well designed, documented, and interpreted. Increased use of special subject studies for research purposes would be beneficial.

Collected accident data are most frequently used by state agencies. Discussions with officials in various states revealed the following four major uses of the accident data:

1. Determination of accident location and accident description.
2. Maintenance and updating of driver and vehicle data files for financial responsibility and driver improvement programs.
3. Production of routine accident summaries.
4. Furnishing copies of the accident report form to interested agencies and individuals.

Because of the active interest in accident location methods, a survey of location practices was conducted throughout the United States. The results indicated that three methods are in use or are being developed—a route number-accumulated mileage system, a node-link system, and a coordinate system. The method most frequently used is the route number-accumulated mileage system, which is simple to

use, allows direct location coding in the field, and is compatible with existing road inventory records. However, this system is not adaptable to complex highway configurations, is difficult to use in urban areas, and produces problems when the highway network is modified. The node-link system has advantages similar to those for the route number-accumulated mileage system and, in addition, is adaptable to highway changes by simply adding another node. The system requires field markers. The chief disadvantage of the coordinate system is that each patrolman must have maps of his area and be experienced in map reading.

A multi-level system of accident investigation is recommended. The multi-level system is designed to provide accident records that are appropriate in both quantity and quality for the specific tasks for which the data are intended. The suggested three levels of investigative effort are:

Level 1. Basic reporting of all reportable accidents: Collected data include driver and vehicle identification, time and place of occurrence, and a brief description of the accident. Data are to be used to identify high-frequency accident locations, drivers, and vehicles; to obtain rate and risk estimates; and to satisfy agency operational requirements.

Level 2. Limited investigation of a sample of accidents for preselected research objectives on special topics: The information would be collected for statistical analysis of special study topics by technicians or specially trained police, and would be used to evaluate topics concerning the highway, the driver, and the vehicle. Sample size would be dependent on study requirements.

Level 3. Intensive investigation of a limited number of accidents: Detailed information would be collected on a small number of accidents by multidisciplinary teams. Data would be used to improve investigative techniques, establish research needs, and hypothesize causal relationships which may be examined further at level 2.

Implicit in the proposed system is the need to integrate accident data with the appropriate non-accident data—driver, vehicle, and highway records. Thus, full cooperation between those agencies concerned with accident records is a requirement. Possible means of obtaining the necessary cooperation are:

1. A state department of transportation responsible for the entire accident record system.
2. A commission composed of members of appropriate departments.

Until formal coordination of state agencies is achieved, voluntary cooperation among those agencies responsible for the operation and regulation of the highway system is of primary importance. Projects with similar objectives—highway department spot improvement programs and police selective enforcement programs—should be conducted jointly.

State-of-the-art knowledge varies at different operational, governmental, and research levels. A continuing education program for practicing engineers (e.g., a series of seminars) is recommended.

A safety review board is recommended for the review of all highway plans and programs to insure incorporation of current safety knowledge.

A simplified accident report form should be developed to provide basic accident data. Use of current technology—photographs, tape recorders, license data imprinting devices—could enhance data reporting and minimize reporting subjectivity.

Based on a small sample of accidents, intensive investigation was found to be a promising approach for developing new investigative techniques and equipment, discovery of additional accident causal factors, and proposing causal hypotheses. A few of the specific highway and traffic problems identified included traffic signal failures, improper timing of signals, and inadequate warnings at highway construction sites.

A number of studies conducted as part of this project and using available state data, as well as specially collected data samples, demonstrated, first, that statistical analysis permitted interpretation of the significance of various observations and, second, that properly trained police could collect useful and reliable information.

CHAPTER ONE

INTRODUCTION AND RESEARCH APPROACH

One of the more pressing domestic problems of the United States today concerns motor vehicle accidents.* Any attempt to illustrate the existence of this problem would result in needless repetition of statistics published by the Insurance Institute for Highway Safety, the National Safety Council, state traffic authorities, and others. Therefore, by accepting the existence of the problem as presented in the other published sources, this study can be directed to the methods used to determine the magnitude, the cause, and the advocated solutions of the problem.

The almost exclusive source † of information on motor vehicle accidents is the accident report, or description, which is prepared subsequent to the occurrence of the accident. The accident report is a written history of the occurrence and is normally prepared by either the people involved, a member of a police unit or, in many instances, both. Collectively, these reports form the base of the entire accident record system. Theoretically, if sufficiently accurate and comprehensive, these records would indicate the magnitude of the problem, reveal the causes of accidents, and thereby suggest remedies and measure the effectiveness of corrective efforts.

The present record system is one that has been constructed piecemeal over a period of more than half a century. During this period, the ever-increasing number of automobiles and the use of these vehicles on the highways have been paced by an increasing number of accidents. The role of the police as accident investigators was a natural consequence of the fact that accidents occurred on public highways and often involved violations of law as well as damage to property and injury or death to individuals. The traditional role of the police in maintaining law and order, and their ready availability at the scene, led to the new assignment of reporting accidents.

At first, accident reports involved a fairly simple record of those involved, their injuries and disposition. As time went on, however, litigation increased, the police officer often became a principal witness, and his report became a vital piece of evidence. Later, the needs of highway departments, financial responsibility agencies, licensing departments, etc., dictated that more and more information be collected.

Today, the accident record system has become so massive, and so many individuals and agencies are involved, that there is often a tendency to resist any change for fear of its effect on the entire system or its component parts. This is exemplified by an increasing trend toward uniformity in the collection of specific items of information that are of questionable value. Although uniformity in the collection of useful data is a desirable and even laudable goal, uniformity for its own sake can lead to stagnation and impede progress.

During recent years, there has been considerable dissatisfaction with the accident record system. Critics point to both a lack of information on the magnitude of the total accident picture and a lack of knowledge on accident causation, and in general claim that the system is obsolete and ineffective. The nation's motor vehicle accident experience for the last few years suggests that the criticism is justified.

Questions concerning the adequacy and effectiveness of the existing accident record system led to the formation of the research project reported herein. The objective of Project 17-1 was to investigate existing motor vehicle accident record systems and develop accident investigation

* The National Safety Council(*1*) defines accident as "That occurrence in a sequence of events which usually produces unintended injury, death, or property damage." The same source defines motor vehicle traffic accident as "a motor vehicle accident which occurs on a way or place, any part of which is open to the use of the public for purposes of vehicle traffic." These basic definitions are used in this study.

† Various factors—such as vehicle crashworthiness, seat belts, etc.—have been investigated in controlled laboratory experiments.

procedures, records, and methods of analysis that will more accurately reveal accident causation than the reporting systems presently used.

RESEARCH APPROACH

In this study, the approach was: (1) to review the existing accident record system in order to determine the weaknesses and limitations of the present system; (2) to outline the concept of an improved accident record system as a long-term objective; (3) to demonstrate the operation and feasibility of specific components of the proposed system (within the limits of the contract); and (4) to make recommendations for immediate or short-term improvements to the existing system.

State-of-the-Art Review

The examination of the existing system consisted of the following:

1. Available literature was reviewed to determine the strengths and weaknesses of the system as reported by others, and to enumerate some of the proposed system changes.
2. The accident record systems in several states and a few local communities were examined to determine whether the limitations and deficiencies shown in the published literature were correct and complete. Some of the governmental units contacted were in the process of installing new methods of accident reporting and making other system improvements.
3. The recipients of published reports within states were contacted to determine the use of these reports and to determine whether the data were of benefit to the recipients.
4. The state of the art of accident location procedures was reviewed and evaluated by means of a nationwide survey.
5. The data available from the standard accident report form were re-analyzed to determine whether a more complete analysis of these data would be of benefit; i.e., is it possible, using the present data, to obtain better and more statistically acceptable results?
6. The physical flow of accident data was traced from their collection in the field, through data processing and analysis, to the final reports, to determine whether there were deficiencies, discrepancies, redundancies, etc., in the flow of these data, and whether specific improvements could be suggested.
7. Equipment for data collection, processing, and analysis was studied to determine whether advanced technology could provide data more accurately and more economically.

Outline of Improved Accident Record System

Upon the completion of the state-of-the-art section of the study, some general conclusions were drawn concerning data needs and system requirements so that the "ideal" accident record system could be defined. The basic concept of such a system is outlined in broad terms.

Demonstrations of System Feasibility

A series of demonstration projects was initiated to show the feasibility of the concept, and to outline the operations of various segments of the recommended accident record system. Because total development of the entire accident record system was beyond the capabilities of the present project in terms of financing and time available, demonstrations were limited to selected key areas of the recommended system. Study topics were selected which were thought to be of particular interest to highway and traffic engineers, vehicle manufacturers, the police, and other organizations.

Recommendations

Based on study findings, specific recommendations are made for improvement of the existing accident record system. Although the generic system described is thought to be adaptable to the needs of most state governments, it is recognized that because of economic and other considerations, installation of the system will be a long-term process even if deemed acceptable. Therefore, a number of short-term recommendations (many based on components of the proposed system) have been made which will be useful to the highway engineer and to others concerned with alleviating the problem of highway accidents.

CHAPTER TWO

STATE-OF-THE-ART REVIEW

This study is directed toward revealing the causes of motor vehicle accidents. Thus, in this report the ideal record system is defined as one that fulfills the following basic functions:

1. Defines the problem.
2. Provides data for the solution of the problem.
3. Permits evaluation of the solution.

These functions essentially represent the customary research approach to a problem and, consequently, have been stated in a variety of ways by many others with respect to the traffic accident problem.

The first task in this study was to evaluate the present accident record system with respect to the service intended as well as to the service actually provided. To facilitate discussion, examination of the existing records system is divided in this chapter into six sections, as follows.

1. Review of literature.
2. Data utilization.
3. Current accident records.
4. Summary tabulations and special reports.
5. Recent accident records projects.
6. Accident location.

REVIEW OF LITERATURE

Functions of Accident Record Systems

A publication by the Traffic Institute of Northwestern University (*2*) lists the following five basic purposes of traffic accident records:

1. To have knowledge of traffic accidents as a cause of mortality, morbidity, and economic loss.
2. To point out where, when, and to whom traffic accidents are a critical problem.
3. To suggest lines of preventive action to be taken.
4. To measure the effect of accident prevention efforts.
5. To determine negligence or fault.

In addition, *Traffic Safety Memo No. 69* (*3*) lists:

> Some of the ways that good traffic accident records contribute to the traffic accident prevention efforts of agencies having a responsibility to take corrective actions:
>
> a. They identify problem drivers who are in need of corrective action by agencies concerned with driver license administration, education, enforcement, and administration of financial responsibility laws.
> b. They assist educators in the development of driver education programs and provide meaningful information for the general public on traffic accident causation and prevention.
> c. They point out high accident or hazardous locations for corrective action by traffic engineers.
> d. They indicate over-all deficiencies in streets and highways for traffic engineers and provide general guides for roadway designs that assist in the elimination of traffic accidents.
> e. They define the scope of the problem with which traffic police must deal, and provide guidelines for the development of selective enforcement procedures.
> f. They assist legislative bodies in the preparation of laws and ordinances, and governmental administrators in the formulation of administrative regulations.
> g. They identify areas in which further research is needed about drivers, vehicles, and traffic controls.
> h. They provide traffic accident prevention program data that allow the effectiveness of the city traffic accident prevention efforts, based on the "Action Program" (*8*), to be evaluated.

Because the present study is directed toward reduction of traffic accidents, the most pertinent objectives for the accident reporting and record system are summarized in the following statement from the National Safety Council's *Traffic Safety Memo No. 69* (*3*):

> What is to be prevented must be known before it can be prevented. Therefore, the economic cost of traffic accidents, loss of life, and disabling injuries, as well as the time and money spent in traffic accident prevention work, warrant a reasonable investment in collecting traffic accident information and studying it to determine:
>
> a. The nature and extent of the traffic accident problem;
> b. The possible methods of correction; and
> c. The effectiveness, or ineffectiveness, of treatment applied.

The function of the accident record system is extremely broad and the problem is further complicated by the large variety of agencies which make use of the accident records. A publication of the Traffic Institute of Northwestern University (*2*) lists the following functional types of agencies as desiring access to traffic accident data:

1. Law enforcement
   - Police
   - Courts
2. Education
3. Public information
4. Legislation
5. Driver licensing
   - Examination
   - Improvement
6. Engineering
   - Traffic engineering
   - Highway design
7. Vehicle design
8. Vehicle inspection
9. Financial responsibility

Utility of Present Accident Record System

The next question is: Do the present accident records satisfy the requirements for data?

There appears to be no staunch defender of the system as is, although there are those who indicate that the existing records system has provided the means of reducing the number of accidents per unit exposure. For example, Mattson (*4*) emphasized that the traffic accident mortality rate (per 100 million vehicle-miles) dropped from 16.7 in 1934 to 5.4 in 1963. He attributed much of the gain to physical improvement of specific locations or areas which the records have shown to have either high accident frequency or high accident severity, because the existing data allow publicity, police patrolling, geometric redesign, traffic operation procedures, etc., to be concentrated on these locations. However, he also stated: "One of the shortcomings that we now are trying to remedy is that some states and cities still do not realize the potential value of accident record systems as a key to traffic safety work."

Other and more basic weaknesses of the present system are revealed by the dissatisfaction expressed by several researchers. As examples, Baerwald (*5*) lists six visible indications of the problems presently associated with traffic accident reporting, as follows:

1. Incomplete or inconsistent national totals.
2. Duplication of effort and excessive costs.

3. Absence of the application of modern techniques for processing.
4. Lack of intergovernmental or interbureau exchange and cooperation.
5. Failure to produce significant facts about accidents.
6. Absence of a satisfactory rate basis.

Haddon et al. (*6*) list three problems encountered in attempting to use accident data currently collected by motor vehicle agencies:

> First, the extent to which reportable accidents are in fact reported is usually largely or totally unknown. Second, there is usually a complete absence of reliable information as to the qualitative and quantitative errors in the information reported. Third, collateral sources are often employed, which themselves suffer from the same related deficiencies.

Haddon also lists a source of bias in the report as ". . . the influence of age, sex, socioeconomic level, and other characteristics of the driver on the decisions reached by police officers, judges, and others officially concerned with the driving public."

Moynihan (*7*), a severe critic of the existing reporting systems and their resulting statistics, states:

> Traffic statistics have been neglected over the past half-century in this country and, as far as we could see in the U.S. Labor Department, are useless and haven't contributed anything to our information. . . . We have no information on injuries, no information on accidents.

The literature usually documents the absence of solutions to the traffic safety problem by drawing attention to the enormity of the unresolved portion of the problem. In addition to this, the Little report (*44*) on the state of the art displays another attitude. With few exceptions the summaries following each content area contain statements referring to the failure to achieve conclusive empirical results. In particular it is indicated that much of the research suffers from the absence of empirically demonstrated relevance to accident phenomena. Some specific uses of accident data are suggested; these include the determination of the roles of vehicle malfunctions, skidding, blood alcohol level, and transitory psychological states.

The report concludes that current research efforts are inadequate, that the multifactor nature of the problem must be recognized, that the interaction of these factors cannot be ignored, and that the available information is insufficient. Regarding the last conclusion, it is suggested that the primary requirements for data are in the areas of cost information and "basic observational data on the accident event."

Recommendations pertaining to the safety activities of the motor vehicle industry call for the investigation of collision and injury dynamics, including the integration of data obtained from accidents and experimental crash tests. It is suggested that more information is needed about vehicle use and maintenance, and that the role of malfunctions and other vehicle performance characteristics in traffic accidents be explained. The industry is also called upon to make greater efforts in the publication of non-proprietary research findings.

The report also makes recommendations to the Federal Government: It suggests that the government establish a professionally staffed traffic safety center to promote effective use of funds and to assess proposed and existing remedial measures. It calls for the government to provide an accident record system to collect, integrate, and disseminate accident-related information. Finally, it recommends that the Federal Government provide for in-depth accident investigation on an appropriate sampling basis.

In summary, the existing accident record system is inadequate, has many obvious deficiencies, and needs improvement. This does not deny that the use of the existing system has provided the means for reducing the mortality rate and for mitigating the severity of injuries. However, with the continuous increase in the daily use of the motor vehicle, more imaginative, more profitable, and more systematic steps must be taken in order to cope with the traffic accident problem. The initiation of these steps awaits improved investigation procedures, improved accident records, and improved data analysis, which must be developed to meet the challenge presented by the motor vehicle traffic accident.

DATA UTILIZATION

To determine how accident records data are utilized, available literature was reviewed and visits were made to officials in a number of states. Two states (Maine and Connecticut) were selected as typical, although there are substantial variations in state organization, accident records system, and data use throughout the country. These two states were chosen primarily because a research agency consultant had worked with them and was thoroughly familiar with the state organization and accident records system. General findings concerning data use in most states are summarized in this section.

A major problem in this phase of the study involved the definition of the term "data utilization." Although many organizations and individuals receive and use accident data, relatively few use these records for the purpose of reducing traffic accidents. The improved use of accident records for that purpose is the objective of this report. Among the generally accepted users of accident data in various forms are police, courts, legislators, highway departments, motor vehicle departments, financial responsibility agencies, insurance firms, involved individuals, and attorneys.

In most states there is a legal requirement that accidents be reported to a specified state agency on a report form developed by that agency. This agency then becomes the repository for accident records and usually is regarded as a principal user of the data. In practice, the amount of accident information required by this agency and the other agencies involved varies (Table A-1) and no single agency uses a major amount of the information collected. Often, the approach of the involved agencies is not integrated, and coordinated activities involving several agencies are rare. Consequently, the use of accident data is circumscribed severely and many of those involved most deeply with the problem of highway accidents are not considered data users at all. Physicians, public health officials, and automobile manufacturers, to name a few, receive little useful information. In this section, the various uses of accident data, and other factors influencing data use, are discussed and an effort is made to describe the relative importance of these uses for purposes of perspective.

The extent to which data are used by various agencies is dependent on many factors other than the need for information. The sheer volume of accident data was a limiting factor before the advent of the computer. (It should be noted that the use of the computer for storage and manipulation of accident data is relatively recent in most states.) Initial use of the computer in most states involved accounting and other large-scale data handling problems such as the processing of driver licensing and vehicle registrations. Driver violation data and sufficient accident information to determine the need for reexamination or license revocations also received a high priority. Although periodic routine summaries of accident data were produced, the manipulation of accident data rated a rather low priority.

In part, this problem arose because the orientation of the present system is largely operational. As a rule, one agency (often the motor vehicle department) receives and processes accident data. Despite the large number of accidents, these data represent a relatively small part of the total information system handled by the department. Because driver licensing and vehicle registration are the principal functions of the motor vehicle department, it is natural that these operations have taken precedence over accident data. Similarly, requests for accident information from other state agencies, when indeed there were any, were handled when routine processing permitted. This led to redundancy in data handling and processing until, at times, several agencies were processing the same accident report forms, and often for the same purpose.

Other factors also influenced data utilization. Lack of confidence in the accident location and description information reported by involved individuals, and sometimes by police, resulted in minimal use of these records by some traffic and highway departments. Many police organizations received no data for accidents reported by other police groups operating within their area. Consequently, even selective enforcement efforts often were based on incomplete information. In some instances, accident data were prepared periodically for use by police or other agencies without any assurance that the data ever were used.

Although the structure of the state government and the systems employed varied from state to state, the response from state officials was remarkably consistent regarding the use of data, the type of information required, and the format in which it was required. Four of the major uses for accident data that were reported by all of the states contacted (not necessarily listed in order of importance for all states) were:

1. Determination of accident location and description of accident type.

2. Maintenance and updating of necessary records; licensing, registration, driver violations, accidents, financial responsibility.

3. Producing routine (monthly, quarterly, annual) accident summaries.

4. Providing copies of the accident report form, usually for purposes of litigation.

Accident location is used primarily by police and highway departments in selective enforcement and spot improvement programs. Except for intersection accidents, the police require less precise definition of the accident location because enforcement usually entails patrol of a highway section. Traffic and highway engineers prefer a more precise location which may enable them to pinpoint the source of a specific problem.

A spot map, or less frequently an automated procedure, is used to locate the accidents on the roadway and to identify sites of high accident frequency. When a site is located, copies of the original accident reports are referred to for determining the types of accidents and the environmental conditions and other factors which may have caused the accidents.

A survey of highway administrators was conducted in all 50 states, the District of Columbia and Puerto Rico (Table B-4) to obtain data concerning accident location. The response from 44 of the 49 jurisdictions that cooperated indicated that they routinely received accident reports; 34 believed that police accident location data were reliable; one considered driver report data reliable; nine thought both were reliable; and five stated that neither report was reliable. Discussions with individual highway and traffic engineers suggested that they placed less reliance on other accident report data than indicated for accident location.

Certain portions of the accident report form, particularly those concerned with the driver, are used in the maintenance of driver records, in driver improvement programs, and in financial responsibility programs. These data usually are concerned with driver violations, the identification of involved drivers, information concerning the physical and mental condition of the driver, and other driver-oriented information. In certain states having financial responsibility laws, the accident report form provides information needed for the administration of the program and, in others, pertinent information is obtained from a section added to the accident form, or a separate form must be completed. In states having compulsory insurance laws, the need for this type of information is reduced drastically.

Much of the output derived from the accident reports consists of routine tabulations of individual report items. These routine accident data summaries are published periodically in every state, often with subclassifications for rural, urban, county, city, and other jurisdictions. This torrent of paper, often without appreciable change in the data from year to year, has questionable value in most action programs to reduce accidents. Their primary use by state public service or public information officials is to educate and inform the public concerning automobile accidents. Because reporting is incomplete, their usefulness even for this purpose is questionable. The summaries vary but little from state to state. (A typical summary is shown in Figure A-1.) Cross-tabulations are rare and use of the data in scientifically valid research programs is virtually nonexistent. The consensus among officials engaged in programs to reduce accidents in the states visited is that these reports are not useful for this purpose, but may serve to inform administrators and the public of the nature and extent of the problem.

Most states provide copies of the accident report form to interested attorneys, insurance firms, or individuals, for a fee which usually covers the cost of this operation. Certain information from driver records also is provided for a fee, and providing this service for credit organizations, employers and others represents a substantial portion of the total activity in many motor vehicle departments. Whether all of these are legitimate activities for a public agency is largely a matter of viewpoint. It is a fact, however, that as the scope of these activities increases they assume a relative importance that is out of proportion to the original purpose for which the agency was established.

By and large, it was the consensus among highway and traffic engineers that the accident report form requires improvement, and in some states changes already were being made. In Pennsylvania, for example, a new form has been introduced in which the investigator describes the accident in narrative form and provides a sketch of the scene. This, in turn, is stored in a computer and a brief narrative description of the accident can be retrieved as required.

Programs that actively seek to modify the system in order to prevent or mitigate the seriousness of accidents have been conducted by police, highway, and motor vehicle departments, and other agencies. Except in limited areas, it is impossible to document the effectiveness of any of these efforts. Furthermore, even these agencies have not made full use of the available resources they command. Cooperative programs are rare and few efforts have been made to determine accident rates in terms of drivers, vehicles, accident locale, or environmental conditions.

Perhaps the most surprising results of efforts to determine how accident data are used are: (1) the limited extent to which accident data are generally used, considering the time and manpower consumed in obtaining the information, and (2) the even more limited scope of action programs to reduce the frequency and severity of accidents.

CURRENT ACCIDENT RECORDS

Origin of Accident Reports

Motor vehicle traffic accident records originate from one—or sometimes from both—of two sources. One of these is the involved drivers, the other is a police officer. Both sources have limitations and restrictions. Most states require that drivers involved in accidents complete a report on a prescribed form when the accident meets certain criteria in terms of injury or property damage. Similarly, the police are required to report accidents that meet specific criteria, not necessarily the same as those applied for reporting by the individual. The police report form usually differs from that supplied to the individual, and the forms used by police in different jurisdictions within a state generally differ as well.

It is perhaps ironic that in most states all citizens are expected to report accidents on a uniform report form, whereas it is a rare state indeed in which all police agencies provide data on a uniform report form. This, despite the fact that it generally is conceded that the police report is less biased than that completed by involved drivers.

The involved individuals presumably have the best opportunity to know the events prior to and during the accident. However, the driver report must be viewed with suspicion for several reasons, including the following:

1. An accident is a sudden and unexpected occurrence. Most of the involved individuals are not prepared or trained to accurately describe the sequence of events leading to the actual accident, especially when observations are made under an emotional strain.
2. Involved persons tend to present a biased view of the happenings. This bias may or may not be deliberate.
3. Involved drivers generally are not familiar with the type of data required or how to report an accident.

Police reports should be less biased, although, as previously mentioned, bias may be present even in a police report. To understand other limitations of the police report, it is necessary to realize that accident reporting is normally only one of many police duties: care of the injured and restoration of traffic flow receive attention prior to securing accident data; the police report often consists of descriptions provided by drivers and witnesses; the police are more likely to be trained in accident reporting than in scientific accident investigation—if trained at all; if a report form is used, reported information usually is limited to those items listed; if a report form is not used, the investigating officer often reports only apparent—and possibly superficial—information.

Disposition of Accident Reports

In most states, accident reports are received and maintained by a state agency that usually is selected by legislative decree. The agencies most commonly assigned the responsibility for accident records are the department of motor vehicles, the state police, or the state highway department.

Despite legal requirements, the data received by the state usually are far from complete. All states require an accident report from the driver of each vehicle involved in a reportable accident. In addition, certain accidents are investigated by a police unit and, if the investigating police unit is at the state level, a copy of that report is automatically sent to the agency that receives the driver reports. Local police units generally are required to submit accident reports, but compliance often is poor because no report form is completed or a form different than the state form is used. In many states, large cities merely provide a periodic summary of accidents rather than the individual reports. These summaries are not always compatible with the method of reporting used by the states. In brief, records available are not complete and the bulk of the reporting is done by the least qualified and most biased individuals—the involved drivers.

Superficially, it would appear to make little difference which of the three state agencies mentioned receives the accident data, because all are concerned with the problem of highway accidents (although this is not the major function of any of the three). In practice, departmental needs and interests dictate the priorities assigned to various tasks, in terms of the total work load borne by the department.

As a consequence, accident records have rated a relatively low priority until recent years.

Because the responsibility for accident records resides in a single agency, and because that agency usually is responsible for only one element in the system, such as the vehicle or the highway, the accident data recorded often reflect agency interest. This tends to minimize the usefulness of the data to other agencies with different requirements, and has led to considerable redundancy because the other interested departments obtained copies of the completed report forms and even coded much of the same information. Further confusion occurs because some state agencies place more reliance on the police report than on the driver report and, consequently, secure copies of only the police report for their use.

The agency which receives both the police and driver reports matches these reports to provide complete coverage of the accident event. When this agency is also responsible for the processing and coding of the accident records, it proceeds directly to this task. However, in many instances data are processed and coded by a different government agency than the one that first receives them. Often, prior to forwarding the records for processing, the first agency will process and code certain data which are required for its own activities. For example, if the responsibility for the collection of accident records resides in the motor vehicle department, which is also responsible for driver licensing, an automated record of specific items concerning drivers of accident vehicles may be maintained. This driver information file generally represents a partial duplication of the file maintained for the complete accident record.

During this process, other groups may also code all or part of the accident record. For example, the state police may record certain items from the accident records (generally using only the state police reports and not the driver's report) in order to maintain a current summary of accident information for purposes of selective enforcement (scheduling personnel requirements, shifts, and patrol areas). The reason given for this duplication is that response to requests for information is slow and the data are obsolete by the time they are obtained.

Until the creation of the U.S. Department of Transportation, there was no federal agency responsible for accident records. The National Safety Council attempted to fill this gap by summarizing annual accident experience as reported by the states. Thus, when coding was completed, initial state efforts attempted to satisfy the criteria of the National Safety Council, with respect to a summary of accidents in terms of accident type, general highway type, and pertinent data concerning driver, time of day, day of week, etc. These criteria generally were met by the routine summaries described in other sections of this report.

Data Contained on Current Accident Report Forms

A review of the accident report forms currently in use in various states was undertaken. For this task, accident report forms used by all but 8 of the 50 states were available in the (Cornell) Automotive Crash Injury Research (ACIR) files. As part of an ongoing program at the research agency, a file of state police report forms and state accident summaries is maintained and updated periodically. This file was brought up-to-date in February-March 1967; at that time, 42 of the 50 states provided copies of their current state police report forms. The eight states from which current report forms were not available were excluded from this review. These were: Colorado, Hawaii, Illinois, New Hampshire, North Carolina, Rhode Island, Tennessee, and West Virginia.

Accident forms for the 42 states were examined and the information appearing on each was tabulated (Table A-1). Some of these report forms have since been revised by the reporting states or are currently undergoing revision. Many items appearing under the headings of time and weather, location, roadway, and accident description are used rather uniformly in all states. Even within these headings, however, a number of items apparently have been added by individual states. Moving down the list of subheadings, however, the degree of uniformity among the states tends to decrease and the questions asked apparently are chosen by the individual states for specific purposes of their own.

The greatest uniformity was found among items under the headings of date, day of week, and time of accident. Light and weather conditions were also requested almost unanimously by reporting states. In respect to accident location, the town and county in which the accident occurred were requested by nearly all states, as were the road or route number, and whether the accident occurred at an intersection. If the accident occurred in a rural area, most states requested either the distance to the nearest town, or the mileage from the nearest intersection. Seven states asked if an engineering study of the accident location was necessary.

Some roadway data were requested in every state. The surface condition (wet or dry), the character of the roadway (level, etc.), and traffic control information were required in virtually all states. Information on items such as obstructions to view, road condition in terms of defects, highway type, railroads, bridges, etc., was requested less frequently.

Considerable uniformity with respect to accident description was also found. A written description and a diagram were requested in all states. The severity of the accident (property damage, injury, or fatal) was normally obtained by recording the names and addresses of the injured or killed. Pedestrian actions were required in 39 states. Information pertaining to witnesses was requested in 37 states. Items such as overturn, burning, or the distance traveled after impact were requested in only 2 to 5 states.

A total of 23 items pertaining to the vehicle (Table A-1, Subject Vehicle No. 1) appeared on the report forms in the 42 states studied. Except for such items as year, make, type of vehicle, registration, and name and address of vehicle owner, there was little agreement or uniformity with respect to vehicle items requested. Many states requested information concerning such factors as directional analysis, estimated speed, the speed limit, and whether seat belts were installed and used. Few were concerned with vehicle color, whether the vehicle was legally parked, or the names of insurance companies.

Similar observations may be made concerning driver information. Except for name, address, age or birth date, sex, driver's license number, and licensing state, there was little agreement as to the kind of items that appeared here. Information on driving experience was required by 15 states; whether the driver had completed a driver education course was required in 9; driver's race was recorded in 15 states; questions concerning alcohol tests were asked in 9 states; violations were asked in 19 states; and driver license restrictions were required by 17 states.

Occupant and injury information revealed much the same picture. Except for name, address, sex, and age of occupants killed or injured, there was little consistency in the types of questions asked. Thirteen states requested information concerning the race of the occupants, and 9 required information concerning the occupation of involved pedestrians. Information concerning the police investigation followed this pattern as well. The source of report information was asked in 12 states and the arrival time of the police was asked in 13. Badge number, and arrest and charge information were requested by most, but not all, states.

Although there is a considerable lack of uniformity with respect to the items that appear on the forms, a certain pattern emerges upon careful examination of Table A-1. More than 30 items that appear in at least 40 of the 42 states can be identified. In general, these reveal when and where an accident occurred, describe the accident, and provide data concerning the vehicles, the occupants, the injuries in the accident, and the investigating agency. Many of these are items that are routinely summarized for the National Safety Council annual accident reports; it may be surmised that this is one of the reasons for uniformity.

Beyond these central points of agreement, many specific items on the report form appear to have been added almost as an afterthought. Indeed, the types of items requested indicate that these were requested by a specific individual or agency for a specific purpose. As an example, many of the items concerning the roadway that appear on individual state reports very likely were placed on the form at the request of the state highway department. Without attempting to evaluate the need for these items at this point in the study, it is apparent that need was evaluated differently by different states—i.e., only 2 states felt that information concerning the type of median was sufficiently important to appear on the form, but 25 were interested in highway defects, and 24 in type of road surface.

Evaluation of Completed Accident Report Forms

To evaluate the completeness and accuracy of reporting, a sample of 100 accident reports was examined. These sample cases were from one state, as reported on the state form by the investigating state police. The reports were examined in terms of the interpretation of report form questions by the police; i.e., did the investigating officer understand the intent of the question? Photographs of the vehicle and accident scene also had been obtained to serve as a check against certain items reported.

As far as possible, the intent here is to evaluate the report form and not the investigating officer. However, all errors detected are summarized and described. It should be noted that many factual errors could not be detected (e.g., age of driver), although photographs permitted a good check on vehicles and accident scene.

In the 100 cases examined, 227 errors were detected in this study. An additional 41 errors previously had been detected and corrected by the police supervisor who checked these cases. The 227 errors may be summarized as follows: 61 omissions (no response to question), 10 discrepancies, 30 apparent discrepancies, 39 incomplete, 87 misinterpretations.

Errors of omission are fairly obvious, but the reason for these errors is not. The investigator simply did not provide the information required; but whether this indicates an answer of "no," or that he could not obtain the information, or forgot it, is not apparent. Three areas accounted for most of these omissions: the distance to the nearest milepost, first aid given, and whether there were witnesses. It may be presumed that a "no" answer is intended, or that there were no mileposts or witnesses in many cases. This cannot be determined or would require additional work to check.

Actual or apparent discrepancies were found in 40 cases. A discrepancy represented a disagreement in reporting the same information in two places on the form; e.g., Vehicle No. 1 was listed as heading north on the face of the form and west on the accident description. An example of an apparent discrepancy would be reporting a violation as a contributing factor without making an arrest (or vice versa).

Incomplete items simply refer to those items where the investigator began to answer a question but for some reason did not finish his answer.

Misinterpretation of poorly worded questions, or misunderstanding of the question, constituted the largest body of errors. A question concerning whether a driver's license was "regular" or "other" evoked responses about either the type of license (e.g., "chauffeur"), or about license restrictions (e.g., "eyeglasses"), but never both. Vehicle body style and type of vehicle also produced a variety of responses describing number of doors, type of top, truck or car, etc., thereby suggesting a lack of understanding on the part of many officers.

Although it is difficult to measure and describe errors on the diagram and description of the accident, this important part of the report often presented a poor or confusing picture of the accident. The sketch of the scene frequently left much to be desired; the accompanying remarks helped but little in a number of cases. Identification of the vehicles, their paths, objects struck, overturn data, and physical measurements frequently were lacking. In general, it was difficult to get a clear picture of the accident, and even factual items that could have been recorded were missing. It should be noted that photographs at the scene often permitted error detection, and corrections were possible. However, the states do not routinely obtain photographs at the scene.

Lest this description reflect unfairly on the ability of the investigating officer, it should be reiterated that a single police officer frequently must provide first aid for the injured, have them transported to the hospital, call for a tow truck, clear the scene of the accident, direct traffic, and record the data being discussed. There also are great differences between officers in terms of capability, training, motivation, and intelligence. If all these factors are considered, it is not surprising to find that report forms do not always contain the desired detail.

Data Stored for Retrieval

The accident report forms from eight states were selected and compared with the accident report code book of the corresponding state in order to determine which types of data are recorded on the report forms only and which are then stored in the computer record file or on the punched card file (Table A-2).

In Table A-2 it will be noted that in some instances data are listed in the "coded" column although they do not appear in the "form" column. This occurs when information that is not requested explicitly can be derived from another part of the report form. Some examples are: "member of the armed forces," information obtained when the driver is listed by military title and address; "accident class" information obtained from damage and injury listed for vehicles and occupants; "directional analysis" data obtained from sketch or description.

Provision is made for date, day of week, time, light, and weather conditions almost without exception.

Accident location information is not stored in the detail present on the report. In general, county, city or town, and route identification may be coded. To a lesser extent, a more precise location of the accident site is available by a milepost and road section number or distance from nearest town. Often a description of the area development is provided, as well as a population figure.

Roadway factors such as surface condition (wet, dry), character (level, curve), and traffic control are coded for the accident record by the vast majority of the states. Other roadway data (type of surface, visibility limitations, road defects, bridges, railroads, etc.) are coded by comparatively few states.

Accident description data are stored by all ten states in varying degree. All ten states code severity (class) and type of accident; eight states code pedestrian actions. Provisions also are made to record data from the written description or diagram in many of the states.

Vehicle data concerning the age, type of vehicle, and where registered are coded most frequently. Directional analysis information and vehicle defects also were coded in many states.

Only a few items pertaining to drivers involved were coded. Age, sex, licensing state, contributing circumstances (drinking, etc.), and driver's intention were coded most often. Occupant data coded most often included age, sex, seat occupied, and injury data.

Police activity or investigation data (source of report data, time notified, etc.) were recorded rarely. Even arrest and charge information was coded infrequently.

Other items that rarely are coded for computer storage include: distance to nearest town, intersection information, car make, driver intention, driver license data. Many of the items listed are not recorded by the state agency responsible for storage and maintenance of accident records; but they may be stored by other state agencies. Thus, much of the roadway data ignored by the department of motor vehicles when that agency is responsible for accident records may be stored by the highway department. Also, the police may store certain data concerning police activity under similar circumstances. Even if not actually stored, some of the data may be used on a case-by-case basis when copies of the report form are studied.

The net effect is that it becomes difficult to determine how many data are stored and how many are retrieved at a later date. However, there is a definite redundancy in data recorded and a duplication in equipment, personnel and operations when various agencies record only those data pertinent to their own operations.

SUMMARY TABULATIONS AND SPECIAL REPORTS

Routine Accident Data Summaries

Copies of routine accident data summaries are obtained periodically from all states.

A sample of ten of these summaries was selected and reviewed in detail in order to evaluate the information contained thereon. The items listed on these ten reports are given in Table A-3. The ten states follow a somewhat standard presentation of statistics with respect to both format and the items presented. The Florida summary shown in Figure A-1 was arbitrarily selected as being representative of the general form and layout of the ten summaries reviewed.

In the following review, the standard statewide summaries are considered. Many of the states produce similar summaries for jurisdictions within the state, listing only urban accidents, city accidents, or, for counties, using only accidents on county roads.

Initially it can be observed that there is far more agreement between states with respect to data tabulated than was observed for data reported or stored for retrieval. In this section, specific summary categories are described and discussed.

Type of Accident.—As given in Table A-3, all ten states provide a listing of the type of accident. There are only a few variations in the types used: four states use the category "collision with other motor vehicle" without subdividing as to whether the motor vehicle was in traffic or parked; three provide for "collision with animal-drawn vehicle"; one lists "collision with street car"; and one provides for "collision with another vehicle and pedestrian."

For each type of accident all ten states provided a tabulation of: (1) the number of accidents categorized as total, fatal, non-fatal injury, and property damage (California also carries a category of the sum of fatal and injury accidents); (2) the number of persons killed, total number injured, and the total injured in each of three classes of injury severity; (3) comparative totals for the same month last year of all accidents, persons killed, and persons injured (California does not use all accidents and adds fatal accidents and injury accidents). Nine states (New York being the exception) provide similar comparative totals for this year to date and the same period last year with a calculated percentage change cumulative death record. California provides an additional tabulation of the number of drivers for combined fatal and injury and for fatal and injury accident types independently. The New York report gives a cross-tabulation of the type of accident with age, sex, and class (in terms of driver, passenger, pedestrian, or other) for each fatality or injured person.

Rates.—All ten states provide a death rate per 100,000,000 vehicle-miles. Eight list fatal accident rate per 100,000,000 vehicle-miles. Utah gives persons injured per 100,000,000 vehicle-miles and South Carolina tabulates an estimated economic loss in dollars.

Accident Location.—Nine of the ten states provide on the standard summary a tabulation of the number of accidents (same classifications as above) for cities or urban areas by population grouping. The exception, New York, has the data available, but only on summaries for rural populated areas, urban populated areas, and New York City. All ten states list the road system in various refinements ranging from extremely broad classifications such as roadways in urban areas and in villages (under 2,500 population), rural state highways, and other rural roads, to a comparatively narrow classification such as state routes, county routes, town routes, municipal streets, parkways, thruway, other limited, non-traffic, and Interstate highways. Half of the summaries provide space for the listing of accidents on roadways administered by independent agencies (turnpike, parkways, etc.), although this space was used in only two of the reviewed summaries.

Time.—Eight of the ten states provide a tabular listing of the number of accidents of different severity by time of day and day of week.

Victim.—Two state summaries (North Carolina and South Carolina) contain no statistics on the victims of accidents. The other eight states report age, sex, and whether the victim was a pedestrian or bicyclist. New York and California list whether the victim was a driver or passenger in the vehicle.

Directional Analysis.—Seven summaries include a brief description of the accidents in the form of directional analysis. The Florida summary (Fig. A-1) is typical of the data presented—intersection or non-intersection accidents, movement of vehicles, etc. Also, the table of pedestrian actions is typical for these seven states. The other three state summaries (California, North Carolina, South Carolina) do not tabulate traffic movements prior to the accident.

Contributing Circumstances.—Six states list contributing circumstances, which is directed to a driver cause of accident (such as passing stop sign, speeding). New York also tabulates special conditions involved, which includes additional information on driver condition, vehicle defects, road defects, etc. California tabulates driver violation as a separate item.

Driver.—Two states (North Carolina, South Carolina) do not present information on drivers involved in accidents. California tabulates age only. The remaining seven states provide information on age, sex, and residence. New York and Nebraska summarize driver conditions (normal, fatigued, ill, etc.), and Nebraska also lists driver's occupation and whether the driver had taken a driver education course.

Vehicle Type.—Eight states summarize vehicle type in their reports. The listing of Florida is typical. California has the most complete coverage in that trucks and truck combinations are subdivided by number of axles.

Highway.—New York presents the most inclusive summary of highway conditions in that a listing is presented of road conditions (dry, wet, snowy), road character (grade, curve), road location (bridge, railroad, underpass), and traffic control devices (signals, sign). Five of the other states tabulate surface condition only. The remaining four present no information on roadway character or condition.

Kind of Location.—Five states summarize the number of accidents by areas which are built up or not built up.

Light Conditions.—Seven states give a tabulation of how many accidents occurred during the daylight, dawn or dusk, and darkness.

Seat Belts.—Florida and Nebraska summarize whether seat belts were installed and used.

County.—Six states provide a summary of accidents by county of occurrence.

City.—North Carolina lists the number of accidents occurring in each city of the state.

Weather Conditions.—New York lists the number of accidents for various weather conditions (clear, rain, etc.).

Position of Occupants.—Nebraska lists the number of victims in each seated position of the vehicle.

Discussion of Typical Summary Tabulations

A study of routine state summary tabulations reveals that certain information needed for the determination of accident causation is presented in these publications. In general, this information relates to the magnitude of the problem, with some isolation by type of accident, age and sex of driver, age and sex of victim, etc. The value of these data is best demonstrated by an example, such as the tabulation of the number of accidents of various types. The December 1965 Florida summary (Fig. A-1) reveals that there were 12,106 motor vehicle collisions with other motor vehicles in traffic, and that 3,221 of these accidents were at intersections with the two vehicles entering at angles, 536 were at intersections with both vehicles entering from the same direction and going straight, 669 were at intersections with both vehicles entering from the same direction but one turning and the other going straight, etc. The breakdown of accidents by type allows the isolation of broad segments of the accident problem and suggests a measure of the relative importance of each accident type. In the foregoing example, the 3,221 two-vehicle collisions at intersections with the vehicles entering at angles indicates—or rather reinforces previous knowledge of—the need for improvement of traffic control devices and intersection design.

Some summary data are listed in extremely broad classifications and as a consequence are of little use. One of these broad classifications is the "location" heading, where urban accidents are placed according to a population grouping of the urban areas, or where rural accidents are placed according to such broad highway classifications as Interstate routes, controlled-access highways, state routes, county routes, etc.

Another data presentation which is of little value in determining accident causation in its present form contains items such as time of accident, kind of location, type of vehicle, road surface condition, etc. To illustrate the shortcomings of this grouping, consider the listing of the numbers of accidents for day of week and hour of day. First, the general time distribution of accidents is similar from month to month and the presentation represents needless repetition. Second, the accident distribution is similar to, but not the same as, the weekly and hourly traffic volume distribution. However, without knowledge of the traffic volume or a suitable measure of exposure, the number of accidents per time period is of little value. For example, the 133 accidents (Fig. A-1) that occurred between 5 and 6 AM, a period of low traffic volumes, may represent a much higher accident rate (accidents per unit exposure) than the 1,428 accidents between 5 and 6 PM, a period of high traffic volumes. This particular inadequacy of the data reflects the lack of a convenient usable measure that would permit meaningful interpretation.

There is also a need to improve the method of presentation of much of the data listed on the summaries. The increments of age used for casualties, and especially those used for drivers, are excellent examples of how possible errors may be read into the tabulations. The driver's age listing begins with age increments of one year, then changes to a two-year increment, to a five-year increment, and finally to a ten-year increment (ignoring the two extreme age groups). The number of drivers involved in accidents naturally shows large changes in the different age brackets because of the variation of the incremental change. As a result, an inexperienced observer could easily reach an incorrect conclusion from the given table. Equal age increments would allow a proper appraisal without further interpretation by the reader, and reduce the possibility of incorrect conclusions.

It is concluded that the routine state data summaries provide minimal aid in the determination of accident causes. The primary benefits are the identification of problems in terms of total numbers of reported accidents, injuries, and fatalities, and the isolation of broad areas which require specialized study. The limitations of the summaries point out the need for an exposure rate and the difficulty of itemizing the complex causes of accidents.

Special State Reports

A sample of 12 special studies was selected randomly for review. One restriction placed on the selection was an attempt to limit the number from any one state. This restriction was adopted because two states have been much more productive in the publishing of special reports, and thereby would tend to dominate the choices. The reports selected were:

1. *Motor Vehicle Accidents Involving Excessive Speed: December 1962 through November 1963.* New York State Dept. of Motor Vehicles (1964).
2. *913 Compact Car Accidents.* Indiana State Police (1964).
3. *Comparison Between Single-Car and Multiple-Car Accidents.* New York State Dept. of Motor Vehicles (1964).
4. *Comparison of Injuries Sustained by Occupants—Standard Car vs. Small Car.* Traffic Division, Connecticut State Police (July 1963).
5. *The 1964 California Driver Record Study.* Dept. of Motor Vehicles, State of California (Mar. 1965).
6. *Study of Compact Vehicles Registered in New York State 1962.* New York State Dept. of Motor Vehicles (Sept. 1963).
7. *A Re-evaluation of Group Driver Improvement Meetings.* Dept. of Motor Vehicles, State of California (Jan. 1965).
8. *Accident Characteristics of Four Types of Passenger Automobiles.* California Highway Patrol (Apr. 1964).
9. *Causes and Characteristics of Single-Car Accidents: Part Two.* California Highway Patrol (Oct. 1964).
10. *The Small Car in Motor Vehicle Traffic Accidents in Illinois—1962,* State of Illinois, Dept. of Public Works and Buildings (Oct. 1963).
11. *The Motor Vehicle Inspection Program and Its Relationship to Highway Safety in New Jersey.* State of New Jersey, Dept. of Law and Public Safety (Sept. 1963).
12. *The Roles of Carbon Monoxide, Alcohol and Drugs in Fatal Single-Car Accidents.* California Highway Patrol (Nov. 1965).

Special reports are prepared in response to a variety of needs—to answer a particular question or problem, to justify a special program or public service, to indicate a problem area, etc. The individual study concentrates within a somewhat narrow field of investigation in an effort to provide a solution to a specific problem. Although some of the special studies have their limitations, this type of research undoubtedly has considerable value.

Sources of Data

Many special studies use data acquired from the regular accident report form. The general procedure in these studies is to compare the effect of the subject factor against the effect produced by the entire population, a sample population without the factor, or a sample population with the opposite factor, etc. (i.e., the age grouping of drivers having accidents may be compared with the age grouping of all drivers or of accident-free drivers; the accident records of drivers under the influence of alcohol may be compared with the accident records of drivers not under the influence of alcohol; the accident severity associated with small cars may be compared with the severity observed in large cars, etc.)

Other special studies, requiring the collection of specific data for utilization in the study, may involve anything from a special question on the regular accident form to complete and elaborate observations. Examples are: a specialized compact-car accident investigation form used by the Indiana State Police for a study of compact-car accidents; the collection of data for the California study on carbon monoxide, alcohol, and drugs involved testing of blood samples, medical opinions, criminal histories of decedents, and other data not usually collected.

Regardless of the source of data, the quality of data varies drastically from report to report—even within a particular state. Certain studies have employed adequate and statistically accepted methods of experimental design, whereas others appear to use a haphazard collection of those facts which may relate to the subject at hand.

Presentation of Data and Findings

All 12 reports present the original and processed data in tabular form. Seven reports also used a graphic representation to emphasize the points of interest. The general approach to data presentation is sufficient to inform the reader of the information involved. However, the accuracy and details of presentation are often poor and in need of improvement. Examples of these deficiencies are:

1. Poor choice of labels for selection titles, tables, and graphs. For example, one report used "accident severity" for a heading while the accompanying discussion and chart (also labeled "accident severity") dealt entirely with injury severity categories.

2. Poor choice of increments in constructing frequency diagrams. By definition a frequency distribution is composed of frequencies for a given constant unit. For example, a chart illustrating the distribution of the number of licensed drivers by age should use a constant increment of age and not variable increments of age. Figure 1 shows the different visual interpretation evident from observation of a graph based on unequal age increments and one based on equal age increments. The same comments apply to a tabular listing of frequencies.

3. Lack of definition of terms employed. Occasionally, the reader of a report must assume that his interpretation of a term is the same as the author's definition. For example, one report contains the term "excessive speed" in the title and in various places within the report without definition. However, "excessive speed" means different things to different people, and the report reader needs the author's definition in order to properly understand the report's full meaning.

These comments appear to be minor in content, but the reader of a report containing discrepancies, errors, or a lack of information tends to distrust the entire report and thus to minimize the results regardless of their value. The reports generally reflect a need for adequate interpretation and review to avoid misleading the less informed reader.

Statistical Analyses

There are tremendous differences in the amount of statistical analysis undertaken or attempted in the 12 reports reviewed. One report is basically a tabulation of data with superficial remarks (which is all that the authors intended). The other extreme is represented by a report which used standard statistical tests for the significance of observed variations and provided a brief appendix explanation of the procedure.

The quality of the statistical analyses is as diverse as the quantity (there is definitely not a relationship between quality and quantity in the subject reports). Some of the reports indicate that the writers had a good knowledge of the limitations of their data, knew the pitfalls to be avoided, and in general drew their conclusions with caution. Other reports reveal the use of poor comparisons, emphasize small random variations, appear to use correlation coefficients in a mechanical manner, and in general give the impression of little knowledge of proper use of statistical methods.

Results

The results of the special studies generally reflect the workmanship involved in the data collection and analysis. Therefore, a report is generally either good, mediocre or poor in its entirety—that is, if the researcher was capable

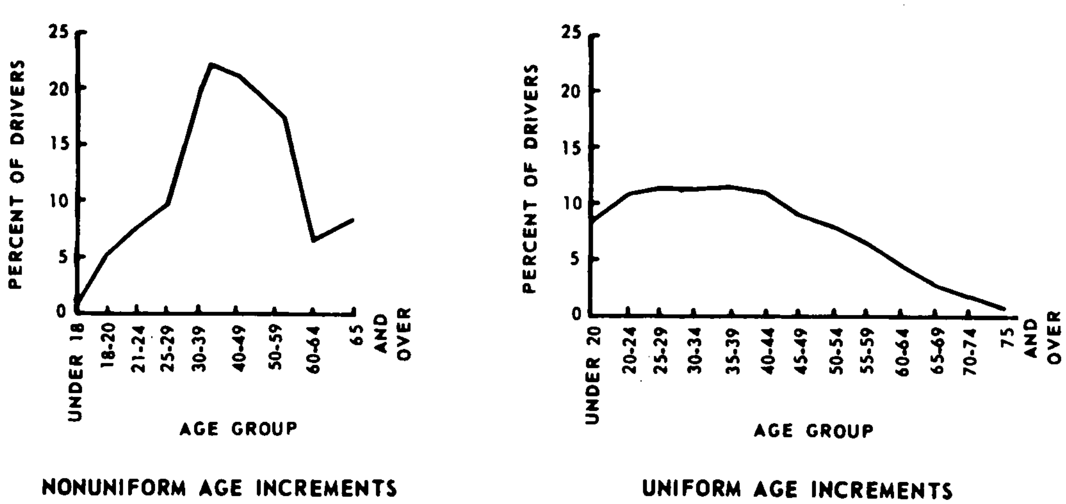

Figure 1. Effect of poor choice of increments in constructing frequency distribution graphs.

of selecting the proper data and if he knew how to analyze these data, he also knew how to interpret the findings.

Occasionally, writers allow personal convictions or opinions to supersede the findings of their study. In such cases, the report usually reflects this fact with a high degree of certainty.

Summary

The special studies are a very useful tool in determining the causes of accidents. Nevertheless, they must be considered in the proper perspective; namely, they are limited in scope and are directed toward finding or disproving a specific relationship. A good report will reveal the limitations of the study and present clear concise results.

There are dangers in some of the reports reviewed. These contain errors in analysis, reveal poor judgment in the interpretation of findings, and produce misleading results. This is not to suggest that special reports should be abandoned, but rather indicates the need for careful research and emphasizes the need for caution in the use of the results. The special study can be one of the most useful research tools when properly designed and conducted.

RECENT ACCIDENT RECORDS PROJECTS

National Safety Council

The National Safety Council Traffic Accident Data Project has adopted a "bi-level concept" of accident reporting (*29*). The basic level of reporting consists of those items necessary to place the accident (temporal or spatial), identify drivers and vehicles, briefly describe the event and its consequences, and list police activity. These data would identify the problem, indicate solutions, and measure the results.

The second level of reporting would provide greater detail and provide statistical samples of data on any desired specific factor of highway, vehicle, or driver. The supplemental report is of the variable content form, and the specific data sought could be varied to meet requirements.

The Traffic Accident Data Project also urges: (1) more extensive use of magnetic storage devices, with the goal of storing all information produced by the accident form; (2) improved means of locating the accident scene; and (3) a better description of the sequence of events (less emphasis on one particular event) prior to the accident.

Pennsylvania Study

The Commonwealth of Pennsylvania has made a number of revisions in its accident record system during the past few years, as follows:

1. The police accident report form has been simplified and stresses the use of narrative reporting of accident investigations.
2. Efforts have been made to induce all police units in Pennsylvania to use this standardized form in reporting motor vehicle accidents and to provide a copy to the state agency responsible for accident data.
3. The police records are matched with the reports received from the drivers involved.
4. Accuracy in the location of accidents is emphasized during processing.
5. The cases are analyzed to determine a maximum of three basic causal factors in the particular accident event.
6. The description of the accident event is stored in the computer in simple narrative form.

During the past few months Pennsylvania has also undertaken the use of specially trained teams to investigate certain accidents which occur throughout the state. This program is supported by Pennsylvania and the National Highway Safety Bureau. The teams consist of a highway engineer and a Pennsylvania state highway patrolman, and may include mechanics and physicians. These teams were given a two-week course of training by representatives of the research agency. The objective of the team approach is to study accident causation factors in detail in order to obtain data that will aid in reducing the frequency and severity of accidents.

Surveys and Research Corporation

The subject of a 1966 Surveys and Research Corporation report (*30*) advocating the creation of a national highway records center can best be expressed in the following words from that study:

> This report provides the basis for establishing and operating a national Highway Accident Records Center (HARC). As the authors see it, the operations of HARC will result in a fund of comprehensive accident data that has not been available before. With such improved accident facts in hand, the lack of fundamental information will be rectified, accident situations of importance can be better identified, and specific action to prevent accidents can be taken.

Minnesota Records System

This is a joint Minnesota-Automotive Safety Foundation study which recommends a state central records system for accident, driver, and vehicle data. The report (*10*) contains estimated cost figures, benefits obtained, uses, etc., of the proposed system.

It also indicates a need for dual-level accident reporting and recommends: (1) better locating of accident scenes on the highway; (2) the use of plastic vehicle registration cards (similar to their present driver license cards) with card imprinters for police use; and (3) better training of accident investigators, police reporting of a larger percentage of accidents, and a change to a requirement that all property damage accidents of $100 or more be immediately reported to police.

National Highway Safety Bureau

The National Highway Safety Bureau is one of three agencies reporting to the Federal Highway Administration in the recently created U.S. Department of Transportation. In turn, NHSB consists of three groups: the Motor Vehicle Safety Performance Service, the Highway Safety Programs Service, and the National Traffic Safety Institute.

The area of operation of the Motor Vehicle Safety Performance Service centers on standards for motor vehicles. It is concerned with the complete accident picture: avoidance, injury reduction, and post-crash factors. Thus, although the area of occupant protection may be most familiar to the public, the service is also concerned with, as examples, vehicle-driver interactions, crashworthiness, and post-crash fire prevention.

The Highway Safety Programs Service is concerned with standards for state highway safety programs. The Highway Safety Act requires that each state have a highway safety program which meets the uniform standards of the office of the Secretary of Transportation. Several standards are germane to accident-related information systems and provide state and local governments with guidelines for traffic records, motor vehicle registration and inspection, driver education and licensing, identification of accident locations, etc.

The third agency, the National Highway Safety Institute, is responsible for the research and development activities of the two services, and contains within its framework three working units. The National Traffic Safety Data Center is responsible for all safety data and its analysis, and computer systems with their transmission links. The National Traffic Safety Documentation Center is responsible for safety documentation, such as training films. The National Traffic Safety Research Center is responsible for research, evaluation, and development activity in the Bureau. It will operate regional facilities at several locations. Currently all research is performed by existent non-government research groups, with the exception of the National Bureau of Standards. As this report is written, the National Highway Safety Bureau has two studies in progress that involve the accident investigation process and accident records.

ACCIDENT LOCATION

The ability to locate the site of an accident as precisely as possible—many states would like to be within 0.01 mile—is considered of major importance by both highway engineers and police. The requirements of the engineers are more stringent because their task is to determine if a relationship exists between the accident and the highway at, or near, the accident site. For selective enforcement purposes, the police do not require such precision because patrol areas cover larger distances.

Because both the highway engineer and the police administrator are interested in accident location—the highway engineer for design and reconstruction and the police for law enforcement—both require much the same information, and the location system should be compatible for both users. Ideally, there should be complete compatibility and a cooperative working arrangement between appropriate police and highway engineer personnel. The objective of both is identical in studying a high-frequency accident location—to make it safer for the motorist. Only the method is different; the police use selective enforcement procedures, the highway department uses a spot improvement program.

A survey of state officials throughout the U.S. was conducted to obtain pertinent information concerning location criteria, data processing, and accident analysis procedures. The results are summarized in Table B-4. Appendix B contains the detailed report on accident location and this section summarizes that report.

Review of Accident Location Methods

Basically, three types of accident location methods now are being used or are under serious development. They are:

1. A route number-accumulated mileage system.
2. The node-link system.
3. The coordinate system.*

Of the three methods under consideration, the route number-accumulated mileage system has been employed most frequently by the various states. Some definite advantages of this system include comparative simplicity of use, direct coding of the location in the field, a comparatively short period of training for proper use, and compatibility with the existing road inventory records. Conversely, the route-mileage system has some disadvantages in that it is not adaptable to complex highway configurations (interchanges and channelized intersections, etc.), is difficult to use in urban areas, requires a change in logic of concept or a change in reference markers when modifications are made to the highway network, and may require an addition or subtraction procedure by the investigator, which increases the possibility of an error.

The coordinate system (not in use at the present time, but in the testing stages) also has certain advantages and disadvantages. Among the advantages are: presents no need for field reference markers; permits direct coding of locations in the field; can be expanded to cover all streets and highways; and does allow for ease in computer acceptability. Some of the disadvantages of the coordinate system are: if coded in the field, each patrolman must be supplied with maps of the entire area which he covers; the map scale is normally small and therefore requires fine reading for close location of accidents; the user must have some experience in reading maps; modifications to the highway network require new maps; and the map-reading process permits additional errors to enter into the data.

The node-link concept has the advantages of being simple to use by the man in the field; can be used in rural and urban areas; can be adapted to complex highway configuration; can be expanded to all streets and highways; the simplicity of use suggests a potential for fewer field errors; and changes in the highway system can be handled by the placement of another node. To be effective, the node-link system must have field reference markers. Computer programs have been developed for node-link network systems and the methods and procedures could be borrowed for use by the highway data accident record system.

In summary, any method chosen for the location of a large number of accidents should meet certain requirements, such as (a) be simple to use; (b) be economical in the cost of this use; (c) provide location data within the

* A fourth method, using the Public Land Survey grid as reference locations for intersections, is being tried in one state.

required precision; and (d) provide for compatibility of accident data with highway data.

In reviewing the various accident location methods, no specific recommendation is made with respect to the three methods discussed. It is perhaps apparent that the node-link system is regarded as most flexible in a changing system. However, the route number-accumulated mileage system has been more extensively developed and is compatible with a variety of uses other than accident location. It obviously would not be reasonable to change such a system for the sake of change. The method used should fit the conditions and requirements of the individual state.

Factors Involved in Accident Location

There are several problems involved in locating an accident which require additional consideration and emphasis. One of these is to determine what part—or parts—of the accident event is to be located. For example, a ran-off-roadway accident may initiate on a curve, with the vehicle running off the paved surface on the subsequent tangent and striking a roadside pole still farther along the roadway. The question then is which location or locations to place in the records system.

There also is a need for a built-in quality control check allowing confirmation of the accident location during processing. In the current operating systems many location errors occur; the process of correcting them is time consuming and difficult.

As a matter of economics and convenience, the highway data should be coded and stored using the same location system as that used for accidents, because the two sets of data will often be used together. The matching of the accident to the highway will become even more important once the engineer begins to use a predictive method of analysis with the intention of determining the relationship between geometric features, traffic operation conditions, and sites of high accident frequency.

SUMMARY OF STATE-OF-THE-ART REVIEW

It is stated elsewhere in this report that "the purpose of the accident records system is to provide statistically adequate, accurate and useful information upon which an effective control program can be based."

Based on the review of literature, the investigation of organizations concerned with motor vehicle accidents, discussion with those responsible for various segments of the system, and observations of the results obtained by the system, the only possible conclusion is that the present accident record system does not fulfill its intended function; in brief, the system fails to produce significant results. Accident records do not provide an accurate measure of the problem; data use for accident prevention is minimal; and there are major inadequacies in virtually every area of the system, including the reporting, processing, analysis, and interpretation of the data, and the use of the findings.

Inadequacies exist for a number of reasons:

1. Highway accidents represent a complex, multi-dimensional problem with numerous interrelationships between factors, most of which are poorly understood.
2. The accident report forms currently used are oriented to operational and regulatory functions and as such are not responsive to research requirements.
3. Accident reporting is incomplete at best, and the bulk of the reporting is done by the least qualified and most biased individuals—the involved drivers.
4. Many states do not have an adequate means of locating the site of an accident—an item considered by many engineers and police as the most important single bit of data obtainable.
5. Published routine summaries are of little value to programs to reduce accidents. Hence, efforts to use them for this purpose are rare.
6. Accident record systems seek to correct existing hazards. For optimal benefits, the accident records system also must be designed to provide predictive information so that the frequency and cost of accidents become a part of future operational and planning procedures.
7. Various agencies are responsible for the operation of various parts of the system. This separation of responsibilities promotes a lack of cooperation, inefficient use of data, duplication of effort, unwarranted delay, and poor acceptance of results.
8. There is a general apathy, and in some instances a strong negative attitude, not only on the part of the public but also on the part of many who are concerned with corrective action. Some engineers refuse to accept the fact that a geometric design may be inferior, even after a series of fatal accidents; some courts of law and some police are lenient with proven hazardous driving practices; legislators hesitate to appropriate adequate funds to correct the situation.

CHAPTER THREE

IMPROVED METHODS FOR REDUCING TRAFFIC ACCIDENTS

The problem of highway accidents is a multi-dimensional one involving a system comprised of man, machine and environment and all of the complex interrelationships that are possible between these variables. It is clear that there can be no single solution and, indeed, suggested improvements have been numerous, but generally have been confined to specific subject areas such as report forms, accident investigation, specific data needs, data use, and modifications in system operations.

Suggestions for improvement generally may be described as representing a piecemeal approach wherein system components are improved individually to correct what are regarded as weaknesses in the system. Unfortunately, in many instances neither the requirements nor the capabilities of the total system are considered. It does little good, for example, to improve report forms and to mandate that all police use the forms if only a small proportion of all officers are trained to use them properly. One may argue that it would be desirable for all police officers to be well trained in accident investigation, but there are many reasons why this argument is specious. One is that the primary function of the police is not accident investigation and the inroads into time that could be spent in other areas already is considered intolerable by many police officials. A second is that it is not economically feasible to attain such a training level in view of the more pressing problems facing society. Even if possible, it is neither desirable nor necessary to obtain details on all of the estimated 13,600,000 accidents that occur annually—and the 24,300,000 drivers (*1*) involved in these accidents. The majority of the accidents are minor and the costs incurred in obtaining data, delaying traffic flow, and clogging the record system with useless paper probably would be greater than the damage losses involved.

It will be recalled that the functional types of agency needing accident data previously were listed as: law enforcement (police and courts), education, public information, legislative, driver licensing, engineering (highway and vehicle design), vehicle inspection, and financial responsibility. To this list should be added the automotive and insurance industries and the medical profession. All three are responsible for major areas of the problem.

In this chapter, the broad outlines of an improved accident record system for the reduction of traffic accidents are provided. This concept represents a long-range objective and no attempt is made to define the system in detail; that was beyond the scope of the present effort. Demonstrations of various parts of the system in operation are described in later chapters. Specific short-term improvements that can be made now, and that would facilitate transition to the longer-term program, also are suggested.

LONG-TERM IMPROVEMENTS

Basic to any program concerned with improving the use of accident records for accident reduction is a closely coordinated, cooperative program that utilizes the skills and capabilities of responsible state and local agencies. At the state level, three agencies have primary responsibility for accident reduction—the state police, the highway department and the motor vehicle department. In many respects, the data requirements of the first two agencies are similar: both need accident location, driver violations, type of accident, weather conditions, and other data pertinent to an action-oriented program. The motor vehicle department can provide much-needed driver and vehicle data.

Economic considerations necessarily impose restrictions on the operations of all government agencies. With respect to personnel in the highway department, for example, this means that available funds provide for a limited number of trained professional personnel who must be allocated to the various design, traffic, maintenance, and other operations as judiciously as possible. Methods of enhancing their capability or operations should be sought actively. Therefore, a close operating relationship, particularly between the police and highway engineers, is regarded as essential if accident reduction programs are to achieve maximum success.

The police are at the accident scene, they collect the data, and they patrol the highway day after day. Their experience complements that of the highway engineer, who must design, maintain, and when necessary improve the highway facility, using available accident data. It is ludicrous that at high-frequency accident locations the police and the highway engineer work independently to solve the same problem through spot improvement and selective enforcement programs. A collaborative effort is clearly called for in this, and a number of areas, involving signing, traffic, and other mutual problems.

If one accepts the fact that highway accidents represent a multi-dimensional problem—and this appears to be widely accepted—then a multi-level approach that is responsive to current requirements, and sufficiently flexible to respond to future requirements, is needed.

Multi-Level Concept (MLC) of Accident Investigation

The functional agencies listed earlier require data of varying sophistication, ranging from simple frequency tabulations to detailed information obtained only through a comprehensive coverage of a single accident event. The task of meeting all of these requirements suggests a need for variable reporting in terms of quantity and quality of investigation. A variable data collection approach using a sampling procedure and three levels of investigative effort based on data requirements is recommended. The recommended three levels of investigation are:

1. Basic reporting of all accidents.
2. Limited investigation of a sample of accidents.
3. Intensive investigation of a limited number of accidents.

Basic Reporting

The basic report is designed to provide the information necessary to determine frequencies and rates. Basic data would include time and date, location, individuals involved, vehicles involved, pertinent ambient factors, injury or property damage, and a brief description of the event. The basic form would serve those administrative and operational needs requiring a measure of the total problem or general classifications of accident types, participants, locations, etc. Used in conjunction with driver, vehicle, and highway records (stored in automated files) studies could be undertaken to isolate specific drivers, vehicles, and highway locations subject to a higher than normal frequency of accident events.

The basic accident form prepared by the police would inevitably contain more data than that required for use in the state accident record system. The routine operations of the police require information concerning the disposition of damaged property and accident victims, law enforcement action, accident details for use in legal proceedings (civil or criminal), etc. Although these data are needed for local operations, it is not necessary to code or process them for use in the accident record system.

The basic form would be completed by all police units in a state for all accidents above a minimum predetermined severity. (The level of severity is an appropriate subject for a research project.) Improved compliance with compulsory reporting regulations could be obtained through a state law requiring a state police permit for automobile repairs (Utah has such a requirement) or possibly a state form to be filled out at the repair shop prior to commencement of work (this would allow for verification of cost of vehicle repair). In case the vehicle is destroyed, notification of the event could be made through the vehicle registration system.

Limited Investigation of a Sample of Accidents

Special topic investigations would be conducted on a statistically controlled sample to overcome the statistical limitation of the intensive investigations. Technicians would be specially trained and, where necessary, equipped to collect the pertinent factual data from the specified sample of accidents. Data collection would be concluded when sufficient data were available. The data to be collected would pertain to particular subject matter as desired and would be useful for confirming or rejecting hypotheses formulated by the professional teams and by state agencies. The procedures and equipment used by the technical investigators would be determined by the professional team personnel.

The technical report could be prepared by the police, if desirable, or by technicians trained or hired for the particular task. The sample size and approximate study duration would be determined through proper statistical design of the experiment.

Use of the technician report would provide an economical means of collecting data, would free professional investigators for research functions, and would provide statistically reliable results.

Intensive Investigation

Multi-disciplinary teams would undertake intensive investigation of a limited sample of accident events in order to accomplish several objectives, as follows:

1. Determine those factors that contribute to accidents.
2. Develop new techniques and investigative procedures and aid in data analysis.
3. Obtain sufficient information to establish hypotheses and direction for a larger-scale investigation effort employing technicians.

The intensive investigations should be conducted by a team of professionals from different disciplines—highway engineers, vehicle engineers, psychologists, medical doctors, etc.—so that a broad and diversified approach to the problem would be possible. Limitations to the extensive use of the teams are the lack of professionally qualified investigators and the high cost per investigation (a minimum of at least $1,000 per case), which would limit the sample size.

Benefits of Proposed Investigation System

The recommended reporting scheme should overcome many of the deficiencies in the present system. Among the benefits that should accrue from this approach, the following deserve particular attention:

1. *Data quantity.* The requirement that a basic form be completed prior to repair would assure minimum data loss and would provide gross frequency data for determining magnitude and cost of the accident and injury problem. The simplified form should reduce the over-all work load of the police, although a portion of their effort would be diverted to the technician level.

The quantity of data on the entire range of causal factors that result in accidents provided by in-depth investigations and augmented by technician programs would provide sufficient data for statistical studies. Emphasis would be placed on statistically adequate samples for use in many phases of the system.

2. *Data quality.* By drastically reducing the amount of data reported on every accident and providing a built-in check system (vehicle identification number and make and year of manufacture), more accurate information can be obtained. Also, the emphasis on factual data would eliminate much of the bias now present in reports. Use of appropriate professional personnel for the in-depth studies should assure accuracy and completeness of data. In some disciplines it should be possible to draw upon existing state personnel. Emphasis on factual data in the technician studies and the use of the multidisciplinary team for correlation and control purposes also should insure good data.

Non-Accident Data

Non-accident data from state agencies should be in automated storage available for use. The data files should include: files containing pertinent information concerning each licensed driver, each vehicle registered in the state, including its inspection record, a file on the highway system containing information on geometric elements, traffic volumes, types of construction, etc. Statistical studies of drivers, vehicles, highway, and other exposure variables (such as odometer readings, driver mileages) would permit the design of scientifically controlled experiments that are not feasible today. The non-accident data also could be used for many purposes other than accident studies. Considerable care would have to be exerted in the design of this phase of the system to insure protection of the individual against misuse of personal information. Some of the non-accident data could be available to the police at the scene of the accident for law enforcement reasons—i.e., checking the validity of a driver's license, checking ownership of a vehicle, etc. File data conceivably could be useful in other phases of law enforcement as well. Adequate communication between the police in the field and the record files therefore would be of utmost importance.

Political and Technical Organization

Insuring complete coordination of the activities of the various agencies cooperating in the system is essential. As noted earlier, examination of this subject at the state level indicated that there was duplication of effort in data processing and the maintenance of accident record files. It was evident that even in states where several state agencies claimed to have cooperative programs, there was little agreement concerning the nature and degree of cooperation.

The magnitude and complexity of the accident problem indicates the need for a collaborative effort to insure an efficient program. A study of the structural organization of the state government may be needed in many states to establish such a venture. Although the design of the necessary state structure is beyond the scope of this program, two obvious approaches could be used, as follows:

1. Establishment of one agency responsible for the entire highway system, vehicle registration, driver licensing, and policing of the highway system—in effect, a Department of Transportation similar to that of the Federal Government and some states. This approach is logical because many of the problems of the present system derive from the decentralized and often overlapping functions of different state agencies. A central research organization could be established to handle the data.

2. Establishment of a commission representing appropriate departments and reporting directly to the chief executive. The responsibility and authority for directing the data collection center which would collect and maintain data files for the various participating departments would reside with the commission. The commission would establish study priorities and objectives and generally operate in a fashion similar to a central department.

No recommendation can be made concerning the desirability of either approach because of the many variations in state government organizations.

Success of the system also would depend on many specific technical improvements. Several of the more important are:

1. The exclusive or high-priority use of central data processing equipment for the data records system. At present, computers assigned to individual state departments are used heavily for routine projects such as accounting and other departmental tasks, thereby drastically restricting the use of the computer for research purposes.

2. Creation of an integrated data system. Traffic accident information must be collected with information on road characteristics, traffic volumes, vehicles, and drivers. Therefore, accident report data must be stored with identification of location and participants, either vehicles or individuals. Once this has been accomplished—and this is perfectly feasible with modern computer technology—it is possible to pool data from a large number of accidents having similarities and thus obtain sufficient data for meaningful statistical analysis.*

3. Use of qualified personnel. Analysis and interpretation of a volume of data as large as that in the accident records system represents a major statistical problem. Only recently, however, have statistical personnel been brought into the system in some states.

4. Constant review of the procedures employed, equipment used, and technique involved should be provided. Rapid changes in technology require that new developments be appraised constantly.

5. Cost of the proposed system is an important factor. Many of the necessary data files are available now and primary emphasis would involve creating a compatible record system. In states that are now revising their systems, data compatibility can be planned at minimum cost.

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* The possibilities of this approach are exemplified in *NCHRP Report 47(41)*. In an entirely computerized research program the highway networks of several states were described on the computer tape as consecutive segments of equal length, the record for each segment carrying information on gradient, curvature, structures, intersections, traffic volume, and nature of traffic on that segment. Into the highway data were merged data on the number and nature of accidents on the same segments, the accidents being located by milepost information in the same way as the segments were identified.

The procedure made it possible to assemble large numbers of segments of any given type (e.g., straight segments without any disturbing features as contrasted to segments with some curvature and intersections in them) and to calculate volume-based accident rates for each type of segment for comparison. The findings of the report show that the method is very powerful in identifying road features which interfere with traffic and contribute to traffic accidents, and in ranking those features in terms of increase in accident rates.

The data system outlined could be used in other ways as well. Use of mass data from the recent past makes it possible to calculate for any portion of the road the number of accidents that should be expected to happen during any given period of time, taking into account the traffic volume and specific characteristics of that portion. The actual accident experience then can be compared with that expected, and if statistically significant deviations from expectation are found, it becomes possible to geographically identify highway portions either favorable or dangerous in terms of the number of accidents. From there, the highway engineer can determine the nature of the problem and take the necessary corrective actions. Ultimately such a system could be used as a predictive model for design purposes, as well.

Uses of Accident Records

Purpose of Present System

It is appropriate in the beginning of this discussion to establish the scope and purpose of the present system. Primary concern is accident records at the state level, and this discussion is limited to state uses of the records. In a sense, the criteria developed at the state level in the past have influenced or controlled the development of records systems at all levels. The most vivid illustration of this is the accident report form. To some extent, the model forms developed by the states are used at the local level by accident investigators. At the same time, it should be realized that the development of a model and uniform report form for use at the state level need not limit the amount of data collected by the towns, cities, or counties. It would be more fruitful to consider the state criteria as minimum criteria, which could and should be exceeded by local authorities. This, in fact, now exists to some degree. The local police agency, for example, needs to keep records about the garages to which accident vehicles are removed. This information actually appears on some state forms and certainly is completely useless at this level.

It is suggested that the accident records system be regarded as a state mechanism, develop the criteria so that state-level programs are adequately served, and at the same time clearly encourage the local agencies to collect other data for their own needs.

In this context, the following is suggested as a generalized statement of purpose for a state-level accident records system:

> The purpose of the accident records system is to provide statistically adequate, accurate, and useful information upon which an effective control program can be based.

One other point should be emphasized here. In the past much energy has been devoted to the fatal accident, and as a result the rural aspects of the safety problem have been emphasized. Economic losses due to accidents are to a large extent an urban problem, and should be recognized as such in the development of accident records systems.

Uses of the Proposed Accident Information System

Given the multi-level structure for an accident information or records system, Table 1 gives a summary of the proposed uses for the information generated at each level of investigation. Each of these proposed uses is described in brief in the following.

The first use of the routine police investigation would be to provide necessary frequency and operational data. Such a program would ensure that the records system provides complete and accurate information. This aspect of the records system should be emphasized as much as possible, because current accident reporting is incomplete at best. Evaluation of both the quality and the quantity of the records obtained should be a routine procedure, and should form the basis for corrective actions on weak points in any area of the reporting system.

Second, most selective enforcement programs have been aimed at keying police enforcement activities to locations known to have high accident frequencies. Although some recent studies have indicated that all these programs are not effective, they nevertheless remain a part of many national programs and will undoubtedly continue for some time in the future. Modifying these programs so that they are keyed to driving situations rather than location might be worth some thought.

The third use of the basic police investigations would be the identification of locations with high accident frequency. This subject has been given much consideration

TABLE 1

PROPOSED STRUCTURE OF STATE ACCIDENT INFORMATION SYSTEM

SOURCE OF INFORMATION	SCOPE OF OPERATIONS	USES
A. Basic reporting—routine police investigations	Minimum data, maximum number of cases	1. Frequency data 2. Selective enforcement program 3. Identification of high-frequency locations 4. Identification of high-frequency drivers 5. Identification of high-frequency vehicles 6. Formulation of some highway design and operating policies
B. Limited investigations of a sample of accidents by special police or technicians	Broad-scale investigations on specific variables for a valid sample	1. Refinement of motor vehicle inspection procedures 2. Evaluation of causal hypotheses resulting from level C investigations 3. Evaluation of physical driver characteristics 4. Relation of highway design and operating elements to accident production
C. Intensive investigations by professional personnel	Very intensive investigations, limited number of cases	1. Improvement of investigative techniques 2. Hypothesis of causal relationships 3. Establishment of research needs

in recent months, and nearly all states are now involved in planning or operating such programs. Basic to the success of these programs is location of the accident expressed in terms which are readily understandable at the state level and amenable to computer language. As the number of accident cases which are reported increases, so will the reliability of this program. In theory, only the location is required in order to identify the high-frequency spots on the highway system. However, the ability to classify the accidents in some uniform and consistent manner will make the analysis of corrective actions an easier task.

The fourth proposed use of the data would be the identification of drivers with high accident frequency. This is also a subject which has had considerable attention in past years, and there is some continuing controversy concerning the relative benefits that might accrue from such a program. There can be little doubt, however, that there are a number of drivers who have had abnormal accident and violation frequencies and that their identification and elimination from the highway is a useful program. The key to this program is a tie between the accident file and the driver licensing and violation file. The ability to accomplish the identification via high-speed computers makes the program easy to accomplish on a regular periodic basis. Here again, the greater the number of accidents reported, the more efficient the program.

The identification of vehicles with high accident frequency is related to the state's motor vehicle inspection program. The identification of specific vehicle manufacturers, models, or body types can be a first step in uncovering vehicle defects. Compatibility and coordination of vehicle identification information from the accident file and the motor vehicle registration file are required.

Combining the accident locations from the accident records file with a computer file of road inventory data will allow formulation of some highway design and operating policies. It should be realized, however, that the full range of questions involving highway design and operation cannot be answered from these data sources.

The refinement of motor vehicle inspection procedures should be a high-priority program. It seems reasonable to expect that the data on which this program can be based could come from the second level of investigations to be performed by police investigators or technicians. The collection of a wide range of data for accident-involved vehicles should provide the keys to improved inspection procedures.

Under the proposed multi-level data scheme, professional-level investigators would hypothesize causal relationships and design statistical procedures to evaluate these hypotheses using the second-level investigations.

The data from the second-level investigations should be designed to describe the physical characteristics of the accident-involved drivers. Evaluation of these data would be related to the driver licensing function.

Very detailed environmental descriptions will allow a more sophisticated analysis of highway design and operating characteristics. This approach will carry the work several steps further than is possible using records sources.

Finally, professional-level work, conducted on a very limited number of cases and involving very intensive investigations, would be used primarily to improve investigative techniques and to hypothesize causal relationships. Obviously, these personnel would also play an important role in the development and maintenance of the other two sources of accident information. Establishment of general research needs would be another important function of this group.

It should be emphasized that other research approaches must be tried in order to combat the accident problem. Obviously, there is a need for laboratory research in all three areas (human, environmental, and vehicle factors). The more difficult the problem may be, the more likely that special research conducted by universities and other agencies will be required.

Application in a National Program

Development of the type of accident records system described would provide a simple means of obtaining uniform basic accident frequency data on a national scale. It also would be a relatively simple task to coordinate research programs conducted by several states when research needs warranted a large-scale program. In this context, an approach that has considerable merit is the concentration of a large and sustained research effort in a few states.

Strategically located states would be chosen in order to obtain data that include the variety of geographical and climatic conditions encountered throughout the United States. These states could serve as a "laboratory" for highway safety research. It would be difficult for a state to justify such a program; but as part of a federal program, it is probable that state participation could be obtained.

A program of this type could, and should, include all of the elements of the state program outlined earlier. Although this would not eliminate the need for state program improvement, certain types of studies that currently are conducted at a minimal level, or not done at all, could be accomplished. These might include studies of vehicle design or injury studies that are not done by individual states.

SHORT-TERM IMPROVEMENTS

It will take time to organize, staff, and place in operation a system of the type described and, as always, there are problems pressing for immediate solution. Although the present system has limitations and deficiencies, a number of improvements can be made to increase its utility in order to reduce the present accident toll and to avoid repetition of earlier mistakes. Recommendations are listed in the following.

Cooperative Programs

Voluntary cooperation between the various state agencies responsible for the operation and regulation of the highway system should be initiated. The highway department and the state police force are the key organizations, because they are responsible for the operation, maintenance, and surveillance of the system. The research agency has conducted collaborative efforts with state police units in 31 states on a sampling basis over a period of 15 years. Cooperation and data produced have almost invariably been good.

In terms of driver and vehicle regulation, the police require the cooperation of the appropriate departments for the efficient conduct of their work. Conversely, the police can assist the highway department in terms of traffic control devices and other fixed roadway furniture. Because of their constant patrol activities, interested police officers often can detect deficiencies in the roadway system. The highway engineer could make use of this knowledge.

Accident location is a factor of major interest to both police and engineers, because the one must modify patrol schedules and the other must redesign or improve facilities. Joint studies by police and highway engineers—from both engineering and enforcement aspects—could be beneficial in producing consistent measures.

Because of mutual interests, both agencies would benefit from the establishment of a realistic and precise method of locating the site of an accident. An established system would enable the police to pinpoint the accident scene and allow the engineers to maintain a highway inventory on the same location scheme. Both agencies could use the reported locations as required in their work without duplication in many areas.

Another type of cooperation is demonstrated in later sections of this study; i.e., the collection of specialized data by the police. With proper instructions and equipment, data on specific factors on all components of the system can be obtained for study. See "Analysis of Sample Data Collected," in Chapter Four, for the demonstration subtasks of the present study.

Accident Report Forms

Based on the examination of accident report forms in Chapter Two, and the interest displayed in new methods of reporting, some change in the forms would be welcomed by most users. When revised, the accident reporting procedure should be simplified. It literally is impossible for the police to provide all the information that is desired by various users. A thorough re-evaluation of the specific uses for each data item, the costs of obtaining it, and the benefits derived therefrom is warranted.

A brief accident report form based on the Michigan State Police form is shown in Figure D-7, together with the standard form, shown in Figure D-8. The revised form is not to be construed as a final effort, but rather as a starting point for a dialogue on report form data. The form shown is one of several attempts to develop an acceptable, brief report form. It will be noted that the information required for police use at the local level and licensing use at the state level is retained. Environmental details have been deleted, as well as road type and driver intent data. (The latter can be obtained from the sketch if clearly drawn and described.)

Undoubtedly many will suggest retaining certain deleted items and others will suggest further deletions. The evaluation of report forms should be conducted by the individual states to insure appropriate data.

Modern technology also could be employed to simplify and accelerate the task of the investigating officer at the scene of an accident. Driver license and vehicle registration data could be impressed on the type of plastic or metal plates which are in common use for identification cards (mentioned previously in the Minnesota-Automotive Safety Foundation study). This information could then be imprinted (in duplicate if desired) on an accident form or summons using a simple device that requires a single motion of the hand, and records without error. Symbols to facilitate translation to magnetic tape for computer use also could be imprinted. Other simple devices that could aid the investigating officer might also be developed.

Personnel

The success of the accident record system is going to depend on the personnel—the investigators, data processors, analysts, and writers—who are responsible for the component parts of a system. Initial steps to improve the present system also rely on having responsible and knowledgeable people in the proper positions to oversee the collection, processing, analysis, and final preparation of the conclusions. Therefore, the following should be inaugurated:

1. A group of accident investigators should be trained for an in-depth and thorough investigation of accidents. These personnel would form a nucleus of experts whose task would be to determine the causes of accidents.
2. Personnel should be hired who know the procedures for proper coding and checking of data prior to placement into the computer file.
3. There is a tendency to emphasize the collection of data and the routine reports instead of exploring the data for possible trends and relationships. Competent statisticians with knowledge of the over-all problem should be employed. These positions will be difficult to fill because a knowledge of the highway system and the problems involved is required in addition to statistical training. Few people have knowledge in both areas.
4. Writers should be employed who can effectively present the findings and conclusions of studies to the people who can take corrective action. Many research findings that could aid in reducing the magnitude of the problem are not used because the individuals responsible for action either do not know the findings or do not understand the conclusions.

Utilization of Present Knowledge

There is a need for better utilization of known safety concepts in the design and construction of roadway facilities. Present design policies and warrants are often lacking—or are extremely slow in incorporating—safety factors which are known and published. For example, one may point to the hidden exits and entrances being built into many new expressways; the incongruously low speeds at exits from high-speed facilities; improved guardrails which are only beginning to be incorporated into new designs; the slow acceptance of breakaway supports for lights and signs, etc.

To overcome delays in the use of known facts, a safety review board is recommended. The function of the board would be to review all plans for highway construction and reconstruction in terms of safety considerations. The board members should be given the time and the opportunity to review current research and interpret the findings for use. The group's primary function would be to insure that safety knowledge is incorporated into design within justifiable economic costs.

EDUCATION

There is a need for additional training in highway safety for the personnel involved in the design and operations of the highway system. One course of action would be to place more emphasis on safety aspects in the college curriculum in highway transportation. However, the engineers in charge of design and operations are practicing engineers, far removed from the normal college curriculum. Therefore, a more practical and immediate solution would be through a continuing education program directed to highway engineers. Through a series of seminars stressing current safety knowledge in design and operations, engineers could be kept informed of the latest developments in the safety field. Continuing education for all individuals having responsibility for the design, operation, or maintenance of any public road system—state, county, town, or urban—is essential because of the numerous advancements in this field. The nature of the continuing education for each group would be variable and would require a series of seminars directed toward the specific problems encountered in each area. At the present time, the opportunity to review and evaluate current advances in this engineering field is greatest at the federal level and among researchers and decreases as one approaches the local operating level.

Another education concern is to obtain uniform training and experience across state lines. The economic abilities of states vary and quite naturally certain states have fewer economic resources for the continued training of highway engineers. A nationwide organization sponsoring the continuing education program could solve this type of problem.

Design or operational manuals should be stressed as guides and not as absolute authorities on specific problems. There is a tendency to accept the manual provisions as absolute requirements without due consideration of the existing conditions. There is also a tendency to interpret cautionary statements in a manual as if they were rules rather than advice.

CHAPTER FOUR

PROPOSED SYSTEM IMPROVEMENTS

A key factor in attempting to improve the accident records system is the investigation of accidents. The police traditionally have performed this function for a number of reasons: they are on duty on the highways at all hours of the day; they have an operational communications system; they are needed at the accident scene in their role of law enforcement officers to maintain order, protect life, and to determine if a violation of the law produced the accident. It is the last function that perhaps creates the greatest problem in the police investigation of accidents.

At best, accident investigation is a retrospective process that requires a minimum of personal involvement or bias on the part of the investigator. This becomes virtually impossible when the investigator is responsible for the arrest of those violating the law. Because the officer's duty is to produce a legal case for the courts, only an exceptional individual can conduct a completely unbiased investigation. In fact, it appears in many cases that accident investigation ceases when a violation is uncovered.

An accident records system can be no better than the source data that are recorded at the accident scene. Dependent on the type of data required, the data volume, and the purpose for which they will be used, a re-evaluation of data collection is necessary to determine the type of personnel required to collect accident data, and the procedures to be used.

Examination of current accident report forms, coding, and data recording procedures has indicated a number of shortcomings. It is clear that there is a need to reduce the amount of opinion or judgment data and to concentrate on factual data. New methods and, for certain studies, special equipment may be helpful in data collection. Some of these are discussed in other chapters of this report. However, if the data are to be used to reduce accidents, the entire question of who should investigate accidents needs evaluation. A basic problem in data collection procedures is that analytical and interpretive judgments are required of the police because there is no analytical staff to do this task, or because it is believed that the officer at the scene is in a better position to make such judgments. Often the officer is not trained to make the required judgment. In this chapter, the use of a multi-disciplinary team to investigate accidents is explored.

INTENSIVE ACCIDENT INVESTIGATION

The concept of using professionally trained accident investigators is one that has been long accepted in civil aviation and this work has initiated many of the advances in the safety of air transportation. In automotive safety few studies of road accidents have been done by full-time accident investigators. The term "professional" investigator is avoided, for some of the workers on these studies were not professionally qualified in any discipline. This does not condemn their efforts in advance, for professional training is of little use unless, allied with intimate knowledge of the field to be studied, it leads to an understanding of the nature of the problem. Indeed, the most obvious shortcomings of some of these studies have resulted from failure to appreciate this point.

At the present time, no one can accurately predict the variables that should be studied in all traffic accidents. It is probable that an attempt to list all such variables would be defeated by both the size of the task and the difficulty in defining independent variables. With very few exceptions it is not possible to select an independent variable and study its role in accident causation without being able to control, or at least accurately describe, all other variables with which it may interact, or which may affect the significance of the role of the chosen variable.

This situation is not new. Despite the fact that the larger part of scientific research is concerned with the investigation of variables or factors that can be effectively isolated from their environment, there is much that of necessity deals with just an amorphous body of information as is available in a road traffic accident. Haddon (*6*), in discussing this aspect, quotes the classical example of Darwin's observations in the field: ". . . the essence being the open-ended observation and description of phenomena to discover variables which deductively seem to be of importance. Without continuing research of this type there can often be no assurance that variables more formally investigated have been realistically or wisely chosen."

Despite such precedents, work on accidents tends, as Bronfenbrenner (*31*) says, "to count and not . . . to describe." Almost any police accident report form can be taken as an example of this. The format and content of these forms, and particularly the periodic summaries compiled from them, are biased far more toward "counting" than description. There are obvious reasons for this—by selecting a limited number of variables the report can be condensed to a check list, which greatly reduces the compilation time required. A check list also ensures that certain information is collected on all accidents. This is a worthwhile approach if, as suggested earlier, the selected variables are significant, independent, and cover a defined range of the field of inquiry.

A major value of teams of full-time accident investigators should be in the ability to develop hypotheses and to determine the variables to be collected during the more routine accident reports. Another important task should be the ability to improve studies of specific accident sites—for spot improvement or selective enforcement purposes—through bringing greater technical competence to bear on the problem. Therefore, in order to test this hypothesis, investigations of accidents in the area surrounding the research agency were undertaken by agency personnel. The objectives of these investigations were to determine: (1) whether more intensive investigation of accidents is feasible for the state; and (2) what benefits might be derived in terms of improved data.

Organization and Procedures

The area of study included three towns in the Buffalo, N. Y. area—Amherst, Cheektowaga, and Clarence. Within these towns are included rural and suburban areas and highways ranging from undivided two-lane roads to modern expressways. Police in these towns agreed to permit CAL personnel to investigate accidents that occurred within their jurisdiction. The cooperation of service station and tow truck operators in the three towns was also solicited. Because it was not necessary to obtain a random sample of accidents to achieve the goals stated, accidents occurring between the hours of 8 AM and 9 PM were investigated. The composition of the study team varied, but generally consisted of mechanical or civil engineers, technicians, and interviewers, although many agency staff members with a variety of backgrounds and training participated. Investigation techniques varied from simply completing one of several state accident and report forms to a thorough investigation of the accident scene and vehicles involved, including photographs and interviews with drivers and witnesses.

Also of interest is the normal police reporting variation between the three towns selected: one used the standard New York State accident report form; one used a form devised by the town police, although patterned on the state form; and the remaining town police merely recorded an entry on the police blotter.

Police dispatchers in the participating towns alerted agency staff by telephone. A radio monitoring system also was established to pick up police calls concerning accidents when the dispatch system posed problems. When an accident occurred, a specially equipped vehicle bearing two or three investigators was dispatched to the scene. Basically, three major tasks were undertaken by these investigators: drivers and witnesses were interviewed; the vehicles and accident scene were photographed; and vehicle, highway, and other pertinent data, including measurements and location of vehicles, debris, etc., were recorded.

Efforts were made to determine the possible causes or contributing factors in each accident by reconstruction of the circumstances and a post-investigation critique. Comparison of the various techniques and approaches employed demonstrated the minimum levels of effort that would be acceptable to achieve specific goals.

Data Collected

The initial investigations utilized the police accident report forms from the states of New York and Michigan. Experience soon indicated that several questions either were not answered or were incompletely answered by the agency personnel using these forms. The primary reason was that none of the alternatives available on the form adequately described certain specific aspects of the situation. As an example, the categories of "road character" in the New York State form are: (1) straight and level, (2) straight and grade, (3) straight at hillcrest, (4) curve and level, (5) curve with grade, (6) curve at hillcrest.

One local accident investigated by an agency team was located on a straight road, although a curve which ended less than 100 ft away was a factor in the event. Neither category (1) nor (4) completely describes this location and so, to avoid probable misinterpretation, a written location was used. This is not an isolated example and this type of problem is not confined to accident report forms. Any attempt to represent a large and poorly defined body of data on a short check list, which in turn is designed for subsequent storage on punch cards or magnetic tape, is bound to encounter such difficulties.

Then a further problem arises. Not only is it obviously impossible to describe completely all types of road traffic accidents by means of a short check list, but even the data recorded may be ambiguous or misleading to an analyst who is acquainted only with the record and never sees or examines the highway, driver, or vehicle.

There are other cases where the categories listed on the report forms are inadequate and require a special notation or the data are lost. For example, one accident covered by the investigating team involved a woman who lost control of her car while accelerating and turning left at a snow-covered intersection. This woman was short, but not in the lower fifth percentile. Her dissatisfaction with the locations of controls in her automobile was shown by large blocks of wood strapped to both the brake and accelerator pedals, and a thick cushion set against the back of the driver's seat. It is doubtful whether a check space for "blocks of wood strapped to foot controls" would be often used, and even less frequent that it would be related to the accident. It could be suggested that such contingencies could be allowed for with a space to "note any unusual features."

Much information relating to the vehicle can be recorded only by direct measurement; in every case a quantitative measurement is preferred to a qualitative assessment wherever possible (e.g., when recording the depth of tread on a tire). Once again, the description is unlikely to be adequately performed using only a check list.

The description of the environment, including the road layout and traffic control systems, if any, is similarly complex. Effective data collection must depend on the judgment of the investigator at the scene as to what is likely to be needed. The functioning, design, and reasons behind the installation of a traffic control device need to be known and understood before the investigator can feel confident that the role of the device in the accident has been determined. Instances of all of these arose in the accidents covered in this study. In one case, a speed-control traffic light was identified as a significant factor in a rear-end collision. In this case the light was poorly adjusted, and its actual effect on the flow of traffic was either misunderstood or simply not considered. To add to this unfortunate state of affairs, the authority responsible for the light had no record of when or why it was installed.

It is becoming accepted that accident causation, to use a customary but ill-defined word, extends beyond the actions of the operators involved. As an example, an intersection traffic light control should ensure that traffic traveling at the legal speed, and probably also at some higher speed, should be able to either stop prior to the intersection or continue across under the protection of a red light controlling traffic on the intersecting road. This may require both an extended amber phase and an all-red phase at some locations. Yet, in a case covered by the investigating team, where this should have been true, only a short amber phase separated the two traffic streams and a collision resulted. One driver was charged with failing to stop, despite the fact that it was probably physically impossible for him to do so. In this case responsibility, if it must be assigned, would more justly have been directed toward the engineer in charge of the light setting. But a witch hunt to seek out the person at fault is scarcely likely to produce an intelligent understanding of the nature of the problem. If, for example, this light had been set according to recommended standard practice, who is responsible? Despite this, the New York State police accident report form, though severely limited in the data it can list, has space for 24 possible contributing circumstances, with the instruction to "check one box for each vehicle." Twenty-two of these categories relate to the actions of the participant or the condition of the vehicle. One allows for "animal on highway" and the final one is marked "other." If "other" were to be interpreted in the sense of "not determined," it would be encouraging, but this may be asking too much of a police officer who may be called on to justify his opinion, enlightened though it may be.

As a result of the limitations of the accident form, the intensive investigation units gradually changed to a semi-structured approach. Certain data were collected routinely, but the investigators were free to pursue in depth any item that appeared to be a possible cause of the event. For example, if an investigator determined that a driver ran a STOP sign, he would be expected to determine whether visibility was poor, whether the driver was distracted or preoccupied, had poor eyesight, etc.

The routine information collected by intensive investigations may include the following:

1. Introductory data. Location, time of day, day of week, names of investigators, severity of accident.
2. Atmospheric conditions. Light (day, night, dusk, dawn), cloud cover, precipitation, humidity, wind.
3. Scene description. Direction of travel, roadway furniture struck, road surface material, condition of road surface (dry, wet, icy, slick, worn, traffic-polished, etc.), state of repair (chuckholes, ruts, etc.), foreign material on pavement, coefficient of friction, highway lighting, glare, sign and sign data (type, visibility, clarity, etc.)
4. Highway data. Configuration (intersection type, driveway, etc.), curvature, gradient, number of lanes, width, roadway markings and signs, median (width, type or depth), curb (type, height, condition), speed limit, permanent view obstructions, marginal development, crown or

superelevation, obstacle alongside of road, accesses to roadway.

5. On-site accident data. Point of impact, final resting places of involved vehicles, skid marks and tire scuffs, debris, liquids, gouges, location of ejected bodies, pre-impact travel angles, collision and departure angles, description of traffic flow and density, sketch of scene.

6. Vehicle. Description (year, make, body style, color, etc.), license number, inspection data, vehicle identification number, windows and their condition, tires and condition, lights, lubrication data, odometer readings, transmission type and location of selector, brake type and condition, steering type and condition, instrument panel (padded? damaged? bent knobs? etc.), power items (windows, seats, etc.), restraint systems and their use, driving accessories (speed control device, automatic headlight dimmers, air conditioning, etc.), unusual controls (hand-operated brakes, blocks fastened on foot controls, etc.), engine (number of cylinders, horsepower, displacement), power options or modifications, engine accessories (emission control), safety features (such as dual master cylinders, late model windshields, collapsible steering column, etc.), damage to vehicle (location of initial contact, point of maximum penetration, depth of maximum penetration, damaged items of chassis, frame damage, suspension damage, roof buckling), towing service name, taken where?

7. Driver. Vehicle identity, driving experience (years and mileage), driver education (type, completed?), defensive driving course, familiarity with vehicle (time and mileage), restraint system used?, occupation, corrective lenses, color blindness, height, weight, age, sex, marital status, identification and address, trip plan (origin, destination, estimated time of arrival), trip purpose, familiarity with route and areas, injuries, description of accident (approach, during and after impact), lane used, traffic conditions, number of hands on wheel, speed before impact (how determined?), speed at impact, time of impact, first awareness of danger, decisions and actions (if any), left or right foot braking, view obstructions, distractions, point of impact (on road and vehicle), final resting position, assumptions (other car going to stop, signal changing, etc.), in control of vehicle?, meaning of signs or control devices, preferred lane of travel, safe following distances, was accident preventable or avoidable, action if re-occurrence, action of other drivers, activities prior to trip, state of mind, immediate condition (alcohol, drugs, fatigue), smoking?, eating or other activity while driving?, vehicle appraisal (condition, where serviced, when), luggage or cargo, doors opened on impact?, other vehicles owned or driven, appraisal of highway and highway maintenance, opinion of speed limit, previous accidents (how many? where? when? similar type?).

8. Other occupants. Identification, address, description of accident, description of driver's actions, age, sex, weight, height, restraint system, injuries.

The foregoing data are collected on all accidents where and when applicable. Additional data on special conditions can be collected as deemed advisable. For example, if brake failure is suspected, the brake system should be thoroughly examined, or if a driver appears to react abnormally, additional information on his health, medication, emotional background, etc., should be obtained. Extensions of data collection into these areas are the responsibility of the investigators, as are deletions of non-essential data from the listing given.

The semi-structured approach encouraged for use by professional investigators is difficult because the investigators at the scene are permitted rather wide latitude in the selection of topics to be explored in depth. Thus, experience, training, and motivation become critical factors. It may be inferred that the intensive investigation of accidents cannot be assumed by the police along with their many other responsibilities at the accident scene. The State of Pennsylvania has undertaken the intensive investigation of accidents. The research agency's experience was used in training the Pennsylvania teams, which each consist of a highway engineer and a state policeman. The teams also have access to the services of government-employed mechanics when needed, and collection of medical data also has been recommended.

Findings

As part of the evaluation of intensive accident investigation, only 50 events were investigated. This number is too small to obtain more than an indication of possible trends within the data. Because it was necessary to organize the investigation team and develop procedures, the quality of the cases varied considerably as improvements were made. One of the later cases is presented under "A Typical Intensive Accident Investigation Report" in Appendix C. Research findings were not the primary objective in this study. However, some of the data are summarized in the following because they are of interest and because, in many cases, the intensive investigation uncovered facts or causal relationships not normally revealed in the police report:

1. On a 40-mph four-lane urban street, a single traffic signal continually flashes amber until activated by a detector on the exit from a school parking lot. When activated, the flashing amber changes to a solid amber for 4 sec and then to red. An accident investigated at this location involved a car on the main street traveling at 40 mph. The driver did not notice the change from flashing to solid amber and therefore failed to stop. The school bus that triggered the light also did not stop prior to entering the roadway.

The police issued a traffic violation ticket to the driver of the passenger car for running a red light. Further investigation indicated that the school bus drivers have learned that by approaching the signal at a slow speed, they do not have to stop prior to entering the main street. It appeared to the investigators that the operation of the traffic signal constituted a "booby trap," that the single signal was inadequate, and that the school bus driver failed to take proper "defensive driving" measures.

2. A red-green speed-control signal located on a two-lane major urban street remains red until the switch is activated by an approaching vehicle; then, after a variable period of time (seconds), the signal changes to green. Many local drivers have learned that for any speed near the speed limit

the signal will change to green before they reach its location. Drivers unfamiliar with the area tend to obey the initial red phase.

An accident investigated at this location involved a driver unfamiliar with the road, who was some 600 ft behind a lead vehicle and being followed closely by a small truck. The signal changed to green for the lead vehicle, the driver who was unfamiliar with the road started through the street section and the light changed back to red. Attempting to respond, the driver applied his brakes—and the light changed back to green. The driver of the small truck was familiar with the signal, knew that it would change to green in adequate time, and did not expect the vehicle in front of him to stop (he was a relatively inexperienced driver).

The police issued a ticket for following too closely—an undeniable conclusion. However, considerable investigation failed to reveal when or why the signal was placed here, where the activators were (approximate locations were determined by experimentation), or how the device was to be set for proper use. Although the area has a speed limit of 35 mph, it was—and still is—possible to drive through the area at speeds up to 60 mph and have the light change to green before reaching it. The investigators concluded that the signal is unnecessary.

3. A rear-end collision occurred when a female driver's sandal caught on the brake pedal of her passenger car. The woman was distracted by this and was actually looking down at her feet when her vehicle struck the car ahead of her. She was unaccustomed to the vehicle which she had borrowed.

4. A rear-end collision occurred at a construction site, where a vehicle failed to stop and struck the car ahead. The striking car had a deficient braking system and gravel spilled on the pavement allowed additional skidding.

5. An accident occurred at a right-angle intersection where a STOP sign had been rotated 90° and therefore was not visible.

Some of the re-occurring patterns observed in the 50 cases were:

1. Vehicles turning left from parking lots onto four-lane roads in front of a vehicle turning right in the curb lane, or in front of a polite driver who signaled the vehicle to exit, being struck by an oncoming vehicle in the center lane.

2. On four-lane streets, vehicles turning left in front of opposing left-turn traffic and being struck by through traffic in the curb lane.

3. A high proportion of inexperienced drivers, in terms of age and limited annual mileage.

Conclusions and Discussion

The findings are suggestive of the nature of the problem, but because of the small volume are to be interpreted with caution. It is concluded that:

1. The intensive investigation of accidents is feasible for state agencies.

2. This type of investigation reveals accident variables contributing to the accident that often are overlooked, or are not a part of the routine police report.

A major disadvantage is the high cost per accident investigation—a minimum of at least $1,000 per case. It is recommended that a limited number of investigation teams be organized for the purpose of exposing new accident causal factors, and for developing new techniques, procedures, and equipment.

These investigations also produced some information that can be of value in current accident investigations and in the sampling procedure recommended earlier. Providing the police or the highway engineers with the proper equipment and training in its use enhances their capability. Cameras, tape recorders, and simple measuring devices all are extremely useful tools; but the camera, if used properly, is perhaps the most valuable of all.

The police officer may be able to gather much more useful and reliable information if he is equipped with a camera. The techniques required to ensure reasonable photographic coverage of an accident scene are easily taught. In nighttime accidents it should generally be possible to photograph the approaches to the scene on the following day. Much of the data presently recorded on the report form could be left as a photographic record until such time as they are required for a specific purpose. When this need arises the analyst can decide whether or not the variables he is concerned with are present, and the responsibility for accuracy in recording becomes largely his.

The camera is, of course, invaluable for the full-time accident investigator. Unlike the aircraft accident, a road traffic accident is unceremoniously dealt with. The vehicles and any debris are cleared from the roadway as rapidly as possible to permit the resumption of a normal flow of traffic (which ironically is often "normal" in the sense that another accident will occur at the same location, albeit some time in the future). Speed is therefore an essential quality of any recording system, and in this regard the camera is unsurpassed.

There are also other less obvious advantages. First among these is that the camera is not selective; it will record any object in its field of view. The human observer would find it very difficult, even when not hurried, to make such a comprehensive record. The camera can therefore compensate to some degree for poorly developed powers of observation on the part of the investigator. There is a great difference between seeing and reasoning from what is seen, even to the limited degree necessary to make a written or verbal record. This does not mean that a skilled observer will not make better use of a camera, for the selection of the field of view is still his. But the need to study the scene, or a vehicle, to get an informative photograph will often result in the collection of additional information which would not otherwise have been noticed. Furthermore, a skilled photographer can accentuate chosen objects of the field of view, although this is frequently done at the expense of reduced clarity for other objects and should therefore be confined to close-up shots.

But even a well thought out and presented set of photographs cannot contain all the information that may relate to a traffic accident. For example, most of the data relating to the participants are beyond the reach of the camera. Medical factors, such as intoxication, can be accurately assessed only by well-defined tests and criteria. Similarly, psychological factors demand an investigator who is an adroit interviewer and also well versed in the applications and limitations of intelligence and personality tests. Even the basic record of each participant's version of the accident can be obtained accurately only by careful questioning.

ANALYSIS OF SAMPLE DATA COLLECTED

Data Collection and Report Forms

One of the basic tasks proposed in this program was to develop and test a sampling approach using a "variable-content" accident form directed toward revealing accident causes. Testing, as originally conceived, was to be performed by a state police unit using the form in accident reporting. The original intention was to propose a "variable-content form" consisting of some six to ten specialized forms in a pad. Part of each form was to be standard and would provide the general data as to location, driver information, vehicle information, etc. The remainder of the form would be directed toward obtaining sample information on some particular, predetermined accident causation factor.

In meeting with various state police organizations to seek their cooperation in this task, several restrictions became apparent which altered the collection period. All of the police units contacted were willing to cooperate on the project, but only on a short-term and a limited basis. There were several reasons for the reluctance to initiate an extensive program at this time: several states had recently revised their forms and desired to minimize any additions or change at present; there was some apprehension at that time that the Federal Safety Bill of 1966 might require drastic changes in accident reports and therefore a "wait-and-see" attitude was adopted; finally, all states have a manpower problem and desire to minimize any additional work imposed on their police.

To obtain the necessary data, the scope of data collection for new types of forms was defined as follows:

1. Collection would be accomplished in six months or less with a stipulated minimum number of reports.
2. The data collected for the project would be in addition to the regular police report.
3. The "variable-content form" would be used in area sampling; i.e., troopers in different districts would use a different form.

Under these conditions, the states of Virginia, Indiana, Ohio, and Utah agreed to supply certain information for use in the project.

To secure useful data in sufficient quantity for at least preliminary analysis, data for only one study topic were examined for all accidents in a study area. One form was developed to provide data on tires; a second, to provide driver data; a third, to provide data on the trajectory of vehicles that ran off the roadway; a fourth, to provide data on the collapsible steering columns introduced in 1967 models. The data from these four forms were believed to be sufficient to indicate whether police reporting is adequate to determine accident causation and effects when limited to specific items. All studies except vehicle trajectory are reported in Appendix C.

Data Report Forms

The specialized form for tires is designed to record the maximum information that the trooper investigating an accident could be expected to obtain. The tire form used in Virginia is shown in Figure D-3. The tire data requested include the manufacturer, the trade name, the number of ply used in construction, the size, and a check whether a studded, snow, and/or recap tire. These items are factual information either read from the side of the tire or determined by observation of the tire. A simple measurement with a tire tread depth gauge will provide the minimum tread depth in 32nds of an inch, and an observation of the tread is sufficient to determine whether or not there is uneven wear. Air pressure is obtained by a tire pressure gauge; if the tire is flat, a word or two is sufficient to state why. The question of number of passengers is directed toward the problem of whether or not the vehicle was overloaded. Although axle load would be preferred, data of this type can not be expected from police. The vehicle is identified by year, make, and model, allowing a check of actual tire size versus recommended size. The odometer reading is recorded as a check on vehicle exposure.

The tire form used in Virginia includes some accident data. The details of the accident (description and diagram of the accident, weather, road surface, road condition) are listed because Virginia law does not allow the state accident record to be used by outside agencies. Therefore, these data were obtained on the study project's own form. The data on vehicle license and identification number were used for identification purposes. The vehicle inspection number and month were used in conjunction with the records of vehicle in operation to obtain exposure data, further explained below.

The Virginia form for driver data is shown in Figure D-2. The basic accident data and the inspection data were obtained only in the State of Virginia. The purposes of the driver data are to investigate driver experience, driver acquaintance with his vehicle and the roadway, and the purpose of the accident trip. The need for this type of data was indicated by data from the intensive accident investigation phase of the study project, which suggested that a sizeable percentage of accidents involved drivers who were relatively unfamiliar with their vehicles.

The third form (Fig. D-1) was used in a study of the path of vehicles in ran-off-roadway accidents. The data at the top of the sheet are similar to that on the other two forms. This form was used in Utah and on the Ohio Turnpike. Estimated speed has been added because of its relative importance in vehicle trajectories. The circular form was developed to simplify the patrolman's work in locating specific points of interest. The form was used with a device referred to as a vector graph. Essentially, this was a special clipboard equipped with a plastic arrow. The plastic arrow can rotate around the center of the circle on a pivot joint. By following an accompanying set of instructions, the trooper aims the arrow at the object to be located, marks the direction, and later measures the distance—i.e., the angle and distance method of locating points used in many surveying techniques.

The fourth form (Fig. D-4) was used in Virginia to study damage to the collapsible steering columns that were introduced in some 1967 models. Various measurements were taken. A device consisting of two 1-meter sticks attached together in such a way that one could slide along the other (Fig. D-4) was used to measure the distance from the upper edge of the rear window to the direction indicator lever on the steering column. These measurement points were chosen because in front impacts most reference points near the steering assembly (instrument panel, floor, roof) may be distorted. Discussions with automotive engineers indicated that the method of measurements used was appropriate and it was adopted by at least one major firm.

Vehicle Exposure

Arrangements were made to obtain copies of the inspection certificates for the sample of accident vehicles in Virginia. Virginia law requires all motor vehicles to be inspected every six months. Inspection is carried out by private garages under state police supervision. The record of inspection (Fig. D-6), sent to the state police, indicates whether new installations or adjustments were needed to put the vehicle into approved condition. A sample of these records consisting of non-accident vehicles with the sticker number immediately before or after a Virginia accident vehicle also was obtained. Inasmuch as inspection stickers are issued in numerical sequence at each inspection station, the accident vehicle and two non-accident vehicles were likely to have been inspected at the same station and approximately at the same time. Thus, location, seasonal, and driver socioeconomic factors are minimized. These data, with the date of inspection and odometer reading, were used in several studies. The supplemental accident forms which the Virginia State Police agreed to use in cooperation with the study project contained the vehicle's inspection certificate number so that the accident vehicles could be matched to their respective inspection data.

Some of the topics studied using inspection data for accident and non-accident data include (see Appendix C):

1. A study to evaluate a measure of roadway exposure for the various types of vehicles.
2. A comparison of accident vehicle characteristics with the characteristics of the non-accident vehicles.
3. A study of accident vehicles versus elapsed time from inspection was attempted to give some indication of the effectiveness of vehicle inspection. (Hypothesis: Inspection results in fewer vehicle deficiencies thereby reducing the number of accidents; thus more accidents should occur to those vehicles which are near the termination of their inspection period than to those recently inspected.)

The problems and approaches to studies of vehicle exposure are discussed in more detail in later chapters.

ERROR PREVENTION AND DETECTION

In the collection of accident data on a sample basis, using technicians or specially trained police officers, an adequate check system to insure the quality of the data is essential. This applies as well to the current accident data collection system.

Error prevention should begin before the data are collected. An earlier chapter illustrated the types of errors commonly found and suggested that many reflected the inadequacy of the report form. A better report form with self-explanatory titles would help. Checks that are a part of the report form allow a rapid assessment of certain items on a form. Vehicle make or year of manufacture and vehicle identification number are susceptible to many errors, taken alone. If both are recorded, errors diminish markedly. A brief reference manual also is useful.

A spot check of field procedures, preferably conducted by a supervisor and supplemented by an office check, insures completeness of reporting—reporting of all cases and all information in each case. The field check permits an evaluation of the reporting of the basic data. Photographs also provide a check of many accident variables. Such items as condition of road, wet or dry surface, areas of car impacted, and other details, can be readily discerned in good photographs. An office check by a trained individual, particularly if photographs are available, is relatively simple and effective.

Editing Procedures

In collecting data for this section of the study, photographs were obtained for all cases and a computer edit was developed. Because of the costs involved in supporting an agency engineer in the field, only a brief field check was done in one study (the vehicle angle of departure study). In a period of one week, only four incidents that could be checked occurred. In use by a state, it is assumed that the check would be conducted by an officer or engineer in a local area.

The process of generating data cards and magnetic tapes involves many steps, each of which may result in the introduction of errors. The source of all data consists of the responses of the accident investigator and/or the drivers involved. As stated, errors can enter at this point as a result of a misunderstanding of the information required, incorrect judgment, or an error in writing the response. When the written accident report is received at the data processing center, the information is coded in accordance with a formal code book. Here errors may be generated by a failure to interpret the information correctly, by simple misreading, or by failure to select and write the appropriate code value. The keypunching of cards is the final potential source of error.

There are several points in this process where errors may be detected. Although the accident investigator's supervisor can check the accident report for errors, checking and revision in itself represents an additional step where errors can be generated. Second, data may be checked, and revised if necessary, after coding. Finally, all punched data can be run through an IBM verifier in an attempt to minimize the effects of keypunching errors.

In spite of these error detection procedures, it is impossible to eliminate all errors. There are three reasons for this. First, some errors are simply not detectable. For example, if a driver says he is a foreman, it may not be possible to determine the validity of the statement. Second, those people searching out errors are themselves imperfect. Third, the detailed logic involved in detecting inconsistencies may be too time consuming when large numbers of data are to be processed. For these reasons, it is desirable to utilize a final computerized editing procedure.

Generally, such an editing procedure can be thought of as involving several classes of error checks. First, the codes must be readable by the particular computer facility. Of course, no programming is necessary for such detection in that cards containing such characters will not be acceptable to the card reader. Hence, these errors are detectable either via rejection by the card reader or by using card machines such as the sorter, printer, or, in this case, the IBM unit record statistical machine.

The second class of error detection is the search for code values that are outside the range of defined values for each variable. For example, there are eight possible values indicating the day in which the accident occurred: 1 through 7 for each day of the week, and 11 for "not reported." Thus a code value of 9 or M would be detected as an error. A special case within this class is a check of codes whose values are predetermined and independent of the particular accident. These include, for example, the state where the data were collected and the name of the specific study.

The third class of errors to be detected involves impossible combination of codes. This incompatibility may exist in terms of indexing variables which are generated at the time of coding. Here certain card columns are set aside to identify different card types for each vehicle and to identify different vehicles within a case. Here a rule that must be followed, or result in an error message, is that within every card type the cards must be in the same order in terms of the vehicles they represent; furthermore, within each case the card types must appear in a specified sequence. Another check involves the search for unused, or blank, columns as a function of card type.

Another subclass of impossible combinations derives directly from the nature of the variables being coded. For example, the coded values for accident type and impact configuration are such that some errors are detectable as inconsistencies; if configuration is coded as "rollover principal," the accident type code must also reflect the occurrence of a rollover.

The fourth, and last, class of potential errors to be detected involves improbable combinations of codes. This class produces the largest number of error messages from the edit routine. Here the program involves the detection of implied relationships which are sufficiently improbable that it is desirable to require re-examination of the accident report by a case analyst to make a determination of the acceptability of the codes involved. For example, the detection of a code indicating that the driver uses the road daily and the accident site is more than 50 miles from home was cause to re-examine the accident report. Upon so doing, it might be discovered that there was a disagreement between the coded value of the frequency of road use and its value on the report. Or the validity of the combination might be deemed reasonable or be rejected by considering the driver's age, occupation, destination, etc.

Some additional examples of requirements placed on the coded values, or error checks, were selected from the edit program for the driver study, as follows:

1. Hour of the accident must be between 01 and 24, or be coded not reportable.
2. Vehicle inspection number must begin with A or B.
3. Accident month must be between April and October.
4. All vehicle sequence numbers must be less than or equal to the number of vehicles involved in the accident.
5. Columns 37 to 48 on card type two give identifying information about the second accident vehicle; these columns must be all filled or all blank.
6. Rollover type, accident type, and impact configuration must be consistent in reflecting whether or not a rollover occurred.
7. Accident type cannot reflect a collision with another vehicle if the number of vehicles involved is one.
8. If one driver is judged more culpable, the other must be coded less culpable.
9. Vehicle model and year of manufacture must be compatible.
10. Weather conditions may not be snow or sleet if the accident month is between April and October.
11. Work may not be listed as the destination of the trip if the accident occurred more than 200 miles from home.
12. If the driver of a 1966 or 1967 automobile is not a salesman, the odometer reading may not be such as to exceed an average of 50,000 miles per year.
13. The upper limit for annual mileage for a retired person is 30,000 miles; if he drives two cars, the upper limit for the less used vehicle is 10,000 miles.

Analysis of Vehicle Trajectory Data

During recent years, increasing efforts have been diverted toward clearing the roadside of obstructions and obstacles which could be struck by a vehicle going out of control and leaving the traveled portion of the roadway. Data have shown this type of single-vehicle accident to be both frequent and severe. During recent hearings before the Special Subcommittee on the Federal Aid Highway Program of the Committee on Public Works, House of Representatives, Ninetieth Congress, a distance of 30 ft was mentioned in testimony as an indication of a reasonable distance to clear poles, trees, etc., beside the traveled area. Although this 30 ft was intended to be a best estimate based on a small volume of data and not a fixed value, it has virtually become a standard offset distance in the absence of additional data. This was not the intent of the committee that discussed the subject, but rather was intended as an indication of the approximate distance that might be necessary.

One of the deficiencies in developing suitable criteria for proper clear distance from edge of roadway to obstructions is a lack of data recording the distance that a vehicle will travel after leaving the roadway proper. The primary data available were contained in a publication of the findings from General Motors experimental test tracks and compared with data obtained from the ACIR files of CAL. These data when plotted suggested that 80 percent of obstacles were struck within 30 ft of the traveled portion of the roadway and therefore a 30-ft clearance might eliminate 80 percent of the run-off-roadway accidents. Although the desire to clear an area along the traveled way is commendable, establishment of a fixed distance—30 ft or any other value—is impractical, inefficient, and uneconomical. The designer must realize that in many accidents, vehicles struck objects far beyond 30 ft from the roadway and that many obstructions closer than 30 ft were missed. The appropriate approach would be to balance the cost and feasibility of obtaining a cleared area against the probability of an accident occurrence. For example, in certain areas a 30-ft cleared area will be next to impossible to obtain, whereas in others a 100-ft clearance may be available at little if any extra cost. The important consideration is to establish the relationship between accidents and the cleared distance, and available data concerning the relationship are sparse.

Consequently, in reviewing topics for demonstration subtasks early in this program, the subject of vehicle path and angle of departure aroused considerable interest because such a study would provide not only an opportunity to test the hypothesis that police could obtain these data but also would provide some information concerning a relatively unknown highway safety factor.

The data required included the angle of departure of the vehicle from the traveled portion of the roadway, the distance the vehicle traveled parallel to the roadway, the lateral distances traveled, and distances to objects struck. Where possible, these measurements were to be supplemented by estimates of vehicle speed prior to leaving the roadway and at impact. Angle of departure was defined as the angle of the path of the vehicle as it left the paved surface.

Discussions with police officials, as well as tests by agency personnel, suggested that police investigators would have difficulty in obtaining accurately all of the measurements required. A special form (Fig. D-1) and a simple device to aid the investigating officer were developed. The device, referred to as a "vector graph," is basically a clipboard with a peg in the center (the center hole of the form fits over the peg) which supports a plastic arrow free to rotate. In use, the form is placed on the clipboard and the arrow is fitted over the peg. The user places the device on the ground at the point where the vehicle left the roadway, aligns the top of the form with a reference point (generally parallel to the pavement edge), and then marks the required angles after aiming the arrow at the objects to be located. The appropriate distances are measured and recorded. The device is based on a principle used in many surveying techniques—an angle and a distance from a known point on a known reference line.

Data Collected

The Ohio State Highway Patrol used the vector graph technique on the Ohio Turnpike for a period of five months during the summer and fall of 1967. During this time, 324 accident events were recorded, with only three cases not containing an angle of departure. Speed estimates were not reported in several cases. The basic data are summarized in Tables 2, 3, 4, and 5.

Analysis of Data

In analysis, measurements of angles to the left were converted to negative values; for example, —45° refers to an angle halfway between a line straight ahead and one 90° to the left. This procedure facilitates the averaging of angles to the right and to the left.

Many of the analyses discussed in the following are based on derived measures. For instance, of primary importance is lateral distance from the road. To avoid operational difficulties, lateral distance was not measured directly. Instead, it was computed as straightline distance multiplied by the sine of the appropriate angle. This approach might allow large errors, especially when the total distance was large and the angle was small.

Findings in this sample, shown in Figure 2, were that 58 percent of the vehicles first left the road to the right and that the two most frequent 10° ranges of departure angles were 10° to 19° and 20° to 29° to the right, as these two groups accounted for 42 percent of the total vehicles.

Figure 3 indicates that approximately one-third of the vehicles involved in run-off-roadway events on the Ohio Turnpike travel more than 30 ft laterally before striking an object. This percentage is somewhat higher than that previously mentioned but is still within the same relative range.

The speed-mean departure angle relationship is given in Table 6, from which it can be seen that as the estimated speed on the road increases, the angle of departure from the road moves from the right to the left. Although some of the speed intervals are poorly represented, the trend is surprisingly well exhibited throughout the speed range. There are several reasonable explanations for this phenomenon: (1) It is easier to turn sharply at low speeds; and (2) the probability that a vehicle is in the left-hand lane increases as its speed increases.

The data relating speed on the road to the angle of the first object struck appear quite similar to those just discussed. The major difference is that, for most speed ranges, the angle of the first object tends to be more extreme than the angle of departure. This suggests that vehicles leaving the road are, in a sense, turning off the road so that the path, statistically speaking, becomes "less parallel" after the vehicle has left the road (Table 7).

There is a strong relationship between road speed (i.e., speed prior to leaving the road) and speed at impact with the first object (Fig. 4).

The same data were used to plot Figures 5 and 6, which relate loss of speed (i.e., road speed minus impact speed) to road speed and impact speed, respectively. Comparison of these figures and their respective correlation coefficients shows that speed loss appears to be related more closely to impact speed than to road speed. This may be primarily due to the larger variance in impact speed, or impact speed estimates, which, in the computation of the correla-

TABLE 2

SUMMARY OF SPEED AND LANE OF TRAVEL DISTRIBUTIONS

SPEED (MPH)	NUMBER OF OCCURRENCES: ROAD SPEED	IMPACT SPEED, FIRST OBSTACLE	LANE OF TRAVEL	
0-9	0	9	Right	241
10-19	2	22	Left	82
20-29	5	40		
30-39	8	57		
40-49	30	59		
50-59	80	43		
60-69	127	43		
70-79	58	14		
80+	6	0		
All	316	287		323

TABLE 3

SUMMARY OF ANGULAR DISTRIBUTIONS

ANGLE (DEG)		NUMBER OF OCCURRENCES: ANGLE OF DEPARTURE	ANGLE OF FIRST OBSTACLE STRUCK
Left	101-110	1	0
	91-100	0	0
	81-90	1	1
	71-80	0	0
	61-70	1	0
	51-60	0	0
	41-50	8	5
	31-40	9	5
	21-30	30	23
	11-20	43	29
	1-10	42	34
	0-9	31	26
	10-19	77	64
	20-29	58	47
	30-39	11	14
	40-49	6	3
	50-59	2	2
	60-69	0	0
	70-79	0	0
	80-89	0	0
Right	90-99	1	1
All		321	254

TABLE 4

SUMMARY OF DISTANCE-TO-FIRST-OBSTACLE-STRUCK DISTRIBUTIONS

DISTANCE (FT)	NUMBER OF OCCURRENCES: TOTAL DISTANCE	LONG. DISTANCE	LATERAL DISTANCE
0-20	15	24	99
21-40	38	36	60
41-60	35	23	26
61-80	20	21	12
81-100	20	21	4
101-120	17	16	1
121-140	13	11	2
141-160	14	12	0
161-180	7	2	0
181-200	4	4	0
201-300	22	20	1
301-400	4	5	0
401-500	3	2	1
501-750	5	4	0
751-999	2	2	0
All	219	203	206

TABLE 5

SUMMARY OF NUMBER-OF-OBSTACLES-STRUCK DISTRIBUTION

NO. OF OBSTACLES STRUCK	NO. OF OCCURRENCES
0	35
1	229
2	46
3	9
4	2
5	3
6	0
7+	0
All	324

TABLE 6

SPEED-MEAN DEPARTURE ANGLE RELATIONSHIP FOR SAMPLE CASES

SPEED RANGE (MPH)	MEAN DEPARTURE ANGLE (DEG)	NO. OF OBSERVATIONS
10-19	48.5	2
20-29	8.8	5
30-39	7.9	8
40-49	7.1	30
50-59	2.0	78
60-69	3.7	126
70-79	−1.6	58
80+	−1.8	6
All		313

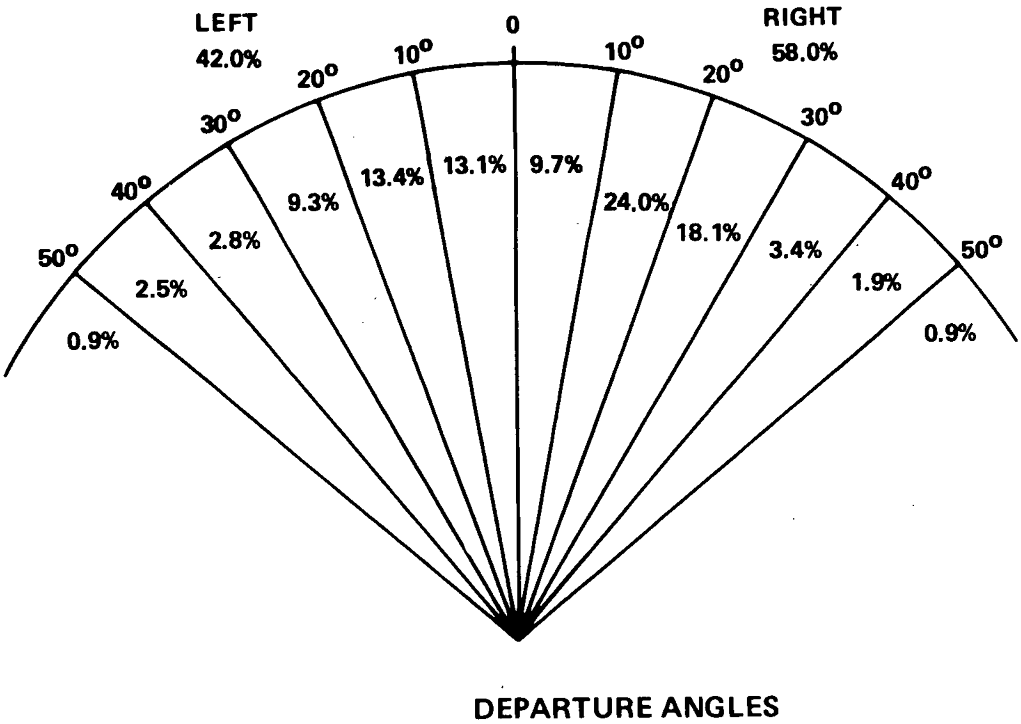


Figure 2. Summary plot of departure angles for sample cases.

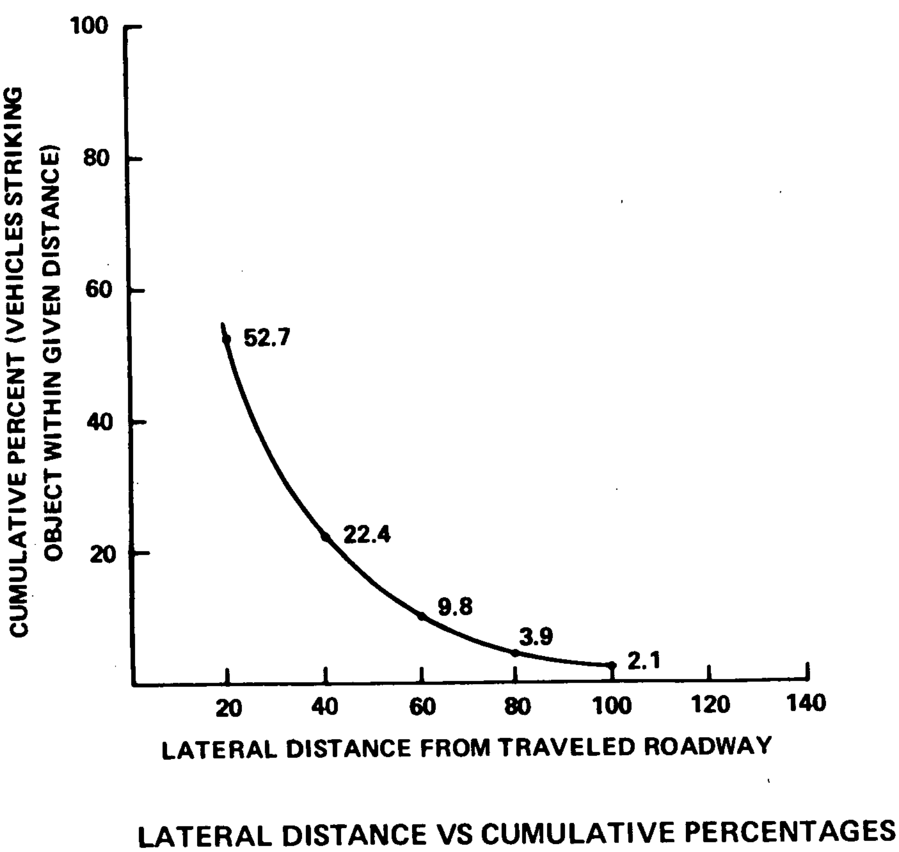


Figure 3. Cumulative distribution of lateral distance to object struck for sample cases.

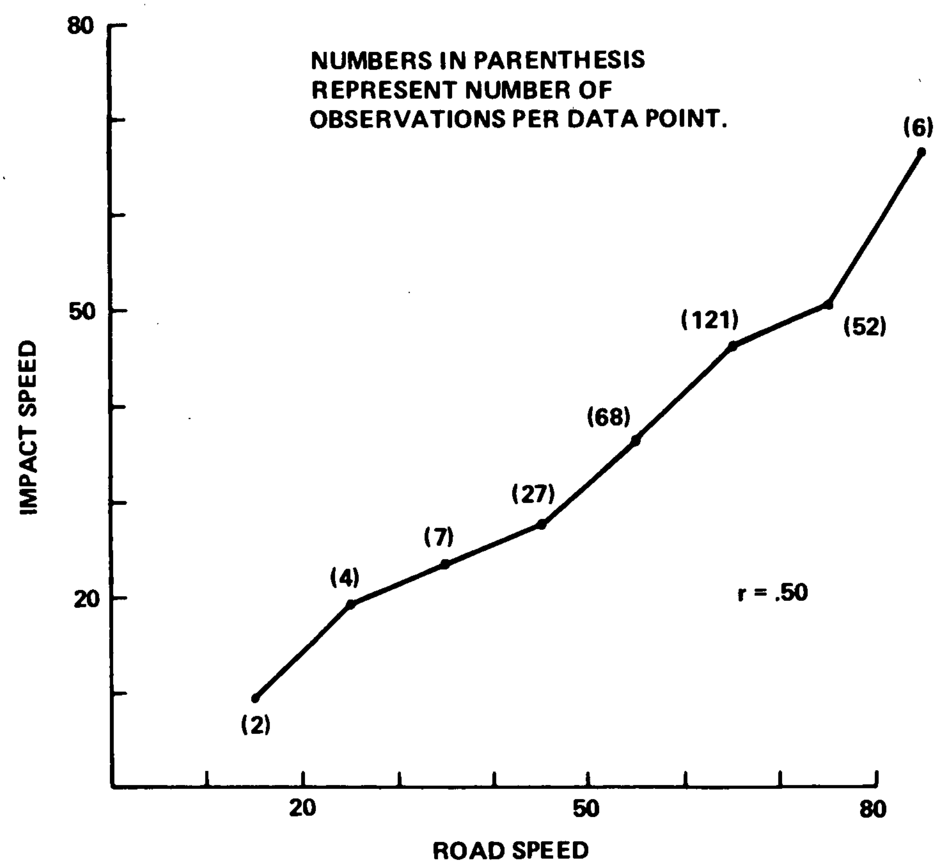


Figure 4. *Mean estimated speed as a function of speed prior to impact.*

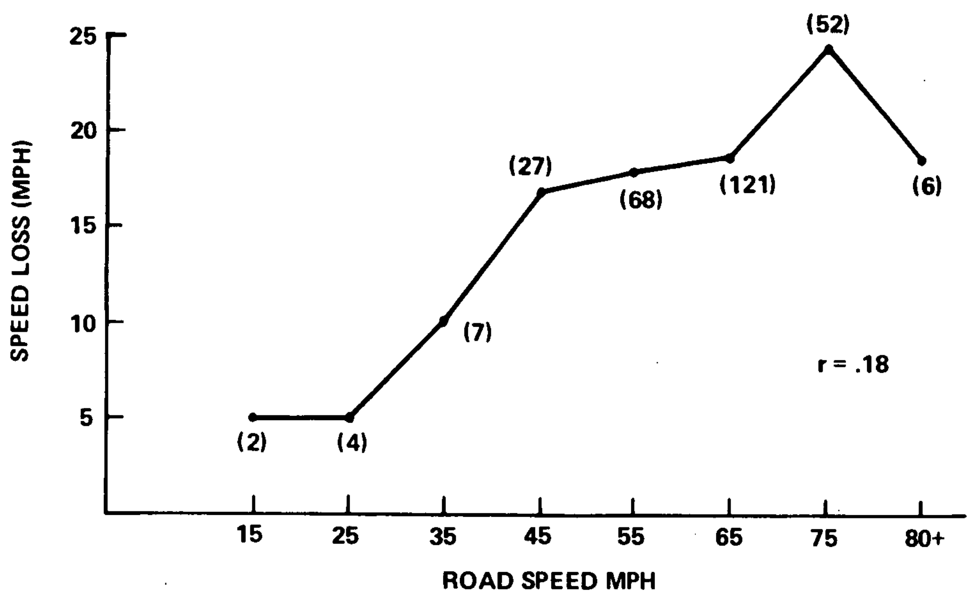


Figure 5. *Mean estimated speed loss (road speed minus impact speed) as a function of road speed.*

tion coefficients, give more weight to points near the ends of the curve.

Lateral distance to the first object struck is plotted against road speed in Figure 7. It is seen that the relationship is very weak; $r = 0.16$ shows a relationship which is just barely significant at the 0.05 level ($N = 204$). Correlation would not be expected to be high, because higher speed would not cause a vehicle to miss nearby objects but merely increase the probability of hitting distant ones should objects close to the road be missed. Also, because high-speed vehicles tend to leave the road at narrower angles, lateral distance traveled would probably not be directly proportional to speed alone.

The relationship between road speed and longitudinal distance to the first object struck was also investigated (Fig. 8). This relationship is stronger than that for lateral distance. Part of this is attributable to the narrower departure angles for high-speed vehicles, thereby allowing more longitudinal travel before the vehicle leaves the rather obstacle-free area close to the traveled portion of the roadway.

A plot of impact speed versus lateral distance to the first struck object is shown in Figure 9. Objects farther from the road might be expected to be struck at lower speeds, but this was not borne out by the data. The statistically insignificant correlation coefficient suggests that impact speed and lateral distance were essentially independent.

TABLE 7

RELATIONSHIP OF SPEED TO ANGLE OF FIRST OBJECT STRUCK FOR SAMPLE CASES

SPEED RANGE (MPH)	MEAN ANGLE TO FIRST OBJECT (DEG)	NO. OF OBSERVATIONS
10-19	48.5	2
20-29	13.0	3
30-39	13.7	6
40-49	12.0	23
50-59	3.9	62
60-69	4.8	108
70-79	0.2	43
80+	−3.4	5
All		252

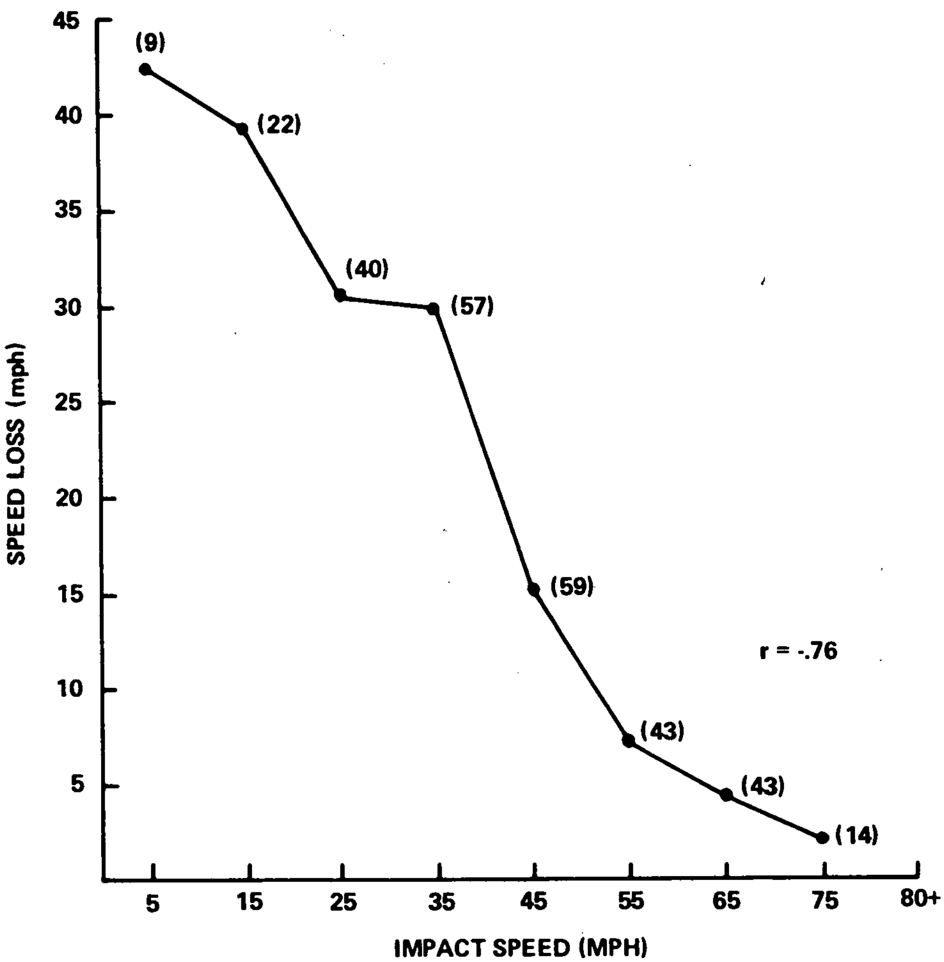


Figure 6. Mean estimated speed loss (road speed minus impact speed) as a function of impact speed.

The possibility that this was due primarily to measurement errors was considered. However, the fairly high correlation for road speed and impact speed suggests that impact speed was estimated with reasonable reliability; the agreement between the angle to first object struck and the angle of departure tends to support the reliability of these two measures and gross errors in the total distance measurements are unlikely. In addition, the independence of lateral distance and impact speed was supported by an analysis in which impact speed was compared with total distance to the first object and no dependence between these two variables was found.

The failure of impact speed to decrease as lateral distance increases is apparently not explainable by the data available.

Comparing speed loss (road speed — impact speed) with lateral distance to the first object struck (Fig. 10), there is a very weak, although statistically significant, relationship: as lateral distance increases, speed loss increases. The degree of correlation may be attributable to the correlation between road speed and lateral distance.

In an attempt to study further speed-distance relationships, those vehicles which left the road but were not reported as striking any obstacles were analyzed. However, there were only 25 of these vehicles and no relationships were found.

Table 8 gives the relationships between the probability of hitting more than one object and (1) impact speed at first object, (2) lateral distance to first object, and (3) total distance to first object. Only vehicles which struck at least one object are included.

In each case, the trend is as expected. (The interval sizes were chosen to attempt to equalize the number of observations in each range; thus change in reliability from range to range is minimized.) Although the trends existing between the variables are noticeable, *t*-tests were actually run on more finely grouped data. Only for lateral distance were the results not statistically significant.

Conclusion

The data obtained by the Ohio State Highway Patrol are sufficiently complete for a number of analyses. Comparisons of the various analyses also indicate that patterns and relationships within the data are consistent.

The actual results obtained are based on a comparatively small number of events and can serve only as an indication of possible results. There is sufficient evidence, however, to suggest that approaches to roadside hazards other than the clearing of nearby obstacles might well be explored. It would be desirable to conduct a similar study on a larger scale to confirm and amplify these findings.

Field Check of Vector Graph Reporting

A study was made in an effort to evaluate the data obtained and the use of the vector graph by a state police organization. The state selected for the study was Utah, where the Highway Patrol had agreed to use the vector graph

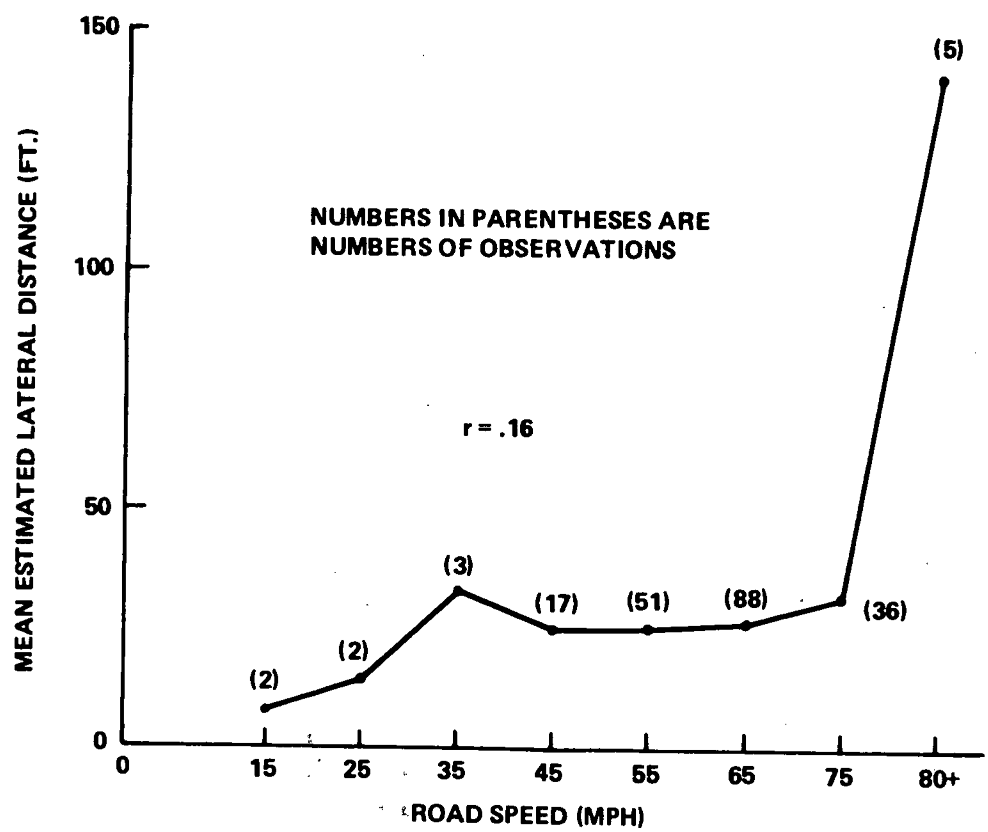


Figure 7. Mean estimated lateral distance as a function of speed prior to impact.

in ran-off-roadway accidents. The officers using this instrument had been instructed in the proper use of the device and also had been instructed to photograph various aspects of the event. The objective of the evaluation was to verify whether the equipment was being used in accordance with the instructions, and to determine whether the data obtained met tolerance limits judged to be acceptable for the particular equipment.

Using the vector graph, acceptable measurement values were considered to be within ± 5° of the true value. The accuracy of the measuring device was limited by the 9-in. arrow, which the operator had to align by eye while standing behind and above the device. This necessarily restricts the accuracy of the unit; hence, the angles recorded represent approximate values.

The distance measurements involved were across the terrain between the vehicle's point of departure from the roadway to the vehicle's final position and to the obstacles struck. A reasonable accuracy for these measurements was considered to be a maximum error of 1 ft for each 100 ft measured. Also, distances to the nearest foot were considered adequate for the proposed use of the data.

Procedure

After the Utah police had been instructed in the use of vector graph and had employed the device in a number

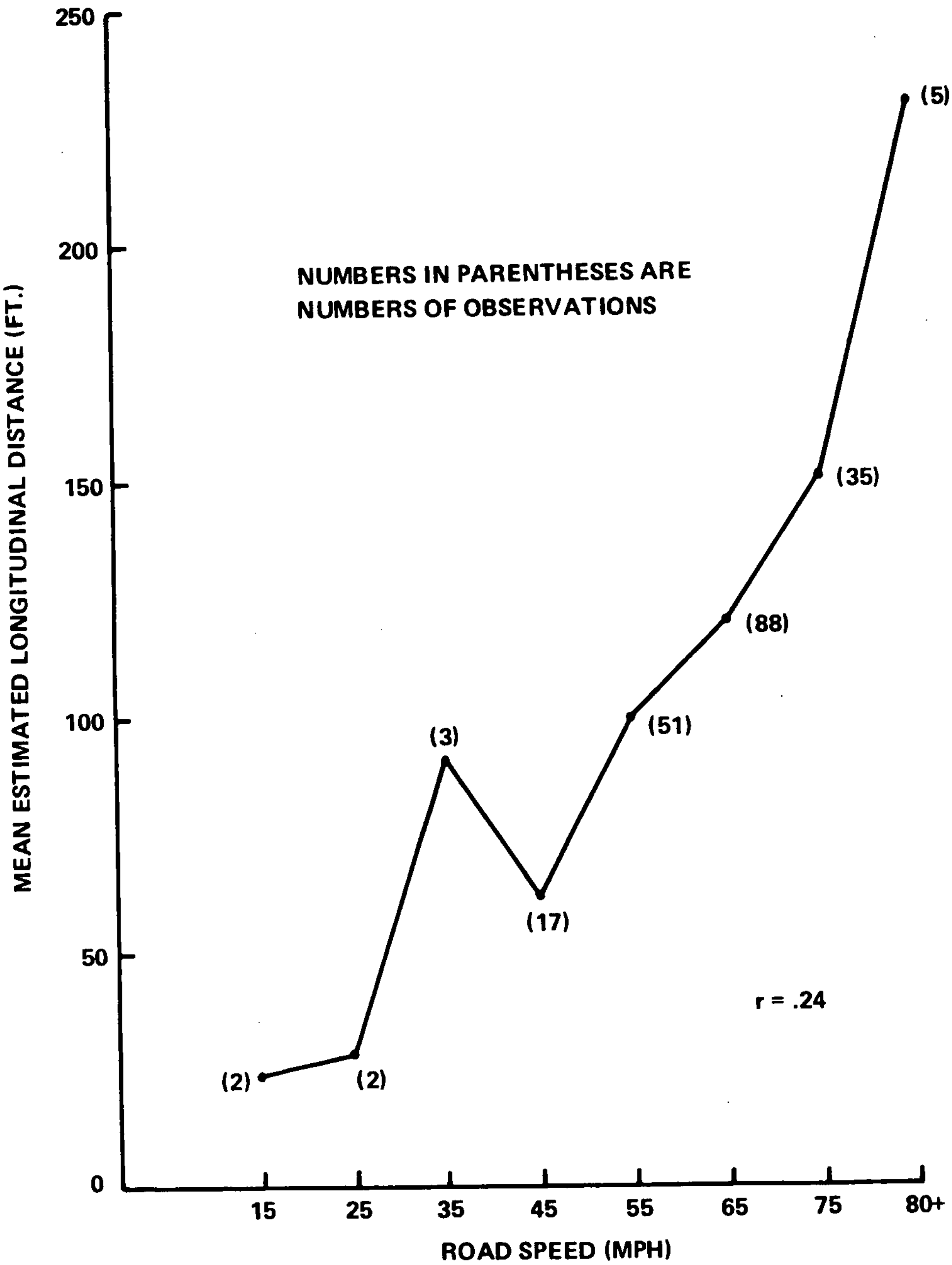


Figure 8. Mean longitudinal distance to first object struck as a function of vehicle road speed.

TABLE 8

PROBABILITY OF HITTING MORE THAN ONE OBJECT AS RELATED TO IMPACT SPEED, LATERAL DISTANCE, AND TOTAL DISTANCE TO FIRST OBJECT

IMPACT SPEED (MPH)	PROBABILITY,[a] P	NO. OF OBSERVATIONS	LATERAL DISTANCE (FT)	PROBABILITY,[a] P	NO. OF OBSERVATIONS	TOTAL DISTANCE (FT)	PROBABILITY,[a] P	NO. OF OBSERVATIONS
0-19	0.06	31	0-20	0.25	99	0-40	0.32	53
20-39	0.20	93	21-40	0.15	60	41-80	0.20	55
40-59	0.24	93	41+	0.15	47	81-140	0.14	50
60+	0.31	52				141+	0.13	61

[a] Probability of hitting more than one object.

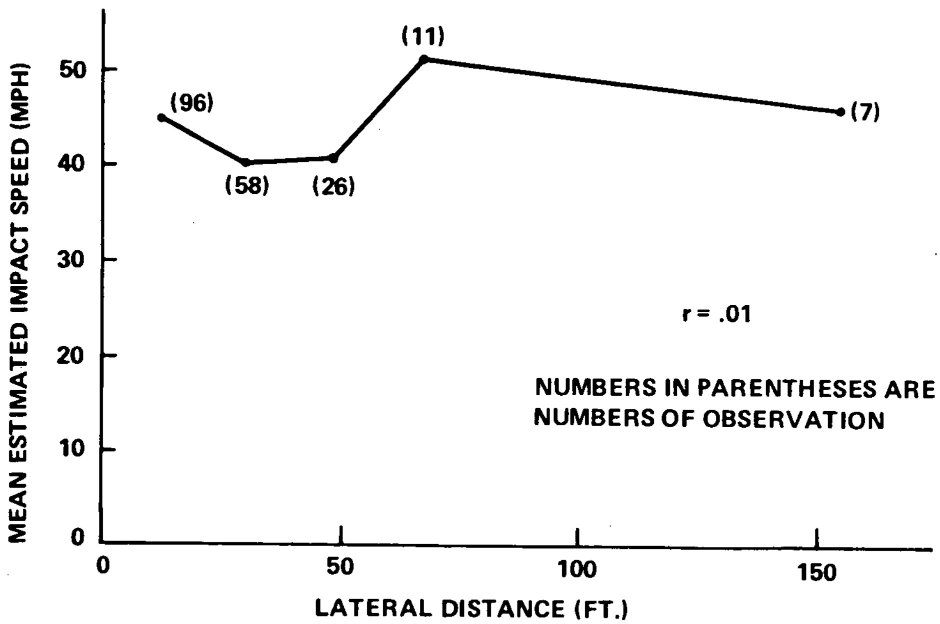


Figure 9. Mean impact speed as a function of the objects' lateral distance from the road.

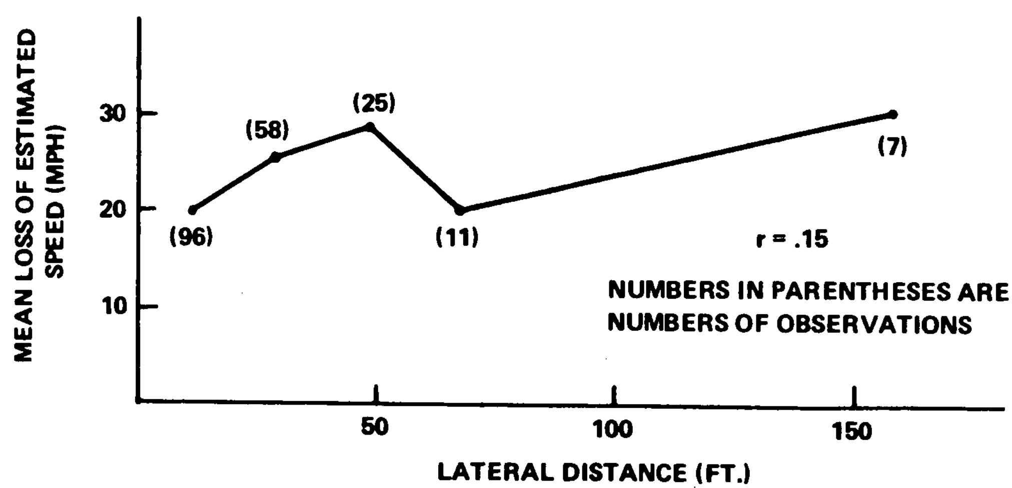


Figure 10. Mean estimated speed loss (road speed minus impact speed) as a function of lateral distance to the first object struck.

of accidents, an engineer-land surveyor secured data for correlation with that obtained by the reporting officer. Seven days were scheduled, with the objective of collecting data on 12 accidents (a reasonable expectation based on previous experience).

The engineer was on call with a highway patrolman as a partner. When an accident occurred, they drove to the scene and, in the few cases obtained, arrived before the investigating patrolman had completed his measurements. The engineer checked the various key points used in the measurement by the investigating patrolman and then took his own measurements and prepared a field sketch.

The field surveying technique used consisted of establishing a base line and making all measurements along the base line with perpendicular off-set distances to desired points. This procedure was employed because the engineer did not have experienced field assistance and had to rely on an accompanying highway patrolman to aid in making the necessary measurements. Taping measurements were easier to obtain accurately—the officer could be instructed to hold the end of the tape at a particular point with confidence—whereas more sophisticated surveying equipment would have required lengthy explanations and elaborate checking of the assistant's activity to avoid introducing further error.

Because the emphasis was on angles and distances, little effort was made to locate the accident in terms of the roadway system. Therefore, the resulting sketches do not locate the section of roadway on which the accident occurred. In a full-scale study of this subject, it would be desirable to include highway geometry, and other data from highway department records, that could influence the vehicle path or accident circumstances.

Data Obtained

During the one-week period in Utah within an area of roughly 75-mile radius from Salt Lake City, only three ran-off-roadway accidents were reported by the state police. In addition, one traffic incident of this type was recorded, to produce a total of four cases for the sub-study. (The incident involved a vehicle that ran off the roadway without damage or injury and the patrolman did not report the event as an accident. He did, however, fill out the forms necessary for use in the sub-study.)

Figures 11, 14, 17, and 20 record the data from the vector graph as prepared by the state highway patrol officers. Figures 12, 15, 18, and 21 show comparison sketches as prepared by the engineer. In each case the engineer's sketch is more detailed and reveals the scene more accurately than the officer's sketch from the vector graph. However, the engineer's sketch also is more expensive and requires considerably more time than the officer's report. The sketch was prepared for presentation in this report and is not necessary for the check itself.

Table 9 compares the angles and distances obtained by the police and those obtained from the engineer's sketches. The angle of departure in the three reported cases was within the 5° previously considered reasonable. The angles to the vehicle also were within allowable limits. However, the measured distances showed more variation than expected; several of the variations in distances exceed the allowance of 1 in 100.

From observations of the methods of using the vector graph in the field there appeared to be some disagreement about or misinterpretation of the instructions. For example, the point of departure from the roadway could be and was defined in different ways. In case No. 627, the difference between the outside edge of the tire mark and the center of the mark produced a difference of approximately 3 ft in measured distance (the vehicle left the roadway at a very shallow angle, recorded as 5° by the engineer and 2° by the police). In other cases, there was indecision about such items as where to begin measurements: from the edge of the traffic lane, the edge of the paved roadway, or the start of the snow-covered area (these would give approximately the same angles but quite different distances). There also was some confusion over which wheel mark should be used as a reference. As a result sometimes a track other than the first one along the roadway was used as the point of departure (again, angles would be nearly equal but distances would vary considerably).

Comments

Several factors became evident during the course of the sub-study, as follows:

1. It is costly to have a man (or two men) standing by to collect data on a particular type of accident. As noted

TABLE 9

COMPARISON OF POLICE AND ENGINEER MEASUREMENTS

ACCIDENT NUMBER	ANGLE (DEG)						DISTANCE (FT)			
	OF DEPARTURE		OF OBSTACLE		TO VEHICLE		TO OBSTACLE		TO VEHICLE	
	POLICE	ENGINEER	POLICE	ENGINEER	POLICE	ENGINEER	POLICE	ENGINEER	POLICE	ENGINEER
627	2	5	5½	6	3	3½	142	139	153-5″	150
633	33	33	—	—	16	17½	—	—	51-9″	59
650	NR	32	—	—	40	44	—	—	72	73
Incident	18	13	24½	15	13	8	59	60	74	71

in this sub-study only four incidents meeting the conditions were reported during a period of seven days. To be economically feasible, a study of this type must be conducted by an engineer in the immediate vicinity who can use his time on other projects while awaiting specific events.

2. Not all ran-off-roadway events were reported as accidents. Actually, one of the cases covered in the sub-study was not listed as an accident by the highway patrol.

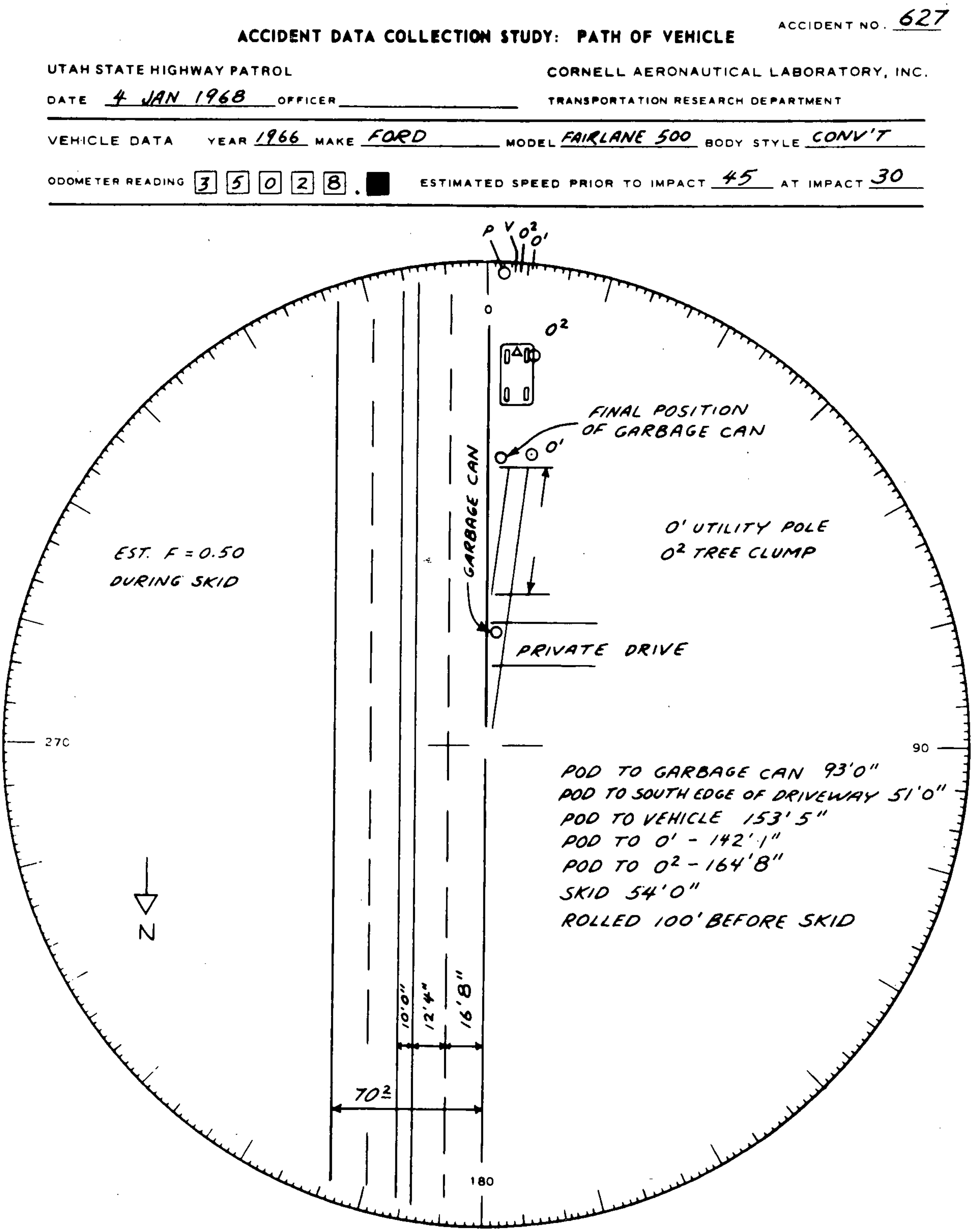


Figure 11. Vector graph record of Utah accident No. 627

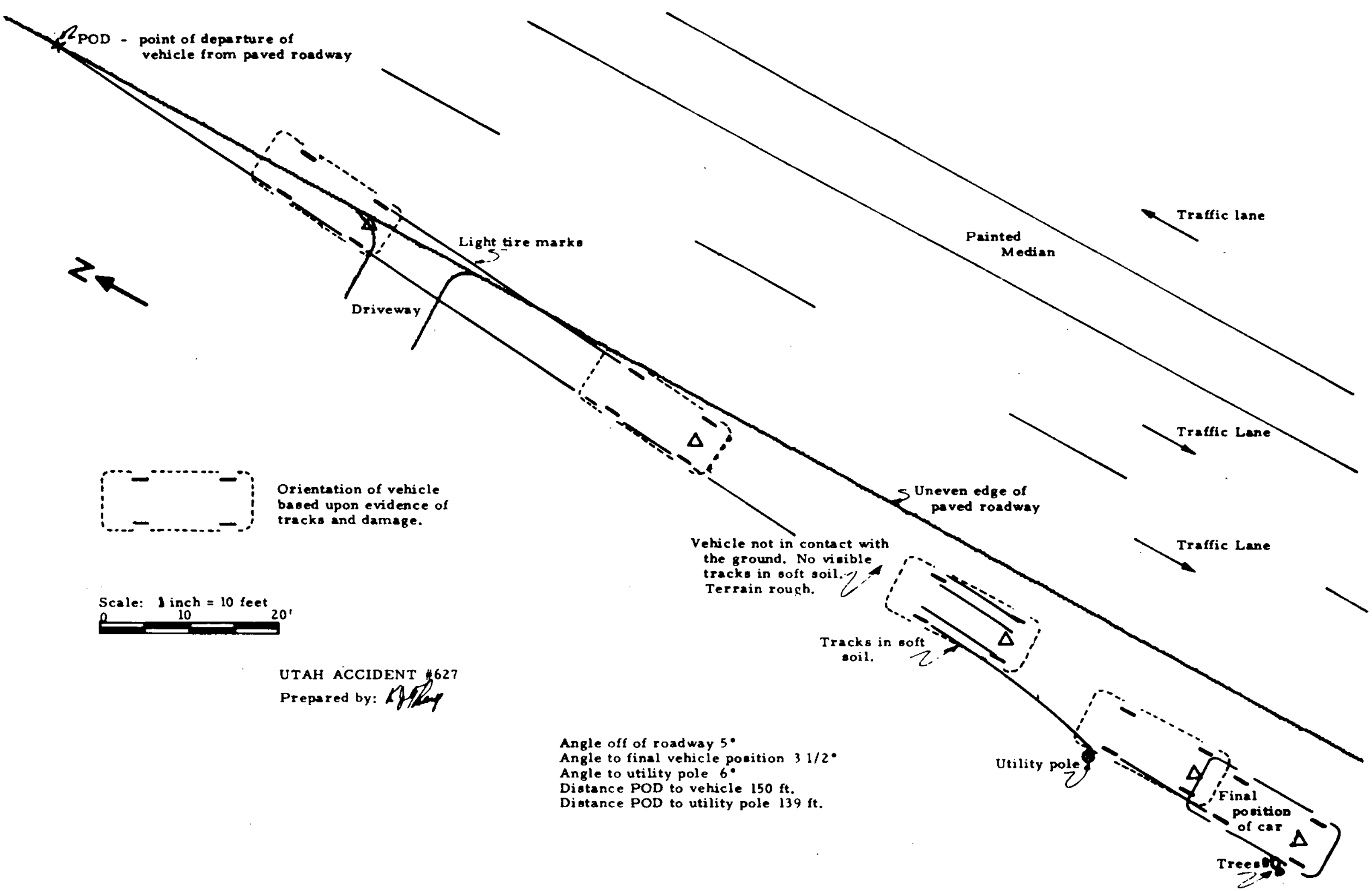


Figure 12. Engineer's field sketch of Utah accident No. 627.

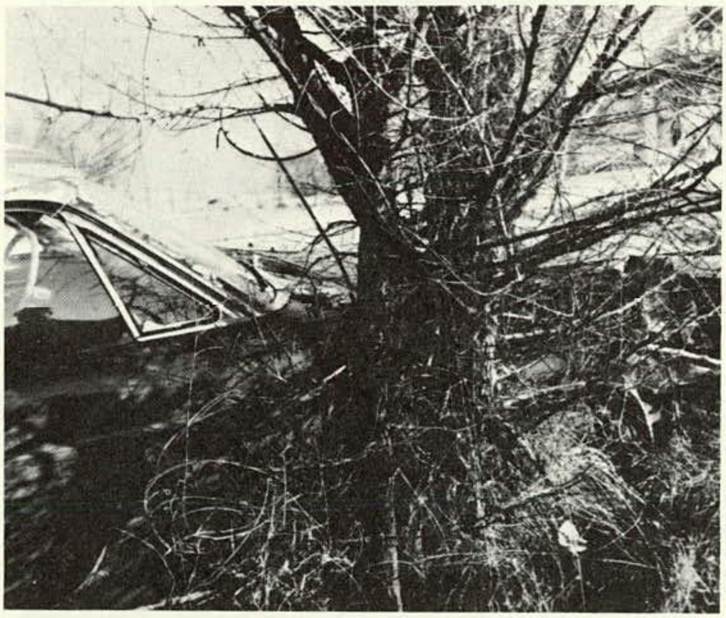
During the period that the engineer was in Utah, there was a light snow and individual patrolmen indicated that many vehicles slid off the roadway. Generally, the patrolman, or others, aided in moving the vehicle back onto the road and no accident report was filed unless damage or injuries were involved. Therefore, the total number of accidents reported was far below the number of ran-off-roadway events which actually occurred.

3. To ensure the proper use of special equipment, detailed instructions are required. The major difficulty arises with respect to the multitude of unanticipated situations that occur in accidents, which make complete coverage of possibilities nearly impossible prior to study. Again, a pilot program of short duration usually is helpful as a test of procedures.

VEHICLE CAME TO REST BEYOND MAIL TRUCK

INITIAL WHEEL MARK

VEHICLE POINT OF DEPARTURE FROM PAVED ROADWAY



FINAL RESTING POINT OF VEHICLE

Figure 13. Utah accident No. 627.

ACCIDENT NO. 633

ACCIDENT DATA COLLECTION STUDY: PATH OF VEHICLE

UTAH STATE HIGHWAY PATROL — CORNELL AERONAUTICAL LABORATORY, INC.

DATE 6 JAN 1968 OFFICER ________ — TRANSPORTATION RESEARCH DEPARTMENT

VEHICLE DATA YEAR 1964 MAKE V. W. MODEL 113 BODY STYLE SEDAN

ODOMETER READING 4 0 6 7 3 . ■ ESTIMATED SPEED PRIOR TO IMPACT 55 AT IMPACT 42

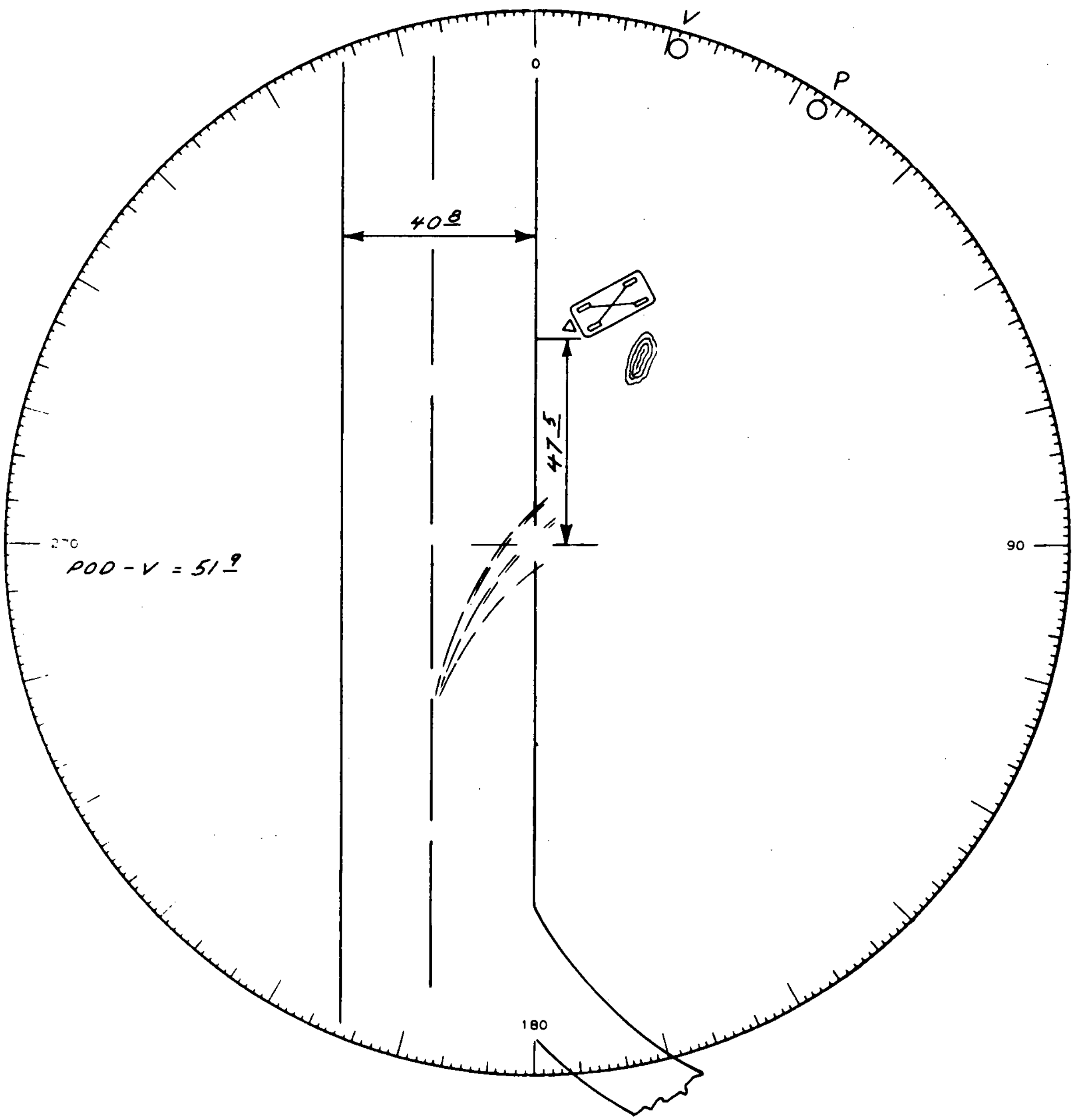


Figure 14. Vector graph record of Utah accident No. 633.

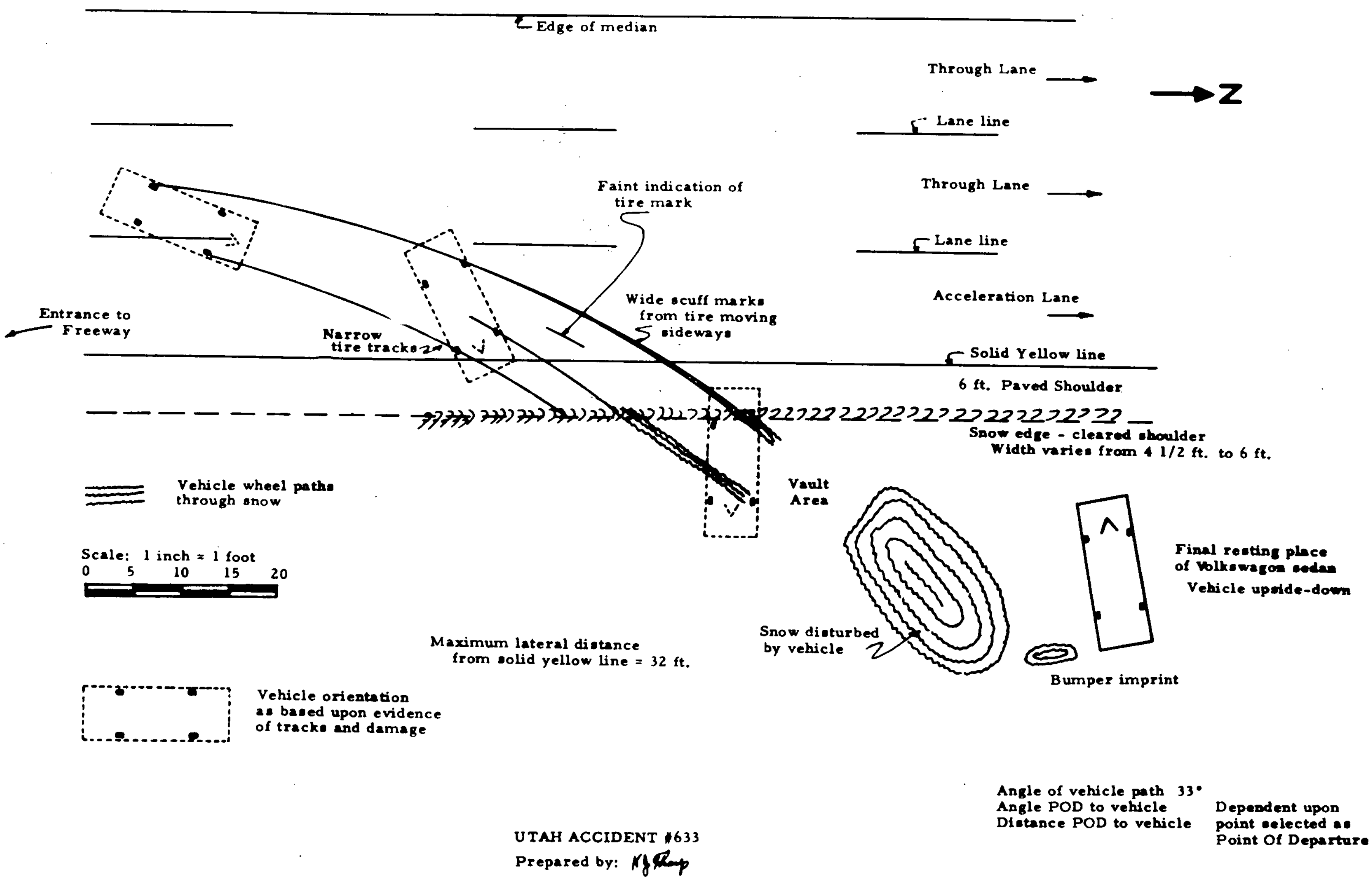
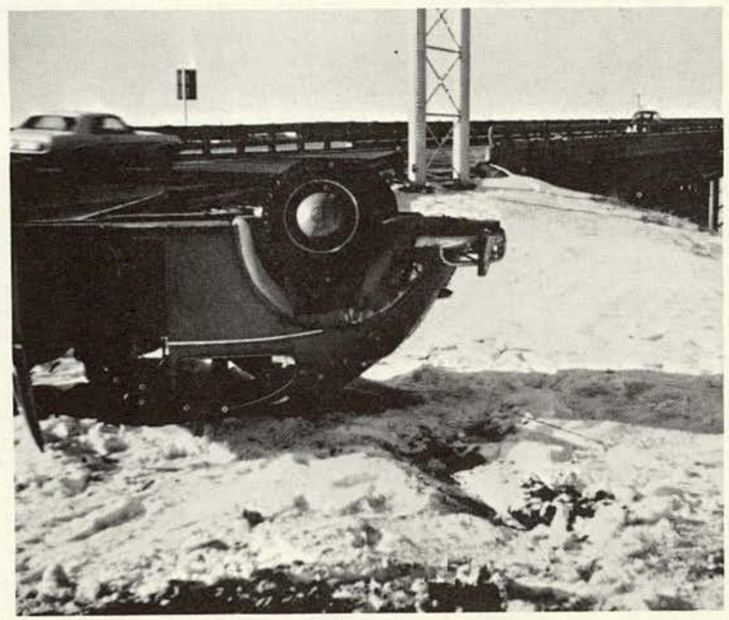


Figure 15. Engineer's field sketch of Utah accident No. 633.

FINAL RESTING PLACE OF VEHICLE

SKID MARKS LEFT BY VEHICLE AT EDGE OF PAVEMENT



NOTE IMPRINT LEFT BY REAR OF VEHICLE AND BUMPER. NO MARKS FOR OTHER PARTS OF VEHICLE IN THIS AREA

VEHICLE IN FINAL RESTING PLACE

Figure 16. Utah accident No. 633.

ACCIDENT NO. 650

ACCIDENT DATA COLLECTION STUDY: PATH OF VEHICLE

UTAH STATE HIGHWAY PATROL | CORNELL AERONAUTICAL LABORATORY, INC.

DATE 9 JAN 68 OFFICER ____ | TRANSPORTATION RESEARCH DEPARTMENT

VEHICLE DATA YEAR 1956 MAKE PLYMOUTH MODEL SUBURBAN BODY STYLE STATION WAGON

ODOMETER READING 9 6 1 7 5 . ESTIMATED SPEED PRIOR TO IMPACT 35 AT IMPACT 30

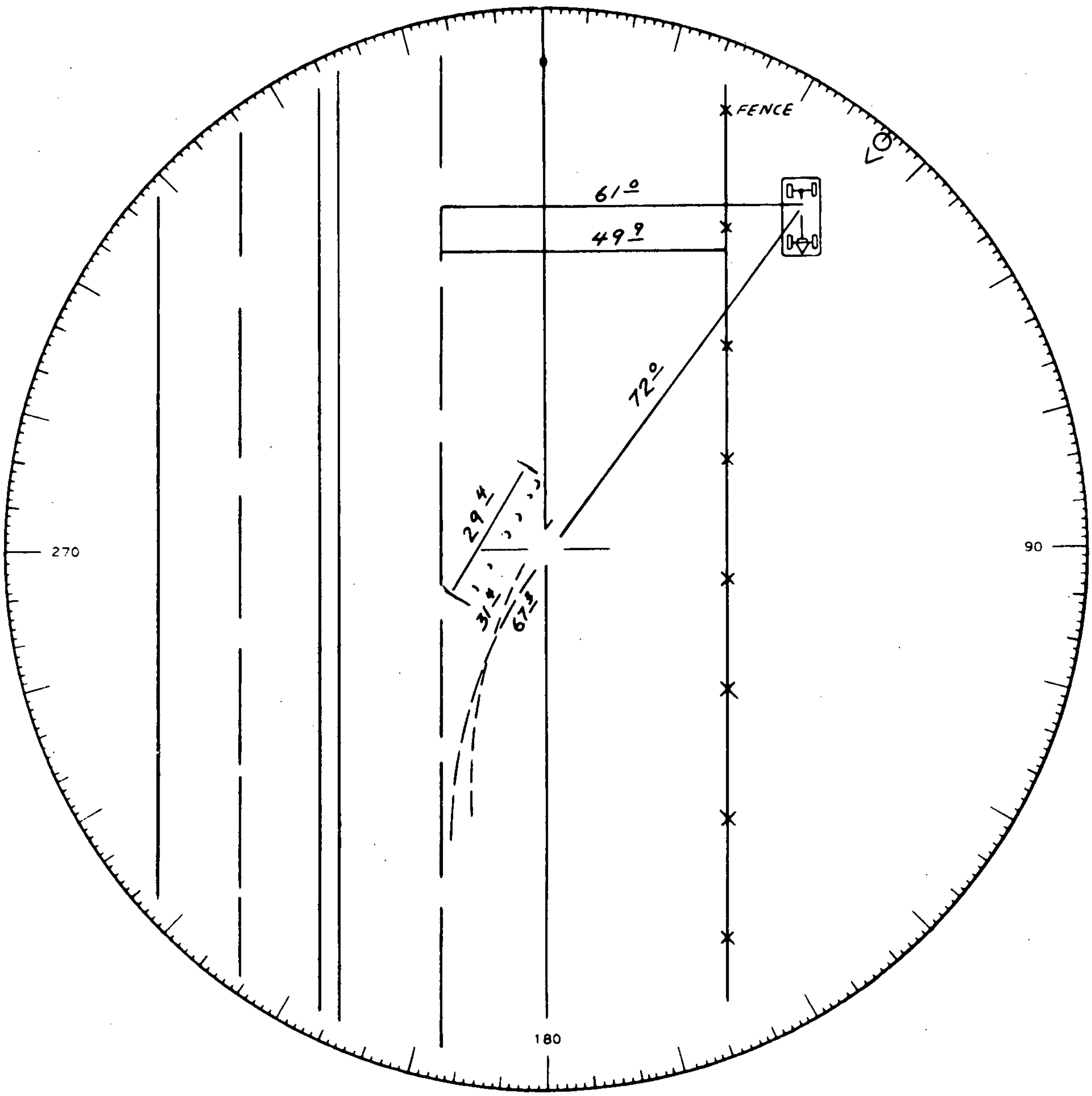


Figure 17. Vector graph record of Utah accident No. 650.

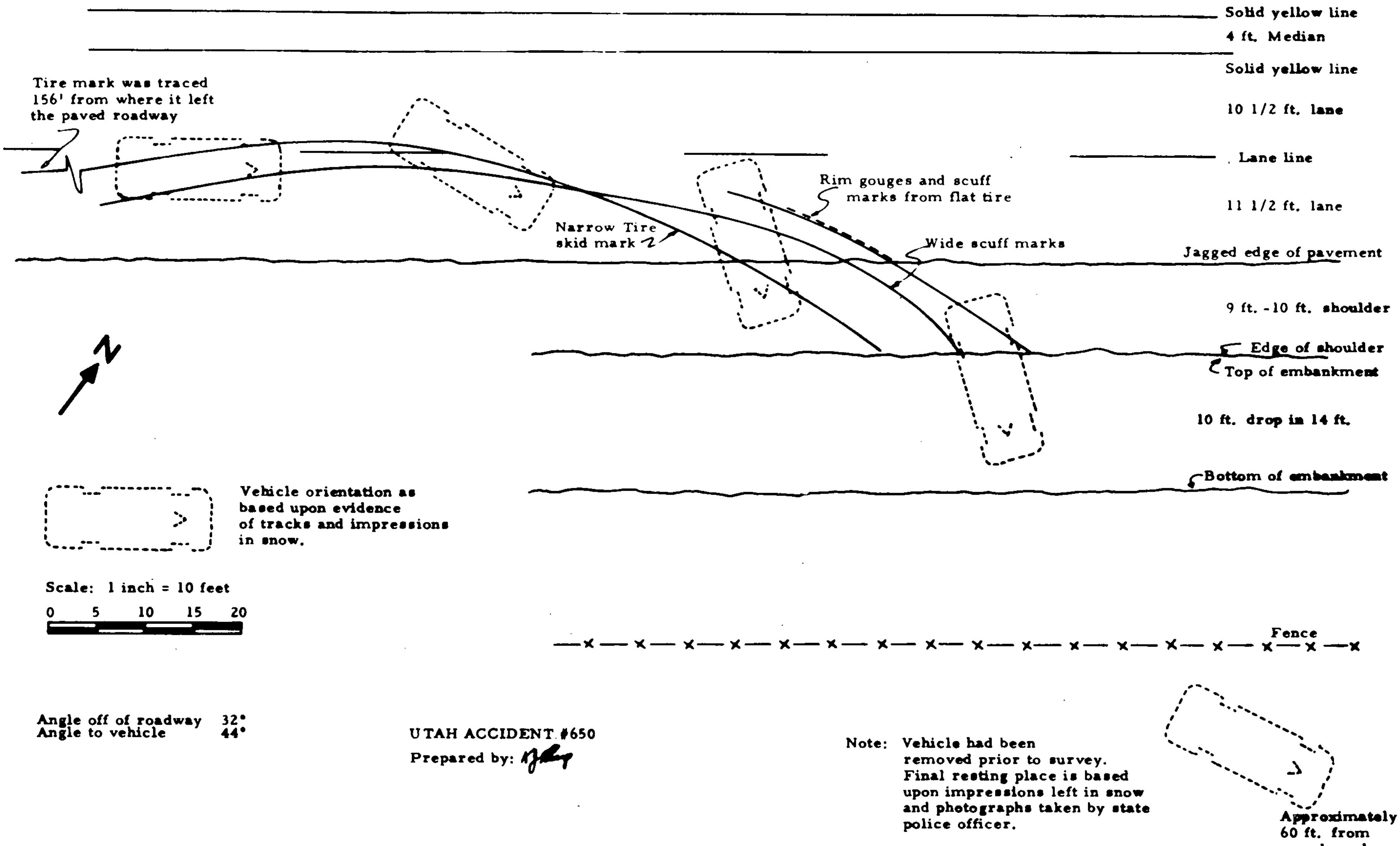


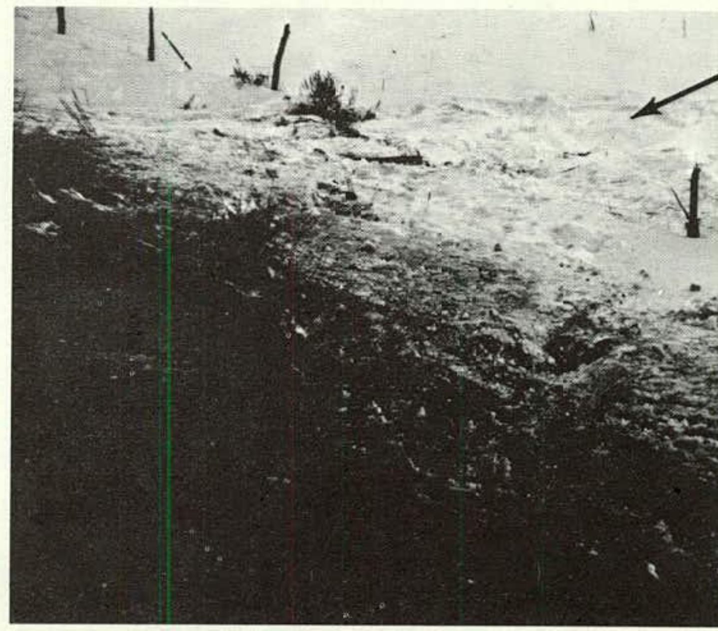
Figure 18. Engineer's field sketch of Utah accident No. 650.

APPROACH TO ACCIDENT SCENE

VEHICLE'S APPROACH TO ACCIDENT SITE
WITH SIDE SCUFFS AND RIM GOUGES

VEHICLE IN FINAL RESTING PLACE

FINAL
VEHICLE
RESTING
PLACE



FINAL RESTING PLACE OF VEHICLE
AT TIME OF SURVEY

Figure 19. Utah accident No. 650.

ACCIDENT NO. ______

ACCIDENT DATA COLLECTION STUDY: PATH OF VEHICLE

UTAH STATE HIGHWAY PATROL — CORNELL AERONAUTICAL LABORATORY, INC.

DATE 11 JAN 1968 OFFICER __________ TRANSPORTATION RESEARCH DEPARTMENT

VEHICLE DATA YEAR 61 MAKE CHEV MODEL IMPALA BODY STYLE SEDAN - 4 DOOR HARD TOP

ODOMETER READING 5 8 3 0 4 . ■ ESTIMATED SPEED PRIOR TO IMPACT 40 AT IMPACT 10

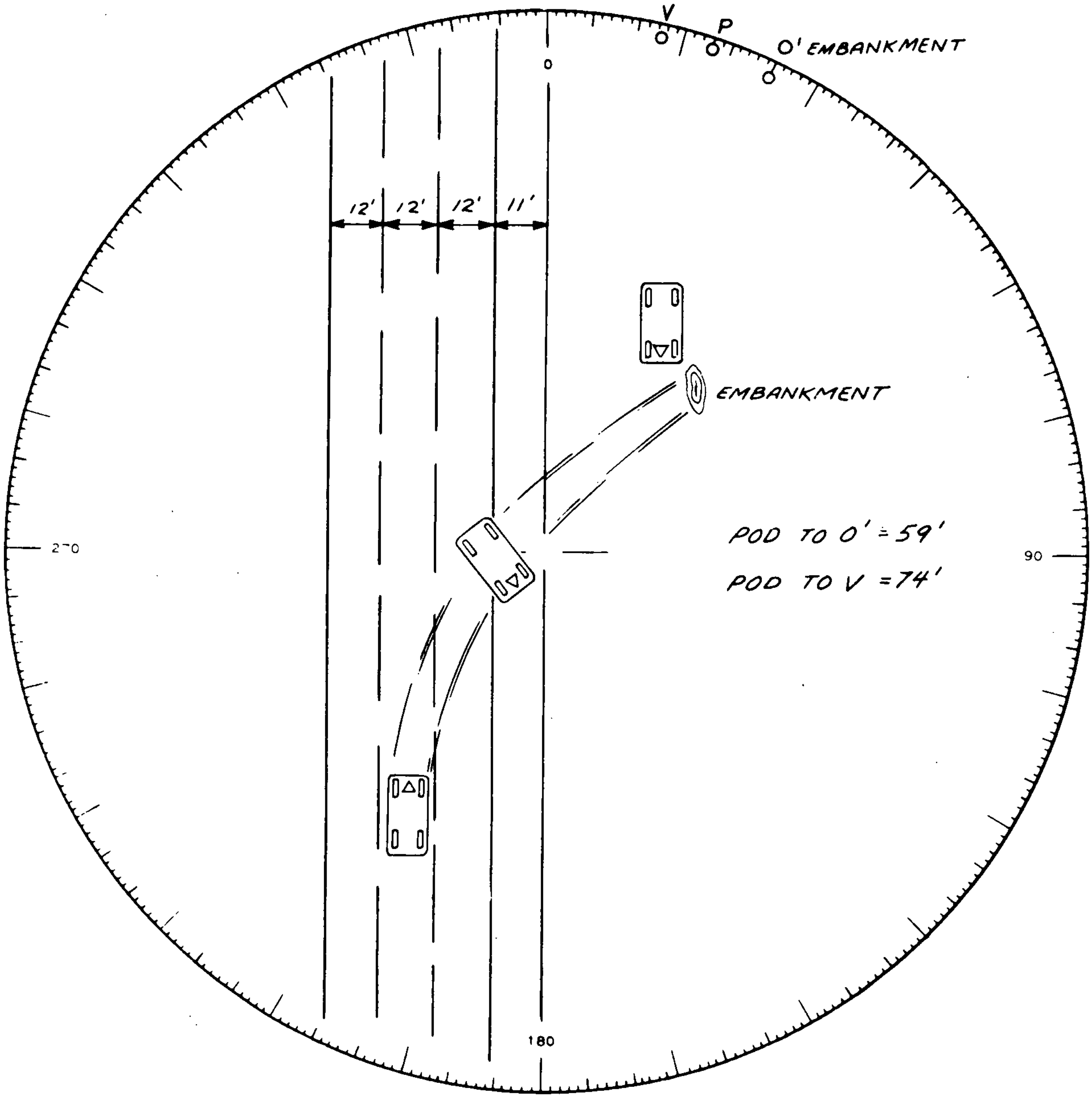


Figure 20. Vector graph record of Utah incident.

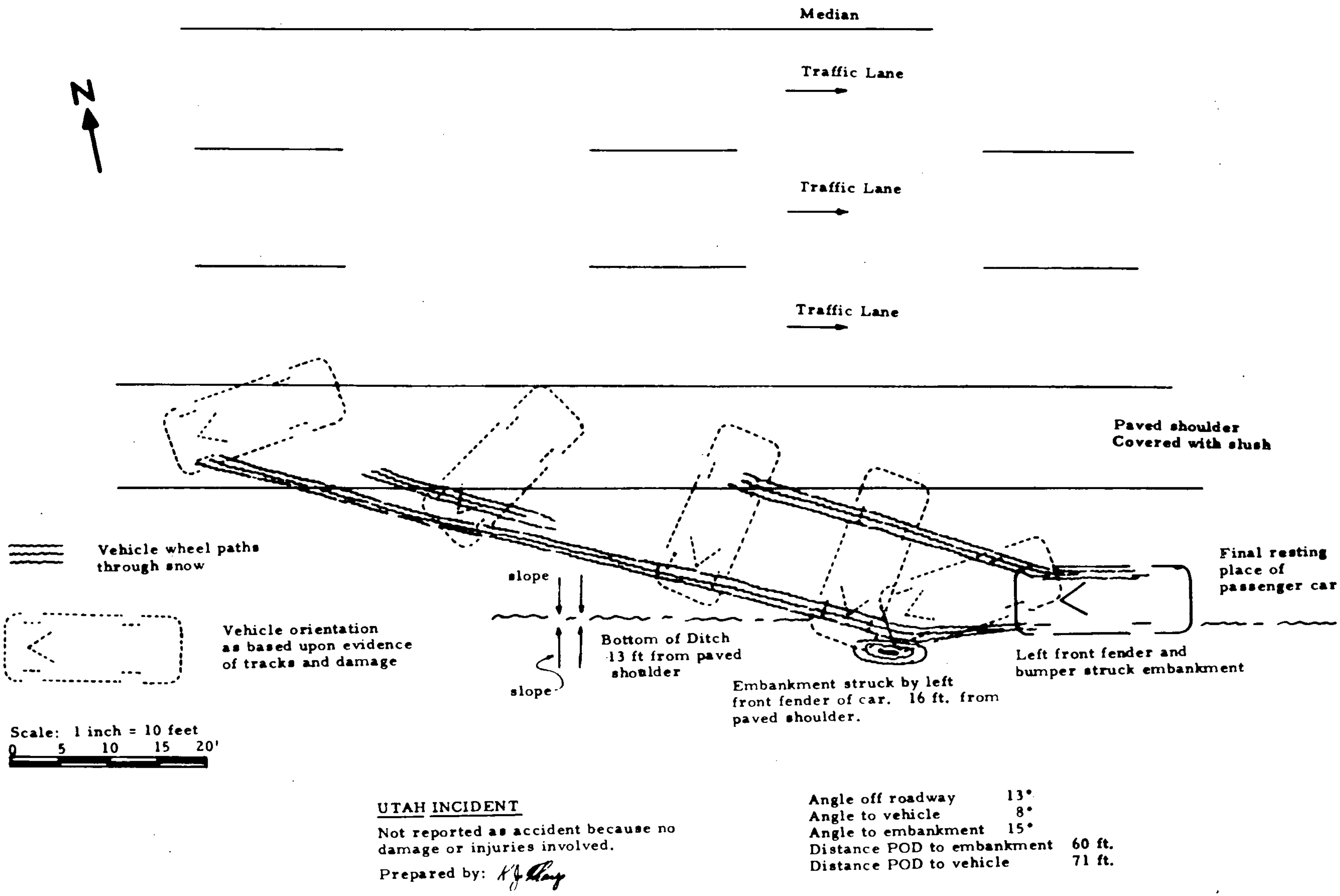


Figure 21. Engineer's field sketch of Utah incident.

ACCIDENT SCENE, VEHICLE, TRACKS AND EMBANKMENT STRUCK

Figure 22. Utah incident.

Conclusions

Based on the small number of events checked, only tentative conclusions may be drawn. The police, even with special equipment and instructions, cannot provide data of the quality that may be obtained from an engineering survey. However, the police can gather specified data from a great number of events at comparatively little cost and the quality of data collected by the police is more than adequate for the tasks to be performed. In particular, the information collected on the four cases reported here provided useful data that could be used for analysis in determining both the angle of departure and the distance traveled by vehicles after they left the roadway.

One limitation to the collected information is that only those incidents reported as accidents would be covered. It is known that during the week in Utah several vehicles were involved in off-the-roadway events and that the desired angles and distances were not recorded because they were not accidents. Many of these could have been obtained (one was received). Data concerning angles and distances traveled by non-accident-involved vehicles also are needed for complete analysis of the ran-off-roadway accident. It is apparent that many cars that leave the roadway at a shallow angle, recover, and drive on will never appear in an accident sample—and would be difficult to obtain in a non-accident population. Both types of data are needed for complete evaluation of ran-off-roadway incidents.

SUMMARY OF DEMONSTRATION STUDY PROCEDURES AND CONCLUSIONS

The sample data studies conducted as reported in this chapter indicate that it is feasible to obtain the cooperation of the state police for valid research programs, and that careful design and control of the study produce useful research data.

The cooperation of four states was obtained for this study during a period when there was some state concern about possible report form changes that might be forthcoming as a result of the formation of the National Highway Safety Bureau. However, experience in other programs of the research agency has shown that police officials believe that their personnel have benefited by the additional training in specialized investigation and that this is reflected in the completion of their own report forms.

Training in the completion of the report forms and the use of special equipment was provided for the police. A one-day course was sufficient in these studies, and time was allocated for practice in the use of such devices as tire tread and depth gauges, vector graph, and the special meter stick for measurement in the steering column study. Specific instructions were given with respect to the proper measurements to take (e.g., for tire tread depth two measurements were taken—one in the center of the tread and one near the outer edge of the tire). Training also included the specific types of photographs required.

In planning the report forms and training, an effort was made to anticipate and eliminate any problem areas. Wording used in the report form is particularly important; any term that could be misinterpreted was eliminated or explained. An instruction sheet (see Appendix D) was provided with each form. Where possible, it was placed on the back of the form and printed upside down for easy reference when attached to a clipboard. The form was tested for interpretation on a number of people before field use.

The first cases returned from the field were scrutinized carefully to determine if any form changes or further instructions were necessary. Generally, a return visit to the state was made to discuss any problems encountered and to take corrective action.

A method of checking to insure the accuracy of the data obtained is necessary. Where possible, photographs provide the best check because, in effect, the investigator provides his own 100 percent check. Checks that are a part of the reporting system (i.e., more than one way of providing the same measurement) also are useful and were used where possible (steering column study, for example). Good scene photographs and vehicle interior and/or exterior photographs add immeasurably to the value of a case. All of these checks were used, as well as a review of each case by a police sergeant, to insure completeness and correction of obvious errors.

A field check of the vehicle angle of departure was conducted for a seven-day period by an agency engineer. When operating in another state, as was necessary, this is a costly process and the return is small because few accidents can be reached in a brief span of time by one man. A local engineer could have continued his normal duties while "on call" for accident investigation far more economically. A computer edit check for completeness and consistency of data also was prepared for the study data. Finally, in data analysis, examination of patterns and trends in the data to determine if they are logical and consistent provided a good indication of the quality of the data.

It was concluded that the data provided by the police were adequate for the studies attempted. By utilizing proper data collection methods with appropriate safeguards, errors can be prevented or corrected at various points along the path to data analysis. The prevention or minimization of errors is a part of good study design and must be an objective from planning through analysis. Errors in the current accident records systems are more a function of poorly planned report form items and the absence of even the most elementary check system, than of poor reporting. In Chapter Two it is shown that a large proportion of the errors in a sample of state reports involved misinterpretation of the question on the report form and another large group represented omissions. The latter often indicated that no answer was required, but there was no way of indicating this simply; "not applicable" or an explanation would have been required. The police generally are highly motivated in this research area and make an honest and conscientious effort to provide good data. Given a good report form, proper training, and appropriate equipment by the researcher, they can be capable members of the research team.

In a special study of the types discussed here, all of the analytical phases of the study should remain in the hands of the analyst. The police should be asked to provide facts and photographs; all subjective judgments should be made when the case is analyzed for data processing. Centralization of case analysis is essential because a small analytical staff can be controlled, and even subjective ratings made, with a minimum of disagreement (*46*). It is impossible to effectively control an army of police (or anyone else for that matter) in areas involving subjectivity or in completing a lengthy and complex report.

CHAPTER FIVE

IMPROVED USE OF CURRENT ACCIDENT DATA

In this chapter the routine summaries of accident data that are reviewed in Chapter Two are discussed in terms of improved methods of examining and presenting the data. The approaches suggested do not require statistical training, but rather represent various methods of manipulating the data to improve data presentation and to facilitate reader understanding.

Also presented in this chapter are three brief statistical studies based on a computer tape containing case records from Louisiana. The reports simply illustrate the use of state data for several specific study topics. If the limitations of the data are kept in mind, studies of this type can be used for guidance in specific areas and can suggest areas where additional or improved data are needed.

STATE TRAFFIC ACCIDENT SUMMARIES

In order to develop, improve and promote traffic accident forms and specifications, definitions, and practices for the collection and summarization of traffic information by state and city governments, Federal agencies, and others, and to promote increased use of the information for accident prevention purposes, the National Safety Council's Traffic Conference organized the Committee on Uniform Traffic Accident Statistics in 1959.

The 25-man committee was headed by N. K. Woerner, Chief of Statistical Services of the Texas Department of Public Safety. In 1962 the committee's Standard Traffic Accident Summary was approved as an American Standard (D16.1—1962), by the American Standards Association. A "Manual on Classification of Motor Vehicle Traffic Accidents" (*23*) was then prepared by the committee in support of the Action Program of the President's Committee for Traffic Safety (*8*). Also, an accident report form to be used by the law enforcement agency investigating the accident was recommended and made an American Standard.

In publishing monthly traffic accident summaries, most of the state agencies responsible for such reporting follow the form recommended by the committee.

The data relating to motor vehicle accidents contained on the summaries would be useful to various groups interested in highway safety, such as police, driver education instructors, state and local legislators, traffic engineers, vehicle and highway designers, vehicle inspection personnel, and insurance companies. These groups could use the data supplied by state monthly summaries as guidelines for driver licensing policy, financial security policy, driver education curriculum, information to the general public on accident causation and prevention, the location of high accident or hazardous locations for corrective action by traffic engineers, finding areas for future research, and evaluation of local accident prevention programs.

The evaluation of the monthly summaries as published by the state was undertaken to determine whether they contain data of sufficient quality or scope to support all of the decision-making functions listed previously and to review the statistical analyses undertaken in their preparation.

Procedure

The traffic accident summaries of the ten states (Table 10) were selected for evaluation. Typical of state traffic accident summaries is the "Standard Summary of Motor Vehicle Traffic Accidents in Florida," issued monthly by the Florida Department of Public Safety for statewide, rural, and urban accidents. Many states issue only a single statewide summary; others issue rural and urban data only for certain items. In addition to the summaries, Florida also issues a "Monthly Summary of Reported Motor Vehicle Accidents by County."

These accident summaries as a group, and the Florida summary in particular, were critically reviewed for information contained therein that would provide an insight into the problem of motor vehicle accidents. Attention was also given to those tabulations of statistics which produce repetitive conclusions month after month and provide no increased knowledge by this repetition. Throughout, suggested methods of providing more meaningful summaries through improved statistical analysis of the data are provided.

General Observations on Monthly Accident Summaries

The tables found in monthly accident summaries consist almost entirely of observed frequencies of occurrence of various phenomena. Percentages are more informative to the reader than observed frequencies (see Table 11), as the percentages more readily reveal the distribution of the total number of accidents into the various groupings.

Percentages are relative and comparative measures of frequency. Thus, if the February report shows 40.1 percent of all accident drivers in the 18-34-year age group and the March report shows 31.8 percent in this group, a comparison may be made. If only frequencies are published, comparisons cannot be made until the total number of drivers in accidents for each of the two months are taken into account.

In interpreting data from tables, readers generally estimate percentages mentally. Published percentages would thus facilitate interpretation and encourage analytic thought. However, percentages should be calculated on the basis of *reported* data (see Table 11).

In addition to the percentages, the column total frequencies should be published so that the reader may, if necessary, calculate a particular frequency. For example, if the 18-34-year age group accounts for 40.1 percent of all drivers with reported ages, the number of reported drivers in this age group would probably be (0.401) × 24,697 = 9,915.

Percentage tables facilitate the study of association. For example, consider Table 12. The data indicate that the driver age distribution for fatal accidents differs from that for injury accidents; fatal accidents tend to involve younger drivers than do injury accidents. This type of analysis is discussed in more detail later.

Need for Exposure Data

It frequently is desirable to know the risk of an accident occurring under different circumstances for some particular variable. For instance, one may desire to estimate the frequency with which drivers of various age groups become involved in accidents. Obviously, a table consisting of the number of accidents involving drivers of various age groups alone cannot answer this question. It is necessary to assess the relative exposure of each age group to motor vehicle accidents.

One way to do this would be to ascertain the number of licensed drivers for each age group and the average number of miles driven monthly by each driver for each age group. The product of these two figures, the number of miles driven monthly by each age group, is an estimate of each age group's exposure to accidents. A relative and comparative measure of the risk of an accident for drivers of each age group is the number of accidents per driver-mile, or

$$r_i = \frac{f_i}{d_i - m_i} \qquad (1)$$

in which

r_i = age accident rate for ith age group;
f_i = number of accidents for ith age group;

TABLE 10

STATE TRAFFIC ACCIDENT SUMMARIES EVALUATED

STATE	YEAR	FREQUENCY	DIVISIONS
1. California	1963, 1965	Monthly	Statewide
2. Florida	1965	Monthly	Rural; urban; statewide
3. Illinois	1965	Monthly	Statewide
4. Kentucky	1965	Monthly	Rural; statewide
5. Nebraska	1965	Monthly	Statewide; county road
6. New York	1965	Monthly	Rural; urban; statewide
7. N. Carolina	1965	Monthly	Rural; urban; statewide
8. Ohio	1964, 1965	Monthly [a]	Statewide
9. S. Carolina	1964	Monthly	Statewide
10. Utah	1964	Monthly	Statewide

[a] Cumulative.

d_i = number of licensed drivers in ith age group; and
m_i = average monthly mileage per driver in ith age group.

Exposure information is necessary when studying such topics as driver's age and sex, type of vehicle, road surface condition, light condition, etc. In general, exposure could be measured in terms of estimates of miles driven by the subject operators (or subject vehicles) under the conditions being considered or in terms of combinations of exposure variables; e.g. age and miles driven. Examples of the use of odometer reading and inspection data in this manner are presented in Chapter Six.

Review of Typical Traffic Accident Summary

Following is a discussion of the Florida summary form (Fig. A-1), but it applies to most similar summaries because the format is essentially the same.

The descriptions used in the "type of accident" tabulation are neither mutually exclusive nor suitably balanced with frequency of events. One classification, "motor vehicle in traffic," accounts for 71.7 percent of all traffic accidents and 9 of the remaining 11 classifications account for less than 2 percent each. This imbalance suggests that greater benefits may be derived with a change in the classification system. Any suggested change in the classifications would require a study of the frequency of the accidents described in more detail and an appropriate regrouping according to frequency of occurrence.

The "comparative totals" afford an opportunity to test the hypothesis that no change has taken place in the accident-type distribution from one year to the next. The fact that these distributions are not expected to change greatly from year to year would suggest that this table need not be presented every month.

The mileage rates are useful, as they present the only measure of over-all accident exposure known. The death and fatal accident rates are of great concern to the general public, state and local government personnel, traffic engineers, etc. The "percent change" should be tested for significance using an approved statistical procedure.

The "location" tabulation has no research utility in its present form. Urban areas are classified by population and rural areas are classified by type of roadway, thus making comparisons between the two impossible. Listing number of fatal, non-fatal, and property damage accidents for these locations does not enhance the research value.

The "time" tabulation is of little value when published on a monthly basis. The distribution of accidents by day of week and time of day is well known and varies but slightly from area to area and year to year. There is little value in repeating it every month.

Age classifications are not grouped on a reasonable basis—not even equal age intervals. Improvements could be made by subdividing age according to some specified plan. For example, a possible grouping for occupants of vehicles could include:

Less than 1 year (infants who have little self-protection from accidents and may be sitting or lying in some kind of child restraint device)

TABLE 11

EXAMPLE OF DISTRIBUTION OF ACCIDENT DRIVERS, BY AGE

AGE OF DRIVER (YR)	NO. INVOLVED IN ACCIDENTS	PERCENT [a]
1. Under 18	796	3.2
2. 18-34	9,915	40.1
3. 35-54	8,279	33.6
4. 55-74	5,049	20.4
5. 75 and over	658	2.7
6. Not stated	800	—
All	25,497	100.00

[a] Based on 24,697 reported driver ages (25,497—800 = 24,697).

TABLE 12

EXAMPLE OF DISTRIBUTION OF AGE OF DRIVERS IN FATAL AND INJURY ACCIDENTS

AGE OF DRIVER (YR)	DISTRIBUTION (%) FATAL ACCIDENTS	DISTRIBUTION (%) INJURY ACCIDENTS
Under 18	10.0	4.0
18-34	60.6	41.1
35-54	20.1	33.2
55-74	8.2	19.6
75+	1.1	2.1
All	100.0	100.0
N	168	8003

1—4 year group (probably seated on the lap of an adult)
5—9 year group (passengers in vehicles driven by mature adults)
10—14 year group (passengers in vehicles driven by mature adults)
15—19 year group (tend to be driving alone or are passengers in vehicles driven by others in their age group)
20—24 year group (tend to be driving alone or are passengers in vehicles driven by others in their age group)
Etc.

Members in the last two age groups tend to have higher accident frequencies, more ejections, and higher injury severity than either the younger or the more mature groups.

The "directional analysis" tables are confusing and have little value without knowledge of the specific roadways involved and the traffic volumes. Better categories also could be used.

The "pedestrian actions by age" table is of considerable interest. The 12 pedestrian action classifications appear to adequately describe the spectrum of possible pedestrian actions and there is little tendency for any of the classifications to have overlapping definitions. The data allow the determination of age groups that are associated with various types of pedestrian actions. Such knowledge is important if corrective action is to be taken.

The "age of driver," "driver's sex," and "residence of driver" tables are merely numerical tabulations and provide no data for comparison or rates. These data would be useful if cross-tabulated with other variables such as type of accident or speed of vehicle. Cross-tabulations could point out a specific need for corrective action and periodic examination of the tables could provide the basis for assessing the effectiveness of the corrective action.

The "contributing circumstances" category basically represents the reporting officer's opinion of traffic violations or other illegal action on the part of one or more drivers. Nevertheless, if presented, the usefulness of the data would be enhanced by cross-tabulation with variables such as type of accident, sex, age, and driver experience. In addition, minor improvements could be made in the classification of contributing circumstances (i.e., in addition to "inadequate brakes" and "inadequate lights," a classification for "other mechanical defects" would be appropriate; a classification for "impossible to determine" would also be advantageous).

The "type of vehicle" classifications appear to cover the full spectrum of motor vehicles with little tendency for one classification to overlap another. Again cross-tabulations of type of vehicle with type of accident, degree of injury to occupants by seated position, etc., would be of benefit. Subgrouping of automobiles by size, body style, or weight also would be useful.

The "road surface condition" tabulation is of little value alone and would be of greater use if cross-tabulated with accident type. Analysis of such a cross-tabulation would indicate the types of accidents which take place on various road surfaces.

The classifications "built-up" and "not built-up" in the "kind of location" tabulation are essentially meaningless.

The terminology used to classify "light conditions" could be improved. For example, the occurrence of an accident on an illuminated roadway at night is not adequately covered by any of the listed choices.

At the conclusion of each monthly summary, there is often a subclassification of motor vehicle accidents by county. The format varies somewhat from state to state, but basically a tabulation of property damage, injury-producing, and fatal accidents is presented for each county in the state. Most states make an urban and rural breakdown and some (e.g., Florida) give the mileage death rate (the number of fatalities per 100 million vehicle-miles traveled).

County data alone—although of interest to that level of government—are insufficient for analysis because counties frequently include both urban and rural elements, a variety of highways and traffic conditions. It might be more useful to summarize data for specific locations, such as cities or towns or other better defined localities. Accident data might then be grouped according to many socioeconomic, traffic, and local government factors easily obtained from other published sources, thereby allowing the data to be subjected to statistical analysis.

Opportunity to use a number of varied statistical techniques exists with the recorded data, especially when data are available for the same period from year to year. Such techniques include tests of significance between two frequencies reported from two different years, tests of significance between successive year's death rates, and tests of the difference between percentages for two different years. All three tests could be performed for counties or areas of particular interest; the results would indicate the results of local traffic safety programs.

Variations in Traffic Accident Summaries

The standard traffic accident summary is merely a recommended form and the responsible state agencies are free to modify and deviate from this standard as they desire. Some of the data collected for these modifications could be of considerable benefit if analyzed in greater detail. For example:

1. Florida includes a section in which seat-belt installation and use is cross-tabulated with all accidents, fatal accidents, and injury accidents. The tabulation does not include seated position or severity of injury. Addition of these two items would permit a more thorough determination of seat-belt effectiveness.

2. Nebraska provides data on "completed driver's education course," which would be of immense interest if some means of comparison between the "yes" and "no" answers was provided. This comparison would require knowledge of at least the numbers of licensed drivers in both categories, or preferably a measure of exposure for each category.

3. The New York State Department of Motor Vehicles provides data concerning manner of collision (head-on, rear end, angle, etc.) cross-tabulated with severity of the event (fatal, non-fatal, property damage). This tabulation would permit a test of the hypothesis that injury severity is the same for each manner of collision.

New York also includes a one-page written commentary each month. This commentary may compare injury and fatality data for the month with last year's data, may compare data from various counties or areas within the state, etc.

4. The California Highway Patrol has modified the monthly summary and has introduced many innovations into the form. One useful table contains a statewide distribution of the age of the state's population and licensed drivers for comparison with a corresponding distribution of the age of drivers involved in accidents under various conditions. These data provide the opportunity to undertake various statistical tests for relationships.

The California summary also contains more detailed information on driver violations and type of motor vehicle in accidents, but only cross-tabulates these with fatal and injury accidents.

The California summary omits time of day, day of week, and directional analysis data.

Use of Written Commentary

The standard summary of motor vehicle traffic accidents consists entirely of the 16 tabulations evaluated previously.

These summaries leave the reader with the task of interpreting the data himself. He is thus expected to analyze the data and note trends, a task he may be unable to perform because of lack of ability, available time, and/or sufficient interest. Indeed, the reader without statistical training who attempts to interpret the motor vehicle accident data is likely to fall prey to the many pitfalls described.

A written interpretive commentary of several pages would be a useful part of each monthly summary. Written by one or more persons on the staff of the issuing agency, the commentary could contain an analysis of some of the data presented in the summary and perhaps introduce data not presented but helpful in the analytic process (such as exposure data, data from the previous year, data from neighboring states, data from national totals). Presentation of every possible contingency table or significance test each month would be impossible, and perhaps even defeat the purpose of the commentary. Rather, various pertinent hypotheses could be selected for testing each month.

Figure 23, based on the February 1965 Florida accident data with supplementing fictitious data, is a brief example of a suggested format for such a commentary.

STUDIES BASED ON STATE DATA

Analysis of Automobile Speed Data

In reporting motor vehicle accidents, Louisiana state police record not only the estimated speed of each vehicle in the

Fatality Rates

The fatality rate for 1965 to date was 6.7, an increase of 8.1% over the same period last year. The increase did not show evidence of statistical significance at the 0.05 level.

The fatality rates for 1965 to date for three neighboring states were: State A, 6.2; State B, 6.9; State C, 6.5. There was no evidence of a significant difference between the death rates of these states and that of Florida, at the 0.05 level.

Four counties (Counties R, S, T, and U) showed a significant increase in death rate over the same period last year, while two counties (Counties X and Y) recorded death rates that were significantly less than those of last year. The decrease in County X may be accounted for in part by the increased police activity along county roads in the more heavily populated areas of the county.

Fatal Accident Rate by Sex

Of the 4,382 million miles traveled in this period, it is estimated that 22.3% were driven by women and 77.7% by men. Consolidating these data with the data in Table 9 of Figure A-1, the following is observed:

Sex	Fatal Accidents	Millions of Miles Driven	Fatal Accident Rate Per 100,000,000 Vehicle-Miles
Male	138	3405	4.1
Female	31	977	3.2
Pct. Diff.			+28.1

$$\text{Pct. Difference} = \frac{\text{Male Rate} - \text{Female Rate}}{\text{Female Rate}}$$

The difference in fatal accident rate between males and females is *not* statistically different at the 0.05 level.

Light Conditions vs Accident Type

Light Condition	Accident Type: Property Damage	Fatal	Injury	Total
Daylight	6949	57	2973	9979
Dawn or dusk	336	6	152	494
Darkness	2450	55	1412	3917
All	9735	118	4537	14390

The association between accident type and light conditions was tested and found statistically significant at the 0.05 level by the Chi-square test. Thus the distribution of accident type differs for different light conditions. Specifically, more injury-producing and fatal accidents occur during hours of darkness than during daylight or dawn-dusk, and more property damage accidents occur under daylight than dawn-dusk or darkness.

Figure 23. Suggested accident commentary format.

accident, but also the posted roadway speed. Availability of these data facilitates an investigation into the relationship of posted speeds and actual speeds for several explanatory variables.

A magnetic tape containing 14,066 one- and two-vehicle Louisiana rural and unincorporated area accident records obtained in 1962 furnished speed data on 19,160 passenger cars. Of these, 18,582 passenger cars were distributed by posted speed as given in Table 13. These 18,582 passenger cars formed the basis of this investigation. For 560 passenger cars the posted speed was less than 21 mph; these are not considered here. The extent of fast and slow driving under varying conditions of road alignment, surface condition, type of roadway, collision type, and day of week-time of day is to be investigated. For each variable a table indicating the incidence of slow and fast driving at various posted speeds is presented.

The analysis that follows attempts to shed some light on when and where speeding, or excessively slow driving, by drivers of vehicles that are involved in accidents takes place. It also attempts to point out the type of collision that the accident represents. Data were not available on the demographic nature of drivers who speed or the extent and types of injuries, if any, that they sustain. No data are available on the actual speed-posted speed distributions for drivers who do not become involved in accidents. Comparison of the accident and non-accident speed distribution under controlled conditions would more effectively point out the effects of speeding. Nevertheless, applications to insurance, law enforcement, and highway engineering practice of the data analyzed herein are numerous. Highway engineers may gain insight into the nature of speeding for various road alignments, road surface conditions, and types of roadway. Law enforcement agencies might be interested in the collision type and day of week-time of day analyses. Insurance executives might find all five variables of interest and would probably be able to draw some inferences regarding the age distribution of speeders from the day of week-time of day analysis (e.g., teenagers tend to drive their cars at different times than housewives, etc.)

Actual speed of each passenger car was classified as stopped, 1-20 mph, 21-40 mph, 41-60 mph, 61-80 mph, or 81-100 mph. Posted speeds were considered at 21-40 mph, 41-60 mph, and 61-80 mph. A driver is said to be driving "slowly" if his actual speed lies at least one class below the class of his posted speed. However, drivers whose vehicles were stopped at the time of their accident are not placed in the "slow" driver group. Drivers whose vehicles were traveling with actual speeds at least one class above that of posted speed are classified as "fast" drivers. Standardized slow and fast driving percentages and mean actual speeds were calculated using the over-all posted speed distribution as the basis of standardization weights.

In general, the slow driving rates increase and the fast driving rates decrease as posted speed increases. The ability and the temptation to speed are probably greater at lower posted speeds than at higher posted speeds. The mean actual speeds for each level of posted speed are considerably lower than would be expected. Table 14 shows the over-all slow driving and fast driving rates and mean actual speeds. The mean actual speeds of 18.0 mph, 32.8 mph, and 35.7 mph for posted speeds of 21-40 mph, 41-60 mph, and 61-80 mph, respectively, are surprisingly low. The over-all standardized fast driving rate is 3.9 percent, whereas the slow driving rate is 43.8 percent. It is surprising that accident vehicles would have fast driving rates as low as 3.9 percent and slow driving rates as high as 43.8 percent, even though it is recognized that slow driving can be a contributing factor in automobile accidents.

The reason for these apparently surprising results is that the "stopped" actual speed group probably includes a high percentage of cars whose actual speed was not reported by the investigating officer. Many of the cars whose speed was not reported could have been speeding at the time of their accident but the officer may have been unable to furnish sufficient evidence of this speeding, and thus merely refrained from reporting any actual speed. In any event, it is believed that although the magnitude of the slow and fast driving rates may be in error, the direction of differences observed is not.

TABLE 13

DISTRIBUTION OF POSTED SPEED FOR 18,582 PASSENGER CARS IN ACCIDENTS IN LOUISIANA, 1962

POSTED SPEED (MPH)	DISTRIBUTION	
	NO.	PERCENT
21-40	4,805	25.86
41-60	12,406	66.76
61-80	1,371	7.38
All	18,582	100.00

TABLE 14

OVER-ALL SPEED DISTRIBUTION

POSTED SPEED (MPH)	NO. OF AUTOS	MEAN ACTUAL SPEED (MPH)	% SLOW	% FAST
30	4,805	18.0	37.5	6.7
50	12,406	32.8	42.5	5.5
70	1,371	35.7	78.3	0.7
Standardized	18,582	29.2	43.8	3.9

Road Alignment

Table 15 presents the road alignment speed data. The standardized data (mean actual speed, slow driving rates, and fast driving rates) from that table are summarized in Table 16.

The standardized rates and mean actual speeds of accident vehicles indicate that on a level road there was a higher incidence of speeding in curved rather than straight sections. Excessive speed could have been a contributing factor in the accidents that took place on curve-level roads. A similar phenomenon is observed for on-grade and hillcrest-dip-hump accidents. For straight roads, the fast driving rate appears highest in on-grade accidents and lowest in both level and hillcrest-dip-hump accidents. For curve roads the fast driving rate also appears highest in on-grade accidents.

Surface Condition

Table 17 presents the speed data by surface condition at the time of the accident. In addition to the three classifications appearing in Table 17, there were 11 passenger cars involved in accidents in which the surface condition was described as "muddy"; these latter are not included.

TABLE 15

SPEED DATA, BY ROAD ALIGNMENT

ROAD GEOMETRY	POSTED SPEED (MPH)	NO. OF AUTOS	MEAN ACTUAL SPEED (MPH)	% SLOW	% FAST
Straight, level	30	4162	17.5	38.1	5.4
	50	9413	31.1	45.1	3.6
	70	1194	35.2	78.8	0.5
	Std.[a]	(14769)	27.9	45.8	3.8
Curve, level	30	346	22.5	60.9	9.5
	50	1427	39.8	31.2	14.6
	70	59	42.2	79.7	3.4
	Std.[a]	(1832)	35.5	42.5	12.5
Straight, on grade	30	171	20.9	30.4	14.0
	50	833	35.7	36.5	6.4
	70	71	33.8	69.0	2.8
	Std.[a]	(1075)	31.7	37.3	8.0
Curve, on grade	30	71	23.7	35.2	19.7
	50	464	38.5	36.6	14.7
	70	22	43.2	77.2	18.2
	Std.[a]	(557)	35.0	39.2	16.3
Straight, hillcrest-dip-hump	30	38	16.8	36.8	2.6
	50	195	34.2	40.0	5.1
	70	23	39.1	73.9	—
	Std.[a]	(256)	30.1	41.7	4.0
Curve, hillcrest-dip-hump	30	5	22.0	40.0	—
	50	67	36.9	35.8	13.4
	70	2	50.0	100.0	—
	Std.[a]	(74)	34.0	41.6	8.9
Bridge structure	30	7	15.7	28.6	—
	50	3	36.7	66.7	—
	70	—	—	—	—
	Std.[a]	(10)	28.6	24.0	—

[a] Standardized.

TABLE 16

SUMMARY OF STANDARDIZED SPEED DATA FOR ROAD ALIGNMENT

ROAD ALIGNMENT	PERCENTAGE SPEEDING			PERCENTAGE SLOW			MEAN SPEED (MPH)		
	LEVEL	GRADE	HILLCREST	LEVEL	GRADE	HILLCREST	LEVEL	GRADE	HILLCREST
Straight	3.8	8.0	4.0	45.8	37.3	41.7	27.9	31.7	30.1
Curve	12.5	16.3	8.9	42.5	39.2	41.6	35.5	35.0	34.0

The standardized rates and mean actual speeds for surface condition indicate lower fast driving rates for wet, snowy-icy, and muddy conditions than for dry conditions. This is not surprising. Motorists are likely to be cautious while driving on wet or snowy-icy roads and thus drive at slower speeds. Similarly, the standardized rates for slow driving are higher for unfavorable conditions.

Data are not available on the magnitude of speeding rates for non-accident automobiles. It is possible that although the speeding rate decreases under unfavorable surface conditions, the rate is still higher for accident cars than for non-accident cars under similar conditions.

Type of Roadway

Table 18 gives the speed data by type of roadway. The speeding rate on two-lane roads appears to be higher than that on wider roads; similarly, the slow speed rate on the former is lower than that on the latter. There appears to be no immediate explanation to this finding.

TABLE 17

SPEED DATA, BY SURFACE CONDITION

SURFACE CONDITION	POSTED SPEED (MPH)	NUMBER OF AUTOS	MEAN ACTUAL SPEED (MPH)	% SLOW	% FAST
Dry	30	3647	18.4	37.6	7.5
	50	9724	33.2	41.7	6.0
	70	1087	35.6	76.9	0.8
	Std.[a]	(14458)	29.5	43.4	6.0
Wet	30	1138	17.0	36.8	4.3
	50	2553	31.8	44.8	3.6
	70	276	36.0	83.1	0.4
	Std.[a]	(3967)	28.3	45.6	3.5
Snowy-icy	30	19	12.2	72.2	—
	50	117	24.2	63.3	1.7
	70	8	31.3	87.5	—
	Std.[a]	(143)	21.6	67.4	1.1

[a] Standardized.

TABLE 18

SPEED DATA, BY TYPE OF ROADWAY

ROADWAY TYPE	POSTED SPEED (MPH)	NUMBER OF AUTOS	MEAN ACTUAL SPEED (MPH)	% SLOW	% FAST
Two lanes	30	1865	20.1	35.1	11.5
	50	10902	33.9	40.2	5.9
	70	88	31.9	85.3	—
	Std.[a]	(12855)	30.2	42.2	6.9
4 or more lanes [b]	30	1096	16.4	42.1	3.2
	50	707	24.5	63.1	1.4
	70	488	33.9	79.2	0.2
	Std.[a]	(2291)	23.1	58.9	1.8
Divided	30	1826	16.9	37.2	4.0
	50	733	24.0	57.1	2.1
	70	787	37.3	77.1	1.1
	Std.[a]	(3346)	23.1	53.4	2.5

[a] Standardized. [b] Double center.

Data for one-way roads comprised only 21 accident cars, insufficient for meaningful statistical analysis, so were omitted from Table 18.

Collision Type

Table 19 gives the speed data by collision type. The most noticeable effect of collision type on fast driving standardized rates is found in the ran off road-out of control collision type. The fast driving rate for this group is 12.3 percent and standardized mean actual speed is 39.4 mph. Both are considerably higher than those for the other collision types. In addition, the slow driving standardized rate (28.6 percent) is considerably less than those of the other collision types. It appears that more ran off road-out of control accidents take place while a driver is exceeding safe speed levels.

Day of Week-Time of Day

For this analysis the day was divided into four 6-hour time intervals. These intervals are considered for both weekdays and weekends, making eight levels. The weekend is defined as Friday 6 PM to Sunday 6 PM.

The day of week-time of day data are given in Table 20 and the standardized data are summarized in Table 21. Fast driving rates and mean actual speed were highest for 12:01—6 AM and 6:01 PM—12 M for both weekdays and weekends.

Speeding is a frequent contributing circumstance to accidents occurring between 6:01 PM and 6:00 AM. Thus, these findings are not surprising. It is possible that state troopers are more likely to overestimate the actual speed of an auto during this period, especially on weekends when teenagers are driving in great numbers, as a result of previous experience and prejudices. However, the lower traffic volume and general atmosphere of these hours tend to support the results of higher fast driving rates and mean actual speeds.

From the Louisiana 1962 experience it appears that passenger cars involved in accidents are operated in excess of posted speeds when they are traveling on curved roads on grades, on dry pavement, between 6:01 PM and 6:00 AM on weekends. The resulting collision type is frequently "ran off road."

Property Damage Cost and Impact Speed

The purpose of this investigation was to determine the relationship between the higher impact speed * of two vehicles in a two-vehicle accident and the dollar amount of the resulting property damage. The results of this analysis may be useful in making estimates of resulting property damage from accidents of various impact speeds and configurations. The dollar value of the resulting property

* Higher impact speed is (1) the speed of the fastest moving vehicle at the time of impact in a two-vehicle collision or (2) the impact speed of the vehicle in a one-vehicle collision.

TABLE 19

SPEED DATA, BY COLLISION TYPE

COLLISION TYPE	POSTED SPEED (MPH)	NUMBER OF AUTOS	MEAN ACTUAL SPEED (MPH)	% SLOW	% FAST
Head on	30	176	21.7	26.1	6.8
	50	928	32.0	48.9	3.3
	70	779	41.7	92.1	0.1
	Std.[a]	(1883)	30.1	46.2	4.0
Rear end	30	2136	14.3	30.8	3.8
	50	4039	26.3	47.2	2.4
	70	617	34.1	71.0	0.6
	Std.[a]	(6792)	23.8	44.7	2.6
Right angle	30	1733	18.5	51.5	4.9
	50	3624	29.1	54.1	1.9
	70	410	32.3	86.3	—
	Std.[a]	(5767)	26.6	55.8	2.5
Sideswipe	30	348	20.5	39.9	5.2
	50	740	31.7	53.6	2.0
	70	132	37.7	67.9	3.0
	Std.[a]	(1220)	29.2	51.1	2.9
Ran Off road-out of control	30	196	27.8	23.0	20.4
	50	1283	43.3	25.3	10.5
	70	70	45.3	78.5	—
	Std.[a]	(1549)	39.4	28.6	12.3

[a] Standardized.

TABLE 20

SPEED DATA, BY DAY OF WEEK—TIME OF DAY

DAY AND TIME	POSTED SPEED (MPH)	NUMBER OF AUTOS	MEAN ACTUAL SPEED (MPH)	% SLOW	% FAST
Weekday 12:01-6 AM	30	149	24.1	24.2	16.1
	50	711	38.9	28.6	10.9
	70	67	38.7	74.6	3.0
	Std.[a]	(927)	35.1	30.9	11.7
Weekday 6:01 AM-12 N	30	843	16.4	44.5	4.2
	50	1856	29.9	49.1	2.1
	70	192	34.7	79.7	0.5
	Std.[a]	(2891)	26.8	50.2	2.5
Weekday 12:01-6 PM	30	1373	15.7	42.9	3.1
	50	2877	29.0	49.6	2.9
	70	324	33.0	80.5	—
	Std.[a]	(4574)	25.9	50.1	2.7
Weekday[b] 6:01 PM-12 M	30	787	19.8	34.7	9.8
	50	1895	34.2	38.0	6.1
	70	215	37.1	77.6	1.4
	Std.[a]	(2897)	30.7	40.1	6.7
Weekend 12:01-6 AM	30	194	24.9	18.0	19.0
	50	988	40.2	25.6	14.8
	70	117	41.9	77.8	0.9
	Std.[a]	(1299)	36.4	27.5	14.9
Weekend 6:01 AM-12 N	30	315	17.0	39.4	4.4
	50	888	32.4	46.4	3.9
	70	91	35.1	79.2	1.1
	Std.[a]	(1294)	28.6	47.0	3.8
Weekend 12:01-6 PM	30	571	17.4	35.6	6.0
	50	1618	31.8	46.8	4.8
	70	179	36.2	78.2	1.1
	Std.[a]	(2368)	28.4	46.2	4.8
Weekend[c] 6:01 PM-12 M	30	573	20.9	29.3	10.1
	50	1569	35.3	37.4	6.7
	70	190	34.2	74.7	10.0
	Std.[a]	(2332)	31.5	38.1	7.8

[a] Standardized. [b] Does not include accidents occurring Friday 6:01 PM-12 M, but does include accidents occurring Sunday 6:01 PM-12 M. [c] Includes accidents occurring Friday 6:01 PM-12 M, but does not include accidents occurring Sunday 6:01 PM-12 M.

TABLE 21

SUMMARY OF STANDARDIZED DATA FOR DAY OF WEEK—TIME OF DAY

TIME OF DAY	WEEKDAY NO. OF AUTOS	WEEKDAY MEAN ACTUAL SPEED (MPH)	WEEKDAY % SLOW	WEEKDAY % FAST	WEEKEND NO. OF AUTOS	WEEKEND MEAN ACTUAL SPEED (MPH)	WEEKEND % SLOW	WEEKEND % FAST
12:01-6 AM	927	35.1	30.9	11.7	1299	36.4	27.5	14.9
6:01 AM-12 N	2891	26.8	50.2	2.5	1294	28.6	47.0	3.8
12:01-6 PM	4574	25.9	50.1	2.7	2368	28.4	46.2	4.8
6:01 PM-12 M	2897	30.7	40.1	6.7	2332	31.5	38.1	7.8

damage (i.e., damage to both vehicles and other private and public property) may be looked upon as an index of accident severity, and thus estimates of the effect of higher impact speed on accident severity for different configurations may be formulated. Once again, 1962 Louisiana Department of Public Safety data wcrc utilized.

During their investigation of motor vehicle accidents, Louisiana state police are asked to estimate the speed of each vehicle in the accident just prior to impact. Wherever possible they measure skid marks and include this measurement as a part of their accident report.

The state police are unlikely to report any speed that cannot be proven, at a later date, to have been sufficiently close to the actual speed observed. This enhances the credibility of the accuracy of the data. Moreover, with impact speeds classified into 20-mph categories it is reasonable to assume that errors in classification of impact speeds are minimal.

The 14,066 one- and two-vehicle accidents in the study were broken down into 16 accident configurations. Within each configuration, the accidents were further broken down into speed categories by the higher impact speed of the two vehicles (or the impact speed of the vehicle in one-vehicle accidents). Speed was classified at 20-mph intervals (1-20, 21-40, etc., mph). Within each speed category, the median dollar amount of property damage was determined.

It is desired to find an algebraic expression that describes the relationship between the higher impact speed and the median dollar value of resulting property damage. A preliminary investigation of the data suggests that a linear relationship is involved. Consider the model:

$$Y = b_0 + b_1 X (\text{for } X > 0) \quad (2)$$

in which Y is the property damage, in dollars, and X is the higher impact speed.

This model has a good deal of intuitive appeal. The higher the impact speed, the greater the property damage. However small the higher impact speed, there exists some lower limit on the property damage. The term b_0 may be called the "initial cost" and b_1 the incremental cost per each additional 1 mph of higher impact speed.

Insurance executives could apply this analysis to determine the effect of the higher impact speed of the two vehicles in a two-vehicle accident on the magnitude of the resulting property damage claim (in dollars). Highway engineers could similarly use these data to estimate the effect of higher impact speed on the severity of accidents. Both of these investigations could lead to research into the nature of speeding and methods of curtailing speeding and setting of safe speed levels. The existence of an algebraic relationship between property damage and higher impact speed might be of use to law enforcement agencies and insurance companies in training personnel to estimate the cost of property damage.

Within each of the 16 accident configuration classes, the median property damage within each speed class was regressed against the midpoint of the speed class (the midpoint of the 1-20 mph speed class is 10 mph, of 21-40 mph is 30 mph, etc.).

The regression analysis was weighted; i.e., property damage medians based on larger samples counted more heavily in determining b_0 and b_1 than did medians based on smaller samples.

Table 22 presents the median property damage figures by the higher impact speed, and the estimates of b_0 and b_1 for the various configurations of two-vehicle accidents. Regression analysis was not applied to those configurations where medians were available for fewer than three speed levels. Even with three speed levels, the errors associated with the estimates of b_0 and b_1 may be substantial. Nevertheless, the data indicate that for accidents involving passenger cars the incremental property damage cost (b_1) is between $7 and $9 per 1 mph of the higher impact speed. It seems apparent that property damage increases approximately linearly with increasing impact speed. In some configurations the incremental property damage cost is greater than in others. It is expected that the incremental cost of a passenger car-motorcycle/bicycle accident will be less because whatever damage is done to the motorcycle or bicycle by the passenger car is done at low speeds, with little additional cost accruing with higher impact speeds.

To form more reliable estimates of b_0 and b_1, all two-vehicle accidents were pooled and one weighted regression

TABLE 22

MEDIAN PROPERTY DAMAGE IN TWO-VEHICLE ACCIDENTS BY THE HIGHER IMPACT SPEED, AND REGRESSION COEFFICIENTS

ACCIDENT CONFIGURATION	MEDIAN PROPERTY DAMAGE ($) FOR HIGHER IMPACT SPEED (MPH) OF						
	1-20	21-40	41-60	61-80	81+	b_0	b_1
Passenger car-passenger car	156	321	488	709	1000	61	8.7
Passenger car-light truck	128	308	427	810	—	43	8.3
Passenger car-heavy truck	98	312	450	712	—	27	8.9
Passenger car-tractor-trailer	174	321	449	—	—	112	6.8
Passenger car-bus	151	279	451	—	—	60	7.7
Passenger car-bicy./motorcycle	75	230	201	—	—	85	2.8
Light truck-light truck	201	329	434	—	—	152	5.7
Light truck-heavy truck	91	306	334	—	—	125	4.6
Heavy truck-heavy truck	75	346	584	—	—	−38	12.6

estimate of b_0 and b_1 was formulated to cover all two-vehicle accidents (Table 23). The resulting regression equation is

$$Y = 54.88 + 8.62X \quad (3)$$

and 98.4 percent of the variation in property damage is explained by this curve. In other words, the initial cost is \$54.88 and the incremental cost is \$8.62; for instance, the property damage for a 35-mph impact speed would be $Y = 54.88 + (8.62 \times 35) = \$356.58$, or \$357. It is realized that sampling error is inherent in this estimate. Figure 24 shows the regression line of Eq. 3, as well as the 95 percent confidence band. For each property damage estimate on the regression line, the probability is 95 percent that the mean value of property damage lies between the points on the confidence bands directly above and below it. In the case of a 35-mph impact speed, the value \$357 is read from the regression line and the confidence band indicates that the probability is 95 percent that the true property damage lies between \$340 and \$373.

Table 24 presents the median property damage figures and the estimated regression coefficients for one-vehicle accidents. For out-of-control accidents the initial costs (b_0) and incremental costs (b_1) both increase as the weight of the vehicle involved increases. This indicates that at any speed more property damage takes place when a heavier vehicle, such as a heavy truck, runs out of control than for a light vehicle like a passenger car. The regression line is very steep for passenger car impacts with animals. The incremental cost per 1 mph of the higher impact is \$15.70. This may be explained by the fact that the cost of caring for or replacing injured or deceased animals can be substantial and the extent of damage increases considerably with increasing speed.

It has been demonstrated that property damage, and, perhaps equivalently, accident severity, increases linearly with impact speed. The extent of this dependence differs somewhat between vehicles of various types, but the general equation (Eq. 3) has proven satisfactory for all types of two-vehicle accidents combined. Linear dependence of property damage on impact speed has also been observed for selected types of one-vehicle accidents. It may prove valuable to law enforcement agencies as an aid in estimation of property damage. The sizes of the one-vehicle accident samples are given in Table 25.

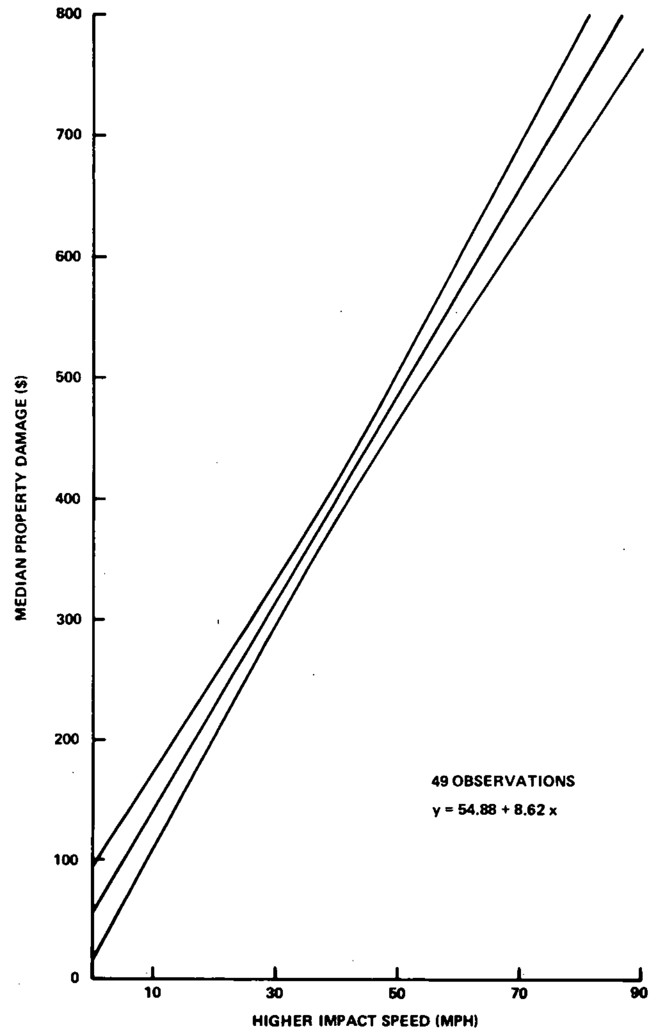


Figure 24. Median property damage vs higher impact speed.

TABLE 23

SAMPLE SIZES IN TWO-VEHICLE ACCIDENTS, BY THE HIGHER IMPACT SPEED

ACCIDENT CONFIGURATION	ACCIDENTS AT HIGHER IMPACT SPEED (MPH) OF				
	1-20	21-40	41-60	61-80	81+
Passenger car-passenger car	958	2517	2666	246	14
Passenger car-light truck	190	547	707	55	5
Passenger car-heavy truck	220	550	490	44	2
Passenger car-tractor-trailer	22	45	67	3	—
Passenger car-bus	20	48	50	13	—
Passenger car-bicy./motorcycle	24	31	35	3	—
Light truck-light truck	15	41	46	—	—
Light truck-heavy truck	20	77	69	1	—
Heavy truck-heavy truck	21	78	43	—	—

Property Damage Cost and Collision Type

The purpose of this investigation was to ascertain the relative costs, in property damage, of motor vehicle collisions of various types. The study utilizes 1962 traffic accident data from the Louisiana Department of Public Safety. These data consist of 15,311 accidents occurring principally in rural and unincorporated urban areas of Louisiana. The 14,066 single-vehicle and two-vehicle accidents available were used in this analysis.

During their investigation of motor vehicle accidents Louisiana state police are required to estimate the total property damage in the accident. It is assumed that these estimates are of sufficient accuracy to make the following analysis meaningful.

The term "accident configuration" refers to the types of vehicles involved in the accident. Thus, the configuration "passenger car-light truck" refers to an accident in which a passenger car collided with a light truck. The following list of motor vehicle and non-motor vehicle classifications is used by the Louisiana Department of Public Safety:

Motor Vehicle	Non-Motor Vehicle
Passenger car	Pedestrian(s)
Light truck	Train or street car
Heavy truck	Fixed object
Tractor-trailer	Tree, animal
Bus or school bus	Out of control/non-collision
Bicycle or motorcycle	

The estimated property damage figure reported by the investigating authorities represents the total property damage (in dollars) attributable to the accident; i.e., the estimate includes all damaged vehicles as well as other property.

Insurance executives require information regarding the cost of accidents of various types. Such information is used in establishing insurance rates and in determining priorities for accident research and prevention. Similarly, the highway engineer can use property damage as an estimate of accident severity to evaluate the costs of accidents at various sites and establish priorities for corrective action. Tables 26 through 29 should prove useful in this regard.

TABLE 24

MEDIAN PROPERTY DAMAGE IN ONE-VEHICLE ACCIDENTS, BY THE HIGHER IMPACT SPEED, AND REGRESSION COEFFICIENTS

ACCIDENT TYPE	MEDIAN PROPERTY DAMAGE ($) FOR HIGHER IMPACT SPEED (MPH) OF						
	1-20	21-40	41-60	61-80	81+	b_0	b_1
Out of control:							
Passenger car	274	336	489	658	769	121	7.5
Light truck	358	314	461	680	—	153	6.4
Heavy truck	434	720	846	—	—	408	9.5
Tractor-trailer	—	2251	2601	—	—	—	—
Passenger car with:							
Pedestrian	—	201	95	—	—	—	—
Fixed object	—	344	578	—	—	—	—
Animal	—	286	404	1418	—	327	15.7

TABLE 25

SAMPLE SIZES FOR ONE-VEHICLE ACCIDENTS, BY THE HIGHER IMPACT SPEED

ACCIDENT TYPE	ACCIDENTS AT HIGHER IMPACT SPEED (MPH) OF				
	1-20	21-40	41-60	61-80	81+
Out of control:					
Passenger car	33	300	1179	392	72
Light truck	11	52	131	19	2
Heavy truck	27	132	111	2	—
Tractor-trailer	5	17	20	—	—
Passenger car with:					
Pedestrian	21	73	89	1	—
Fixed object	5	21	46	9	—
Animal	2	64	323	14	—

The median property damage (in dollars) was calculated by collision type for those accident configurations for which the sample size exceeded 10.

Table 26 presents the median property damage for two-vehicle accidents of various collision types and configurations; Table 27 gives the sample sizes on which the medians are based. For each accident configuration for which median property damage was calculated, the head-on collision accounted for the highest property damage figure, while those of rear-end, right-angle, and sidewipe accidents accounted for considerably less property damage. A head-on collision may result in substantial damage to the contents of the engine compartment of both vehicles, whereas at least one of the vehicles involved in rear-end, right-angle, and sidewipe accidents may incur sheet-metal damage only. Thus, the median property damage would be expected to be greater for head-on collisions. Angle collisions have higher median property damage figures than the rear-end and sideswipe collision types for almost all accident configurations, possibly because the angle impact frequently results in a vehicle roll-over, which on the average would probably generate more sheet-metal damage than the rear-end and sideswipe collision.

From a law enforcement and public health standpoint, examination of the median property damage figures alone is apt to be misleading. A particular collision-type accident configuration combination may have a high median property damage although the actual occurrence of this combination may be relatively infrequent. Therefore, priorities for corrective measures should be established from both frequency and property damage cost.

For this reason Tables 26 and 29 were prepared. Table 28 presents the total property damage for each accident configuration and collision type. The total property damage is equal to the mean property damage for each accident configuration and collision type, multiplied by the number of accidents observed. In this analysis the distributions of property damage are assumed to be sufficiently symmetrical so that the median is a reasonable estimate of the mean. Total property damage was thus estimated by the product of sample size and median property damage for each accident configuration and collision type. Table 29 presents

TABLE 26

MEDIAN PROPERTY DAMAGE IN TWO-VEHICLE ACCIDENTS

	DAMAGE ($) BY COLLISION TYPE				
ACCIDENT CONFIGURATION	HEAD-ON	REAR-END	ANGLE	SIDE-SWIPE	ALL [a]
Passenger car-passenger car	814	331	379	333	366
Passenger car-light truck	795	317	373	297	354
Passenger car-heavy truck	751	309	393	226	334
Passenger car-tractor-trailer	918	364	283	301	364
Passenger car-bus	—	232	344	301	289
Passenger car-bicy./motorcycle	—	—	236	—	158
Light truck-light truck	—	312	244	334	352
Light truck-heavy truck	—	249	295	301	304
Heavy truck-heavy truck	—	368	401	238	340

[a] Includes a small fraction of ill-defined collision types.

TABLE 27

SAMPLE SIZES FOR TWO-VEHICLE ACCIDENTS, BY COLLISION TYPE

	ACCIDENTS BY COLLISION TYPE				
ACCIDENT CONFIGURATION	HEAD-ON	REAR-END	ANGLE	SIDE-SWIPE	ALL [a]
Passenger car-passenger car	426	2825	2445	714	6501
Passenger car-light truck	111	592	627	165	1527
Passenger car-heavy truck	69	518	482	188	1327
Passenger car-tractor-trailer	13	68	24	26	138
Passenger car-bus	4	59	50	17	133
Passenger car-bicy./motorcycle	—	8	51	3	93
Light truck-light truck	9	31	46	16	103
Light truck-heavy truck	10	51	67	37	170
Heavy truck-heavy truck	6	52	30	45	143

[a] Includes a small fraction of ill-defined collision types.

the total property damage for each accident configuration-collision type combination as a percentage of over-all property damage; i.e., the sum of total property damage over all configurations and collision types.

The over-all property damage for two-vehicle accidents investigated in 1962 by the Louisiana State Highway Patrol was $3,603,000. Tables 26 and 29 indicate that although passenger car-passenger car head-on collisions had median property damage of $814 and passenger car-heavy truck had median property damage of $865, they account for only 9.6 and 1.2 percent of over-all property damage, respectively. The passenger car-passenger car rear-end collision and passenger car-passenger car angle collision have median property damage figures of $331 and $379, respectively, yet their occurrence on the road is so frequent that they account for 26.0 and 25.7 percent of over-all property damage, respectively. Thus, corrective measures by law enforcement agencies, research by safety engineers, and protective measures by insurance companies should pay particular attention to the latter two types of accidents.

Figure 25 shows the distribution of over-all property damage by collision type for all accident configurations combined. The rear-end and angle collision types together account for more than three-fourths of over-all property damage.

The distribution of the over-all property damage by accident configuration over all collision types is shown in Figure 26. Passenger car-passenger car accidents accounted for $2,379,000, or about 66 percent of over-all property damage. The passenger car-light truck and passenger car-heavy truck configurations contribute to 15.0 and 12.3 percent, respectively. This leaves only 6.7 percent for all other configurations, which occur less frequently on the

TABLE 28

TOTAL PROPERTY DAMAGE INVOLVED IN TWO-VEHICLE ACCIDENTS

ACCIDENT CONFIGURATION	DAMAGE ($1,000) BY COLLISION TYPE				
	HEAD-ON	REAR-END	ANGLE	SIDE-SWIPE	ALL [a]
Passenger car-passenger car	347	935	927	238	2379
Passenger car-light truck	88	188	234	49	541
Passenger car-heavy truck	52	160	189	42	443
Passenger car-tractor-trailer	12	25	7	8	50
Passenger car-bus	—	14	17	5	38
Passenger car-bicy./motorcycle	—	—	12	—	15
Light truck-light truck	—	10	11	5	36
Light truck-heavy truck	—	13	20	11	52
Heavy truck-heavy truck	—	19	12	11	49
All	499	1363	1429	369	3603

[a] Includes a small fraction of ill-defined collision types.

TABLE 29

PROPERTY DAMAGE AS A PERCENTAGE OF TOTAL PROPERTY DAMAGE, TWO-VEHICLE ACCIDENTS

ACCIDENT CONFIGURATION	PERCENTAGE BY COLLISION TYPE				
	HEAD-ON	REAR-END	ANGLE	SIDE-SWIPE	ALL [a]
Passenger car-passenger car	9.6	26.0	25.7	6.6	66.0
Passenger car-light truck	2.4	5.2	6.5	1.4	15.0
Passenger car-heavy truck	1.4	4.4	5.3	1.2	12.3
Passenger car-tractor-trailer	0.3	0.7	0.2	0.2	1.4
Passenger car-bus	—	0.4	0.5	0.1	1.1
Passenger car-bicy./motorcycle	—	—	0.3	—	0.4
Light truck-light truck	—	0.3	0.3	0.1	1.0
Light truck-heavy truck	—	0.4	0.5	0.3	1.4
Heavy truck-heavy truck	—	0.5	0.3	0.3	1.3
All	13.8	37.8	39.7	10.3	100.0

[a] Includes a small fraction of ill-defined collision types.

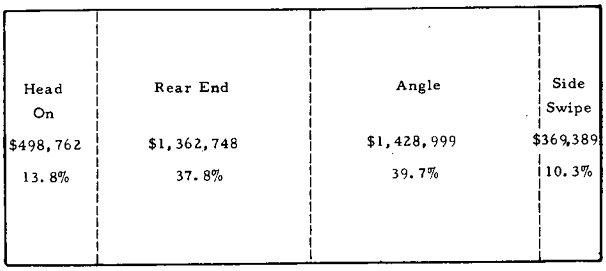
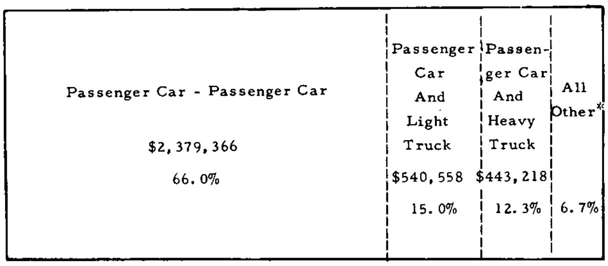


Figure 25. Distribution of the 1962 Louisiana accident dollar, two-vehicle accidents, by collision type.



* Accounts for $239,919 in property damage and includes:

Passenger Car and Tractor Trailer	Light Truck and Light Truck
Passenger Car and Bus	Light Truck and Heavy Truck
Passenger Car and Bicy. /Motor Cycle	Heavy Truck and Heavy Truck

Figure 26. Distribution of the 1962 Louisiana accident dollar, two-vehicle accidents, by accident configuration.

road because the number of tractor-trailers, bicycles, motorcycles, etc., on the road is substantially less than that of passenger cars.

Table 30 presents median property damage figures for selected one-vehicle accidents. In out-of-control accidents the median damage increases with the increasing weight of the vehicles involved. This is not surprising, as one would expect a heavier vehicle to do more damage to itself and

TABLE 30

PROPERTY DAMAGE IN SELECTED ONE-VEHICLE ACCIDENTS, BY ACCIDENT TYPE

ACCIDENT TYPE	SAMPLE SIZE	MEDIAN PROPERTY DAMAGE	TOTAL COST ($1,000)	PERCENT OF TOTAL COST
Out of control:[a]				
Passenger car	2144	481	1215	66.9
Light truck	225	433	97	5.4
Heavy truck	285	643	183	10.1
Tractor-trailer	44	2201	97	5.3
Passenger car with:				
Pedestrian	192	99	19	1.0
Fixed object	88	480	42	2.3
Animal	410	393	161	8.9
All	3388	536	1814	100.0

* Includes an unknown number of object impacts.

other property when going out of control than a lighter vehicle. It is interesting to note that passenger car collisions with pedestrians resulted in median property damage of only $99, whereas passenger car collisions with animals resulted in median property damage of $393. A reasonable explanation for this difference is that in animal collisions the value of the animal is included in the property damage figure, while a value for a human is not included.

Table 30 also indicates that the total over-all property damage for the selected single-car accidents was $1,814,000 and that 66.9 percent of the total was accounted for by passenger car out-of-control accidents.

Because of their great volume, accidents involving passenger cars dominate other accidents in contributions to over-all property damage. Corrective measures in the passenger car accident area thus constitute an essential part of any motor vehicle safety program.

CHAPTER SIX

USE OF NON-ACCIDENT RECORDS: VEHICLE EXPOSURE TO ACCIDENTS

Vehicle exposure to accidents in terms of inspection and odometer data is examined in this chapter to demonstrate the uses of relevant exposure information in the analysis of accident data. The relative importance of various accident factors is difficult to determine in the absence of some measure of exposure to the risk of accident. Other exposure measures include driver license data (driver sex, age, and other characteristics), vehicle registration (make, year of manufacture, etc.), mileage driven by different drivers, etc. All of these measures have weaknesses, but all are useful and all can add to an understanding of accidents. Although data available for the present study are insufficient for a complete evaluation of the effectiveness of vehicle inspection, a definitive study in this area is needed and the approach employed here could be used in a full-scale study.

If vehicle maintenance and vehicle defects were found to be responsible for a significant proportion of accidents, state licensing and inspection officials could be alerted to needed changes in the system. Repeated measurements of vehicle-related problems would permit evaluation of the effectiveness of their efforts. This information could also be extremely important to highway officials for perspective purposes in evaluating the role of the highway relative to that of other variables in the system. At the present time, the exposure of individuals and vehicles to accidents represents a largely unexplored area of accident research.

It was proposed that studies in this subject area be conducted using both available and new data, with the objective of possibly demonstrating that the use of some measure of exposure could add knowledge beyond that provided by accident frequency information alone. One study is based on odometer data obtained from both accident cars and other cars that passed through the same vehicle inspection stations at approximately the same time. Appropriate data for this study were available in Virginia and that state agreed to participate in the study.

Before undertaking these studies, a rationale was developed for the statistical analysis of odometer data. This rationale is given and discussed in Appendix C.

In this area of the study, the following four separate analyses were conducted:

1. Analysis of Virginia accident and non-accident data.
2. Analysis of Automotive Crash Injury Research (ACIR) odometer data.
3. Analysis of Virginia accident and date of inspection data.
4. Analysis of Virginia inspection, accident driver, and accident tire data.

The first of these studies is presented in the following section and the remaining three are presented Appendix C.

ANALYSIS OF VIRGINIA ACCIDENT AND NON-ACCIDENT DATA

Copies of inspection records were obtained for approximately 1,000 accident vehicles during a six-month period in Virginia. (The time between inspections in Virginia is six months.) These records contained information concerning vehicle repairs required at inspection, date of inspection, vehicle make and body type, year of manufacture, odometer reading, and inspection charges (Fig. D-6). In addition, inspection records were obtained for the non-accident vehicles whose inspection number immediately preceded or followed those of the accident vehicles. Thus, the inspection records were obtained in such a fashion that each accident vehicle and the two non-accident vehicles were likely to have been inspected at the same inspection station and at essentially the same time. This method of sampling resulted in a high probability of matching accident and non-accident vehicles with respect to season of inspection and with respect to variables associated with location, such as gross traffic characteristics and driver socioeconomic level.

TABLE 31

FAILURE RATE FOR INSPECTION CHECK POINTS, VIRGINIA SAMPLE

CHECK POINT	PERCENT FAILED
Other lights	9.81
Headlights	9.24
Brakes	7.07
Exhaust line	4.22
Signal lights	4.11
Wipers	3.36
Steering mechanism	7.00

Table 31 gives the failure rate for those check point items which most frequently failed inspection. These data are based on approximately 1,700 non-accident vehicles.

One important area of interest was the comparison of accident and non-accident vehicles to determine differential characteristics. Due to the matching of accident and non-accident vehicles, as previously described, special statistical techniques were necessary to permit valid comparisons. Generally speaking, these analyses were designed to allow comparison between the blocks of three vehicles so as to preserve the matching and thus control the matched characteristics. It should be noted that not all blocks contained three vehicles; in some there was only one non-accident vehicle. This may have been due either to failure to obtain an inspection record, or to missing or questionable pertinent information in the record. For those characteristics having full numerical meaning (e.g., year of manufacture or number of repairs), the mean for the two non-accident vehicles was compared to the value for the accident vehicle and a paired *t*-test was performed on the differences. If a block contained only one non-accident vehicle, its value was used instead of the mean of the two.

For those characteristics which are not numerically meaningful (e.g., vehicle make or body style), a different method was used. For example, the following procedure was used to determine if a vehicle of make M or year of manufacture M or body style M, etc., is more likely to have been involved in an accident than a vehicle of any other make, etc., X. Here, a sample point is defined as the make of the accident vehicle, given the block in which it appeared. Thus, the expression (A = M, given MMX) can be used to denote the sample point consisting of a block of two M's and one X in which the accident vehicle is of make M. Assuming vehicle make and accident involvement are independent, the probability of (A = M, given MMX) is ⅔. The occurrence of such a sample point is evidence that M's are more likely to have accidents than would be expected by chance alone. Similarly, if make and accident involvement are not related, the probability of (A = M, given MXX) is ⅓; this sample point is also evidence that M's have disproportionately more accidents. Further, it is stronger evidence than that provided by the first sample point, as the second is less likely to occur by chance alone.

This procedure provides information for testing the assumption that vehicle make and accident involvement are independent. The observation of a sample point whose occurrence is unlikely under the assumption is evidence that the assumption is incorrect; the more unlikely the sample point, the stronger the evidence. For each sample point, as given in Table 32, there is an index equal to one minus the probability of occurrence; this measures the strength of the evidence in favor of rejecting the assumption of independence. Each index has associated with it an algebraic sign: (+) if the accident vehicle is M, (—) if it is an X. Finally, the indices are multiplied by a constant to give a whole number score for each type of data point.

If the make of accident vehicles is determined by chance alone (that is, if the assumption of independence of make and accident involvement is correct), the expected mean score is zero. If, however, vehicles of make M have a higher accident rate than other vehicles, a positive mean will result. To determine the significance of a non-zero mean, a *t*-test was used. For example, a significant positive mean score would call for a rejection of the independence assumption in favor of the premise that, for the different block types, M exhibits greater-than-chance accident rates.

It was first found that there was a significant difference in terms of year of manufacture of the accident versus the non-accident vehicles. Results showed accident vehicles to be 0.41 years newer than non-accident vehicles; the mean year of manufacture for the former was 1962.27, and for the latter, 1961.86. Considering that this might be attributable, in some way, to new vehicles whose inspection was by a new car dealer, the analysis was run again after eliminating all 1967 vehicles. The difference was still significant and had increased slightly to 0.45 years. One plausible explanation derives from the decreased likelihood of reporting an accident if one's vehicle is quite old; this would serve to bias the year of manufacture of accident vehicles toward the newer vehicles.

In spite of the comparative newness of the reported accident vehicles, results also showed: (1) the mean number of repairs at inspection was slightly greater for accident vehicles (0.05 versus 0.44); and (2) odometer readings at inspection were considerably higher for the accident vehicles. (Recall that the inspection preceded the accident, so the accident could not influence the odometer reading at inspection.) It is possible that the higher odometer readings observed for accident vehicles may simply be attributable to the increased accident likelihood for higher-exposure vehicles. The greater number of repairs for accident vehicles may indicate that vehicles which are characteristically in need of repair are more likely to be involved in accidents. A larger volume of data and some information concerning other pertinent factors (driver age, type of driving vehicle was used for, etc.) would be needed to ascertain if this assumption holds true.

Table 33 gives the odometer results for accident vehicles compared with non-accident vehicles. The first column specifies the oldest model year to be included in the respective row. Limiting the age of vehicles studied was necessary to provide some control on the recycling of odometers; the older the cutoff model year, the larger the sample size but, also, the larger the error. It is clear, both with respect to the means and the difference between the means, that recycling has an obvious effect as an earlier cutoff is used, although the tendency for greater odometer readings for accident vehicles is not completely hidden.

As shown in Appendix D, the inspection procedure includes 15 check points. All but the air conditioner were checked for differences between accident and non-accident vehicles. Only two significant results were found, as follows:

1. The probability of repair of lights, other than head-

TABLE 32

BLOCKS AND THEIR SCORES

ACCIDENT VEHICLE	NON-ACCIDENT VEHICLES	CONDITIONAL PROBABILITY	INDEX	SCORE
M	X, X	⅓	⅔	4
M	M, X	⅔	⅓	2
M	M, M	1	0	0
X	M, M	⅓	−⅔	−4
X	M, X	⅔	−⅓	−2
X	X, X	1	0	0
M	X	½	½	3
M	M	1	0	0
X	X	1	0	0
X	M	½	−½	−3

TABLE 33

ODOMETER STATISTICS FOR ACCIDENT AND NON-ACCIDENT VEHICLES

		ODOMETER READING		
EARLIEST YEAR	NO. OF OBSERVATIONS	ACCIDENT VEHICLE MEAN	NON-ACCIDENT VEHICLE MEAN	MEAN DIFFERENCE
1962	485	28,108	27,263	845
1963	383	24,749	24,019	730
1964	288	22,758	19,197	3,561 [a]
1965	192	18,066	14,606	3,460 [a]
1966	82	11,162	7,510	3,652 [a]

[a] Statistically significant for $p = 0.05$.

lights and signals, was lower for accident vehicles than would be expected by chance.

2. The probability of repair of glass other than the windshield was lower for accident vehicles. (Note: This was significant only when the "zeroes," or nondiscriminating values, were removed from the data.) It should be pointed out that the true significance level is unclear when one or two out of many tests are "significant."

The make of accident versus non-accident vehicles also was considered. Of the six makes studied (Chrysler, Ford, General Motors, American Motors, Studebaker, and foreign), one significant difference was found. Based on a sample of 2,742 vehicles, 73 of which were American Motors cars, it was found that the probability that the accident vehicle was an American Motors vehicle was lower than would be expected if make and accident involvement were independent (Table 34). However, considerable caution is required in data interpretation because of the small volume of cases available. A similar study based on statewide data could undoubtedly provide useful data concerning various vehicle features.

The observed number of accident vehicles manufactured by American Motors was always less than, or equal to, the number which would be expected if make and accident involvement were independent. Similarly, the actual number of other accident vehicles is as high as, or higher than, expected. Thus, the assumption of independence was rejected. The reason for this conclusion cannot be determined in this analysis. It could be attributable to characteristics of the automobiles or, for example, it could be attributable to the characteristics of the people driving them. Use of statewide data undoubtedly would provide sufficient information to take other variables into consideration. Such a study might well be considered in a state where all of the appropriate data were available in automated form.

TABLE 34

ACCIDENT INVOLVEMENT OF AMERICAN MOTORS VEHICLES[a]

	FREQUENCIES OF ACCIDENT VEHICLE			
BLOCK	EXPECTED A'S	ACTUAL A'S	EXPECTED X'S	ACTUAL X'S
AXX	13	9	26	30
AAX	4.67	2	2.33	5
AA	6.5	4	6.5	10
AAA	1	1	0	0
XXX	0	0	603	603

[a] A = American Motors vehicle; X = any other make.

CHAPTER SEVEN

APPLICATIONS

MULTI-LEVEL DATA SYSTEM

In conducting this study, a number of tasks were completed which, although in a sense intangible, represent applications that may be used by the state. These tasks included: demonstrations of feasibility of a close cooperative effort with state police, the use of error prevention and correction techniques in the field and in the office, development and testing of forms to minimize errors, providing special training and equipment to simplify the police task, the use of both accident and non-accident records to provide an improved measure of the accident problem, and the use of statistical techniques and personnel for the analysis of data.

Some of the possible applications of this research are implicit in the general concept of a multi-level accident records system described in detail in Chapter Three. Data may be collected at three levels: (1) accident frequency data and operational data for state agencies may be collected by police on all accidents, using a brief report form; (2) data concerning specific research study factors may be obtained by technicians or specially trained police officers; and (3) detailed data for hypotheses development, procedural improvement, and quality control may be obtained by multidisciplinary teams through intensive accident investigation. The proposed system offers the advantage that any of these levels may be attempted independently, although all three ultimately are integrated.

A number of more specific applications of the findings in this report are suggested in the following.

COOPERATION BETWEEN OPERATIONAL AGENCIES

The engineering personnel of the highway department and the police patrolling the roadways have a mutual interest in reducing the accident toll of the highway system. These two agencies have the most direct contact with the motoring public—the police for law enforcement and the engineer for design, maintenance, and traffic operations. Close cooperation between the two would prove a beneficial interchange of information: a patrolman is a close observer of traffic conditions, accident areas, driver behavior, maintenance needs, and innumerable little details, all of which are valuable information for the engineer; the engineer can use this knowledge to improve traffic flow, reduce dangerous conditions, and in general to help reduce the accident problem and thereby aid the police. These unquestionably are specific instances where a joint engineering-law enforcement program would be the optimal solution.

Creation of an integrated accident records data system would permit the collation of accident information with highway data. In turn, this would permit accurate evaluation of accident rates for various highway classes and detail features. Eventually, it should then be possible to develop a predictive analytical model, or series of models, for highway design purposes.

ROADSIDE OBSTRUCTIONS

Although knowledge of accident causation factors is incomplete, sufficient information is available so that application of countermeasures could provide a decrease in accident and severity rates. The severity of ran-off-roadway accidents may be mitigated by recent engineering developments stimulated by the Bureau of Public Roads and the Highway Research Board, including breakaway sign supports (Texas Transportation Institute) and redirecting guard railing (State of New York and CAL). Use of energy-absorbing materials at certain hazardous points, such as bridge abutments, is another approach.

INTENSIVE ACCIDENT INVESTIGATION TECHNIQUES

A team of accident investigators trained in various disciplines—highway engineer, mechanical engineer, psychologist, mechanic, physician, and police officer are useful members—can provide detailed data that cannot be obtained in any other way. Many of the necessary personnel already are in the state employ. In this study, the knowledge and training of team members uncovered a number of failures in the system that would not have been apparent to a less skilled investigator.

ACCIDENT LOCATION SYSTEM

Highway engineers and police both emphasize that the location of the accident event is essential information. Although there is great interest in the subject, a number of states do not have a workable system. The evaluation of accident location methods presented in Appendix B may aid in the choice of the appropriate method for a given state.

EDUCATION AND TRAINING

There is a definite lack of awareness of safety aspects in the design of some new highway facilities—new signs hidden behind lights and bridge piers, exit ramps on hill crests, inadequate signal timing, etc. These and other conditions could be corrected—or even prevented—if responsible personnel were better informed with respect to safety considerations. At the college level there is need for additional emphasis on safety in the highway engineering curriculum, and for the practicing engineer a series of seminars (continuing education), preferably in local areas to achieve maximum coverage, could be used to inform him of current findings and developments. Training of professional personnel as accident investigators would also be fruitful because of the almost total absence of such trained personnel.

SAFETY REVIEW BOARD

An immediate and promising approach to the problem of minimizing design hazards in new highways would be the creation of a safety review board. The board would have the responsibility, with appropriate authority, to review all highway construction plans to insure the incorporation of current safety knowledge. The members of the board would necessarily maintain close contact with current knowledge through research review.

SPECIAL STUDIES OF PROBLEM AREAS

In this report, the collection and analysis of data on special problems demonstrates that such studies are feasible and that statistical analysis enhances the interpretation of the data. Through cooperation between operating agencies, adequate sample data can be obtained under the present system and used to indicate solutions to specified problem areas. Properly designed and controlled studies can provide answers to many of the problems now plaguing the highway administrator.

SYSTEM IMPROVEMENTS

Data Collection Forms

Accident report forms should be closely scrutinized to eliminate unnecessary data. In a multi-level system, the basic report form needs little more than identification of drivers and vehicles, location and time of accident, and a brief description, with additional data collected as needed for local purposes. The design of the accident report form is dependent on state requirements, and, beyond the basic data, may be varied to meet individual state requirements. An example of a simple basic report form that meets some local requirements as well, is shown in Figure D-7. The data should be factual and opinion information should be eliminated.

A simple and uniform report form used throughout a state would provide consistent and compatible data without additional cost.

Data Processing

The use of simple error checks and programs to check data completeness and consistency are essential. Adequate trained personnel and equipment would minimize delays and insure availability of data for use within a reasonable time after the accident occurred. Access to the data should be available for all functional agencies that have a need for them.

Data Analysis

Useful data can be obtained from the existing accident records files. Caution must be exercised in interpretation, but this information could be better utilized to gain further knowledge.

Although the analysis of a large volume of data represents a problem requiring statistical procedures, relatively few statisticians have worked with the accident records system. The use of competent statistical personnel would release much-needed knowledge now hidden in the system.

Adequate Facilities and Equipment

The accident record system is sufficiently complex and of sufficient proportions to warrant rapid and continuing access to a computer. Without adequate facilities, competent personnel cannot cope with an information system as large as that involving accident records.

CHAPTER EIGHT

CONCLUSIONS AND SUGGESTED RESEARCH

The objectives of this study were: "to determine and describe the most important methods for using traffic accident information to reduce the likelihood of accidents." In pursuing these objectives, the following conclusions were reached:

1. The current accident record system does not meet the requirement of providing data for measurement of the magnitude of the accident problem, determination of countermeasures to the problem, or measurement of the effectiveness of attempted countermeasures.
2. Accidents are reported by the police, by the driver/owner, or both. The vast majority of reports are completed by the most biased reporter—the driver. The typical report contains some useful data, but due to biases and inaccuracies must be used with caution.
3. Several different agencies are often involved in the collection, processing, and maintenance of accident records. Cooperation between agencies is at a low level and the lack of coordination reduces the efficiency of the system so that processing and transmission of data are impeded. Additional safeguards, such as improved report forms and computer consistency edits to prevent or correct errors, are needed.
4. Operational agencies desire the precise location of an accident and a brief description of the event. Although at present there are wide variations in the ability of states to obtain this information, interest is high and this appears to be one of the most promising areas of development.
5. Routine accident summaries prepared by most states are simple tabulations of accident report items, such as time of occurrence, severity, rural-urban, etc., and generally are not informative. Consequently, they are of little use for devising accident reduction measures. Statistical analyses and interpretations, and even simple cross-tabulations, could enhance the usefulness of the data, but are rarely employed.
6. Accident records involve the analysis of a large volume of data. Special studies, particularly, require competent analytical personnel. The use of statistical personnel in this field is relatively recent and not widespread.
7. Few programs of continuing education are available for the practicing engineer. Highway safety research information is not available to engineers at various operating levels.
8. On the basis of current data volume and research requirements, it is concluded that a sampling of accident data is sufficient for most research purposes.
9. The total state information system, and specifically pertinent non-accident data files concerning the highway, the vehicle, and the driver, are not being brought to bear on the accident problem in an effective manner.
10. Useful research data can be obtained by the police if proper training and equipment are provided and appropriate checks to insure accuracy are taken.
11. Because of the nationwide scope of the highway accident problem, it is concluded that data collected should be sufficiently compatible to permit meaningful and complete summarization of basic accident data throughout the country.

SUGGESTED RESEARCH

As work on this project progressed and conclusions were drawn, a number of questions were raised for which no answer was evident. Many of these questions could be solved only by additional, and often specific, studies that were beyond the scope of the present project. A number of subjects deemed worthy of further research are suggested in the following.

A basic recommendation in this report is the unification of the accident records system under one agency with complete responsibility for all related functions: data collection (accident and non-accident), data processing, data analysis, release of data to appropriate agencies, application of solutions, and evaluation of solutions. Several studies would be required to determine the best method of accomplishing the desired unification in various states.

The basic accident report form must contain information recording who, when, where, and what occurred. In addition to these data, other items must be recorded for operational use at the local and state level. The precise data required should be a research objective of each individual state because of differences in state structure and data use.

A method of identifying "reportable" and "not reportable" accidents is needed. The present policy of classifying reportable accidents on the basis of injury, fatality, or property damage that exceeds a minimum cost is not satisfactory and has created some of the problems related to data completeness. Research may reveal a better means of classifying reportable accidents. A related question of importance is the method of insuring complete reporting. Utah requires a state police permit before a damaged vehicle may be repaired. This could be one approach. Another might be the completion of a report form by the collision shop prior to repairing a damaged vehicle. Modifications of these concepts, or entirely new ideas, may be preferable.

A method is needed to classify accidents in a manner that describes the path of the collision vehicles in terms of the highway geometry; i.e., a descriptive accident classification which reflects the highway characteristics. A related study involves the determination of accident costs so that they may be related to highway geometry and other variables.

Accident rates or risk measures are needed for various functions. Some of the risk measures needed by highway engineers are related to the geometric classification of the highway, traffic volumes, general area descriptions, etc. Rates also are needed for different types of vehicles, drivers, weather conditions, etc. Use of these rates would permit comparison of variables on a meaningful basis.

The intensive investigation of accidents in this study, as well as other accident research projects at the research agency, reveals certain highway features that are related to accidents. The magnitude of this problem is unknown at the present time, but the fact that a number of similar incidents has occurred suggests the need for further research. Extensive research may be required to obtain the answers, and some will require at least partial completion of the integrated accident record system for solution: system data would have to be available for matching with corresponding accident records.

Information concerning the relationship between curvature or grade and accidents is inadequate. Some research has been accomplished on this subject, but the results cannot be used for highway design purposes.

One of the sub-studies completed for this project involved the angle of departure and lateral distance traveled when a vehicle ran off the roadway. The data indicated that the loss of speed was not dependent on the lateral distance the vehicle traveled from the roadway and the severity of accidents did not decrease with distance from the traveled roadway. These findings indicate that width of clearance may not be the entire solution to the severity of this type of accident. Continuation of this research is recommended.

Other questions associated with this same design consideration include: At what minimum median width does a guardrail on a divided multi-lane highway become an uneconomical safety device? When do construction and maintenance costs of wide roadside clearances become greater than the economic loss from accidents which would occur with a more restricted side clearance?

Problems associated with highway signs suggest a whole area of research activity ranging from studies of driver vision through sign size and coloring to placement of the signs.

Agency research has revealed accidents where vehicles struck curbs used to outline islands on high-speed facilities —at interchanges and along the islands separating through traffic from that on a collector-distributor roadway. These curbs are high enough to cause a vehicle to go out of control if it strikes one at a slight angle, but are not high enough to prevent vehicles from crossing the island. The motoring public might be better served if no curbs were used and only a small space separated the two streams of traffic. Or, perhaps, some other solution is required.

Poor maintenance or the absence of maintenance has been encountered in a number of areas: low shoulders create a situation where an inexperienced or unskilled driver may allow a wheel to drop off the pavement, try to force the vehicle back onto the pavement, and cause the vehicle to run out of control into the opposing traffic lane or off the road. Other problem areas observed include paved surfaces with a low friction coefficient and chuck holes that resulted in loss of control of a vehicle. Research to determine the relationship between road maintenance and accident costs might result in an entirely new concept of maintenance expenditures and surveillance.

In a number of cases, drivers (especially strangers to an area) have slowed down or even stopped because they could not read or interpret the message conveyed by a sign or symbol. Research should be initiated to evaluate the accident potential of confusing and/or illegible signs.

A related problem area involves the maintenance and operation of traffic signals. Agency accident research has revealed accidents that occurred because of signal malfunctions, improper timing of signals, and in one particular instance even the intended purpose of the signal was questionable. Additional research is needed to determine the extent of the problem and to evaluate signal failures in terms of accident cost.

A number of accidents have occurred at highway construction sites, some as a result of improper markings and warnings. It is apparent from observation alone that methods of marking construction sites need improvement. Once again, measurement of the extent of the problem and cost-benefit information are needed.

A study of motor vehicle inspection is needed in order to determine the effectiveness of present inspection methods and to improve these procedures where necessary. A definitive study of vehicle inspection and its influence on highway accidents has never been attempted and present practices are based on the best judgment of experienced personnel. This study will require data from accident files and from vehicle, driver, and inspection files.

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APPENDIX A

SUMMARY OF ACCIDENT REPORT FORMS AND DATA

STANDARD SUMMARY OF MOTOR VEHICLE TRAFFIC ACCIDENTS IN FLORIDA

National Safety Council
Chicago

For December 1965 (Month or other period)

SUMMARY OF Statewide ACCIDENTS

LEGALLY REPORTABLE ACCIDENTS ARE THOSE INVOLVING DEATH, BODILY INJURY OR PROPERTY DAMAGE OF $50 OR MORE IN THE ACCIDENT

THIS SUMMARY INCLUDES REPORTS AND INFORMATION AVAILABLE ON February 20, 1966

REPORT PREPARED BY
Florida Department of Public Safety

1. TYPE OF ACCIDENT

Motor Vehicle Collision with:	Number of Accidents: Total	Fatal	Non-Fatal	Property Damage	Number of Persons: Total Killed	Injured: Total	A	B	C
1. Ran off road	2463	27	960	1476	32	1363	662	421	280
2. Overturned on road	128	0	80	48	0	110	47	38	25
3. Pedestrian	324	23	301	0	24	321	152	105	64
4. Mtr. veh. in traffic	12106	62	3896	8148	69	6952	1747	1631	3574
5. Parked mtr. vehicle	1238	1	147	1090	1	199	68	68	63
6. Railroad train	48	4	22	22	6	31	20	8	3
7. Bicyclist	159	3	140	16	3	148	62	52	34
8. Animal	156	0	32	124	0	47	26	10	11
9. Fixed object	294	3	79	212	5	106	53	27	26
10. Other object	56	1	3	52	1	8	3	3	2
11. Other non-collision	121	3	41	77	3	45	29	10	6
12. Other	79	1	6	72	2	6	3	2	1
TOTALS	17172	128	5707	11337	146	9336	2872	2375	4089

Note: The three categories of injuries follow the Manual of Uniform Definitions of Motor Vehicle Accidents.
a. Bleeding wound, distorted member, or any condition that required victim be carried from the scene.
b. Other visible injuries such as bruises, abrasions, swelling, limping, or other painful movement.
c. Complaint of pain, without visible signs of injury, or momentary unconsciousness.

2A. COMPARATIVE TOTALS

Motor Vehicle Collision with:	Same Month Last Year: All Accidents	Persons Killed	Persons Injured	This Year to Date: All Accidents	Persons Killed	Persons Injured	Same Period Last Year: All Accidents	Persons Killed	Persons Injured	Change Cumulative Death Record
1. Ran off road	2159	33	1245	25038	378	13656	23033	383	12954	- 1 %
2. Overturned on road	94	2	72	1286	37	1167	1129	28	1053	+32 %
3. Pedestrian	312	28	294	3301	267	3192	3271	255	3197	+ 5 %
4. Mtr. veh. in traffic	11001	73	6241	117207	730	65730	112425	626	62334	+17 %
5. Parked mtr. vehicle	1165	0	177	12165	17	1878	11808	29	2022	-41 %
6. Railroad train	43	4	35	416	61	261	369	50	227	+22 %
7. Bicyclist	160	2	132	1783	33	1586	1840	32	1609	+ 3 %
8. Animal	130	0	37	1293	1	330	1024	3	254	-67 %
9. Fixed object	307	1	145	3170	50	1253	3155	51	1307	- 2 %
10. Other object	42	0	6	626	1	108	357	0	64	+INF %
11. Other non-collision	119	4	42	1483	41	634	1464	42	640	- 2 %
12. Other	69	0	10	730	3	69	780	2	78	+50 %
TOTALS	15601	147	8436	168498	1619	89864	160655	1501	85739	+8 %

2B. MILEAGE RATES

	This Year to Date	Last Year Same Period	Percent Change
1. Motor vehicle traffic deaths	1619	1501	+8%
2. Estimated motor vehicle mileage traveled (millions)	26948	25551	+ 5%
3. Death rate per 100,000,000 vehicle-miles	6.0	5.9	+1.7%
4. Fatal accident rate per 100,000,000 vehicle-miles	5.0	4.9	+2.0%
5.			%
6.			%

3. LOCATION

A. Trafficways Administered by Governmental Agencies: State Highway Dept., counties, cities, towns, villages, etc.

Location	Number of Accidents: Total	Fatal	Non-Fatal	Property Damage	Number of Persons: Killed	Injured
URBAN: All incorporated places of 2500 or more people and all areas classified as urban by special rules followed in 1940 census. 1. 2,500 to 10,000	1136	12	308	816	12	488
2. 10,000 to 25,000	1514	8	470	1036	9	744
3. 25,000 to 50,000						
4. 50,000 to 100,000	4023	12	1202	2809	15	1850
5. 100,000 to 250,000	4190	18	1257	2915	18	1945
6. 250,000 or more						
7.						
8.						
TOTAL URBAN	10863	50	3237	7576	54	5027
RURAL: All locations other than those above. 1. Interstate routes	159	2	71	86	4	116
2. Controlled access highway	155	1	58	96	3	105
3. State routes	3431	60	1400	1971	69	2624
4. County routes						
5. Other	2564	15	941	1608	16	1464
6. Not stated						
TOTAL RURAL	6309	78	2470	3761	92	4309
TOTAL URBAN AND RURAL	17172	128	5707	11337	146	9336

B. Trafficways Administered by Independent Agencies: Turnpike, parkway, military, freeway authorities and commissions, etc.

Number of Accidents: Total	Fatal	Non-Fatal	Property Damage	Number of Persons: Killed	Injured
51	1	24	26	3	52

16. SEAT BELTS

	Number Vehicles Involved In: All Accidents	Fatal Accidents	Injury Accidents
1. Seat belts installed	5995	59	2138
In use	2636	18	932
Not in use	3359	41	1206
2. Seat belts not installed	18862	127	6399
3. Not stated	5365	17	1639
TOTALS	30222	203	10176

5. TIME

Hour beginning	Total All	Total Fatal	Monday All	Monday Fatal	Tuesday All	Tuesday Fatal	Wednesday All	Wednesday Fatal	Thursday All	Thursday Fatal	Friday All	Friday Fatal	Saturday All	Saturday Fatal	Sunday All	Sunday Fatal	Not Stated All	Not Stated Fatal
Before Noon: 0. Midnight	395	4	46	1	29		31		42		53		90	2	104	1		
1. 1:00	321	3	19		19		41		39		54	1	81	1	68	1		
2. 2:00	237	5	16		22	1	14		24		37	1	67	1	57	2		
3. 3:00	179		16		8		9		19		22		61		44			
4. 4:00	106	2	6		9		6	1	10		25	1	28		22			
5. 5:00	133	3	12		10		11		16		22		40	2	22	1		
6. 6:00	234	2	35	1	34	1	36		37		41		34		17			
7. 7:00	734	5	127	1	104		143	2	145		137	1	50		28	1		
8. 8:00	751	1	128		103		158		132		142	1	64		24			
9. 9:00	608	5	107	1	84		88	1	97	3	107		75		50			
10. 10:00	827	8	121		96	1	133	1	129	2	159	2	120	1	69	1		
11. 11:00	932	5	160	1	108	1	125		136	1	171		155	1	77	1		
After Noon: 12. Noon	1040	9	141	1	137	1	143	1	157	1	197	3	153		112	2		
13. 1:00	988	8	127		113		163	1	136		183	1	159	3	107	3		
14. 2:00	1067	7	150	1	116	1	184		161	1	208	1	148		100	3		
15. 3:00	1305	7	199	1	145	1	213	1	212		251		153	1	132	3		
16. 4:00	1510	3	206		185	1	255	2	229		308		168		159			
17. 5:00	1428	5	177		207	1	240	1	227		264		161	2	152	1		
18. 6:00	1087	11	116	3	122	1	148	2	170	2	236	2	151	1	144			
19. 7:00	919	9	76		99		110	2	144	1	220	5	142		128	1		
20. 8:00	670	8	56	1	73	1	82	2	101	2	136		125	2	97			
21. 9:00	572	5	38		44		74	1	106	1	161	1	76	1	73	1		
22. 10:00	558	5	50	1	42		78		81	1	162	2	76		69	1		
23. 11:00	571	8	42	1	50	2	57		97	2	150		113	3	62			
24. Not stated																		
TOTALS	17172	128	2171	14	1959	13	2542	18	2647	17	3446	22	2490	21	1917	23		

FORM TRAFFIC 13 (PAGE 1) REV.-FLA. D.P.S. 8-22-64

Figure A-1. Typical accident report data summary.

SUMMARY OF Statewide ACCIDENTS, CONTINUED

4. AGE OF CASUALTY	Number of Persons Killed									Number of Persons Injured								
	Total Killed			Pedestrians			Bicyclists			Total Injured			Pedestrians			Bicyclists		
	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE
1 0 to 4	3	1	2	1	1	0				298	157	141	34	21	13	1	1	0
2 5 to 9	3	2	1	1	1	0				402	221	181	76	49	27	47	36	11
3. 10 to 14	4	3	1	2	1	1	1	1	0	408	224	184	34	22	12	57	52	5
4. 15 to 19	21	17	4				1	1	0	1502	951	551	32	19	13	16	15	1
5 20 to 24	9	7	2							1193	733	460	18	12	6	6	4	2
6. 25 to 34	15	13	2							1460	838	622	16	10	6	2	2	0
7. 35 to 44	20	13	7	4	1	3				1270	658	612	22	18	4	2	1	1
8. 45 to 54	1818	11	7	4	2	2				1104	560	544	15	11	4	4	4	0
9. 55 to 64	11	7	4	2	2	0				839	381	458	26	17	9	4	3	1
10. 65 to 74	22	15	7	5	4	1	1	1	0	562	267	295	32	20	12	3	2	1
11 75 & older	14	9	5	4	2	2				204	105	99	31	17	14			
12. Not stated	6	5	1	3	3	0				94	55	39	19	13	6	6	5	1
TOTALS	146	103	43	26	17	9	3	3	0	9336	5150	4186	355	229	126	148	125	23

6. DIRECTIONAL ANALYSIS - An accident consisting of a series of collisions, overturning, etc., is classified according to the first event on the road.

A. TWO MOTOR VEHICLE ACC. (AT INTERSECTION)	Total	FATAL ACCIDENTS	INJURY ACCIDENTS	PROPERTY DAMAGE ACC
1 Entering at angle	3221	17	1270	1934
2a From same dir. — both going straight	536	0	120	416
b Same — one turn, one straight	669	0	119	550
c. Same — one stopped	1607	1	543	1063
d. Same — all others	217	0	23	194
3a From opp. dir. — both going straight	47	1	14	32
b Same - one left turn, one straight	767	7	351	409
c Same - all others	77	0	16	61
4 Not stated	13	0	2	11
TOTALS	7154	26	2458	4670

B. TWO MOTOR VEHICLE ACC. (NOT AT INTERSECTION)	Total	FATAL ACCIDENTS	INJURY ACCIDENTS	PROPERTY DAMAGE ACC
1 Going opposite dir. — both moving	387	21	155	211
2 Going same direction — both moving	1427	4	396	1027
3a One car parked	1238	1	147	1090
b. One car stopped in traffic	1526	3	586	937
4a One car entering parked position				
b. One car leaving parked position	579	1	58	520
5a. One car entering alley or driveway	440	2	131	307
b. One car leaving alley or driveway	317	1	57	259
6 All others	275	4	55	216
7 Not stated				
TOTALS	6189	37	1585	4567

C. PEDESTRIAN ACCIDENTS	All Pedestrian Accidents	Fatal Accidents			Injury Accidents		
		TOTAL	INTER-SECTION	NON INTER-SECTION	TOTAL	INTER-SECTION	NON INTER-SECTION
1. Car going straight	269	22	6	16	247	59	188
2. Car turning right	9				9	8	1
3. Car turning left	25	1	1	0	24	23	1
4. Car backing	10				10	0	10
5. All others	11				11	0	11
6. Not stated							
TOTALS	324	23	7	16	301	90	211

D. ALL OTHER ACCIDENTS		Total	FATAL ACCIDENTS	INJURY ACCIDENTS	PROPERTY DAMAGE ACC
AT INTERSECTIONS — COLLISION WITH	1. Non-motor veh.: train, bicycle, etc.	135	1	64	70
	2. Fixed object in road	55	0	13	42
	3. Overturned in road	24	0	17	7
	4. Left road	474	5	175	294
NOT AT INTERSECTIONS — COLLISION WITH	5. Non-motor veh.: train, bicycle, etc.	284	7	133	144
	6. Fixed object in road	239	3	66	170
	7. Overturned in road	104	0	63	41
LEFT ROAD	8. At curve	427	10	222	195
	9. Straight road	1563	12	563	988
	10. Fell from moving vehicle	24	1	23	0
	11. All others	176	3	24	149
	12. Not stated				
	TOTALS	3505	42	1363	2100

7. PEDESTRIANS ACTIONS BY AGE	Pedestrians Killed	Ages Of Pedestrians Killed and Injured									
		Total	0 TO 4	5 TO 9	10 TO 14	15 TO 19	20 TO 24	25 TO 44	45 TO 64	65 & OLDER	NOT STATED
1a. Crossing or entering roadway—at intersection	8	100	4	16	8	6	4	10	15	35	2
b Same — not at intersection	12	179	23	53	17	12	6	13	16	24	15
2a Walking in roadway — with traffic		11				3	1	2	1	4	
b. Same - against traffic		8		2	3		2		1		
3 Standing in roadway	3	12					2	4	4	2	
4. Getting on or off other vehicle		3					1	2			
5. Pushing or working on vehicle in roadway		10				6		2	2		
6 Other working in roadway		4					1	2	1		
7 Playing in roadway		10	4	1	3	1					1
8 Other in roadway		5	1	1	2					1	
9 Not in roadway	2	37	3	4	3	4	1	6	6	6	4
10. Not stated	1	2						1	1		
TOTALS	26	381	35	77	36	32	18	42	47	72	22

Drivers of vehicles in proper parking locations are excluded.

8. AGE OF DRIVER	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. 15 & younger	187	2	112
2. 16	730	8	288
3. 17	1000	11	335
4. 18 to 19	2202	18	789
5. 20 to 24	3952	24	1376
6 25 to 34	5627	35	1995
7 35 to 44	5364	31	1811
8. 45 to 54	4291	21	1464
9 55 to 64	3118	18	1051
10 65 to 74	2049	21	637
11 75 & older	637	10	179
12 Not stated	1065	4	139
TOTALS	30222	203	10176

9. DRIVER'S SEX	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. Male	2149	160	7276
2. Female	7923	41	2815
3. Not stated	804	2	85
TOTALS	30222	203	10176

10. RESIDENCE OF DRIVER	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. Local resident	24330	136	8268
2. Residing elsewhere in state	2889	41	1082
3. Non-resident of state	2156	24	735
4. Not stated	847	2	91
TOTALS	30222	203	10176

Vehicles in proper parking locations are included.

12. TYPE OF VEHICLE	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. Passenger car	27927	173	9237
2. Passenger car and trailer	73	1	16
3. Truck or truck tractor	1602	8	460
4. Truck tractor, semi-trailer	359	7	105
5. Other truck combination	900	9	230
6. Farm tractor and/or farm equip.	18	2	10
7. Taxicab	133	0	42
8. Bus	147	2	35
9. School bus	30	0	3
10. Motorcycle	298	5	231
11. Motor scooter or motor bicycle	104	1	78
12. Others and not stated	494	0	49
TOTALS	32085	208	10496
Special vehicles included above			
13. Emergency (including privately owned)			
14. Military vehicles			
15. Other publicly owned veh.			

13. ROAD SURFACE CONDITION	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. Dry	14683	107	4856
2. Wet	2439	21	835
3. Snowy or icy			
4. Other	48	0	16
5. Not stated	2	0	0
TOTALS	17172	1128	5707

14. KIND OF LOC.	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. Built-up	14145	69	4439
2. Not built-up	2888	59	1230
3. Not stated	139	0	38
TOTALS	17172	128	5707

15. LIGHT COND.	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. Daylight	10721	56	3336
2. Dawn or dusk	761	5	282
3. Darkness	5690	67	2089
4. Not stated			
TOTALS	17172	128	5707

Contributing Circumstances (Table 11) compiled only from police reports.

11. CONTRIBUTING CIRCUMSTANCES	ALL ACCIDENTS	FATAL ACCIDENTS	INJURY ACCIDENTS
1. Speed too fast	5045	57	1155
2. Failed to yield	3051	26	1213
3. Drove left of center	601	21	211
4. Improper overtaking	650	0	95
5. Passed stop sign	559	7	280
6. Ignored traffic signal	425	2	191
7. Followed too closely	2154	1	674
8. Made improper turn	1100	0	254
9. Other improper driving	2991	5	423
10. Inadequate brakes	326	3	118
11. Improper lights	37	0	15
12. Had been drinking	1666	24	777
TOTALS	18605	146	5406

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Figure A-1 (continued).

TABLE A-1

SUMMARY OF ACCIDENT REPORT FORMS FOR 42 STATES

	ALABAMA	ALASKA	ARIZONA	ARKANSAS	CALIFORNIA	CONNECTICUT	DELAWARE	FLORIDA	GEORGIA	IDAHO	INDIANA	IOWA	KANSAS	KENTUCKY	LOUISIANA	MAINE	MARYLAND	MASSACHUSETTS
DATE OF FORM	UNK	UNK	1967	1966	1965	UNK	UNK	1962	1965	UNK	1960	1965	UNK	1963	UNK	UNK	1960	1966
DATE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DAY OF WEEK	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TIME OF DAY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LIGHT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WEATHER	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LOCATION RURAL-URBAN	X	X								X						X	X	
COUNTY OR BOROUGH	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
CITY OR TOWN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
IF OUTSIDE CITY DIST. NEAR. TOWN	X	X		X		X	(	X	X	X	X	X	X	X	X	X	X	
ROAD, US ROUTE NO. OR CLASS OF HWY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
INTERSECTION ..... WITH	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
NON-INTERSECTION .. MI FROM			X					X						X	X			
NON-INTERSECTION .. FT FROM	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X
IS ENGINEER STUDY NEEDED								X										
KIND OF LOCALITY/LOCATION	X		X	X	X	X	X	X	X	X	X	X			X	X	X	X
MILEPOST					X					X								
NRST INTR ST HOUSE NO. POWER TEL POLE MILEPOST CURVE ETC.	X	X		X		X	X	X	X		X	X	X		X			
NRST ST MARKER MILEPOST PERM LNDMK					X					X				X				
MILEPOST OR CENSUS TRACT NQ.			X															
LANDMARK MILES TO																X		
NAME OF ALLEY, ST, RD, OR HWY NO.																	X	
NEAREST ST OR OTHER MEANS OF IDENT																		X
MILEPOST OR BEAT NO.																		
DISTRICT/QUADRATE OF COUNTY			X		X													
ROADWAY TYPE(ACCESS CONTROL NO. LANES)	X	X	X	X	X	X	X	X		X			X	X	X	X	X	X
TYPE SURFACE (CONCRETE ETC.)	X		X				X	X	X		X	X	X		X		X	
SURFACE (WET ETC.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CHARACTER (LEVEL, ETC.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
VEHICLE OBSTRUCTIONS TO VIEW	X		X		X		X		X			X						
HIGHWAY OBSTRUCTIONS TO VIEW	X		X		X		X		X		X	X						
TRAFFIC CONTROL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ROAD CONDITIONS/DEFECTS	X		X		X		X	X	X	X	X	X	X	X	X			
MEDIAN-TYPE (INCL. ISLANDS)																		
CHAR.RD: FEATURES (RR BRIDGE ETC)																X	X	

		x	x	x	x	x	x	x	x								x		x	x	x	x	x	x		x	x		x	x	x	x	x	1963	MICHIGAN
		x	x			x	x		x							x			x	x	x		x	x	x	x	x		x	x	x	x	x	1966	MINNESOTA
		x	x	x	x	x	x	x	x		x								x	x			x	x	x	x	x	x	x	x	x	x	x	1966	MISSISSIPPI
			x	x	x	x	x	x													x	x	x	x		x	x		x	x	x		x	UNK	MISSOURI
		x	x	x	x	x	x		x			x								x	x		x	x	x	x	x		x	x	x	x	x	UNK	MONTANA
	x		x	x		x	x	x	x								x		x	x	x	x	x	x	x	x	x		x	x	x	x	x	1964	NEBRASKA
		x	x	x	x	x	x	x	x								x		x		x		x	x			x		x	x	x	x	x	1966	NEVADA
	x	x	x	x	x	x	x	x	x							x			x	x	x	x	x	x		x	x		x	x	x	x	x	1965	NEW JERSEY
			x			x	x		x							x			x		x	x	x	x	x	x	x	x	x	x	x	x	x	UNK	NEW MEXICO
x			x			x	x	x	x							x					x	x	x	x		x	x		x	x	x	x	x	1965	NEW YORK
x		x	x	x	x	x	x	x										x			x		x	x	x	x	x		x	x	x	x	x	1966	NORTH DAKOTA
			x	x		x	x	x	x									x			x		x	x	x	x	x		x	x	x	x	x	1965	OHIO
		x	x			x	x	x	x							x					x		x	x	x	x	x	x	x	x	x	x	x	1960	OKLAHOMA
			x			x	x	x	x									x	x		x		x	x	x	x	x		x	x	x	x	x	1964	OREGON
							x		x								x				x		x	x		x	x		x		x	x	x	1965	PENNSYLVANIA
		x	x	x		x	x		x										x		x		x	x	x	x	x		x	x	x	x	x	1966	SOUTH CAROLINA
		x	x	x	x	x	x	x									x		x		x		x	x	x	x	x		x	x	x	x	x	UNK	SOUTH DAKOTA
		x	x			x	x		x								x		x		x		x	x	x	x	x		x	x	x	x	x	1964	TEXAS
			x			x	x									x		x	x		x		x	x	x	x	x		x	x	x	x	x	1967	UTAH
x			x			x	x		x							x			x					x	x	x	x	x	x	x	x	x	x	1965	VERMONT
		x	x	x	x	x	x	x									x		x		x		x	x	x	x	x		x	x	x	x	x	1965	VIRGINIA
			x	x		x	x		x	x							x		x		x		x	x	x	x	x		x	x	x	x	x	1966	WASHINGTON
			x			x	x		x							x			x		x		x	x	x	x	x		x	x	x	x	x	1964	WISCONSIN
x		x	x			x	x	x	x							x					x	x	x	x	x	x	x		x	x	x	x	x	1965	WYOMING
6	2	25	41	20	15	40	42	24	34	3	1	2	1	1	1	12	19	6	31	7	38	11	40	42	33	41	41	9	42	41	42	41	42		

TABLE A-1 (*Continued*)

	ALABAMA	ALASKA	ARIZONA	ARKANSAS	CALIFORNIA	CONNECTICUT	DELAWARE	FLORIDA	GEORGIA	IDAHO	INDIANA	IOWA	KANSAS	KENTUCKY	LOUISIANA	MAINE	MARYLAND	MASSACHUSETTS
DATE OF FORM	UNK	UNK	1967	1966	1965	UNK	UNK	1962	1965	UNK	1960	1965	UNK	1963	UNK	UNK	1960	1966
DESCRIPTION WRITTEN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DIAGRAM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ACCDNT CLASS PROPERTY/INJ/FATAL		X	X												X			X
TYPE ACCDNT/IMP WITH	X	X	X		X		X					X				X	X	X
PROPERTY DAMAGED OWNER	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
TOTAL NO. VEHICLES		X	X	X		X	X	X	X	X	X		X	X	X			X
TIRE IMPRESS. (LENGTH SKID MRKS)															X			
DIST TRAV AFTER IMPACT	X						X											
BURNING?								X										
ROLLOVER?								X										
WITNESSES/NAME & ADDRESS.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
PEDESTRIAN ACT., DIR OR INTENT.	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
TTL AMT PROPERTY DMG 'OR DESCRIPT	X	X	X	X		X	X	X	X	X	X	X	X		X		X	X
PEDESTRIAN'S CONDITION	X		X		X				X	X	X		X	X	X	X	X	
SUBJECT VEHICLE #1 YEAR OR AGE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
MAKE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TYPE (SEDAN, TRUCK, BUS)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LIC. PLATE REG.#/STATE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SPECIAL I.D.	X								X				X			X		
COLOR			X		X													
DIRECTAL ANALYSIS/ COLL. TYPE	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
EST. SPEED	X		X		X		X	X	X		X	X	X		X			
SPEED LIMIT	X		X		X		X		X		X		X		X	X		
LEGALLY PARKED?																		
VEHICLE CONDITION OR DEFECTS	X		X		X		X		X		X	X				X	X	
SEAT BELTS INSTALLED		X	X					X		X		X		X		X		
SEAT BELTS USED		X	X					X		X		X	X	X		X		
VEHICLE OWNER'S NAME & ADDRESS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OWNER'S AGE/SEX/INJURY														X				
PARTS DAMAGED		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
REMOVED BY/TO	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	
DRIVABLE?							X		X					X		X	X	
INSURANCE/CO.		X						X	X					X				
DAMAGE ESTIMATE	X	X	X		X			X	X	X	X	X	X		X	X	X	

MICHIGAN	1963				X	X		X			X			X	X		X	X	X	X	X	X	X	X	X					X	X			X	X
MINNESOTA	1966	X				X		X	X	X	X		X			X		X	X	X	X	X	X	X	X					X	X			X	X
MISSISSIPPI	1966	X			X	X		X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X					X	X	X	X	X	X
MISSOURI	UNK	X			X	X		X			X		X	X	X			X	X	X	X	X		X	X							X		X	X
MONTANA	UNK	X			X	X		X	X	X	X		X	X	X			X	X	X	X	X	X	X	X				X	X	X			X	X
NEBRASKA	1964	X				X		X	X	X	X							X	X	X	X	X	X	X						X	X			X	X
NEVADA	1966	X	X	X	X	X		X			X		X	X	X	X	X	X	X	X	X	X	X	X	X			X		X	X	X		X	X
NEW JERSEY	1965				X	X		X	X	X	X	X	X	X			X	X	X	X	X			X	X			X	X	X	X	X		X	X
NEW MEXICO	UNK	X			X	X		X	X	X			X	X	X		X	X	X	X	X	X		X	X						X	X	X	X	X
NEW YORK	1965				X	X		X	X	X								X	X	X	X			X	X					X		X	X	X	X
NORTH DAKOTA	1966	X				X	X	X	X	X	X			X	X		X	X	X	X	X	X	X	X	X						X	X		X	X
OHIO	1965	X	X	X	X	X	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X				X		X	X	X	X	X
OKLAHOMA	1960	X			X			X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X					X	X			X	X
OREGON	1964	X			X			X	X	X			X	X	X			X	X	X	X	X	X	X	X			X		X	X	X	X	X	X
PENNSYLVANIA	1965	X			X			X					X	X				X	X	X	X		X		X						X		X	X	X
SOUTH CAROLINA	1966	X						X			X	X	X	X	X		X	X	X		X	X	X	X	X						X	X		X	X
SOUTH DAKOTA	UNK	X				X		X	X	X	X			X	X			X	X	X	X	X	X	X						X	X	X		X	X
TEXAS	1964	X			X			X	X	X			X	X				X	X	X	X		X	X	X					X	X		X	X	X
UTAH	1967	X			X	X		X	X	X	X				X		X	X	X	X	X				X	X				X		X		X	X
VERMONT	1965	X		X	X	X		X	X	X	X			X	X			X	X	X	X	X		X	X						X	X		X	X
VIRGINIA	1965	X	X			X		X	X	X	X		X	X	X		X	X	X	X	X	X	X	X						X	X		X	X	X
WASHINGTON	1966	X				X		X	X	X	X		X	X	X			X	X	X	X		X	X	X	X				X	X			X	X
WISCONSIN	1964	X	X		X	X		X	X	X					X			X	X	X	X	X		X	X					X	X	X	X	X	X
WYOMING	1965		X		X			X	X	X	X	X	X	X				X	X	X	X	X	X	X	X						X	X		X	X
		33	9	8	33	35	3	42	27	26	28	3	25	29	34	5	13	42	42	41	41	29	32	39	37	3	1	5	4	29	38	24	13	42	42

TABLE A-1 (*Continued*)

	ALABAMA	ALASKA	ARIZONA	ARKANSAS	CALIFORNIA	CONNECTICUT	DELAWARE	FLORIDA	GEORGIA	IDAHO	INDIANA	IOWA	KANSAS	KENTUCKY	LOUISIANA	MAINE	MARYLAND	MASSACHUSETTS
DATE OF FORM	UNK	UNK	1967	1966	1965	UNK	UNK	1962	1965	UNK	1960	1965	UNK	1963	UNK	UNK	1960	1966
TIME AND WEATHER																		
VEHICLE #2 (OR PEDESTRIAN) SAME INFO	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DRIVER VEHICLE #1 NAME AND ADDRESS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AGE OR BIRTH DATE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OCCUPATION	X		X		X		X	X	X	X		X	X				X	
DRIVING EXP.	X				X		X		X	X						X		
COMP. DRIVER'S ED.?										X			X					
RACE	X			X			X	X	X						X		X	
SEX	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MEMBER OF ARMED FORCES?			X													X	X	
RESDNT (STATE, TOWN, PROXIMITY)			X															
INTENTION (TURN, STOF, ETC)	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	
PHYSICAL CONDITION	X		X		X		X		X		X	X	X	X	X	X	X	
DRINKING CONDITION	X		X		X		X		X		X	X	X			X	X	
CONTRIBUTING CIRCUMSTANCE (USUALLY INCL DRNK)		X	X	X		X		X		X	X		X	X	X	X		
VIOLATION? (SPEED ETC)	X				X		X		X			X					X	X
ALCOHOL TESTS?			X				X				X			X				
DRIVERS LICENSE*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DRIVERS LICENSE STATE	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DRIVERS LICENSE EXP. DATE								X										X
TYPE OF LICENSE	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
LICENSE RESTRICTIONS		X	X			X				X				X	X	X	X	X
SAME INFO FOR DRIVER #2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OCCUPANT AND/OR INJURY INFO NO. KILLED		X	X		X				X		X	X		X			X	X
NO. INJURED	X	X	X		X		X		X		X	X		X	X		X	X
INJ/OCC LOCAT OR SEATING POS		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	
AGE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SEX	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
STD INJURY CODE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
INJ TAKEN TO/BY	X	X	X	X	X	X		X		X		X		X	X	X	X	X
FIRST AID GIVEN BY:				X		X		X		X						X		
EJECTION					X													
EJECTION AREA																		
NAME & ADDR OF OCC'S OR INJ	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SAME INFO FOR #2 OCC OR INJ	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
CLASS (BICYCLIST, PED ETC)	X	X	X		X		X									X		
PEDESTRIAN OCCUPATION			X				X		X									
RACE	X		X				X	X	X			X			X		X	
POLICE ACTIVITY INV ETC INV BY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OFFICER TROOP NO/BADGE DIST#	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SOURCE OF REPORT INFO		X		X	X	X				X	X							
POLICE ARRIV TIME					X			X	X	X	X		X					
TIME NOTIFIED	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
INV. AT SCENE?	X		X				X	X				X			X		X	
ARREST?	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
CHARGE	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	
DATE OF REPORT	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
PHOTOS TAKEN		X	X		X			X	X		X		X	X	X		X	
AGENCY INVESTIGATING			X		X													
IS INV COMPLETE	X							X	X		X	X	X		X		X	

		x	x	x	x	x	x		x	x	x				x	x				x	x	x	x	x			x		x		x	x		x		x	x	x			x					x	x	x	1963	MICHIGAN
				x						x	x				x	x					x	x	x	x			x	x	x		x	x			x	x	x	x			x				x	x	x	x	1966	MINNESOTA
		x	x	x	x	x		x		x	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x	x		x	x			x	x	x	x	x	x	x	x			x	x	x	x	1966	MISSISSIPPI
x			x	x	x	x	x			x	x		x	x		x				x	x	x	x				x		x			x				x	x	x			x	x	x	x	x	x	x	x	UNK	MISSOURI
x			x	x	x	x	x	x		x	x		x		x	x			x	x	x	x	x	x			x	x	x		x	x	x	x		x	x	x	x		x		x	x	x	x	x	x	UNK	MONTANA
x		x	x	x	x	x	x			x	x				x	x				x	x	x	x	x			x				x	x			x	x	x	x			x		x		x	x	x	x	1964	NEBRASKA
x		x		x	x	x	x			x	x	x	x	x	x	x				x	x	x	x		x		x		x		x	x	x	x		x	x	x			x	x		x	x	x	x	x	1966	NEVADA
				x	x		x		x	x	x			x	x	x				x	x	x	x	x	x	x	x			x	x	x	x		x	x	x	x			x			x		x	x	x	1965	NEW JERSEY
x			x	x	x		x	x		x	x		x		x	x			x	x	x	x	x	x	x		x	x	x		x	x	x		x	x	x	x			x				x	x	x	x	UNK	NEW MEXICO
			x	x	x	x				x	x			x	x	x		x		x	x	x	x	x	x	x	x		x		x	x			x		x	x			x					x	x	x	1965	NEW YORK
x			x	x	x	x	x			x	x					x					x	x	x	x			x				x	x		x		x	x	x			x		x	x	x	x	x	x	1966	NORTH DAKOTA
			x	x			x	x		x	x			x	x	x				x	x	x	x		x	x	x		x		x	x		x	x	x	x	x			x				x	x	x	x	1965	OHIO
x			x	x	x	x	x			x	x			x		x				x		x	x		x		x		x	x	x	x		x		x	x				x		x			x	x	x	1960	OKLAHOMA
			x	x	x		x	x	x	x	x				x	x			x	x	x	x	x				x		x		x	x			x	x	x				x					x	x	x	1964	OREGON
			x		x	x				x	x				x	x				x	x	x	x	x	x	x	x				x	x		x							x					x	x	x	1965	PENNSYLVANIA
			x	x	x					x	x	x	x	x	x	x				x	x	x	x				x		x		x	x		x			x	x			x	x		x	x	x	x	x	1966	SOUTH CAROLINA
x			x	x	x	x	x			x	x	x				x					x	x	x	x			x				x	x		x		x	x				x	x			x	x	x	x	UNK	SOUTH DAKOTA
x		x	x	x	x	x	x	x		x	x			x	x	x				x	x			x	x		x		x		x	x		x		x	x	x			x	x			x	x	x	x	1964	TEXAS
x			x	x	x		x		x	x	x				x	x	x	x	x	x	x	x	x	x			x	x	x		x	x	x		x			x			x					x	x	x	1967	UTAH
			x		x		x			x	x				x				x	x	x	x	x	x			x	x			x	x		x	x		x	x			x		x	x		x	x	x	1965	VERMONT
			x	x						x	x	x		x		x					x	x	x	x	x		x		x		x	x		x	x	x	x				x	x		x	x	x	x	x	1965	VIRGINIA
			x	x	x					x	x				x	x					x	x	x	x	x		x	x	x		x	x			x	x	x	x					x	x	x	x	x	x	1966	WASHINGTON
	x	x	x	x	x		x		x	x	x			x	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x			x			x			x	x				x	x	x	1964	WISCONSIN
			x	x	x		x	x	x	x	x				x	x				x	x	x	x				x				x	x			x		x	x			x					x	x	x	1965	WYOMING
18	3	16	38	38	38	19	33	13	12	42	42	13	9	17	36	41	1	3	10	33	41	41	41	32	24	15	42	17	34	5	40	42	9	19	25	27	33	34	3	4	41	15	9	15	24	42	42	42		

TABLE A-2

ACCIDENT DATA COLLECTED AND CODED BY EIGHT STATES

	FLORIDA		KENTUCKY		NEBRASKA		OHIO		WISCONSIN		S. CAROLINA		UTAH		CONNECTICUT		TOTALS	
F = ON FORM C = CODED	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C		
TIME AND WEATHER																		
DATE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
DAY OF WEEK	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
TIME OF DAY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
LIGHT	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	7
WEATHER	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	8	7
LOCATION, RURAL-URBAN		X				X										X	-	3
COUNTY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
CITY OR TOWN	X		X	X	X	X	X		X	X	X	X	X		X	X	8	5
IF OUTSIDE CITY, DISTANCE NEAREST TOWN	X	X	X		X		X		X		X		X		X	X	8	2
ROAD, U.S. ROUTE NO., OR CLASS OF HIGHWAY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
INTERSECTION? ...WITH	X	X	X		X	X	X		X	X	X		X	X	X		8	4
NON-INTERSECTION...MI. FROM -	X		X		X		X		X		X		X		X	X	8	1
IS ENGR. STUDY NEEDED?	X				X												2	-
KIND OF LOCALITY/LOCATION	X	X		X	X	X			X	X	X	X	X		X	X	6	6
MILEPOST OR SECT. CONTROL NO.	X	X	X	X	X	X	X	X	X				X			X	6	5
POPULATION				X		X		X		X		X				X	-	6
DISTRICT/QUADRATE OF COUNTY						X											-	1
ROADWAY																		
TYPE (ACCESS CONTROL NO. OF LANES)	X	X	X	X	X	X	X		X	X	X			X	X	X	7	6
TYPE SURFACE (CONCRETE, ETC.)					X	X										X	1	2
SURFACE (WET, ETC.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
CHARACTER (LEVEL, ETC.)	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	7
OBSTRUCTIONS TO VIEW					X	X	X				X						3	1
TRAFFIC CONTROL	X	X	X	X	X	X	X		X	X	X		X	X	X	X	8	6
ROAD CONDITION/DEFECTS	X		X								X	X				X	3	2
MEDIAN-TYPE (INCL. ISLANDS)					X	X											1	1
FEATURES (R.R., BRIDGE, ETC.)				X		X	X	X				X					1	4
DESCRIPTION																		
WRITTEN	X		X		X		X		X		X		X		X		8	
DIAGRAM	X		X		X		X		X		X		X		X		8	
ACCIDENT CLASS - PROPERTY/ INJURY/FATAL		X		X		X	X	X	X	X		X		X		X	2	8
TYPE OF ACC. - IMPACT WITH		X		X		X	X	X	X	X	X	X	X	X		X	4	8
PROPERTY DAMAGED - OWNER	X		X		X		X		X		X				X		7	-
TOTAL NO. OF VEHICLES	X	X	X		X			X	X				X	X	X	X	6	4
TIRE IMPRESSIONS							X										1	
																	-	
BURNING?	X																1	
ROLLOVER?	X												X				2	
WITNESSES	X		X				X		X		X		X		X		7	
PEDESTRIAN - ACTION, DIREC TION OR INTENTION	X		X	X	X	X	X	X	X	X	X	X			X	X	7	6
PROXIMITY OF PED'S RESIDENCE						X											–	1
TOTAL AMT. OF PROPERTY DAMAGE	X				X		X	X			X		X	X		X	5	3
PEDESTRIAN'S CONDITION			X	X	X	X	X		X		X	X					5	3
SUBJECT VEHICLE (*1)																		
YEAR (OR AGE)	X		X	X	X		X		X	X	X	X	X		X	X	8	4
MAKE	X		X		X		X		X				X	X	X		7	1
TYPE (SEDAN, TRUCK, BUS.)	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	8	7
LIC. PLATE-REGIS. /STATE	X	X	X	X	X		X	X	X	X	X	X	X		X		8	5
SPECIAL IDENTIFICATION											X		X				2	
DIRECTIONAL ANALYSIS/COLL.TYPE	X		X	X		X	X	X	X	X	X			X	X	X	6	6
EST. SPEED	X						X	X			X	X	X				4	2
SPEED LIMIT							X				X						2	

LEGALLY PARKED?											X					X	1	1
WHAT WAS VEHICLE TOWING?						X											-	1
VEH. CONDITION OR DEFECTS				X	X	X	X				X	X	X				4	3
SEAT BELTS - INSTALLED	X		X	X	X	X	X		X	X			X				6	3
SEAT BELTS - USED	X		X	X	X	X	X		X	X			X				6	3
VEH. OWNER'S NAME & ADDRESS	X		X		X		X		X		X		X		X		8	
OWNER'S AGE/SEX/INJURY			X				X										2	
PARTS DAMAGED	X		X		X		X		X				X		X		7	
REMOVED-BY/TO	X		X				X		X				X		X		6	
DRIVABLE?			X				X										2	
INSURANCE/CO.	X		X				X	X	X			X					4	2
DAMAGE ESTIMATE	X				X		X	X	X		X		X				6	1
VEH. #2 (OR PED) INFO - SAME	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
DRIVER (VEH. #1)																		
NAME & ADDRESS	X		X		X		X		X		X		X		X		8	
AGE OR BIRTH DATE	X		X	X	X	X	X	X	X	X	X	X	X		X	X	8	6
OCCUPATION	X				X	X	X				X	X					4	2
DRIVING EXPERIENCE											X						1	-
COMPLETED DRIVER'S ED?					X	X											1	1
RACE	X								X		X	X					3	1
SEX	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	7
RESIDENT (STATE, OWN, PROXIMITY)				X		X		X								X		4
INTENTION (TURN, STOP, ETC.)	X		X	X	X	X	X		X	X	X	X	X		X		8	4
PHYSICAL CONDITION			X		X	X	X				X	X					4	2
DRINKING CONDITION					X	X	X	X				X					2	3
CONTRIBUTING CIRCUMSTANCES (USUALLY INCLS. DRINKING)	X	X	X	X	X	X	X	X	X	X			X		X	X	7	6
VIOLATION? (SPEED, ETC.)						X	X	X			X	X					2	3
ALCOHOL TESTS?			X										X				2	
DRIVERS LICENSE#	X		X		X		X		X		X		X		X		8	
DRIVERS LICENSE - STATE	X		X	X	X	X	X		X	X	X	X	X		X		8	4
DRIVERS LICENSE-EXPIRATION DATE	X								X								2	
TYPE OF LICENSE	X		X	X		X	X	X	X	X	X		X		X		7	4
LICENSE RESTRICTIONS			X						X	X			X		X		4	1
SAME INFO. FOR DRIVER #2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
OCCUPANT AND/OR INJURY INFO.																		
NO. KILLED		X	X			X	X		X	X		X		X		X	3	6
NO. INJURED		X	X			X	X		X	X		X		X		X	3	6
INJ/OCC LOCATION OR SEATING POS	X		X	X	X	X			X	X			X		X		6	3
AGE	X		X	X	X	X	X	X	X	X	X	X	X		X		8	5
SEX	X		X	X	X	X	X	X	X	X	X	X	X		X		8	5
STANDARD INJURY CODE	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	7
INJURED TAKEN BY/TO	X		X		X		X		X		X		X		X		8	
FIRST AID GIVEN BY -	X												X		X		3	
EJECTION													X				1	
EJECTION AREA													X				1	
NAME & ADDRESS OF OCC'S OR INJ.	X		X		X		X		X		X		X		X		8	
SAME INFO FOR #2 OCC'S OR INJ.	X		X		X		X		X		X		X		X		8	
CLASS (BICYCL, PEDEST, ETC)						X	X	X	X	X	X	X					3	4
PEDESTRIAN - OCCUPATION											X	X					1	1
RACE	X										X	X					2	1
POLICE ACTIVITY, INVESTIGATION, ETC.																		
INVESTIGATED BY -	X		X	X	X		X		X		X		X		X		8	1
OFFICER TROOP NO/BADGE DIST #/	X		X	X	X		X		X		X		X		X		8	1
SOURCE OF REPORT INFO.								X	X	X		X	X		X		3	3
POLICE ARRIVAL TIME	X						X										2	
TIME NOTIFIED	X		X		X		X		X				X		X		7	
INV. AT SCENE?	X				X												2	
ARREST?	X		X		X				X	X	X	X	X		X		7	2
CHARGE	X		X	X	X		X		X		X		X		X		8	1
DATE OF REPORT	X				X		X		X		X		X		X		7	
PHOTO'S TAKEN?	X		X		X				X								4	
AGENCY INVESTIGATING									X			X					1	1
ACC. UNDER SAFETY RESP. ACT?												X						1
IS INVESTIGATION COMPLETE?	X				X								X				3	

TABLE A-3

ACCIDENT DATA CONTAINED ON ROUTINE TRAFFIC ACCIDENT SUMMARIES OF TEN STATES

	FLORIDA	UTAH	NEW YORK	KENTUCKY	NORTH CAROLINA	ILLINOIS	NEBRASKA	OHIO	CALIFORNIA	SOUTH CAROLINA
TYPE OF ACCIDENT										
RAN OFF ROAD	x	x	x	x	x	x	x	x	x	x
OVERTURNED ON ROAD	x	x	x	x	x	x	x	x	x	x
OTHER NONCOLLISION	x	x	x	x	x	x	x	x	x	x
PEDESTRIAN	x	x	x	x	x	x	x	x	x	x
MOTOR VEHICLE IN TRAFFIC	x				x	x	x	x	x	
PARKED MOTOR VEHICLE	x				x	x	x	x	x	
OTHER MOTOR VEHICLE		x	x	x						x
RAILROAD TRAIN	x	x	x	x	x	x	x	x	x	x
BICYCLIST	x	x	x	x	x	x	x	x	x	x
ANIMAL	x	x	x	x	x	x	x	x	x	x
FIXED OBJECT	x	x	x	x	x	x	x	x	x	x
OTHER OBJECT	x	x	x		x	x	x	x	x	x
STREETCAR		x								
ANIMAL DRAWN VEHICLE		x		x						x
OTHER VEHICLE AND PEDESTRIAN			x							
ACCIDENT CLASSIFICATIONS FOR EACH OF ACCIDENT TYPES										
NUMBER OF ACCIDENTS										
TOTAL	x	x	x	x	x	x	x	x	x	x
FATAL	x	x	x	x	x	x	x	x	x	x
FATAL AND INJURY									x	
NONFATAL	x	x	x	x	x	x	x	x	x	x
PROPERTY DAMAGE	x	x	x	x	x	x	x	x	x	x
NUMBER OF DRIVERS										
FATAL AND INJURY									x	
FATAL									x	
INJURY									x	
NUMBER OF PERSONS										
KILLED	x	x	x	x	x	x	x	x	x	x
TOTAL INJURED	x	x	x	x	x	x	x	x	x	x
INJURY CLASS A	x	x	x	x	x	x	x	x	x	x
INJURY CLASS B	x	x	x	x	x	x	x	x	x	x
INJURY CLASS C	x	x	x	x	x	x	x	x	x	x
CUMULATIVE TOTALS										
SAME MONTH LAST YEAR	x	x	x	x	x	x	x	x	x	x
THIS YEAR TO DATE	x	x		x	x	x	x	x	x	x
SAME PERIOD LAST YEAR	x	x		x	x	x	x	x	x	x
LISTED ON CUMULATIVE TOTALS										
ALL ACCIDENTS	x	x	x	x	x	x	x	x		x
PERSONS KILLED	x	x	x	x	x	x	x	x	x	x
PERSONS INJURED	x	x	x	x	x	x	x	x	x	x
FATAL ACCIDENTS									x	
INJURY ACCIDENTS									x	

PERCENT CHANGE CUMULATIVE										
DEATH RECORD	x	x		x	x	x	x	x	x	x
RATES										
ESTIMATED VEHICLE MILEAGE	x	x	x	x	x	x	x	x	x	x
DEATH RATE PER 100 MVM	x	x	x	x	x	x	x	x	x	x
FATAL ACCIDENT RATE PER 100 MVM	x	x	x	x	x	x	x	x		
PERSONS INJURED PER 100 MVM		x								
PERCENT CHANGE FROM LAST YEAR	x	x	x	x	x	x	x	x		x
ECONOMIC LOSS										x
ACCIDENT LOCATION URBAN-RURAL	x	x	x	x	x	x	x	x	x	x
SIZE CITY	x	x		x	x	x	x	x	x	x
HIGHWAY CLASS	x	x	x	x	x	x	x	x	x	x
INDEPENDENT AGENCIES	x		x			x	x			
TIME - DAY AND HOUR	x	x	x	x	x	x	x	x		
VICTIM										
AGE	x	x	x	x		x	x	x	x	
SEX	x	x	x	x		x	x	x	x	
PEDESTRIAN	x	x	x	x		x	x	x	x	
BICYCLE	x	x		x		x	x	x	x	
PEDESTRIAN ACTION	x	x	x	x		x	x	x		
DRIVER			x						x	
PASSENGER			x						x	
OTHER			x							
DIRECTIONAL ANALYSIS	x	x	x	x		x	x	x		
DRIVER										
AGE	x	x	x	x		x	x	x	x	
SEX	x	x	x	x		x	x	x		
RESIDENCE	x	x	x	x		x	x	x		
DRIVERS ED							x			
CONDITION			x				x			
OCCUPATION							x			
VEHICLE TYPE	x	x	x	x		x	x	x		
HIGHWAY										
SURFACE CONDITIONS	x	x	x	x		x	x	x		
ROAD CHARACTER (GRADE,CURVE)			x							
LOCATION (BRIDGE,RAILROAD)			x							
TRAFFIC CONTROL			x							
KIND OF LOCATION	x	x		x		x	x			
LIGHT CONDITION	x	x	x	x		x	x	x		
CONTRIBUTING CIRCUMSTANCES	x	x	x	x		x	x			
SEAT BELTS	x						x			
COUNTY	x			x	x		x		x	x
WEATHER CONDITIONS			x							
CITY SUMMARY					x					
POSITION OF OCCUPANTS							x			
PEDESTRIAN CONDITION			x				x			
DRIVER VIOLATION									x	

APPENDIX B

ACCIDENT LOCATION METHODS

SUMMARY

The principal conclusions and recommendations growing out of this review of accident location methods may be summarized as follows:

1. Historically, the procedures which have been used for locating accidents have not adequately served the highway and traffic engineer.
2. The traffic and highway engineer has been at a disadvantage in traffic safety work, because he is far removed from the data collection phase.
3. Aside from deficiencies in the basic methodology of accident location, there is an additional need for built-in quality control features designed to continually monitor the quality of the data.
4. The improvement of location methodology should include direct field coding as a desirable goal.
5. It is felt that a system of reference markers on the highway is a basic requirement for continual improvement of the location process.
6. Three types of location methods now being used or under serious development are (a) the route number-accumulated mileage system, (b) the nodal system, and (c) the coordinate system.
7. Of the three methods, the route number-accumulated mileage system has been most frequently used by the states. The nodal system has definite promise and is being used successfully in one state. The coordinate system has serious limitations and is not widely applicable.
8. The distribution of accidents on a statewide network suggests that more than one year's accident experience is necessary to do a thorough job of identifying high-frequency locations.
9. In developing a location system or improvement of an existing one, the office coding of historical accident data can serve as a useful test of the procedures. At the same time, it can supply an historical record useful in identification of high-frequency locations.

INTRODUCTION

Scope and Purpose

This appendix summarizes work on the subject of accident location. It is intended to be a comprehensive and current review of the entire subject area with the following end products:

1. A detailed review of accident location alternatives either now in use or currently under development.
2. An evaluation of the advantages and disadvantages of each alternate procedure.
3. Suggested improvements to accident location procedures which can be effectuated with a minimum investment of time and funds.
4. A statement of accident location and related topics which warrant further research.

Because accident location data are basic and important to the design and operations engineer, they have been the subject of much discussion. This project has reviewed the major concepts which have been developed to locate an event on a highway network, both in the accident field and in other related fields.

Methodology

In the conduct of the program the following steps were taken:

1. A review of the literature.
2. A review of existing accident report forms.
3. On-site visits to several state highway departments.
4. A survey of state officials soliciting information on location criteria, data processing, and accident analysis procedures.
5. Evaluation of location concepts.

The vital nature of accident location to the traffic and highway engineer has generated a considerable amount of thought and activity in recent months. However, a review of the existing literature indicates that a minimum of specific research has been accomplished; and much of what has been done concerned the development of hardware for field reference markers. In particular, it would appear that the relationship between accident location and road inventory records is worthy of considerable research. In the process of visiting several state highway departments, it became clear that the improvement of accident location procedures is considered a priority item. State highway departments in Maine, Connecticut, and Indiana were contacted, and operation of their accident location systems was observed. Conferences were held with several staff members of the Bureau of Public Roads, the Highway Safety Bureau, and several private organizations interested in the field.

Background

The use of traffic accident data by the traffic-highway engineer for design and operations research has been limited in the past, and it is well to review the reasons for this situation as a setting for the technical discussion. The engineer who is confronted with a problem-solving task can be expected to follow a typical path. The first step invariably consists of the definition of the data he will require to solve the problem, and the design of data collection procedures. In most cases this is followed by careful supervision of the data collection, to ensure that his original specifications are met. In this respect the traffic and highway engineer working in traffic safety is at a severe disadvantage. He has been far removed from the routine accident data collection process, and has had little influence over either design of the data collection procedures or supervision thereof. The problem transcends the obvious need for interdepartmental coordination. Within any particular state a large number of state, county, metropolitan, and local police departments are usually involved in collecting accident information. Further, some states have relied heavily on operators' reports of accidents. The variability in the data reported, the different levels of reporting coverage, and the problem of maintaining quality control have served to make the engineer's job difficult. Obviously, even the basic housekeeping function of identifying locations of high accident frequency requires a uniform level of accident reporting. Good location data are not enough.

A further complication has been in the area of data processing. The typical highway department has had extensive experience in handling large volumes of data. In the past ten years giant steps have been taken, particularly in the highway planning process, and a high level of data processing sophistication has been reached. On the other hand, the state agencies which have held the responsibility for processing accident records have not attained a like sophistication.

As an expedient measure many state highway departments have established accident records files in the past few years. In view of the immediate need to accelerate a sound program of records improvement and use, this has been a logical, though redundant, step. Aside from creating a file of records (which is useful in spite of its shortcomings), this action has tended to familiarize the engineering staffs with the nature of the records. Further, it has served to define the shortcomings, stimulate thought, and in some cases suggest corrective measures. Nevertheless, this should be viewed as an interim step, with data processing reverting back to the central agency as soon as the problems of reporting and data handling are resolved.

The importance of good accident location should be self-evident. It is the beginning place for the traffic and highway engineer and is equally important in developing control programs in some other areas. Without good location information the mass of data is virtually useless in establishing high accident location programs, or developing effective design and operations research programs.

The relationship between the methodology of accident location and the procedures used for highway inventories is likewise an important consideration. Jorgensen (*32*) has noted that "the basic problem of location is the referencing of an accident location so that it may be related to elements of the highway and to other accidents in terms of a common measure." Unless accidents can be related to design and operating features of the highway in an easy and reliable way, effective research would be most difficult, if not impossible. This relationship is discussed in some detail in a later section.

EXISTING LOCATION SYSTEMS

Scope of the Problem

It is well to review at the outset the nature and the scope of street and highway systems as they exist from state to state. The location of accidents on the state level is basically an inventory problem, so an understanding of the nature of the highway system to be inventoried is useful. The classification of highways varies from state to state, depending on legislative and financing requirements. Each state, however, has defined a state-wide highway system for which it exercises some degree of responsibility and control. In some states this may be divided into two or more subsystems, each carrying different degrees of responsibility and/or different financing arrangements. Of the total 3.6 million miles of streets and highways in the U.S., approximately 700,000 miles are state administered, while Federal-aid highways encompass 875,000 miles. Table B-1 summarizes the mileage variations in the designated highway systems from state to state. Initial programs would indicate that the states are putting early emphasis on their most important highways, while at the same time recognizing that the accident location procedure must be adaptable to the balance of the state's roads and streets. This first step, then, usually involves the state's primary highway system, which varies in size from a low of 1,000 miles to a high of 73,000 miles. The median system length (state administered) is 10,000 miles. The process of inventorying accidents and design and operating characteristics on a system of this magnitude involves significant expense and should proceed along carefully planned lines.

The changing nature of the highway environment should also be recognized at this point. Most state highway systems are composed of both rural and urban environments. Historically the state highway departments have placed much emphasis on the rural portions of these systems. This has happened primarily because the development and improvement of a state-wide highway system linking urban areas was obviously a job for the state. It appears that a substantial shift in emphasis is now under way and that future years will see a greater proportion of highway funds spent in urban areas. The accident "problem" has historically been considered a rural problem, mostly because of a preoccupation with the fatal accident. In terms of sheer numbers and magnitude of economic loss, the accident problem is, in fact, an urban problem. It is reasonable, then, to expect the accident location procedure which

TABLE B-1

STREET AND HIGHWAY MILEAGE SUMMARY

STREET AND HIGHWAY SYSTEM	NUMBER OF MILES ON SYSTEM		
	HIGH	LOW	MEDIAN
1. All	238,600 (Tex.)	3,270 (Haw.)	75,000
2. Federal-aid	51,800 (Tex.)	950 (R.I.)	18,000
3. State-administered	72,700 (N.C.)	1,040 (R.I.)	10,900

is adopted within a particular state to be adaptable for urban and rural use. The development of a uniform procedure within a state carries with it a very obvious advantage in the training of accident investigators. It will also simplify the state's problem of fulfilling its obligations on the urban portions of its highway systems.

What Is to Be Located?

Logically, the first step in the planning of an accident location procedure should be a definition of exactly which portion of the accident event is to be located. Baker (*33*) has described the accident as a chain of events, which he has itemized as follows:

1. Perception of hazard.
2. Encroachment.
3. Start of evasive action.
4. Leaving the roadway.
5. Leaving the road.
6. Initial contact.
7. Maximum engagement.
8. Disengagement.
9. Stopping.

Further, he suggests that a key event be designated which determines the exact time, place, and type of accident. This key event would be whichever of the following three events occurs first:

1. Running off the road.
2. Non-collision on the road.
3. Collision on the road.

It seems obvious that some kind of rigorous definition needs to be established, and yet this has not been a part of recent activity in the accident records field. The decision of which accident event to locate has generally been left to the individual coder. Perhaps the most frequent dilemma is the situation involving a vehicle running off the roadway and striking a fixed object. In analyzing the responsibility of highway variables at the particular site, it would be more advantageous to record the point of departure from the roadway as the accident location. On the other hand, in some cases the location of the fixed object which is struck has been recorded as the accident location on the premise that corrective action may involve removal or protection of the object.

There are few data available today from which one can draw an analytical picture of the accident problem. Neither the relative geometry of the collision path on the highway nor the length of the collision path are known characteristics. Many options are available for fixing the collision location and determining the location accuracy which is required, but it is extremely difficult to scientifically justify any of them.

The first alternate would be the identification of a segment of the highway over which the accident events were distributed rather than the location of one of the events itself. Although this procedure would offer maximum benefits to the users of the data, it would require a sophistication on the part of the data collector which would be difficult to attain. It presumes that a complete reconstruction of the collision paths would be accomplished in each case, and given the present-day limitation on the data collection subsystem, this appears to be beyond the potential of the mass data approach. Each of the events listed by Baker would then be another alternate, assuming that the location of a single event will represent the accident location.

Perception of the hazard, the first of these events, may be eliminated quickly as a candidate, inasmuch as it would represent a most difficult determination that would strain the capabilities of the most highly skilled and experienced professional researcher. The point of encroachment of one vehicle into the path of the other is likewise very difficult to fix in many cases. In others, such as intersection collisions, it would coincide with the principal impact. The position where evasive action begins is hardly ever noted on routine accident report forms, and it would take a high level of competency to determine this point in any particular case. In many instances, of course, no evasive action is taken at all.

Baker distinguishes the points of leaving the roadway and the road. Even with wide shoulders and a flat angle of departure, these two points would seldom be more than 15 to 20 ft apart. Reports seldom differentiate between the two; in fact, it is not clear that the average police accident investigator fully understands the distinction, particularly in rural areas where unpaved shoulders may not be sharply defined. If one of these points is to be used as accident "locator," the point of departure from the pavement is the most easily understood concept and would produce the most uniform and reliable results. This event on the collision path is a critical one, because once the vehicle leaves the pavement there is clear-cut evidence of a malfunction in the driver-vehicle-highway system. If a highway or traffic variable has influenced the path, it will be an easier task to relate the two if the collision is referenced to the departure point, rather than, say, the point of initial contact or maximum engagement. Presumably, if a highway variable did influence the path (e.g., a sharp curve) it would be upstream from the point of departure, and the relative proximity between these two points as opposed to the contact point would result in a clearer relationship. The length of collision paths is nearly an unknown quantity, although what little data are available (*12, 34*) suggest a range of lengths up to 1,000 to 1,200 ft. Use of the contact point as the accident locator would allow easier recognition of the object struck (if any) and its eventual removal or protection. Because the development of roadside standards is well along, it is likely that programs for roadside modification on the existing network will be based on the application of uniform standards. The use of accident data as an input to such a program to locate specific fixed objects is, therefore, not an important consideration.

The choice between initial contact and maximum engagement is not difficult. In terms of environmental variables, the location of the initial contact carries more significance, because it is upstream on the collision path and presumably closer to the beginning of the accident. The use of a contact or impact point as the accident locator is familiar to police investigators, although experience suggests that initial impacts are often overlooked by virtue of the subtlety of the physical evidence.

Under existing conditions the long distance used to reference accident locations lessens the importance of a definition of the accident events to serve as the accident locator. The improvement of field techniques, particularly the installation of reference markers with the attendant reduction in reference distances, will increase the necessity of a uniform and rigorous treatment.

The foregoing discussion suggests that the location accuracy, the accident type, and the selection of which accident event to locate are intimately related. All three subjects need basic research. The existing method of accident classification does not provide the environmental researcher with a very flexible or useful tool. Many state highway departments have recognized this and have treated classification along with improvement in location procedure. The attempt has been made to describe the accident in more useful detail, and to the environmentalist this implies a reconstruction of the geometry of the collision paths. The method of treatment has varied, but the goal in each case has been this symbolic representation of the vehicle geometry in computer language.

Until such time as a research effort produces some illumination on the interrelationship mentioned, some improvement can be made by defining the events to be located in each accident group. A suggested approach is given in Table B-2.

TABLE B-2

RECOMMENDED EVENTS TO BE LOCATED

ACCIDENT GROUP	EVENT TO BE LOCATED
1. Run off road	1. Point of departure from pavement
2. Non-collision on road	2. First definable point on vehicle path
3. Collision on road	3. Point of major impact

Sources of Data

It is relatively important to define the sources of data which are to be used by the highway engineer before the selection of an accident location process. Baker (*33*) has listed 24 possible sources of accident data. For the most part routinely collected information is available from two sources—the police investigator and the involved driver. The establishment of an accident location process is, of course, intended primarily for external suppliers of accident data. Should a highway department, for example, establish a small group of accident investigators to supply accident data on a sample basis, there would be no real problem in locating the events. In such a case the data collection personnel are working directly for the users of the information. Of all the state highway agencies queried, only eight felt that driver reports were a reliable source of data for their work. Even though there seems to be a general reliance on police reports, information from the driver can be useful to the traffic and highway engineer. Typically a larger number of accidents is reported by drivers, and thus a more complete inventory is possible by supplementing the police data with driver reports. Estimates of economic loss and the definition of high-accident locations are then more complete. However, beyond the fact of the accident occurrence, there appears to be little additional information on the typical driver report which is unbiased, and therefore useful for research purposes. Because the driver as a source of information is further removed than the police investigator, the reduced quality of the location data he reports creates additional data processing problems, and in general is more costly to handle. In summary, a location process which can be understood and used by the driver offers some advantage. Obviously, the advantage is related to the gap between the numbers of accidents reported by the two different sources, and the amount of resources which can be committed to processing the data.

Existing Field Procedures

Over the years the concept of accident location has developed into a more or less standardized procedure in most states. In reporting the location of an accident the police investigator typically fixes the spot in relation to a landmark in the field. The landmarks most frequently used have been major intersections (numbered routes), city-town lines, and major structures. The execution of the process has varied considerably in detail from state to state, but the concept has remained standard. The distance from the accident site to the landmark, as well as the direction, is usually reported in miles and tenths of miles (rural) or feet (urban). Some typical problems can be summarized as follows:

1. Locations based on street or highway names which do not appear on available maps.
2. Locations which are long distances from the landmark.
3. Errors in the direction from the landmark to the accident site.
4. Locations based on the name of a business or residence.
5. Estimates of distance rather than measurements.
6. Vague or incomplete data.

It should be kept in mind that this review approaches the problem from a "state level" viewpoint. Thus, accident locations which are referenced to specific utility poles may exceed minimum accuracy requirements, but are totally useless without an index at the central processing office. Observation of accident reports suggests that the distances reported are frequently estimated rather than measured, and this problem can be solved only by a quality control program and increased emphasis during training programs. Where the distances are measured they are reported to the nearest tenth of a mile, because most odometers in use read to this level. Quality control on this portion of existing records systems is nonexistent.

Office Procedures

The survey of state highway departments reveals that most of these agencies have assumed the responsibility for coding accident locations onto punch cards and computer tapes. Procedures now in use are heavily office-oriented. In other words, the accident coder working with data supplied by the police investigator makes the transformation into a form which is amenable for computer work. Many different tools have been used to assist in this operation. They include highway logs, straight-line diagrams, locally prepared street maps, business and other types of directories, utility pole indices, sign inventories, telephone contact with investigating agencies, and field observations.

Office-oriented systems carry inherent disadvantages regardless of the methodology used. First, they offer little hope of improvement in the quality of incoming location data. Second, even with the aid of all of the coding accessories listed, a significant number of cases are impossible to locate. Third, although these systems are attempts at a less costly method (i.e., than field reference markers), they are undoubtedly more expensive when the cost of creating and maintaining the coding aids is added to the cost of the coding process itself. This approach commits the state highway department to data processing burdens which can only grow larger as the number of accidents increases.

A substantial number of states have begun the improvement of the accident location process, and this has mostly taken the form of the installation of reference markers in the field. Although the specific details of the process vary considerably from state to state, the general concepts which have been developed or are under consideration fall into a relatively small number of groups. Each of these is discussed in some detail in the following.

Research Needs

There are several accident location subject areas or closely related topics which would justify more thorough and comprehensive research. Some of these are briefly mentioned in previous paragraphs and should be summarized at this point. These specific areas may be listed as follows:

1. The geometric characteristics of collision paths.
2. Collision path lengths.
3. Accuracy of accident location procedures, existing and proposed.
4. Correlation of accident location data and road inventory records.

In reviewing the current work in the accident location field, it has been observed that many states have devised procedures for describing collision paths and driving maneuvers in computer-oriented language. Indeed, outside of accident location this has received the most attention. The reason for this can be related to the engineer's responsibility for designing and operating the highway system. He thinks and designs in terms of geometry, and any analyses he might make in attempting to relate accident production to design characteristics would begin with some understanding of relative geometric patterns of the vehicle as superimposed on the geometry of the highway. The approach has taken different forms from state to state, but the general objective remains the same. Connecticut (*35*), for example, codes a descripion of each vehicle's maneuver which also identifies the roadway element (left lane, center lane, parking lane, etc.). Maine (*36*) utilizes a different approach that classifies the entire collision on the basis of the paths of the two primary vehicles involved and the highway geometry. Existing data in state records systems could be used to construct a geometric profile of the accident event. This profile would, of course, be of a qualitative nature and would describe patterns for intersection and nonintersection cases, but would not analytically describe the event. By themselves, these data would have considerable value. They would, for example, provide the traffic and highway engineer with the geometric description of the traffic accident, which he has long been lacking. Selection of the procedures for describing the geometry of the vehicle paths and the highway would, of course, be the first step in the process. The over-all task would require relatively small amounts of money and could be accomplished within a relatively short time. In essence, the creation of a classification system for the environmentalist is proposed.

It has been shown that accuracy requirements for locating accidents are related to the accident type and the length of the collision paths. Very little is known about the lengths of collision paths, although some limited data (*12, 34*) suggest that accident events can be spread over relatively long segments of highways. If this is actually the case, research relating accidents to highway variables must account for these large spatial separations. There is no substantial source of existing data which could be used to supply a comprehensive answer to this research question. For this reason new data would have to be collected, requiring substantial amounts of time and money.

Actual field testing of the accuracy of accident location procedures would be another valuable project. The highway and traffic engineer's relative exclusion from the data collection phase of the accident records system has left him without a clear picture of the capabilities of this portion of the system. At this point it is difficult, if not impossible, for him to assess the accuracy implications of alternate proposals as related to the police officer in the field. If the enforcement agency is to continue in the prominent role of data collection, it will be necessary for the engineer to obtain a better understanding of the capabilities involved. Actual field demonstrations comparing the accuracy of alternate location methods would have bearing on the need and frequency of field reference markers as well.

The amount of research relating accidents to highway variables which can be accomplished from records systems will depend on a correlation of accident and road inventory records. Although some states have extensive computer files of their road inventory, few have made a correlation with accident records systems. The amount of road inventory data which can be collected, their detail, and the most desirable method of sectioning the highway network for this records system are questions which need considerable research and study.

ACCIDENT LOCATION CONCEPTS

There are only three distinct location concepts which have been used or are being seriously considered in the United States, as follows:

1. Route number-accumulated mileage system.
2. Nodal system.
3. Coordinate system.

As already noted, each of the three basic concepts may be executed in different manners with substantially different internal procedures (see Table B-3). Perhaps the most frequently observed difference is the presence or absence of field reference markers. Each of the systems can be operated with or without field reference markers, although there seems to be general agreement among the state highway departments that reference markers will be a requirement. Of the 49 states queried, 20 departments felt that markers were necessary in rural areas only, while 23 departments felt that they were necessary in both rural and urban areas (see Table B-4).

The vast majority of states that have taken recent action in the field are using the route number-accumulated mileage concept. The nodal concept has been under development in only one state (Maine) and has been used for surveillance of high-accident locations on a state-wide basis (state and Federal highways). The coordinate concept is likewise under development in only one state (Indiana), but it has not been used for any state-wide analyses at this time.

Because this project emphasized improvements that can be made to existing systems, no attempt was made to explore more sophisticated processes now in the "brainstorming" category.

TABLE B-3

SUMMARY OF ACCIDENT LOCATION CONCEPTS

A. *Route number-accumulated mileage system:*
   1. Reference markers at regular intervals (1 mile, 2 miles).
   2. Reference markers at irregular intervals (existing sign posts, structures).
   3. Reference markers at irregular intervals (intersections).
   4. No field markers; straight-line diagrams; field coding (diagrams distributed to police).
   5. No field markers; straight-line diagrams; office coding.

B. *Coordinate system:*
   1. No reference markers; field coding (maps distributed to police).
   2. No reference markers; office coding.

C. *Nodal system:*
   1. Reference markers (intersections, structures, city-town lines, etc.); field coding.
   2. No reference markers; office coding.

Route Number-Accumulated Mileage System

As noted, the concept of using a route number and accumulated mileage to locate accidents is by far the most prevalent system now being used or under consideration in the United States. Essentially, this system calls for the identification of each portion of the highway network by assignment of a route number. These route numbers are identical to the highway route numbers used for motorist guidance in many states, but exceptions have been observed. These routes are mapped, and the accumulated mileage starting from a zero point is assigned to landmarks or at regular intervals.

The manner in which the police officer reports the location on his accident form will, of course, vary with the design of the system itself. Where reference markers are used in the field, it is customary for the officer to report the route number and the accumulated mileage of the accident site directly. He determines the accumulated mileage by measuring the distance from the accident site to the nearest field reference marker, and either adds or subtracts the measurement to the reading on the reference marker. The reference markers have been placed in the field in two different ways. Most commonly, reference markers have been placed at even 1-mile increments. However, a substantial number of states have placed the markers on existing structures (such as bridges or sign posts), or are marking accumulated mileage of major intersections. Several states have successfully used detailed straight-line diagrams or highway logs in the location process, and these procedures have been substituted for the reference markers in the field. Obviously, in this situation the location process remains essentially an office procedure, with the accident coder fixing the location of the accident according to the route number and accumulated mileage and based on all of the usual data reported by the police.

A recent survey by the Insurance Institute for Highway Safety (*37*) showed that 17 states have accident location systems in operation or under development which use the route number-accumulated mileage concept and incorporate field reference markers. Two additional states are using the route number-accumulated mileage concept without field reference markers. Both of these states are using detailed straight-line diagrams, which were created for other purposes. It is interesting to note that the basic procedures for these two states vary, in that one state relies on office coding of the location, while the other supplies police investigators with the straight-line diagrams for coding in the field.

The major advantage of the route number-accumulated mileage concept is that it appears to be the most generally applicable method of keeping highway records. This stems from the fact that it carries with it the ability to divide each highway route into segments of any length. Thus, a highway sufficiency section may encompass 10 or 20 miles of roadway, whereas a road inventory section may only be 0.01 mile long. This probably simplifies the data collection task in these fields, as there is no "forcing" of section termini. There seems to be a consensus that route number and accumulated mileage are desirable as a base for most highway "bookkeeping" operations. There is, however, little published work on the subject. The Bureau of Public Roads has recognized the importance of this records keeping task and is now assisting the states in the development of the systems. The concept is a familiar one to most state highway departments, because it has been used frequently for road inventory and maintenance records systems.

The concept has several disadvantages. Because it is a one-dimensional system, there is little direct use in some allied fields. For example, the use of field reference markers, which may be considered a part of most accident location systems, has been cited as an aid to motorist

TABLE B-4

SUMMARY OF ACCIDENT LOCATION CRITERIA

QUESTION	ALABAMA	ALASKA	ARIZONA	ARKANSAS	CALIFORNIA	COLORADO	CONNECTICUT	DELAWARE	DIST. OF COL.	FLORIDA	GEORGIA	HAWAII	IDAHO	ILLINOIS	INDIANA	IOWA	KANSAS
TOTAL RESPONSES TO SURVEY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1. DOES YOUR HIGHWAY DEPARTMENT RECEIVE ACCIDENT REPORTS:																	
ROUTINELY?	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X
UPON REQUEST?							X								X	X	
AT STATE LEVEL?	X	X	X	X	X	X	X	X		X	X		X	X	X	X	
AT DISTRICT LEVEL?					X		X					X					
2. ACCIDENT REPORTS ARE RECEIVED FROM:																	
POLICE	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
DRIVERS		X					X						X	X		X	X
SPECIAL HIGHWAY INVESTIGATIONS							X				X		X	X		X	X
OTHERS														X			
3a. ARE ACCIDENT LOCATIONS CODED ONTO COMPUTER CARDS OR TAPE:		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
BY HIGHWAY DEPARTMENT?		X	X	X	X		X	X		X	X	X	X	X			X
BY MOTOR VEHICLE AGENCY?						X										X	
BY OTHERS?									X				X				
3b. IF THE HIGHWAY DEPARTMENT DOES NOT CODE ACCIDENT LOCATION AT PRESENT, DO YOU PLAN TO DO SO IN THE FUTURE?	X														X		
4. ENFORCEMENT PERSONNEL REPORT ACCIDENT LOCATION BY DISTANCE FROM A LANDMARK.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5. IS RELIABLE ACCIDENT LOCATION DATA OBTAINABLE FROM:																	
OFFICIAL POLICE REPORTS?	X	X	X	X	X	X		X	X	X	X	X	X			X	X
DRIVER REPORTS?									X								
BOTH DRIVER AND POLICE REPORTS?							X							X	X		
NEITHER DRIVER NOR POLICE REPORTS?																	
6a. ACCIDENTS MUST BE SUMMARIZED FOR THE FOLLOWING PORTIONS OF THE STATE HIGHWAY SYSTEM:																	
A SPECIFIC CURVE OR OTHER MAJOR GEOMETRIC ELEMENT		X	X		X	X	X			X	X				X	X	X
A SPECIFIC LEG OF AN INTERSECTION		X	X		X	X	X			X	X					X	X
A SPECIFIC INTERCHANGE RAMP			X		X	X	X	X			X				X	X	X
A SPECIFIC INTERSECTION OR INTERCHANGE		X	X		X	X	X	X	X	X	X	X		X	X	X	X
A SPECIFIC ROUTED HIGHWAY			X		X	X	X	X		X	X	X			X	X	X
A SPECIFIC FEDERAL AID HIGHWAY		X	X		X	X	X	X	X	X		X				X	X
A SPECIFIC FEDERAL AID OR STATE HIGHWAY SUBSYSTEM (SUCH AS FEDERAL AID PRIMARY, ETC.)		X	X		X	X	X	X	X	X	X	X	X		X		X
A SPECIFIC CITY OR TOWN			X				X	X	X	X	X			X	X		X
A SPECIFIC COUNTY			X					X		X	X	X					X
6b. IN ORDER TO SUMMARIZE ACCIDENTS ADEQUATELY, LOCATIONS MUST BE ACCURATE TO THE NEAREST:																	
0.01 MILE		X		X	X	X	X	X	X				X		X		
0.10 MILE	X		X			X				X		X		X			
0.25 MILE											X					X	X

KENTUCKY	LOUISIANA	MAINE	MARYLAND	MASSACHUSETTS	MICHIGAN	MINNESOTA	MISSISSIPPI	MISSOURI	MONTANA	NEBRASKA	NEVADA	NEW HAMPSHIRE	NEW JERSEY	NEW MEXICO	NEW YORK	NORTH CAROLINA	NORTH DAKOTA	OHIO	OKLAHOMA	OREGON	PENNSYLVANIA	RHODE ISLAND	SOUTH CAROLINA	SOUTH DAKOTA	TENNESSEE	TEXAS	UTAH	VERMONT	VIRGINIA	WASHINGTON	WEST VIRGINIA	WISCONSIN	WYOMING	PUERTO RICO	TOTAL
x	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	49
x	x	x	x		x	x	x			x	x	x		x		x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	44
			x												x																				5
x	x	x	x		x	x	x			x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	44
			x												x									x											6
x	x	x	x		x	x	x			x				x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	44
						x	x			x					x		x	x		x	x		x		x	x	x		x	x	x		x		22
		x	x		x							x			x									x					x			x			14
											x																				x				3
x	x	x	x		x	x	x	x		x				x		x	x	x	x	x	x		x	x		x	x	x	x	x	x	x		x	41
	x	x	x		x	x	x	x		x				x			x	x	x	x	x		x	x		x	x	x	x		x	x		x	35
														x	x	x																			5
x																											x		x	x					6
				x							x	x		x			x																x		8
x	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x	x	48
x	x	x	x		x			x			x			x		x	x		x	x			x	x			x	x	x	x		x		x	34
																																			1
						x	x														x				x	x					x				9
				x								x			x			x															x		5
x	x	x	x		x							x		x	x		x	x	x	x	x			x	x			x	x	x	x	x	x		31
			x		x							x		x					x	x	x				x		x		x			x	x		21
		x	x	x	x							x		x					x	x	x			x	x		x	x	x	x	x	x	x		27
x	x	x	x	x	x	x		x				x		x	x		x	x	x	x	x		x	x	x		x	x	x	x	x	x	x		40
x	x	x	x	x	x	x	x	x						x	x		x	x	x		x		x	x	x		x		x	x	x	x	x		35
x			x		x	x	x							x	x		x	x	x		x		x	x	x		x		x	x	x	x	x		31
x		x	x		x	x	x	x						x	x		x	x	x	x	x			x	x		x	x	x	x	x	x		x	36
		x	x	x	x	x	x							x	x		x	x	x	x	x						x		x		x		x	x	27
			x	x	x	x	x							x	x		x	x	x		x						x		x				x		20
			x		x							x				x		x		x	x				x					x	x	x			20
x	x	x		x		x		x			x			x	x				x				x	x		x	x	x	x				x	x	24
							x										x																		5

TABLE B-4 (*Continued*)

QUESTION	ALABAMA	ALASKA	ARIZONA	ARKANSAS	CALIFORNIA	COLORADO	CONNECTICUT	DELAWARE	DIST. OF COL.	FLORIDA	GEORGIA	HAWAII	IDAHO	ILLINOIS	INDIANA	IOWA	KANSAS
7. FIELD MARKERS ARE:																	
NECESSARY IN RURAL AND URBAN AREAS	X		X	X						X	X	X	X				
NECESSARY IN RURAL AREAS ONLY		X			X	X	X		X					X		X	
NECESSARY IN URBAN AREAS ONLY																	X
NOT NECESSARY								X							X		
8a. ACCIDENT RECORDS DATA ON CARDS OR TAPE:																	
CURRENTLY OPERATIONAL		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
IN PLANNING STAGE																	
UNDER CONSIDERATION	X																
8b. ABILITY TO IDENTIFY HIGH FREQUENCY ACCIDENT LOCATIONS ON A PERIODIC BASIS:																	
CURRENTLY OPERATIONAL			X	X	X	X	X	X	X		X		X	X			X
IN PLANNING STAGE										X		X			X		
UNDER CONSIDERATION	X	X														X	
8c. ACCIDENT AND HIGHWAY INVENTORY DATA ON CARDS OR TAPE WITH GOOD COMPATIBILITY OF LOCATION METHODS:																	
CURRENTLY OPERATIONAL					X					X	X						
IN PLANNING STAGE		X		X			X	X	X					X	X		
UNDER CONSIDERATION	X		X			X						X	X			X	
HAVE NO PLANS																	
8d. ABILITY TO USE ACCIDENT AND INVENTORY DATA (MECHANICALLY) AS INPUTS IN FORMULATION OF GENERAL DESIGN AND OPERATING POLICY:																	
CURRENTLY OPERATIONAL					X												X
IN PLANNING STAGE				X			X				X			X			
UNDER CONSIDERATION	X		X			X		X		X		X	X		X		
HAVE NO PLANS		X							X							X	
8e. ABILITY TO MAKE ANALYSES AT SPECIFIC LOCATIONS FOR ENGINEERING PURPOSES BY COMPUTER (FEW SUCH PROJECTS REQUIRE REVIEW OF SOURCE DOCUMENTS):																	
CURRENTLY OPERATIONAL					X		X		X		X		X				X
IN PLANNING STAGE				X						X				X	X		
UNDER CONSIDERATION	X	X	X			X		X				X				X	
HAVE NO PLANS																	
8f. ABILITY TO MAKE ALL ANALYSES MECHANICALLY (BY COMPUTER) WITHOUT RESORTING TO ACCIDENT SOURCE DOCUMENTS:																	
CURRENTLY OPERATIONAL							X										
IN PLANNING STAGE					X			X			X				X		
UNDER CONSIDERATION		X	X	X		X				X				X			
HAVE NO PLANS	X								X				X			X	

KENTUCKY	LOUISIANA	MAINE	MARYLAND	MASSACHUSETTS	MICHIGAN	MINNESOTA	MISSISSIPPI	MISSOURI	MONTANA	NEBRASKA	NEVADA	NEW HAMPSHIRE	NEW JERSEY	NEW MEXICO	NEW YORK	NORTH CAROLINA	NORTH DAKOTA	OHIO	OKLAHOMA	OREGON	PENNSYLVANIA	RHODE ISLAND	SOUTH CAROLINA	SOUTH DAKOTA	TENNESSEE	TEXAS	UTAH	VERMONT	VIRGINIA	WASHINGTON	WEST VIRGINIA	WISCONSIN	WYOMING	PUERTO RICO	TOTAL
X		X		X		X	X	X		X		X			X	X		X	X							X	X				X			X	23
	X										X			X			X			X	X			X	X			X	X	X		X	X		20
																																			1
			X		X																		X												5
X	X	X	X		X	X	X	X		X		X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	46
				X																															1
											X																								2
X	X	X	X		X	X	X	X				X			X	X		X	X	X	X		X	X	X	X	X		X		X	X		X	35
				X						X																				X			X		7
											X			X			X											X							7
			X				X	X								X		X	X		X		X	X		X	X	X	X			X		X	18
	X	X			X							X			X										X					X	X		X		16
X				X		X				X				X			X			X															13
											X																								1
			X				X									X					X		X			X	X		X					X	11
		X			X			X											X				X	X						X	X	X	X		14
X	X			X		X				X		X		X	X		X	X																	18
											X									X								X							6
		X				X	X									X		X		X	X		X			X	X		X			X			18
			X		X			X											X					X						X	X		X		12
	X			X						X					X	X		X																	13
X											X	X													X			X						X	6
							X									X				X	X		X			X	X		X						9
								X										X													X	X	X		9
	X		X	X	X	X				X					X				X					X				X		X					17
X		X									X	X		X			X								X									X	12

guidance. Inasmuch as most field reference markers do not carry a route number, but only the accumulated mileage, the real benefits in this area have been quite small. At the same time, more sophisticated methods of route guidance and vehicle control have received some attention and are worth considering. At the present time the Bureau of Public Roads (*38*), as an aid to the motorist, is developing a guidance system that would include the transmission of data from roadside transmitters to each vehicle. Development of this system has reached the point where early work on the system hardware is under way. This innovation is based on a nodal principle, and the issuance of guidance information will take place at highway decision points or intersections. There has been some departure in detail from the nodal systems developed for accident records and for highway planning studies. The process proposed for the route guidance system uses a nodal identification number and a branch indicator. The branch indicator signifies the leg of a particular intersection which the motorist must follow. Thus, the system can be easily adapted to a dynamic process, because it can indicate both position on the network and direction of travel. Although the route number and accumulated mileage concept can be made compatible through a computer correlation program, it obviously is less adaptable in this field and in the highway planning process than a nodal system would be.

Changes in route numbers, modifications to existing routes, and overlapping route numbers all create some problems in the data processing phase using the route number and accumulated mileage concept. Obviously, these can be overcome by the use of equations, but here again this means a growing inefficiency in the data processing work as time goes on. It also makes the system appear to be more complex and less logical to the police officers in the field.

At least one state (*39*) solves these problems by conversion of reported route number-accumulated mileage to actual route number-accumulated mileage prior to routine accident summaries.

Specific problems which are difficult to handle are complex highway situations such as interchanges and channelized intersections. Here again, the problems are not insurmountable, although a methodical treatment should probably involve the marking of all ramps and turning roadways to eliminate the confusion which would exist in the police officer's mind. These problems have largely been shelved in the development of the location systems (*40*) awaiting future refinements.

As previously noted, several states have applied the route number-accumulated mileage concept without installing reference markers in the field. It would seem that this has been an attempt to devise a more economical system. There is, however, question as to whether the attempt has been at all successful. Clearly, where sources of highway descriptive data (such as straight-line diagrams) are available, they may result in initial savings. Neither of the states using these diagrams prepared them specifically for use as an aid in locating accidents. The cost of developing the straight-line diagrams has been estimated by one urban state at $100 per mile, with an annual investment for maintenance of the records running about $25 per mile. This can be compared with reference marker costs which have varied from $6 to $15 per mile for initial installation. Reference marker maintenance costs have been estimated at 20% to 30% per year. It should be pointed out that the straight-line diagrams cannot be used exclusively in the accident location process. One of the states now using diagrams has estimated that other sources of information, such as city directories, have been used in approximately 30% of the cases. Coding costs are undoubtedly higher in this type of process, because the routine is entirely office-oriented. The use of reference markers in the field should mean that a large percentage of the locations are computer coded in the field by the accident investigator, and thus office routine can be reduced to editing and checking. Because the numbers of accident cases which have to be processed are quite large, this additional cost should also be considered a significant item. Coding costs (location and other data) are now the order of $1 per case, and location accounts for a substantial portion of the total coding cost. The use of the concept without reference markers leaves little likelihood that location accuracy will be improved in the future.

The posting of reference markers at regular intervals, such as every 1 or 2 miles, carries several disadvantages. In the first place, there is no control over the location of section boundaries, and they thus have little or no significance in terms of the events on the highway or changes in highway characteristics. It has been shown that the number of intersections has a most important influence on the number of accidents in any particular highway link (*41*). For this reason it would be necessary for analysis purposes to have a complete record of the number of intersections in each mile segment. Further, it would be desirable to have a complete computer index of the accumulated mileage location of each of these intersections. This is almost a necessity, because the retrieval of accident data for a specific intersection is perhaps the most common everyday task which highway departments face.

Summary of accidents by Federal-aid system also presents a problem. Although accidents which occur at intersections are generally influenced by both intersecting routes, a decision must be made as to which highway system will be charged. There seems little choice but to do this on some arbitrary basis. Usually the system having the highest level of design has been charged. This at least represents a uniform method of treatment. At the same time, it has been customary to tie intersection accidents to either the lowest or highest route number, and thus a uniform treatment is not attained insofar as accounting on a Federal-aid system basis is concerned. This deficiency could probably be corrected by an elaborate computer program.

This same problem would arise in any attempt to retrieve all accidents for a particular route. Obviously it would be necessary to retrieve all intersection accidents along the route. To do this, the route number and accumulated mileage of every intersection would have to be stated. Although this is possible, it obviously would be cumbersome in execution.

Unless the reference markers carry route designation, it is necessary for the accident investigator to determine the route. Although this in many instances will be routinely recalled from memory, there undoubtedly will be a significant number of cases which involve some additional work on the part of the investigator. There also remains the possibility of error on streets and highways which are marked as access to numbered routes (i.e., "to U.S. Route 1"). The whole concept is completely dependent on a thorough route signing system. In general, route signing is rather comprehensive in rural areas, but many urban areas leave much to be desired. A further problem with the concept is related to the possibility of its use on streets and highways other than primary routes. Unless a more comprehensive route numbering and signing program is adopted, a large number of accident cases will undoubtedly be left for office coding. The probability for successfully using the same procedures for urban areas is low.

Coordinate System

Coordinate systems for location of accidents are under consideration or development in two or three states. Simply stated, the concept calls for location of an accident site to be identified by its unique set of plain coordinates. The system depends on a complete set of maps with coordinate grids imprinted. In Indiana (*42*), where the concept is under development, the U.S.G.S. topographical maps have been used as a base. Extensive work was involved in preparing the grid overlays (state plane), as well as the addition of informative data. The new 7½-min series (1 in. = 2,000 ft) has been used.

There are several approaches to the use of this concept. The first approach involves the printing of a large number of maps and their distribution to all police officers in the state. The police officer then determines the coordinates of the accident site while he is investigating the accident and reports these coordinates directly. An alternate approach, of course, would be to code the coordinate locations in the office using the routine location data which are now on the accident report form. The University of Indiana has used this approach in the development of the final process, which will utilize distribution of maps to the police officers. In order to maintain location integrity, it is necessary to carry the route number as well as the coordinates of the location. Where state plane coordinates are used, the zone identification must also be known and thus county identification is a must.

One of the principal advantages in establishing coordinate benchmarks for a highway system is the ability to use mechanical plotting equipment. The use of this equipment is at a minimal level at the present time, but it can be expected to increase. Although the use of coordinates to locate accidents may simplify and encourage the use of mechanical plotting equipment, it is pointed out that the coordinate concept can easily be correlated with either the route number-accumulated mileage concept or the nodal concept to accomplish the same utility. The coordinate concept has several severe problems which will limit its general usefulness. The quantity of data required under the system to uniquely identify a location is considerably more than in other systems. Fourteen digits are required to express the coordinate location, plus an additional two or three for the route number. Obviously, the more voluminous the information, the greater the data processing costs. In addition, the lengthy identification numbers are more susceptible to recording and reporting errors and the errors are more difficult to detect. At the same time, the accuracy requirements are inherently greater with this process, as allowances for small errors can result in the accident being located in an entirely different facility.

The availability and/or production of maps is a further problem. The U.S.G.S. maps are available in most states at the scale of 1 in. = 4,000 ft, and at this scale 50 ft represents approximately 0.01 in. In some parts of the country U.S.G.S. maps are now available in the new 7½-min series (1 in. = 2,000 ft), but even at this scale 50 ft represents approximately 0.02 in. Assuming that base maps are available, the cost of modification can run in the order of $30 per mile, and this does not consider the additional work which would have to be done to make the maps useful in urban areas.

Re-mapping of the United States at the 7½-min (2,000-ft) scale has proceeded slowly, mainly because 90 percent of the Geological Survey's mapping budget still is spent on covering unmapped areas of the country. A very large percentage of the existing maps are outdated by the U.S.G.S.'s own standard (5 years urban, 10 years rural). At present it takes a full three years from the beginning of aerial photography to issuance of the final product by the U.S.G.S. For these reasons it is clear that the availability of appropriate maps would be a severe restraint on the widespread use of the coordinate system.

Distributing maps to the police for their use in directly reporting coordinates would appear to be a risky procedure based on current knowledge and experience. Field procedures should be kept as simple as possible, due to the wide range of data collection competencies. At this time, it is not clear that the typical accident investigator can accurately locate his position on a map and read coordinates to the necessary requirement. The problem of map reading in adverse conditions (such as darkness, rain, snow, and in relatively rural areas with few landmarks) should be apparent.

Where the start-up time for a new accident location system is critical, this procedure is at a definite disadvantage, because a considerable amount of careful and meticulous map work must be done. Printing and distribution of the maps, along with training programs, are apt to take considerable time. The cost of modifying and updating the maps is an unknown quantity at this time, but it is likely to be a substantial cost which would compare in magnitude with the cost of maintaining reference markers.

Nodal System

Only one state (Maine) has developed a nodal system for locating accidents (*15, 36*). Under this concept, which is adapted from network principles used extensively in the highway planning field, the highway network is simulated mathematically by the identification of nodes or intersections. Field reference markers are optional with this system as with the others, but omitting them reduces the accuracy level. In Maine reference markers are to be installed at all intersections, city-town lines, major bridges, and railroad grade crossings. Reference markers have been laid out, and work will start soon on field installation for the 4,500 miles of state and Federal-aid highways (urban and rural). The procedures call for the police officers to report the accident location directly in coded form. If the event occurs at an intersection which is referenced, a single 4-digit number identifies the location. If the accident took place between nodes, the link is identified by the node numbers on either side, and a distance to one of the nodes is also reported. The field procedures, then, are very similar to the route number-accumulated mileage procedures, with the exception that the police officer does not make a determination of the route number, nor does he compute the accumulated mileage by adding or subtracting his measured distance. To test the concept, the system was designed and the accidents for 1966 were location coded using the existing data on the accident report form and the network maps. Initial reaction to the test was favorable, and further developments, including reference markers in the field, are now under way. Slightly over 10,000 locations are to be field referenced on this 4,500-mile highway system. These locations are distributed by type as follows: intersections, 80%; city-town lines, 8%; major bridges, 6%; dummy nodes, 4%; railroad grade crossings, 2%. Dummy nodes were used where the link length would have otherwise exceeded 1 mile in urban areas or 2 miles in rural areas.

Because most highway departments have used nodal concepts extensively in highway planning, a considerable backlog of experience and familiarity exists. In addition, the construction of a simulated state-wide network would be of considerable use in this planning process. It is possible that state-wide networks for planning purposes (e.g., traffic assignments) would not exactly duplicate networks created for accident location purposes. A network for a state-wide traffic assignment would not require 1-mile links, for example. Nevertheless, the basic framework would be usable and could be easily transformed. A substantial proportion of accidents occur at intersections, and these will be very accurately located with a minimum of location data under this concept. Further, the retrieval of the accident experience at a particular intersection will be easily accomplished. This is a problem which highway departments face routinely. Summaries of accidents on links, at intersections, at specific types of intersections, on specific routes, or at specific areas can also be easily prepared. Location procedure is equally applicable in urban and rural environments and, in fact, conforms to the population density. The field procedures, because they are very similar to existing methodology, should be easily absorbed by the police officer, and extensive training programs are not necessary. Start-up time for the system can be considered relatively short.

The concept is more flexible in complex highway systems, such as interchanges and channelized intersections, than either the route number-accumulated mileage or the coordinate systems. The same methodology can be carried through, with reference markers placed at ramp termini and at the intersections of directional roadways. It should be noted that good correlation can be established between the route number-accumulated mileage and nodal concepts by preparing an index of the route number and accumulated mileage of each node. The degree of flexibility of the nodal concept in terms of road inventories is a subject requiring some further study, and this developmental work is to begin very shortly in Maine. The intersection is a point on the highway network where design elements and operating characteristics frequently change. Traffic volumes are probably the most obvious example. The large majority of significant changes in traffic volume occur at intersection locations. The applicability of the nodal concept as a general means of highway inventory is open to question at this point. Nevertheless, compatibility with route number-accumulated mileage can be established, and thus accidents and inventory elements can be related in this manner.

It has already been mentioned that the more sophisticated work on route guidance systems is based on a nodal principle, and even though the details are not identical, there would appear to be some advantage in the development of both systems along the same general guidelines. This is particularly true when one considers that the "decision points" on the route guidance network are the same intersections or nodes which will be field referenced for accident location.

Some of the early analysis of Maine's new accident data file sheds considerable light on the distribution of accidents on a state-wide network. Table B-5 summarizes the number of nodes and links on the system which experienced specified numbers of accidents during the calendar year 1966. A total of 11,007 accident cases were located on the 4,500 miles of state and Federal-aid highways. (An additional 1,000 cases were tied to a highway system in a specific city or town, but could not be more accurately located.) Of these 11,007 cases, 64 percent (7,044) occurred on links, and 36 percent at nodes.

Accident occurrence was more widely dispersed on links as opposed to intersections, with only 18 percent of the intersections having an accident, compared to 40 percent of the links. Of the links having an accident, 8 percent had more than three, whereas the corresponding figure for nodes was 14 percent. These data suggest the desirability of more than a year's information as a base for accident surveillance programs, particularly for nonintersection locations. Coding of historical accident records during the system development process is helpful in this respect, as well as providing an opportunity for testing portions of the system prior to major investments.

The diffusion of accidents on the network also suggests that installation of field reference markers at closer than 1- to 2-mile intervals would be difficult to justify on the basis of accident surveillance needs.

TABLE B-5

STATE-WIDE ACCIDENT DISTRIBUTION ON NODAL SYSTEM, STATE OF MAINE, 1966

NODES
Number of Accidents

HIGHWAY SYSTEM (URBAN)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	TOTAL ACCIDENTS
1. Interstate & Pike	7	3	1	1								1																		13
2. Fed. Aid Primary	476	179	101	64	37	20	18	12	8	8	5	6	9	1	4		1	2	1		1							1		954
3. Fed. Aid Secondary	220	65	16	7	8	6	3	2	1	3	1																			332
4. Non-Fed. Aid (S.H.)	14	2	1	1																										18
SUBTOTAL (URBAN)	717	249	119	73	45	26	21	14	9	11	6	7	9	1	4		1	2	1		1							1		1317
HIGHWAY SYSTEM (RURAL)																														
1. Interstate & Pike	5	1																												6
2. Fed. Aid Primary	191	69	22	14	2	1	1																							300
3. Fed. Aid Secondary	161	38	12	4	2																									217
4. Non-Fed. Aid (S.H.)	12	4				1																								17
SUBTOTAL (RURAL)	369	112	34	18	4	2	1																							540
TOTAL (URBAN AND RURAL)	1086	361	153	91	49	28	22	14	9	11	6	7	9	1	4		1	2	1		1							1		1857

LINKS
Number of Accidents

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	TOTAL
HIGHWAY SYSTEM (URBAN)																														
1. Interstate & Pike	86	23	5	3	1																									118
2. Fed. Aid Primary	630	219	77	42	20	9	10	4	1	3	1	1																		1017
3. Fed. Aid Secondary	253	67	19	9	6	3																								357
4. Non-Fed. Aid (S.H.)	22		3	1				1							1															28
SUBTOTAL (URBAN)	991	309	104	55	27	12	10	5	1	3	1	1			1															1520
HIGHWAY SYSTEM (RURAL)																														
1. Interstate & Pike	234	84	42	20	11	6		3		1																				401
2. Fed. Aid Primary	555	233	119	66	31	14	10	3	2	1		1	1																	1036
3. Fed. Aid Secondary	739	233	67	38	11	2	1		1																					1092
4. Non-Fed. Aid (S.H.)	43	13	7		2		1																							66
SUBTOTAL (RURAL)	1571	563	235	124	55	22	12	6	3	2		1	1																	2595
TOTAL (URBAN AND RURAL)	2562	872	339	179	82	34	22	11	4	5	1	2	1		1															4115

Note: Numbers shown are the number of nodes and links having the specified number of accidents in 1966

DISCUSSION AND EVALUATION

Objectives

Before discussing the advantages and disadvantages of existing location methods, some guiding objectives against which a comparison can be made are suggested. Some of these objectives are alluded to in previous sections, but are summarized here as follows:

1. The location system should provide a uniform means of locating accidents on streets and highways throughout a particular state.
2. The system should be simple in concept in order to increase the reliability of the data collection task.
3. The system should permit field coding of the accident location in computer-oriented language.
4. The system should permit efficient retrieval of accident data for the following urban and rural portions of the total highway network:
   (a) Intersections.
   (b) Highway segments (1/10 mile to 2 miles).
   (c) Federal-aid highway systems.
   (d) State highway systems.
   (e) Routed highways.
5. The system should be compatible with road inventory data.
6. The system should provide for an efficient updating cycle to account for modifications in the existing highway network (i.e., route changes, construction, etc.)
7. The system should be designed so as to minimize data processing time, effort, and cost for accident analyses.
8. The location procedure should be recognized as a tool for accident reduction, and the cost of the system should be reasonable.
9. The system should be operable with a minimum start-up time.
10. The system should be amenable to development in stages.

It is pointed out that accident data are used by highway departments for the following two generalized purposes:

1. The "housekeeping" function of identifying high-frequency accident locations.
2. Research on the relationship between design and operating characteristics and accident production.

The accuracy requirements for locating accidents depend on which of these two functions is under consideration. It has already been shown that accidents on a state-wide network are relatively widely spaced, with the exception of intersection locations. Locating accidents to the nearest 0.1 mile in rural areas should be sufficiently precise to accommodate the first function. The requirement for relating accidents to design elements and operating characteristics is more stringent and is related to the method of evaluation. The examination of one design element can serve to illustrate this point. Highway curvature varies over wide ranges and at frequent intervals on any network. Some recent research (*41*) has shown that curvature of more than 4° strongly influences the accident rate. Although this is of some help to the highway designer, it obviously does not present a complete picture. Ultimately he would like to be provided with the relationship between curvature and accident production over the complete range of current design practice. In addition, he would like to know the interrelationship between horizontal and vertical curvature and accident production. There is some question whether this goal can be fulfilled using the mass data routinely collected by enforcement agencies. The extreme range of rate of curvature and length of curve suggest a very difficult research goal. At the same time, using 0.1 mile as the location increment all but rules out the possibility of such detailed research. The lack of data describing the length and geometry of collision paths, along with the lack of information on the distribution of curvature characteristics, makes a specific recommendation on accuracy requirements difficult. There is general consensus among the state highway departments that 0.1-mile increments should be the longest interval used, and some of the states are considering or using 0.01-mile increments. This smaller interval, which is roughly equivalent to two car lengths, appears well beyond existing system capabilities, particularly in rural areas; but, at the same time, it would appear prudent to provide for this accuracy level in the future.

Discussion

The ability of each of the three accident location methods to fulfill the generalized objectives is summarized in Table B-6. A discussion of each of the points is contained in the following paragraphs.

In its purest form the coordinate system does not require the use of field reference markers, which in theory may be considered an advantage over both the nodal and route number-accumulated mileage methods. However, all of these methods have the option to be used without reference markers in the field, as shown earlier. Attempts at bypassing the reference markers have usually been oriented toward cost saving, but the cost information available does not show that this objective has been met. The usefulness of a system of reference markers goes beyond accident location. If these markers are properly correlated with other highway data records, they can become the benchmarks for other records systems. Although there has been considerable speculation about the usefulness of the reference markers for highway guidance, they have had little use for this purpose until the present time. By the same token, the development of more sophisticated types of motorist guidance may well be aided by reference markers.

Direct coding of the accident location in the field by the investigator is a highly desirable goal. Successful attainment of this goal will reduce the office coding burden to a minimum. Direct coding in the field in computer-oriented language will reduce the number of errors, improve the accuracy level, and reduce cost by a substantial margin. All three methods provide for this technique.

Design of the field procedures for an accident location system must be based on a realistic appraisal of the ability of the data collector and the magnitude of his resources. The nodal approach involves the simplest field procedure of the three alternatives. The procedures can be used in rural and urban areas and apply equally well in simple or complex highway environments. The concept is an extension of

TABLE B-6

COMPARISON OF LOCATION METHODS

ITEM	ROUTE NUMBER-ACCUMULATED MILEAGE SYSTEM	COORDINATE SYSTEM	NODAL SYSTEM
1. FIELD REFERENCE MARKERS	1. REQUIRED	1. NOT REQUIRED	1. REQUIRED
2. DIRECT CODING OF LOCATIONS IN FIELD	2. YES	2. YES	2. YES
3. COMPLEXITY OF FIELD PROCEDURES	3. SIMPLE	3. COMPLEX	3. VERY SIMPLE
4. APPLICABILITY TO RURAL AND URBAN ENVIRONMENTS	4. MORE DIFFICULT TO USE IN URBAN AREAS	4. REQUIRES LARGER SCALE MAPS IN URBAN AREAS	4. CONFORMS WELL TO CHANGES IN POPULATION DENSITY
5. ADAPTABILITY TO COMPLEX HIGHWAY CONFIGURATIONS (INTERCHANGES, CHANNELIZED INTERSECTIONS)	5. LOW - LOGIC OF CONCEPT DIFFICULT TO MAINTAIN	5. HIGH IN THEORY, BUT REQUIRES HIGH DEGREE OF PERFECTION IN SYSTEM OPERATION	5. HIGH - SYSTEM LOGIC RETAINED
6. START UP TIME	6. RELATIVELY SHORT	6. RELATIVELY LONG	6. RELATIVELY SHORT
7. AMOUNT OF TRAINING REQUIRED (DATA COLLECTION)	7. RELATIVELY SMALL	7. RELATIVELY LARGE	7. RELATIVELY SMALL
8. EXPANDABILITY TO ALL STREETS AND HIGHWAYS	8. PROBLEMS WITH ROUTE NUMBERS	8. NO PROBLEM	8. NO PROBLEM
9. COMPATIBILITY WITH EXISTING ROAD INVENTORY RECORDS	9. USUALLY ON IDENTICAL BASIS	9. NONE	9. LITTLE OR NONE
10. ABILITY TO CORRELATE WITH ROAD INVENTORY RECORDS	10. NOT NECESSARY - SEE 9	10. CAN BE DONE	10. CAN BE DONE
11. LENGTH OF LOCATION DATA BIT	11. AVERAGE	11. RELATIVELY LONG	11. VERY SHORT FOR NODAL LOCATIONS: AVERAGE FOR LINK LOCATIONS
12. EFFECT OF MODIFICATIONS TO HIGHWAY NETWORK	12. USE OF EQUATIONS REDUCES LOGIC OF CONCEPT. REQUIRES SOME CHANGES TO FIELD REFERENCE MARKERS	12. REQUIRES MAP UPDATING, RE-DISTRIBUTION OF NEW MAPS	12. REQUIRES SOME CHANGES TO FIELD REFERENCE MARKERS
13. USEFULNESS IN ROUTE GUIDANCE (EXISTING SYSTEMS)	13. HAS SOME VALUE	13. NO VALUE	13. LITTLE VALUE
14. ADAPTABILITY TO SOPHISTICATED ROUTE GUIDANCE (FUTURE)	14. NONE	14. NONE	14. GOOD - SAME GENERAL CONCEPT
15. USEFULNESS IN HIGHWAY PLANNING AREA	15. LITTLE	15. LITTLE	15. CONSIDERABLE
16. ADAPTABILITY TO MECHANICAL PLOTTING TECHNIQUES	16. ONE DIMENSIONAL ONLY	16. EXCELLENT	16. CAN BE ADAPTED: COORDINATES OF NODES REQUIRED
17. EASE OF DATA RETRIEVAL	17.	17.	17.
A. SPECIFIC INTERSECTION: GROUP OF INTERSECTIONS	A. ACCEPTABLE: MUST CHECK MULTIPLE ROUTE NUMBERS	A. ACCEPTABLE: MUST ESTABLISH LIMITS OF ACCEPTABLE COORDINATES	A. VERY EASY
B. SPECIFIC AREA (WITHIN SAME POLITICAL JURISDICTION)	B. SEE A (ABOVE)	B. DIFFICULT IF AREA HAS IRREGULAR BOUNDARIES	B. EASY: MUST SPECIFY NODE AND LINKS REQUIRED: GEOGRAPHIC NUMBERING CONTINUITY A HELP
C. ROUTE	C. EASY IF ONE ROUTE: MUST CHECK MULTIPLE ROUTE NO.: MORE DIFFICULT IF SEVERAL ROUTE NUMBERS INVOLVED	C. REQUIRES USE OF ROUTE NUMBER, PLUS COORDINATES	C. MUST SPECIFY LINKS: ROUTE TRACES (LINK BY LINK) CAN BE ESTABLISHED
D. INTERCHANGE RAMP	D. CAN BE DONE: REQUIRES ADDITIONAL TREATMENT FOR RAMP IDENTIFICATION	D. REQUIRES USE OF ROUTE NUMBER, AS WELL AS CO-ORDINATES	D. EASY - RAMP TERMINAL RETRIEVED IN FIELD ACCORDING TO SYSTEM LOGIC
18. ACCURACY	18.	18.	18.
A. FIELD PROCEDURES	A. POSSIBILITIES FOR ERRORS IN ROUTE DETERMINATION: ROUTE SIGNING IMPORTANT: URBAN AREAS CRITICAL: ALSO ADDITION (OR SUB-TRACTION) BY INVESTIGATOR PROVIDES ERROR OPPORTUNITY	A. POSSIBILITY FOR MAP READING ERRORS: RURAL AREAS WITH LITTLE CULTURE: ADVERSE CONDITIONS SUCH AS DARK-NESS, RAIN, SNOW: LARGE NUMBER OF DIGITS IN CO-ORDINATE INCREASE FRE-QUENCY OF RECORDING ERRORS. POSSIBILITY OF READING ERROR IN DETERMINING CO-ORDINATE WITH STRAIGHTEDGE	A. SIMPLICITY OF PROCEDURE SUGGESTS MINIMUM POSSIBILITIES FOR ERRORS.
B. MEASUREMENT OF REFERENCE DISTANCES	B. CONTROLLED BY EQUIPMENT DE-SIGN AND CALIBRATION: POSSIBILITY FOR ESTIMATES RATHER THAN MEASUREMENTS	B. NO MEASUREMENT INVOLVED	B. CONTROLLED BY EQUIPMENT DE-SIGN AND CALIBRATION: POSSIBILITY FOR ESTIMATES RATHER THAN MEASUREMENTS
C. MINIMUM INTERVAL	C. ONE-TENTH MILE GENERALLY WITH EXISTING EQUIPMENT AND 1-MILE SPACING OF REFERENCE MARKERS: 1/100 MILE POSSIBLE WITH USE OF TRIP ODOMETERS	C. DEPENDENT UPON MAP SCALE AND DETAIL: 1" = 4000' GENERALLY AVAILABLE: APPROXIMATELY 1/10 MILE POSSIBLE	C. ONE-TENTH MILE GENERALLY WITH EXISTING EQUIPMENT (RURAL) ONE-HUNDREDTH MILE POSSIBLE WITH TRIP ODOMETERS (RURAL) ONE-HUNDREDTH MILE WITH EXISTING TAPE MEASUREMENTS (URBAN)
19. USE FOR "HOUSEKEEPING FUNCTIONS" (i.e., ACCIDENT SURVEILLANCE) DURING EARLY DEVELOPMENT STAGES	19. A. ACCIDENT DATA AVAILABLE BY MILE INCREMENTS OR 1/10 MILE INCREMENTS: INTER-SECTION ACCIDENTS SHOULD BE TREATED SEPARATELY: PRINT-OUT OF DATA ORDERED BY ROUTE NUMBER AND ACCUMULATED MILEAGE CAN BE USED MANUALLY: TRAFFIC VOLUME DATA MAY BE AVAIL-ABLE IN ROUTE NUMBER-ACCUMULATED MILEAGE FORM FOR IMMEDIATE DETERMINATION OF ACCIDENT "RATES"	19. A. LONGER DEVELOPMENT TIME SUGGESTS LITTLE USEFUL DATA DURING EARLY STAGES	19. A. ACCIDENT DATA QUICKLY AVAIL-ABLE FOR INTERSECTIONS AND LINKS: SYSTEM DESIGNED FOR SEPARATE TREATMENT OF NODES AND LINKS: PRINT-OUT OF DATA ORDERED BY NODE NUM-BER CAN BE USED MANUALLY: NOT POSSIBLE TO OBTAIN ACCIDENT RATES UNTIL TRAFFIC VOLUME DATA IN NODAL FORMAT
20. USE FOR RESEARCH ON DESIGN AND OPERATIONS CHARACTERISTICS DURING EARLY STAGES OF DEVELOPMENT	20. BEST POSSIBILITIES, SINCE ROAD INVENTORY AND ACCIDENTS LIKELY TO BE DIRECTLY CORRELATED: MINIMUM INTERVAL CRITICAL FOR SOME VARIABLES (i.e., GEOMETRY)	20. NONE	20. LIMITED BY AMOUNT OF CORRELATION WHICH CAN BE ESTABLISHED BETWEEN INVENTORY AND ACCIDENT RECORDS

existing procedures and should be easily learned and accurately used by the average police investigator with a minimum of additional training. Field procedures for the route number-accumulated mileage method are also relatively uncomplicated. There are, however, some illogical situations which may bother the average investigator. The treatment of complex environments, such as interchanges, is one problem. Identifying route numbers in some areas is also a problem, particularly in urban environments. The coordinate approach carries with it an inherently complex field procedure. To use the method as it is now proposed, it would be necessary to teach map reading to all accident investigators. Although this is probably a task which could be accomplished with a substantial investment of time and money, it does not appear feasible from a practical standpoint. The problems of map reading in adverse situations (darkness, rain, etc.) have already been noted. This appears to be one of the most limiting difficulties with the entire concept. At the same time, it should be acknowledged that there is little practical experience available upon which a specific recommendation might be made. In summary, however, there can be no doubt that each of the other alternate methods involves rather simple field procedures in comparison to the coordinate method.

The preponderance of accident occurrence in urban areas, coupled with an increased awareness of urban problems on the part of the state, means that the location method should be equally adaptable to rural and urban environments. A uniform method within a particular state is most certainly a prerequisite for an efficient records system. Here again, the nodal method offers a distinct advantage over both of the other alternates. Because it is based on the marking of intersections which mathematically simulate the network, it conforms very well to changes in street and highway density. The route number-accumulated mileage concept is basically a rurally oriented procedure. This concept can work in urban areas, but with more difficulty. The shortcomings of route signing in urban areas can be cited as one significant problem area. Urban environments impose more stringent requirements on the location method, because the density of accidents is much higher, the street and highway system is more complex, and the unit of analysis must be smaller. The two-dimensional aspect of the coordinate procedure raises the possibility of small errors in location moving the accident site from one facility to another. Obviously, much larger-scale maps would be required in these urban areas for coordinate use. In the urban areas, the available U.S.G.S. maps carry a minimum of cultural data. Keleher (*43*) has raised the possibility of using urban area coordinates which are based on house numbers. This requires a rectangular grid street network and uniformity in numbering, which is not the usual case in U.S. cities, particularly on the East Coast. Here again, this would mean using a different procedure in urban and rural places and should be discouraged.

The nodal approach, because it identifies road segments by their termini, can be used very effectively at highway interchanges, channelized intersections, and other complex environments. Accidents can be located to a particular ramp with no change in the logic of the approach. These types of locations would be special cases within the route number-accumulated mileage concept. Procedural problems are readily apparent, and even though some states have avoided them entirely, a workable solution probably can be found. On the other hand, they would be special cases and would not exactly follow the logic of the rest of the system.

In many instances the length of time necessary to design and develop a system is an important factor in the choice of approach. The high level of interest in traffic safety activities which is now evident, coupled with Federal timetables for state traffic safety activities, suggests that this is indeed the case with accident location. Both the route number-accumulated mileage and nodal methods involve a relatively short start-up time. The design of the basic system involves little more than a mapping of the field reference markers and their installation. This can probably be accomplished in most states in a matter of six months. Complete development of the system, including computer programs for surveillance of accidents and the correlation of road inventory records with accident records, would of course involve an additional and substantial period of time. The extensive and complex mapping requirements for the coordinate approach, combined with the need for a substantial training effort, would result in a longer development time than either of the other two alternates.

Once an adequate location and surveillance program has been accomplished on state highways, extension of the process to county roads and city streets will be the next logical step. This is an important consideration in the planning of the process. To maintain a uniform procedure within a state, the location method should be flexible enough to cover the entire street and highway network. Neither the coordinate system nor the nodal system presents any problem in this area, providing that the design details presume expansion to the entire street and highway network. For example, the numbering sequence for the network approach must reserve enough capacity within each city, town, or county to accommodate the total number of nodes. Likewise, the maps developed for the coordinate system must provide increased cultural and identification information within urban areas. The route number-accumulated mileage procedure has not been used to completely cover an urban area. Obviously, a very small percentage of the street system within any large urban area carries a route number, and most of these can be assumed to be on a state or Federal highway system. Therefore, in order to use the process for an entire urban network, it would be necessary to identify streets in some numerical fashion. Suggested approaches have involved a simple alphabetical listing with assigned code numbers. Following this approach, the police officers would report street names and block locations, and thus would depart from the standard route number-accumulated mileage procedure used on state highways.

Road inventory records have invariably been kept on the basis of route number-accumulated mileage. Consequently, in many states the route number concept should be immediately and directly compatible with accident records kept on the same basis. Compatibility with the coordinate concept would be difficult. A complete "digitizing" of the highway network would probably be the only approach. Compatibility then can be established, but with a substantial effort. There is little compatibility between the nodal system and the route number-accumulated mileage concept. It would be possible to establish this compatibility, but again with some effort. It is difficult to estimate the amount of work which might be necessary. The key question is the relationship between link and inventory termini. Many of the physical and operating characteristics included in road inventory records are susceptible to changes at intersections. Traffic volume is a good example. A limited review of the relationship in Maine has suggested that enough inventory section termini occur between intersections to substantially increase the number of segments which could be expected in the correlation process.

The amount of location information has varied considerably from state to state. In some cases the accident coding process includes the coding of a substantial amount of supplementary location and descriptive information which could be mechanically retrieved if correlation with road inventory was possible. One state, for example, has coded almost an entire punch card with location and descriptive information. Nevertheless a basic minimum amount of data can be established. The city or town is invariably coded onto the punch card regardless of the location system used, and this could be considered a standard part of the location data. For the route number-accumulated mileage concept the coding of the route number and the mileage involves about the same length of data bit as a link location under the nodal procedure. A nodal location, on the other hand, requires a much shorter bit, and this can be some advantage in data processing efficiency. Coding the coordinate location would require in the vicinity of 14 digits in addition to the route number, which should be included as a control of the two-dimensional system aspects.

There have been no factual evaluations of the accuracy limits of the various location alternatives, and so a subjective analysis is all that is possible. The simplicity of the nodal procedures and the minimum length of the data bit suggest a low error potential in the field procedures. The most likely source of error in the route number-accumulated mileage field procedures would be erroneous route numbers, and this could be expected to occur most frequently in urban areas. The use of coordinates would introduce the possibility for map reading errors. Rural areas with a minimum of culture would be most subject to map reading errors. In addition, adverse environmental conditions could be expected to play a substantial role in the accuracy level. Furthermore, the length of the data bit increases the possibility of recording errors. Obviously, measurement inaccuracies are completely avoided with coordinates, because no measurements are involved. In rural areas most measurements have been accomplished with standard 0.1-mile odometers, and this procedure can be expected to continue. The error potential then is primarily related to the calibration and use of the odometer equipment. Regardless of the location procedure (route number-accumulated mileage or nodal), the possibility exists for estimates rather than measurements. This is clearly a problem which can be solved only by increased training efforts directed toward the investigator. The accuracy level obtainable in urban areas would be related to the frequency of reference markers. Use of the nodal concept would result in reference markers spaced at block-long intervals, and thus tape measurements could be uniformly applied. It is believed that the accuracy level necessary for accident location can be defined only with future analytical research on the relationship between the geometry of the collision path and the highway, the length of the collision path, and the type of accident.

The ability to use accident data for surveillance of the network and for design-oriented research is a consideration. Given adequate development time, it is hard to choose any specific advantages or disadvantages of the three concepts in terms of the usability of the information. However, the nodal and route number-accumulated mileage systems are more adaptable to stage development than is the coordinate system. During the initial development stages it is possible that some states will want to use interim products of the system, such as manual print-outs of accident data, and this can be done easily with the nodal or route number-accumulated mileage procedures. In manual form the data would be understandable and usable for some purposes. The time which would be necessary to develop the system to this level is quite short. Manual print-outs of the accident data in coordinate form would be more difficult to interpret, and the development time would be much longer. In short, both the nodal and the route number-accumulated mileage concepts offer the opportunity for use both manually and with computers at an earlier stage. This is judged to be a considerable advantage in the light of existing pressures for program development.

APPENDIX C

DEMONSTRATION STUDIES

1. TIRE STUDY

The accident report form and its instructions for use are shown in Figure D-3. This form was used in both Virginia and Indiana. In addition, the research agency received the regular Indiana state accident report form, from which speed before the accident was obtained for analysis. The following discussion consists of three major sections. The first is addressed to the incidence of flat tires, its causes and its effects. The second section deals with measures of tire wear. Last, there is a discussion of skidding as related to tire and road condition. For the most part these results, in addition to their inherent interest, testify to the value of the measurements taken.

From the accident diagram and the accident description, the temporal relationship between the first known tire failure and other damage to the vehicle was determined. In this way, one can judge something of the contribution of tire failure to accident involvement. First, it was determined that of the 3,993 accident vehicles studied, 3,289, or 82 percent, had no flat tires. There were only 29 vehicles for which it could be shown that tire failure preceded all other damage and 425 vehicles for which tire failure preceded some other vehicle damage. Thus, for only 0.7 percent of the vehicles was there evidence that tire failure initiated the accident; for 10.6 percent of the vehicles, tire failure might have contributed to further damage. Throughout the remaining discussion, all tires which had a zero air pressure are discussed in terms of tire "failures"; those for which failure precipitated the accident are discussed in terms of "initial failures."

These figures might be low because the accident investigators were not specifically asked to provide information on this topic. However, it could be expected that the majority of accidents precipitated by tire failure would have been so noted in the accident description. Accepting this, flat tires could have occurred as the primary disturbance in no more than 1.5 percent of the vehicles. Because there were 2,841 accidents, it can be said that it was very unlikely that tire failure precipitated more than 2.1 percent of the accidents.

That tire failure rarely precedes other vehicle damage suggests that most failures result from impact. Thus, it was thought that the probability of tire failure would be higher as the number of vehicles involved in the accident increased. (Although the number of vehicles involved does not necessarily increase the number of impacts, consideration of the minimum number of impacts as a function of number of colliding vehicles reveals such a trend should exist.) The results are given in Table C-1.

Clearly, the mean number of failures decreases rather than increases with the number of involved vehicles. Inasmuch as this was unexpected, an explanation was sought in terms of vehicle speed. Figure C-1 shows that tire

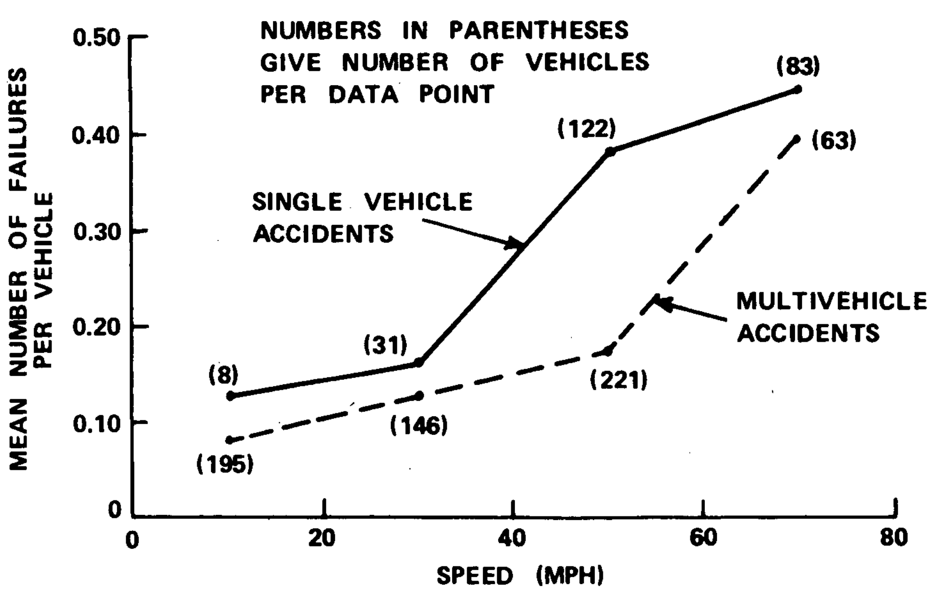


Figure C-1. Mean number of flat tires per vehicle for single- and multivehicle accidents as related to vehicle speed.

failure rate in accidents does increase with speed; it can also be seen that failure rate is lower for vehicles in multivehicle accidents. Furthermore, the frequencies associated with each data point show that, on the average, speeds for single-vehicle accidents are higher than for multivehicle accidents. As a result, it can be said that vehicles in multivehicle accidents usually have lower speeds and therefore the mean tire failure rate for all such vehicles is lower. However, it is of equal interest to note that within any of the speed ranges the failure rate was lower for vehicles in multivehicle accidents; as such, the lower rate for these vehicles cannot be attributed solely to differential speeds.

In order to study the relationships between tire failure and some tire characteristics, the data given in Table C-2 were compiled. These results appear to be quite interesting. However, they are equally misleading. The difficulty is that they fail to take into account the lack of independence among the four tires on each vehicle; they also ignore interrelations between the tire characteristics themselves, as well as their relationships to tire location on the vehicle.

The first of more detailed analyses showed that tire failure depends heavily on tire location (Table C-3). Clearly, the likelihood of a flat tire is much higher for those in front than for tires mounted on the rear wheels.

Next, analyses were carried out to determine if tire failure was a function of plies, recaps, snow tires, and tread depth; in each case, analyses were designed so as to control for tire location. All results were statistically insignificant, except the comparison of tire failure versus tread depth. Here it was found that the probability of tire failure increased as center tread depth decreased. A summary of the results is given in Table C-4.

Explanations for the results in Table C-4 depend primarily on the relationships between the tire characteristics and tire location (front vs rear). That two-ply tires failed more frequently is probably due to the fact that two-ply tires are more frequently used in front than rear. That recaps fail less than original treads is due to the fact that recaps are most frequently used on the rear wheels; the same holds for snow treads. It is interesting that worn tires failed more, in spite of the fact that tires with less than 3/16 in. of tread more frequently appear on rear wheels. These results are based on the data given in Table C-5.

Controlling tire location and tire failure, tire conditions were studied pairwise. All comparisons were significant except that the tread types (snow and standard) did not show differential tread depths. On the other hand, it was found that:

1. Snow tires are more likely to be recaps than are standard tires.
2. Four-ply tires are more likely to be recaps than are two-ply tires.
3. Four-ply tires are more likely to have less than 3/16-in. tread than are two-ply tires.
4. Four-ply tires are more likely to be snow tires than are two-ply tires.
5. Recaps are more likely to have less than 3/16-in. tread than are standard tires.

TABLE C-1

TIRE FAILURE AS RELATED TO NUMBER OF VEHICLES INVOLVED IN AN ACCIDENT

NO. OF VEHICLES	FREQUENCY	MEAN FAILURES PER VEHICLE
1	1249	0.369
2	2453	0.121
3 or more	228	0.114

TABLE C-2

TIRE FAILURE VS TIRE CHARACTERISTICS

CHARACTERISTIC	PERCENT FLAT
Plies:	
2	5.8
4	4.7
6	3.3
Recap:	
Yes	0.041
No	0.054
Tread type:	
Stud	2.4
Snow	3.0
Standard	5.3
TIRE FAILURE VS TREAD DEPTH	
Center tread depth (in.):	
Less than 1/16	6.5
1/16 to less than 2/16	5.7
2/16 or more	4.4

[a] Failure rate essentially constant for tread depth greater than 2/16 in.

TABLE C-3

TIRE FAILURES RELATED TO TIRE LOCATION

	NO. OF TIRES	
TIRE LOCATION	FLAT	NOT FLAT
Left front	215	2898
Left rear	70	3026
Right rear	105	3005
Right front	223	2875

Summarizing, the leading contributors to tire failure in accidents were tire location and tread depth. Number of plies, tread type, and recap versus original tread did not significantly influence the probability of a tire failure. It was also shown that tire descriptors are statistically interrelated among themselves and also with tire location; thus, great care is required in planning and interpreting data analyses.

TABLE C-4

FREQUENCY OF TIRE CONDITION, BY LOCATION ON THE VEHICLE

TIRE	NO. OF PLIES		TREAD TYPE				TREAD DEPTH	
LOCATION	2	4	RE-CAP	ORIG.	SNOW	STD.	LOW	HIGH
Left front	758	2660	826	2287	46	3067	1344	2074
Left rear	663	2640	1065	2031	833	2263	1553	1747
Right rear	667	2624	1057	2053	835	2275	1539	1747
Right front	741	2637	845	2253	58	3030	1351	2017

TABLE C-5

INITIAL TIRE FAILURE FOR FRONT AND REAR TIRES AS A FUNCTION OF VARIOUS TIRE CHARACTERISTICS

TIRE	FRONT TIRES			REAR TIRES		
CHARACTERISTIC	FLAT	NOT FLAT	% FLAT	FLAT	NOT FLAT	% FLAT
2 Ply	5	1494	0.33	1	1329	0.08
4 Ply	6	5291	0.11	6	5258	0.11
Recap	7	1664	0.42	3	2119	0.14
Original	11	4529	0.24	7	4077	0.17
Snow tire	1	103	0.96	3	1665	0.18
Standard	17	6080	0.28	4	4534	0.09
Shallow tread	12	2683	0.45	6	3089	0.19
Deep tread	4	4087	0.10	3	3491	0.09

Two measurements of tire characteristics require some explanation. Tread depth was to be measured at two locations on each tire—at a point near the outer shoulder or edge of the tire, called "outside tread depth," and at a point half way between the two shoulders, or "center tread depth." The difference between these two values provides a useful measure of degree of uneven wear; it is herein defined so that positive values correspond to greater wear at the shoulder. Another derived measure of uneven wear is the absolute value of this difference.

Throughout this study, tread depth or its converse, tread wear, is typically taken as that measured at the center treads. Table C-6, relating center tread depth to outer tread depth, shows that almost one-half of the tires measured in such a way that the difference between the center and outer tread depths was less than 1/16 in. Further, approximately seven of every eight tires had tread depth differences less than $\pm 2/16$ in. Thus, center tread depth appears to be a reasonable index of general tread depth for a given tire.

The second measure is a direct evaluation by the accident investigator of uneven wear, denoted "UW." This is a dichotomous variable with values "yes" or "no." It was to be judged prior to tread depth measurements and to be responsive to visual signs of uneven tread wear, blistering, cupping, etc.

With regard to the likelihood of a flat tire, neither UW nor the absolute value of the difference in tread depth significantly affected this probability. Similarly, the proportion of flat tires showed no obvious relationship with wheel size, rim size, or nylon versus rayon cord.

In spite of the relatively low number of accidents known to be initiated by a tire failure, these cases were examined so that the condition of these failed tires could be compared to all other tires. Most of the comparisons were not statistically significant; this may have been attributable to the independence of tire condition and tire failure. However, some of the results were interesting and, since the insignificance might have been attributable to the small sample size, the results are given in Table C-7.

The data are certainly not conclusive, but they are suggestive. The only chi-square test allowed by the low frequencies was that for tread depth versus tire failure for the front tires; it was significant, showing the probability of an initial tire failure to be higher for worn tires. Although not controlled for tire location, Figure C-2 shows the failure rate for different values of tread depth. Another interesting result was that the proportion of initial failures was considerably higher for snow tires as compared to standard tires. The evidence also suggested that two-ply tires might fail more frequently than the four-ply tires.

Finally, of the 28 accidents in which there was positive identification of which tire initiated the accident, there were 4 for the left front, 5 for each of the rear tires, and 14 for the right front. That a chi-square test for equal likelihood of any of the four tires leading to an accident was insignificant might well be due to the very small sample.

Although the tire failure did not exhibit a relationship with the measures of uneven wear, it is nonetheless of interest to examine how uneven wear relates to some other variables.

An unexpected result was that front tires show less uneven wear than did rear tires (Table C-8). These results might be attributable to the owner's tendency to put the less worn or new tires on the front wheels.

Uneven wear was shown to bear a relationship to number of plies, with less even wear for six-ply tires. The proportion of six-ply tires for which the absolute difference in tread depth was greater than 2/16 in. was 0.26; for two-ply and four-ply tires it was 0.12.

The probability of UW is about 40 percent higher for recaps as compared to original tread tires, the former being 0.13 and the latter 0.09. Recaps also tend to have less tread in use. The average tread depth of recaps was 0.18 in., whereas for other tires it was 0.22 in.

It was desired to compare how evenly tires were worn as a function of age of the tire. Because the age was not measured directly, the year of manufacture of the accident vehicle was used. To avoid the confounding effect of new tires on old vehicles, the study was limited to those vehicles manufactured in 1966 or 1967. The results are given in Table C-9. Contrary to what might have been expected, the older tires did not show significantly more uneven wear. This may be attributable to the better condition of the relatively new cars in terms of wheel alignment.

Because tires are normally expected to wear more at the center treads when overinflated, and at the outer treads when underinflated, a correlation coefficient was computed for air pressure (for nonflat tires) and center minus outer tread depth. The result ($r = -0.0004$) was insignificant. Following this a correlation analysis was performed for air pressure versus the absolute value of the difference between center and outer tread depths. The correlation coefficient

TABLE C-6

RELATION OF CENTER TIRE TREAD DEPTH TO OUTER TREAD DEPTH

CENTER TREAD DEPTH MINUS OUTER TREAD DEPTH (1/16 IN.)	NO. OF OBSERVATIONS	% OF OBSERVATIONS
−3	279	0.02
−2	1153	0.07
−1	4175	0.27
0	7521	0.48
1	1928	0.12
2	425	0.03
3	119	0.01

TABLE C-7

MEAN CENTER TREAD DEPTH FOR FLAT AND NON-FLAT TIRES, BY TIRE LOCATION

	MEAN CENTER TREAD DEPTH (IN.)	
TIRE LOCATION	FLAT	NON-FLAT
Left front	0.197	0.209
Left rear	0.177	0.194
Right rear	0.173	0.195
Right front	0.193	0.208

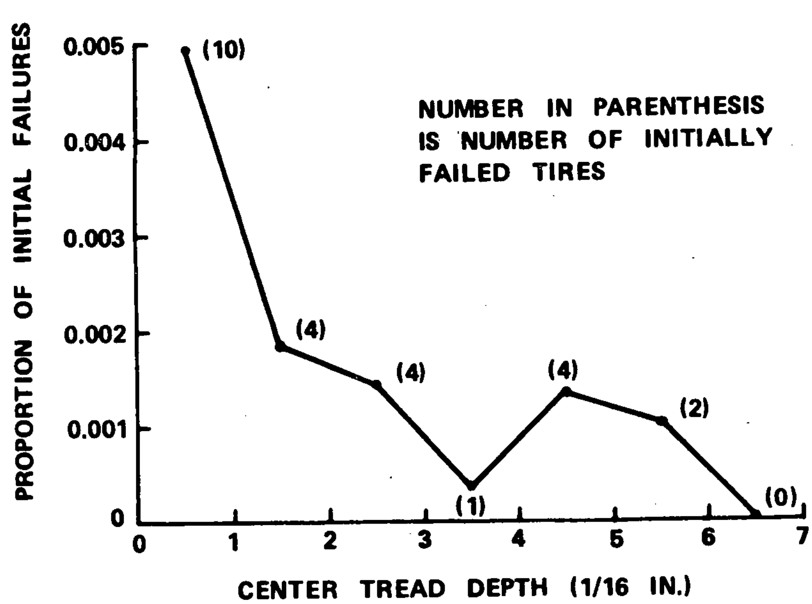


Figure C-2. Initial failure rate as a function of center tread depth.

was small (— 0.02) but statistically significant. Thus, there is evidence that higher pressure reduces unevenness of wear, but neither the center nor outer treads were favored. Too, if air pressure related directly to tread depth, another correlation coefficient was computed; its value was 0.04, which was significant. Therefore, those vehicles for which air pressure was higher showed less tread wear both in terms of the amount and the evenness. Whether this reflects more strongly the actual relationships between air pressure and vehicle wear, or general vehicle care by the owner, is unknown.

Still considering air pressure, a study was made of the difference in air pressure between tires on each vehicle. Differences were computed comparing right front to left front and right rear to left rear; flat tires were not included. The analyses were run for front and rear tires independently; because the results were quite similar, only the front tire results are presented. Of the 3,325 vehicles examined, 2,421, or 72 percent, had differential air pressures of less than 4 psi. Contrasted to this, 8 percent had differences greater than or equal to 8 psi, and 1 percent had differences of at least 14 psi. Considering that maintenance of tire pressure is one of the easiest of maintenance functions, this is indeed a sad commentary on owners' attitudes on vehicle upkeep.

The two measures of uneven wear are compared in Table C-10. Although uneven wear was not intended to measure the same thing as tread depth difference, some relationship would certainly be expected between the two; Table C-11 confirms this. As the difference in depth increases, so does the probability of an uneven wear report. Aside from the fact that both measures have common elements, it is true that a tire with a large tread depth difference is also more likely to have defects of which uneven wear is a measure. Noting that the proportion of uneven wear reports does not increase strongly as the difference goes from 1/16 to 2/16 perhaps suggests that for those investigators for whom the difference is an important contributor to uneven wear a difference of 2/16 is the threshold value.

The relationship between uneven wear and the absolute value of the difference of tread depths was studied as a function of the smaller of two values—center tread depth and outside tread depth. It was thought that as this minimum value decreases, differences in tread depth would be more visually obvious, and the likelihood of uneven wear would increase. Table C-11 shows this to be clearly true. The smaller of the two, outside or inside tread depth, is an important determiner of the sensitivity of uneven wear to tread depth differences. As the minimum value decreases, the sensitivity increases. That the proportion of UW's never exceeds 0.5 in this table indicates that UW is certainly not completely determined by tread depth

TABLE C-8

UNEVEN WEAR VS TIRE LOCATION

ABSOLUTE VALUE OF TREAD DEPTH DIFFERENCE (IN.)	NUMBER OF FRONT TIRES	NUMBER OF REAR TIRES
0	3933	3588
1/16	3142	2961
2/16	621	957
3/16	104	294
All	7800	7800
Mean	*0.038 in.*	*0.046 in.*

TABLE C-9

FREQUENCIES FOR UNEVEN TIRE WEAR VS AGE OF VEHICLE

ABSOLUTE VALUE OF TREAD DEPTH DIFFERENCE (IN.)	1966 CARS	1967 CARS
0	895	737
1/16	863	639
2/16	220	146
3/16	44	39
Mean	*0.044 in.*	*0.042 in.*

TABLE C-10

DIFFERENCES IN TREAD DEPTH VS UNEVEN WEAR

TREAD DEPTH DIFF. (1/16 IN.)	PROPORTION OF UNEVEN WEARS
−3	0.35
−2	0.23
−1	0.12
0	0.04
1	0.13
2	0.29
3	0.23

TABLE C-11

PROPORTION OF UNEVEN WEAR TIRES FOR VARIOUS TREAD DEPTH DIFFERENCES AND MINIMUM OF CENTER AND OUTER TREAD DEPTHS

MINIMUM TREAD DEPTH (1/16 IN.)	PROPORTION OF UW'S FOR ABSOLUTE TREAD DEPTH DIFFERENCE OF				
	0	1/16 IN.	2/16 IN.	3/16 IN.	COMBINED
0	0.11	0.31	0.46	0.39	0.23
1	0.07	0.18	0.34	0.30	0.16
2	0.03	0.11	0.19	0.20	0.09
3	0.03	0.09	0.13	0.10	0.07
4	0.02	0.08	0.07	0.19	0.05
5	0.02	0.05	0.09	—	0.03
6	0.01	0.00	—	—	0.01
7	0.05	—	—	—	0.05
All	0.04	0.13	0.25	0.27	

difference. That UW is sensitive to tire characteristics other than tread depth is attested to by the nonzero proportion of UW reports when depth differences are small.

The probability of skidding in a wet-road accident (0.48) was greater than the probability of skidding in a dry one (0.34). (Note: all of these data exclude skidding after impact.) Of those vehicles that did skid, the probability of leaving the road was 0.52 for wet roads, and 0.43 for dry road. These findings are based on the following:

Road Condition	No Skid Off Road	Skid Off Road	Skid On Road	No Skid On Road
Dry	418	366	488	1247
Wet	95	217	197	356

Thus, it appears that not only is a wet road conducive to skidding, but that skidding is, in a sense, more violent on such a surface. There are other data to support this latter conclusion. First, let rotational effects be defined as the occurrence of an angular velocity and directional changes as the departure from the preskid direction of travel. Then it can be said that the probability that a skid had rotational effects on a wet road was 0.40 (Fig. C-3), whereas for a dry road it was 0.26. Second, the probability that a skid yielded directional changes on a wet road was 0.66; for dry road it was 0.57.

Some qualifying remarks are in order. Because wet-road skidding seems to be less controllable, such skidding might produce more evidence for the accident investigator. This could contribute to an increased difference in the reported probability of skidding when comparing wet roads.

Continuing the study of pre-impact behavior, it was of interest to determine the effect of tread depth upon skidding phenomena. (These data are purely descriptive; tests were not performed because this would have required procedures to preclude the effects of the statistical dependence among the four tires within each vehicle.) First, the relationship between center tread depth and the probability of skidding was extremely weak: the mean depth for skidding vehicles was 0.198 in.; for nonskidding vehicles, 0.203 in. On the other hand, given that skidding occurred, it appeared that there was a mild tendency for the skid to be more violent when tires had less tread depth: the mean tread depth for tires involved in straight ahead skidding was 0.205 in. as compared to 0.194 in. when skidding involved directional change; the mean tread depth for tires involved in nonrotational skidding was 0.202 in. as compared to 0.188 when skidding was rotational. The data are shown in another way in Figure C-3, where the proportion of vehicular direction changes and rotations incurred during preimpact skidding are shown to have increased as tire wear became greater. Whether the skidding data are best explained by physical tread depth-road relationships or by sampling phenomena such as the quality of the tire reflecting the condition of the vehicle's brakes was not determined in this study.

In summary, although tire failures frequently occur in accidents, by far the greater proportion of failures result from the accident; no more than approximately 2 percent of the accidents were initiated by tire failure.

The tire characteristic most closely tied to tire failure was tread depth. It had a significant relationship to the likelihood of a flat tire being produced by an accident, as well as the likelihood of a flat tire which produced the accident. In both cases the failure rate seemed to accelerate as the tread wore down through a range near $\frac{2}{16}$ in.

Although tire failure in accidents at first seemed to be related to number of plies, recap versus original tread, and snow versus standard tires, these relationships were shown to disappear when tire location was taken into account. With regard to the small sample of initially failed tires, the proportion of failed snow tires was considerably higher than of failed standard tires.

It was also seen that failure rate was approximately twice as high for front tires as compared to rear tires; this might be attributable to failures resulting from impact. However, in the 28 initial failure cases the right front tire failed approximately three times more often than any of the others.

Although the various measures of how evenly the tires were worn entered into relationships with air pressure, number of plies, tire location, and recap versus original tread, only tire location bore a measured effect upon tire failure.

Considering skidding as a criterion of tire performance, it was seen that there was a tendency for worn tires to yield less control while skidding; however, they were only slightly more likely to induce skidding than were less worn tires.

With regard to the value of the measures discussed in this section, there would seem to be little doubt but that further studies of this nature can provide meaningful knowledge.

2. STEERING COLUMN STUDY

The form and its instructions for use are shown in Figure D-4. In this study the emphasis is slightly different than in the other studies because the difficulties in measuring movement of the steering assembly were known. The steering wheel represents an odd-shaped structure suspended in space. The wheel can be damaged or bent in any direction and the column on the subject cars is designed to collapse. Furthermore, the structure surrounding the column and wheel are subject to deformation and thus are poor reference points. Measurements of interest were: *G*, the foreshortening of the steering column grid due to collision; *P*, the foreshortening of the distance between the steering wheel and the instrument panel; and *F*, the foreshortening of the distance from the steering wheel to the frame above the rear window (see Fig. D-4). These definitions can be clarified by looking at the accident form. No measurement of column collapse forward of the firewall was attempted.

The reasons for doubt, prior to analysis, as to the quality of these measures fell in two major areas. First, the measures are intended to quantify movement of the steering assembly during the accident. This can be done only if the reference points (the window frame, and the instrument panel) do not move. To exclude from analysis those vehicles in which the references did not remain fixed, photographs were used to determine instrument panel damage and other deformation that could affect measurement.

The second source of error is not so easily managed, the problem here being accuracy of measurement. The measuring instrument is illustrated on the accident report form. In determining standard lengths against which to compare post-accident distances, many of the difficulties were found to arise in making the required measurements.

It was felt that the most difficult measurement to make was the grid length. (It should be noted that the standard

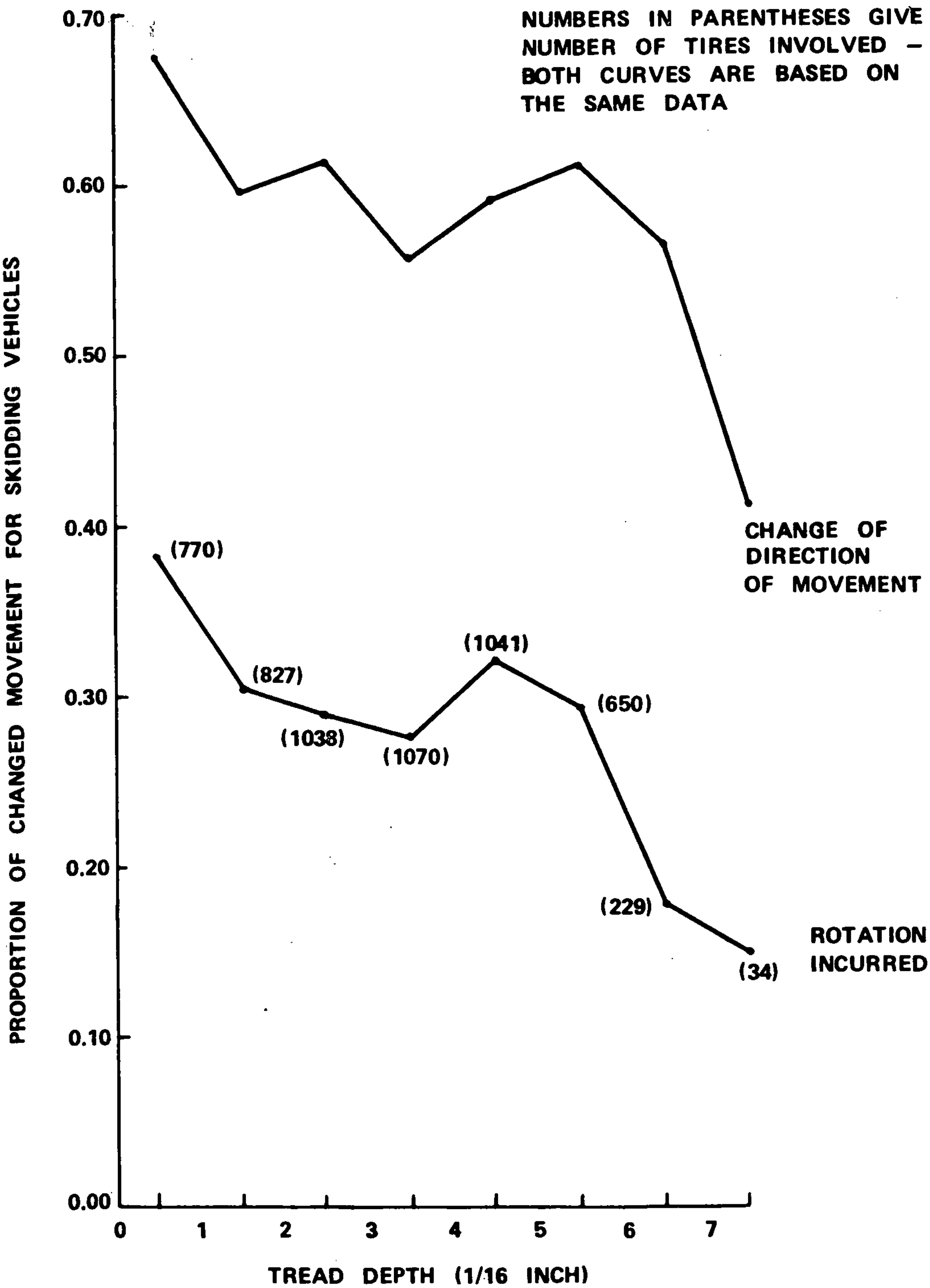


Figure C-3. Proportions of rotation or change of direction as a function of center tread depth.

distance for this measure is 9.7 in.) Reasons for difficulty include:

1. The grid is covered by a jacket and the jacket length varies from model to model.
2. The measuring stick could not be laid along the steering column.
3. It is inconvenient and difficult to make the measurement.

Sources of difficulty in measuring the distance to the instrument panel include:

1. Panel contours often allow for measurements giving considerably different readings.
2. Cowling prevents the measuring stick from reaching the stem of signal levers.
3. It is difficult to see without a lot of bending, etc.

It was thought that the measurement to the frame of the rear window would involve the least deterrent to accurate measurement. Even here, however:

1. If the stick was pointed straight back it often could not touch the stem of the signal lever.
2. In some cars, failing to point the stick straight back could yield large errors.
3. Head-rests must be removed in order to take the measurement.

Of course, for any of these measurements there is the usual possibility of misunderstanding what is to be measured, of moving the stick before the measurement is read, and of simply misreading the value.

Table C-12 gives a summary of empirical results concerning these measures. The data presented are somewhat restricted for the purposes of this discussion. For ΔF, which concerns the rear window frame, vehicles which rolled over were excluded from analysis. For ΔP, the changed distance to the panel, vehicles with panel damage were excluded. First, it can be seen that under the condition of "no damage" there is some deviation of the observed means from zero. These differences are not statistically significant (none of the means in the table is significantly different from zero); this may or may not be attributable to sample size.

When measurements indicated damage but report form questions indicated no damage in the general wheel and column area and case photographs substantiated this, it was possible to correct the case. This was true in the majority of cases. The large error associated with the measurement of the distance from steering wheel to window frame reflects a number of cases where an impossible reading (e.g., twice the possible dimension) was recorded.

Study was carried no further than this because accident severity was low and the number of damaged steering columns was small. The subject and the methodology are thought to warrant further study.

TABLE C-12

NUMBER OF OBSERVATIONS, MEAN, STANDARD DEVIATION, AND HYPOTHETICAL MEAN FOR $\triangle P$, $\triangle F$, $\triangle G$ WHEN NO STEERING COLUMN DAMAGE WAS REPORTED

DETERMINATION	NO. OF OBSERV., N	MEAN MEAS., $\overline{X}$ (IN.)	STD. DEV., σ (IN.)	HYPOTHETICAL MEAN, u
$\triangle P$	125	0.21	1.98	0
$\triangle F$	121	−0.68	5.52	0
$\triangle G$	64	0.41	2.76	0

3. DRIVER STUDY

The accident report form used for this portion of the study is shown in Figure D-2. Data were collected to provide information in the areas of driver characteristics, driving habits, their interactions, and their relationship to accident culpability. The sample included more than 2,800 drivers, of which 22 percent were female. Data were collected at all hours of the day, seven days a week.

The first series of analysis in this study is based on the sex of the driver. Here, as in many of the analyses to follow, care must be taken in interpreting the results because the results relate to sex of a driver, given the fact that the accident occurred, and not necessarily to the likelihood of an accident, given the sex of the driver. With this type of data it cannot normally be determined if proportions change due to a change in the relative exposure of the male versus female driver or due to a change in their propensity toward accident-related variables. Of course, if exposure data were available this problem would be obviated. The analysis which follows illustrates this statement.

Examination of data for time of accident occurrence shows that only 5 percent of the drivers involved in accidents between 1 and 5 AM were females. On the other hand, the peak hours during which women are involved in accidents fall between 7 AM and 12 NOON; during these hours the proportions of female drivers ranged between 0.27 and 0.46. These figures may be compared to 0.22, the proportion of females among all accident drivers. These results are not sufficient to conclude that women are less prone to accidents in the early morning hours. It is more likely that the results derive from a reduced proportion of female drivers at that time of day. If information were available specifying this latter information, more conclusive statements could be made about tendencies toward accident involvement as a function of sex and time.

By contrast, it was found that the proportion of accident drivers who were female did not depend on weather conditions (clear, cloudy, or rain) or on road surface condition (wet or dry). The incidence of such variables as fog, mud, and gravel was so low as to prevent their inclusion in these analyses.

A chi-square test showed that the proportion of female drivers was not independent of distance of the accident from the driver's home. The mean distance for males was lower than that for females (64.5 miles and 70.0 miles, respectively), but the difference was not statistically significant. It may be pointed out that the direction of the difference is primarily attributable to the increasing proportion of females having accidents occurring more than 100 miles from home. For distance of less than 100 miles, the proportion of female drivers tended to decrease as distance from home increased. Perhaps the most notable aspect of these data was that the females had most of their accidents close to home or far from it; they appear least frequently in the 5-to-100-mile range.

In comparing sex of the accident vehicle driver to frequency of use of the accident road, the following values were assigned as frequencies: daily, 250 per year; weekly, 50 per year; monthly, 12 per year; and rarely, 2 per year. Using these, it was found that the average frequency for females was 112.5 per year; for males, a significantly different 98.6 per year. This difference was primarily attributable to the relatively high proportion of females stating that they drove the accident vehicle daily. It was also noted that the proportion of females who used the roads daily or rarely was higher than the proportion using them weekly or monthly.

Comparing the proportions of female drivers in terms of trip destinations, the proportion decreases from shopping, to work, to home and business, to other (primarily social); the respective proportions are 0.38, 0.27, 0.22, and 0.18.

Grouping these data yields a picture of the female accident driver as one who tends toward routine trips on familiar roads. Possible exceptions to this are the lack of effects of adverse weather and the increased proportion of women driving hundreds of miles from home. The data might also be considered to suggest the hypothesis that women are more likely to have accidents when driving on distant, unfamiliar roads.

It was also observed that of those drivers who operated a vehicle in addition to the accident vehicle, the males had almost twice the stated annual mileage on the second vehicle; women averaged about 4,700 miles per year, whereas the average for men was approximately 9,500 miles per year.

Finally, no significant relationship was found between sex and driver education. The proportion of males with driver education was 0.22; for females it was 0.20.

The age of the accident vehicle driver was analyzed relative to the same variables as was sex. With regard to the time of the accident, the youngest drivers appeared between midnight and 4 AM; their mean age was 26.7. Between 9 and 11 AM the mean age of accident drivers was 40.5.

As was observed with respect to sex of driver, weather and road surface condition seemed unrelated to the driver's age. Thus there is no indication that women or certain age groups avoid adverse driving conditions, or that the conditions have a differential adverse effect on those drivers.

Comparing the age of accident vehicle drivers to the distance between the accident site and the driver's home reveals a positive correlation between the two. Figure C-4 shows that age first decreases until the distance reaches 10 miles, then increases with distance. Assuming that the frequency of driving on a road should vary with the distance from home, one would expect age to peak for the extreme frequencies as it does for the extreme distances. This is incorrect, although the effect is not a strong one. The mean age of those drivers using the road daily or rarely was 35.5, whereas for those driving weekly or monthly the mean age was 33.3.

A chi-square test showed that there was a statistical interdependence between age and destination of the trip. The group which stated their destination as "other" (usually social or recreation) had the youngest mean age (31.7 years); those drivers traveling for business reasons (but not to work) had the oldest mean age (40.0).

Finally, as might be expected, there was a strong relationship between age and driver education. The proportion of drivers of ages between 16 and 19 who had driver education was 0.53; between 30 and 39 years the proportion with driver education was only 0.08.

Driving experience, as measured by the number of years of driving, related to many variables in essentially the same way as did the age of the driver. These variables include the time of the accident, the distance from home, road surface condition, and frequency of use of the road.

The total annual mileage driven also provides a measure of driving experience. In terms of the time at which the accident occurred, grouping was less obvious, except that the less experienced drivers tended to be involved in nighttime accidents and experienced drivers were more involved in daytime hours. Annual mileage bore no correlation with weather conditions, or with road condition (wet-dry). On the other hand, annual mileage had small but significant correlations with distance from home ($r = 0.06$) and use of the accident road ($r = 0.05$). Finally, mean annual mileage for drivers with driver education was approximately 11,800 miles; for other drivers it was 1,200 miles per year more.

One would expect that the frequency with which a road is driven would decrease as distance from home increased. This contention was supported by the data, the correlation between the two being − 0.31.

Accident type was used to select accidents involving rollover, stationary objects, or no collision. The drivers were younger than average, had driven a lesser number of years, and drove on the accident road less frequently. Thus it appears that drivers who have accidents involving "loss of control" tend to have less driving experience. The probability that the driver was a female was highest for collisions with other vehicles (0.25) and lowest for collision with other moving objects (0.09).

Accident reports were examined and drivers were judged in terms of culpability. In unclear situations, no culpability judgment was made and the case was excluded from analysis. Culpability, never really rigorously defined, was viewed in terms of responsibility for the precipitation of the accident; events thereafter were ignored. A violation of the law was sufficient grounds for a judgment of "culpable." Unusual behavior antecedent to an accident was not sufficient for the assignment of a culpable score, unless that behavior would normally be expected to produce a disruption of traffic. Restricted vision was never the basis for changing a culpable evaluation to a nonculpable one; rather the attitude was "driver beware." Mechanical fail-

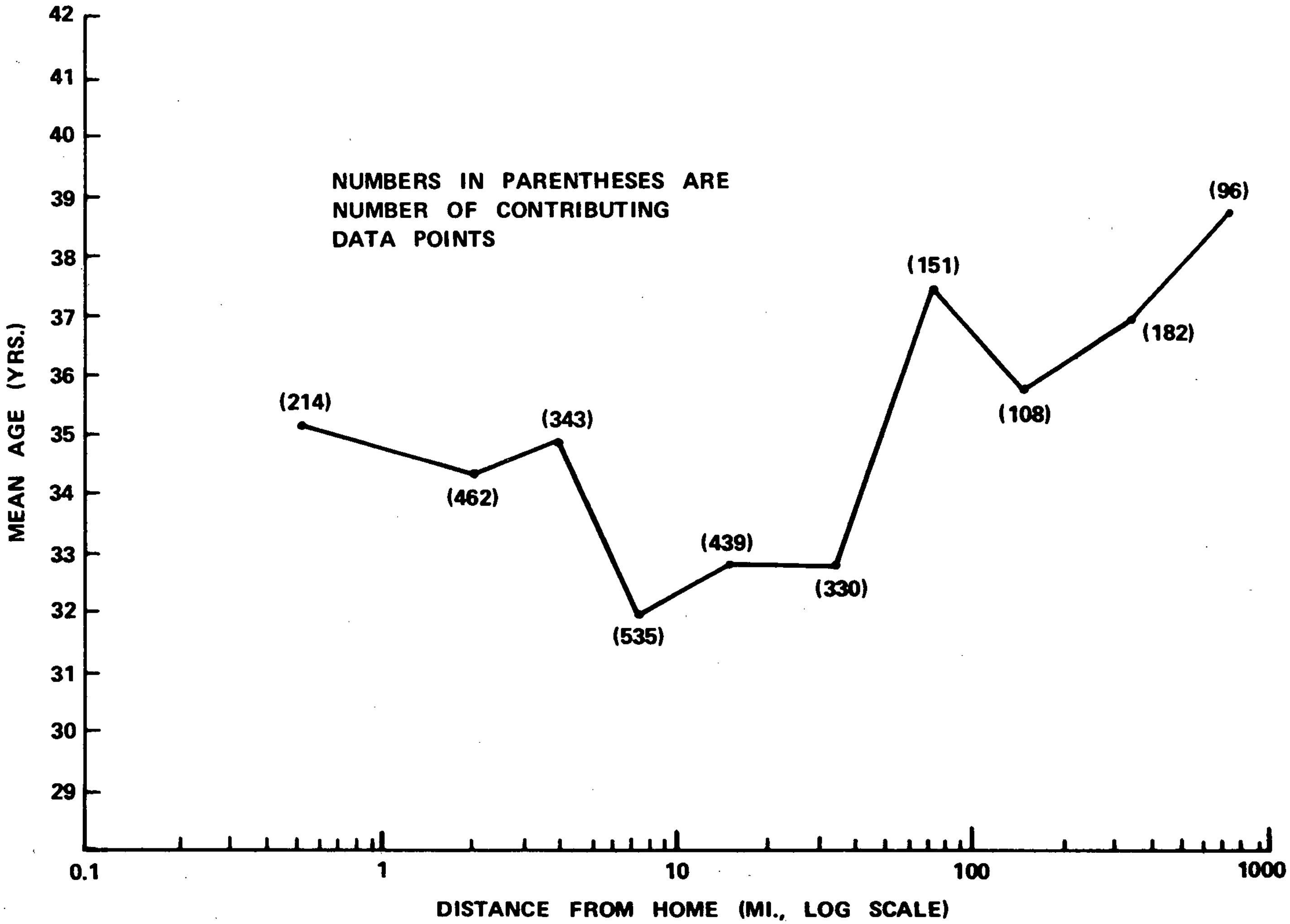


Figure C-4. Mean driver age as a function of distance of accident site from home.

ures as precipitators of accidents led to a nonculpable evaluation.

As might be expected, the proportion of culpable drivers in single-vehicle accidents was significantly higher than the proportion for all accidents. Inasmuch as the analyses for single-vehicle accidents yielded the clearer results, the findings discussed in the following are restricted to them.

The probability that a female was culpable was 0.72; the probability that a male was culpable was 0.82. These figures are based on 863 cases, and the difference is statistically significant.

The relationship between culpability and age was clear; as age increases the likelihood of culpability decreases. As a result, the mean age of culpable drivers was 27.8; for nonculpable drivers, 31.6. Similarly, and certainly not independently, culpability was negatively correlated with years of driving. Mean experience for culpable drivers was 10.4 years; for nonculpable drivers, 13.2. Which of the two, age or experience, makes the greater statistical contribution to culpability was not determined.

Familiarity with the accident road was measured in terms of the frequency with which it is used. The culpable drivers had an estimated mean annual frequency of 76.77 trips per year; the nonculpable, 100.23. Furthermore, the data exhibited a monotonic relationship between the proportion of drivers who were culpable and frequency of road use. Thus, it appears that lack of familiarity with the road is conducive to the precipitation of single-vehicle accidents.

Because culpability decreased with familiarity with the road, culpability might be expected to increase with the distance of the accident site from the driver's home. This turned out not to be true. The mean distance from home for culpable drivers was 54.3 miles; for nonculpable drivers, 85.1 miles. These values are higher than expected, due to the effect of a minority of drivers who had accidents hundreds of miles from home; the median mileage for both groups was 7.5 miles. The difference in means is primarily attributable to the decreased culpability as distance increases beyond 7.0 miles. Thus, a reasonable explanation for the difference in means may be that a greater proportion of experienced drivers operate their vehicles at the larger distances from home. As shown earlier, experience and age, both of which varied inversely with culpability, increased with distance from home.

With respect to the destination of the trip, the lowest proportion of culpable drivers occurred for business (not driving to work in the usual sense) trips, where 61 percent were culpable. The highest proportion occurred for destinations other than home, work, shopping or business (primarily social and recreational trips); the percent of culpable drivers was 87. These proportions were significantly different from each other and also from the proportion of culpable drivers in the remainder of the sample. It is likely that many of the factors previously discussed (e.g., distance from home, age, etc.) contributed to this result.

Finally, for those drivers who operated a vehicle in addition to the accident vehicle, analyses were run relating culpability to the similarity of the two vehicles in terms of (1) standard transmission versus automatic transmission, (2) standard versus power steering, and (3) standard versus power brakes. The sample size for each analysis was not large—214 drivers—and no results were statistically significant. There was no evidence for increased culpability for those drivers whose cars were "mixed" with respect to those types of options. It was interesting, however, that in each analysis the group of drivers which had the highest proportion of culpable drivers consisted of those for whom both vehicles had the standard equipment. This result might be due to a preference for standard equipment by older drivers.

It is obvious that much sufficiently reliable information can be made available through the use of a well-designed accident report form. Summarizing, the measure of frequency of accident road use was a most valuable item. This was shown by the fact that it entered into relationships with so many other variables. The same could be said for driver culpability, at least in single-vehicle accidents.

Probably the most notable over-all implication of these data is that different driver types have different driving habits. The data show that variables such as age, sex, and driving experience tend to affect the time, location and familiarity therewith, annual mileage, and destination.

4. RATIONALE AND ANALYSIS OF ODOMETER DATA

The rationale on which statistical examination of odometer data in this study is based is given in the detailed outline which follows. Although problems may be expected in the use of these data, it is believed that useful information can be obtained. The mileage driven by individuals and vehicles and the times and conditions under which they are driven represent some of the most important measures of accident risk. At present there are few or no data available concerning these factors. They are discussed herein to suggest the types of data that should be recorded and study techniques that can be employed.

Summary

An effort is made to describe the rationale of statistics on odometer reading data. The aspects discussed and the results are as follows:

1. The exact mode of generation of odometer reading distributions is presented.
2. In practice, only approximations of these distributions are available.
3. The mathematical interrelations of an exposure distribution, a risk function, and an accident car distribution are set forth by means of a general mathematical model.
4. It is shown that if two (say) observed accident car distributions are available, without further information nothing can be said about the risks involved.
5. A plausible assumption (risk proportional to mileage) is introduced, under which it is possible to evaluate exposure distributions from observed accident distributions. Still, risk ratios and absolute risk levels remain unknown.
6. It is shown that even if the exposure distributions are known, risk evaluation is not feasible.
7. The value of odometer reading data is seen to be:
    - (a) In risk evaluation, if additional data on the number of cars exposed and in accidents are available.

(b) In exposure evaluation:
   (1) from accident car data if the plausible assumption (item 5) is accepted, and
   (2) from the type of exposure data obtained in Virginia.

Distribution of Odometer Readings at a Given Moment of Time

If the odometer readings of all cars could be obtained at exactly the same time, the resulting distribution of the readings would be determined by three essential factors, as follows:

1. Distribution of cars by age of the vehicle. The effect of this distribution is disturbed by the fact that odometers are, at times, set back to zero or to a low reading. Thus, the reference should be to the distribution of zero-setting of the odometers.
2. Distribution of cars by intensity of use (e.g., annual mileage).
3. Random and semi-random disturbances.

As a first model, the mileage $x_i(t)$ of the ith car at the time t can be written as

$$x_i(t) = b_i(t - t_{0i}) + e \tag{C-1}$$

in which

t_{0i} = time of zero setting of the ith car;
b_i = average mileage per time unit during the period from t_{0i} to t; and
e = random element,

are the t variables to determine the distribution of $x_i(t)$.

The distribution of the t_{0i} is known to be fairly flat and skewed to the left. The distribution of the b_i could be of the gamma type, or nearly normal, as suggested by some California driver interview data, and the distribution of the random variations, e, can well be assumed to be normal or possibly log-normal. Thus, the distribution of the $x_i(t)$ should be of a fairly ordinary bell-shaped type with a single node and maybe a pronounced flatness. Further speculation is made difficult by the strong possibility that the t_{0i} and b_i may not be independent.

For many practical purposes, it will be useful to consider the conditional distribution of the $x_i(t)$, given t_0. This is the mileage distribution of those cars that entered the road at the same time, and obviously the distribution depends only on b_i and e.

Approximate Distributions

In actual practice, ACIR will not be in possession of odometer readings made simultaneously on all cars. On the contrary, the readings will be spread within a time interval—say, one calendar year. This adds another factor of variability to the model, increasing the variance of the distribution.

Similarly, one generally cannot obtain conditional distributions to those cars that entered the road exactly at the same time. Instead, cars of the same year of manufacture are grouped together, thus adding to the model another factor of variability.

Presumably, each of these two variability elements has the rectangular distribution.

Exposure Distribution and Accident Distribution

Let "exposure distribution" be the mileage distribution of all cars on the road, and "accident distribution" the mileage distribution of cars involved in accidents. Then, let

$$f(x) = \text{exposure distribution}; \quad \int_0^\infty f(x)dx = 1.$$

$$g(x) = \text{accident distribution}; \quad \int_0^\infty g(x)dx = 1.$$

Further, let a risk function be introduced which gives the probability of an accident, given the odometer reading, or:

$$r(x) = \text{risk function}; \; r(x) \geqq 0 \text{ for all } x.$$

Then, the following functional relationship exists:

$$\begin{aligned} g(x) &= r(x)\, f(x) / \int_0^\infty r(x)\, f(x)\, dx \\ &= r(x)\, f(x)/\bar{r} \\ &= R(x)\, f(x) \end{aligned} \tag{C-2}$$

in which $\bar{r}$ is the mean risk and $R(x)$ is the relative risk at mileage x.

The results show that unless $r(x)$ is a constant for all x, the accident distribution is different from the exposure distribution. The difference depends entirely on the nature of the relative risk function $R(x)$.

Comparing Two Accident Distributions

Suppose two accident distributions, $g_1(x)$ and $g_2(x)$, are observed. A meaningful comparison is obtained by calculating the ratio

$$\begin{aligned} \rho(x) &= g_1(x)/g_2(x) \\ &= \frac{\bar{r}_2}{\bar{r}_1} \cdot \frac{f_1(x)}{f_2(x)} \cdot \frac{r_1(x)}{r_2(x)} \end{aligned} \tag{C-3}$$

Now, if $f_1(x) = f_2(x)$, Eq. C-3 reduces to

$$\rho(x) = \frac{\bar{r}_2}{\bar{r}_1} \cdot \frac{r_1(x)}{r_2(x)} \tag{C-4}$$

revealing the fact that, provided the exposures are identical, two accident distributions will be identical if (and only if) one risk function $r_2(x)$ is equal to a constant $(\bar{r}_2/\bar{r}_1)$ times the other risk function $r_1(x)$. This is the case, of course, if the two risk functions are equal, but also if one risk is uniformly twice as high (say) as the other. Thus, under these circumstances, the equality of two accident distributions does not necessarily imply equality of the two risk functions.

On the other hand, if the rho-ratio $\rho(x)$ is not uniformly equal to unity, then a difference must exist between the two risk functions, but this difference can not be expressed by

$$r_2(x) = (\bar{r}_2/\bar{r}_1)\, r_1(x) \tag{C-5}$$

Under these circumstances, the $\rho(x)$-curve has one (at least asymptotically) or more locations where $\rho(x) = 1$; elsewhere $\rho(x) \neq 1$. The utility value of the $\rho(x)$-curve is limited, however, because the constant $\bar{r}_2/\bar{r}_1$ in Eq. C-4 remains unknown. The $\rho(x)$-curve reveals the shape of the risk ratio, $r_1(x)/r_2(x)$, but not the magnitude of it. To exemplify, suppose the following $\rho(x)$-curve was observed in comparing two accident distributions:

Mileage (1,000's)	$\rho(x)$
1	1.214
2	1.125
3	1.056
4	1.000
5	0.955
6	0.917
7	0.885

This $\rho(x)$-curve is obtained equally well from a situation where Group 1 has much higher risks than Group 2 (A) as from the reverse situation (B):

Mileage (1,000's)	A		B	
	$r_1(x)$	$r_2(x)$	$r_1(x)$	$r_2(x)$
1	2.55	1.40	1.70	2.80
2	2.70	1.60	1.80	3.20
3	2.85	1.80	1.90	3.60
4	3.00	2.00	2.00	4.00
5	3.15	2.20	2.10	4.40
6	3.30	2.40	2.20	4.80
7	3.45	2.60	2.30	5.20

However, one might as well have $f_1(x) \neq f_2(x)$ in Eq. C-3. If so, equality of the two accident distributions only tells that $r_2(x) \neq \bar{r}_2 r_1(x)/\bar{r}_1$, but no indication is given as to magnitude and direction of the difference between the risk functions. Inequality of the two accident distributions does not tell anything of the possible difference between the two risk functions.

To summarize, two accident distributions, A_1 and A_2, are given, but the underlying exposure distributions, E_1 and E_2, and risk functions, $r_1(x)$ and $r_2(x)$, are unknown. If $K = \bar{r}_2/\bar{r}_1$ (an unknown constant), only the following conclusions are admissible:

1. If $A_1 = A_2$,

either: (1) $E_1 = E_2$ and $r_1(x) = K\, r_2(x)$

or: (2) $E_1 \neq E_2$ and $r_1(x) \neq K\, r_2(x)$

2. If $A_1 \neq A_2$,

either: (1) $E_1 = E_2$ and $r_1(x) \neq K\, r_2(x)$

or: (2) $E_1 \neq E_2$ and $r_1(x) = K\, r_2(x)$ or $r_1(x) \neq K\, r_2(x)$.

In other words, if nothing else is known except two accident distributions, hardly anything can be concluded regarding the underlying exposures or accident risks.

* In this case, the proportionate shape of the risk ratio curve $r_1(x)/r_2(x)$ can be determined.

A Plausible Assumption

If only those cars which entered the road at the same time are considered, $f(x)$ will be, in essence, the distribution of annual mileages. Now if one car is driven 20,000 miles a year and another car just 10,000 miles a year, the former is subject to double the exposure of the latter, and one could expect a doubled risk of accidents. This reasoning leads to an assumed form of the risk function:

$$r(x) = b\,x \qquad b = \text{constant} \tag{C-5a}$$

Under this assumption, the accident distribution obtains a simple form

$$g(x) = b\,x\,f(x)/b\int_0^\infty x\,f(x)\,dx$$
$$= \frac{x}{\bar{x}} f(x) \tag{C-6}$$

It should be noted that the accident distribution defined by Eq. C-6 does not depend on the risk level at all. In other words, any risk level, provided Eq. C-5*a* is satisfied, produces the same accident distribution, if the exposure distribution $f(x)$ is given. Thus, the distribution defined by Eq. C-6 is useless for risk comparison.

However, Eq. C-6 is useful in that it allows estimation of the exposure distribution $f(x)$. Dividing the observed $g(x)$-values by x gives

$$h(x) = g(x)/x \tag{C-7}$$

which has the property

$$\int_0^\infty h(x)\,dx = 1/\bar{x} \tag{C-8}$$

Thus, the mean mileage, $\bar{x}$, can be obtained by measuring the area defined by Eq. C-8. But now multiplication gives

$$\bar{x}\,h(x) = \bar{x}\,g(x)/x = f(x) \tag{C-9}$$

Therefore, given an observed curve $g(x)$, the curve $f(x)$ can be determined, and it becomes possible to compare exposure distributions of groups of cars.

For the sake of curiosity, it can be mentioned that the mean of the $g(x)$-distribution is equal to $(1 + c^2)\bar{x}$, where c is the coefficient of variation and $\bar{x}$ the mean of the $f(x)$-distribution, and that the variance of the $g(x)$-distribution is equal to $(1 - c^2)\sigma^2$, where σ^2 is the variance of the $f(x)$-distribution and the third central moment of the $f(x)$-distribution is assumed to be zero.

EXPOSURE DISTRIBUTION KNOWN

Suppose that in addition to the accident distribution $g(x)$, the underlying exposure distribution $f(x)$ also is known. Is one any better equipped for risk evaluation? The answer is: partially, yes; but not very much.

From Eq. C-2 the following relation is immediately derived:

$$g(x)/f(x) = r(x)/\bar{r} = R(x) \tag{C-10}$$

This shows that the relative risk curve $R(x)$ can be determined if the exposure distribution $f(x)$ is known. However, the absolute level of the risk still remains unknown, and a mean risk difference between any two groups cannot be detected even if both $g(x)$ and $f(x)$ are known.

How Odometer Reading Data Can Be Used

The preceding observations show that data on $g(x)$ and $f(x)$ are of very limited value, if any, in risk comparisons. Perhaps this should be expected, for $g(x)$ and $f(x)$ provide information on only the quality of accident cars and exposed cars, not on quantity. For successful risk evaluation, both of these aspects should be covered. Thus, in addition to odometer reading distributions, one should have at his disposal the number of cars in accidents and the number of cars exposed to traffic accidents, for a given period of time. How to obtain estimates of these is a question beyond the scope of the present study, but certain possibilities certainly exist, although the difficulties may be substantial.

Even if risk evaluation remains a difficult task, odometer reading data certainly have some utility value: derived either from accident car data, under the assumption of the remainder of this section, or from general exposure data (Virginia, Sections 5 and 6) the exposure distributions are useful *per se*. It would help to know whether two-door hardtops are driven more intensively than four-door sedans or whether young drivers are annually exposed to more traffic than middle-aged drivers. Thus, odometer reading data deserve the researchers' attention and efforts for further development.

Analysis of ACIR Odometer Data

In connection with the Automotive Crash Injury Research (ACIR) studies conducted by the research agency, odometer readings in injury-producing accidents were available. The rationale for use of odometer data is given earlier in this section. In addition, some general observations are of sufficient interest to be reported here.

Before interpreting the data it should be noted that a new ACIR data collection form providing for odometer data was placed in use in North Dakota on July 1, 1964, and in several other states on January 1, 1965, or later. Thus, the accidents occurred partly during the latter half of 1964, and in 1965 (some few possibly in 1966). The "center of gravity" of the time of the accidents should fall somewhere during the first half of 1965, while the total spread in time is about 1.5 years.

Table C-13 gives the distributions of odometer readings by year of manufacture. In terms of the median reading, the central tendency can be summarized as shown in Table C-14. The medians were determined from graphs after some smoothing by eye, not from Table C-15. The interpretation of the difference column in Table C-14 is rendered difficult because of the time spread involved and the small size of some of the samples. However, it appears that the annual increment (annual mileage) averages near 10,000 or 11,000, appearing larger when the car is new, then declining slightly. Whether this decline is true at all remains questionable, for with increasing age of the car there is an increasing emergence of "false low" readings, as described later. On the other hand, older cars may be more frequently "second" cars, which may be driven annually less than the newer "first" cars.

TABLE C-13

ODOMETER READINGS ACCORDING TO YEAR OF MANUFACTURE

YEAR OF MANUFACTURE	MEDIAN READING (1,000 MI.)	YEAR-TO-YEAR DIFFERENCE (1,000 MI.)
1965	7.2	12.3
1964	19.5	10.3
1963	29.8	8.7
1962	38.5	6.3
1961	44.8	9.2
1960	54.0	10.2
1957-59	64.2	7.8
−1956	72.0	
All	22.5	

The fundamental feature in the odometer reading data is the changing nature of the distribution with advancing age of the car. For example, false low readings are more frequent, the older the car. This is illustrated by taking an arbitrary cutting point (20,000 miles, say) and determining the percentage of cars whose reading is recorded as under 20,000 (Table C-15).

If there were no false lows, the percentage under 20,000 miles should go steadily down with advancing age of cars and eventually nearly disappear. However, somewhere about manufacturing years 1960 to 1962 a reversal takes place and the percentage starts climbing. This must be taken as an indicator of the emergence of false lows, which are known to come from two sources:

1. At 100,000 miles, the odometer starts measuring from zero again.
2. Odometers are deliberately set back, more frequently as cars get older.

There is no way of knowing to what extent each of these two factors affects the data. Nor is it known how the troopers handle cases where the odometer obviously has passed 100,000. In only 5 cases out of the 1,014 did the trooper indicate "over 100,000." Otherwise, he may have either recorded the apparent reading or written "N.R." (= not reported). Possibly the N.R. alternative is often used to indicate "in excess of 100,000 miles," for the relative frequency of non-reported readings increases with advancing age of the car (Table C-16).

The total non-reporting rate of about 30 percent is quite high, and if non-reporting is associated with the age of car, and thus the true mileage of the car (as it appears to be), there is an additional difficulty in interpretation of the odometer reading data.

The second feature of the distributions is their changing shape, apparently in conjunction with the phenomenon of false lows. The mileage distribution of the 1965 cars is nicely unimodal, narrow, and heavily skewed to the right. As the cars get older, the distribution "travels" to the right and spreads over a wider range, thus flattening out. Eventually, a new bulge appears near the zero end of the mileage scale (false lows), and for the oldest cars the distribution has turned clearly into a bimodal one. (Some of the flattening in the 1957-59 and —1956 groups is, of course, due to combining several years of manufacture.) The development is shown in Figure C-5, which is drawn freely by hand but which quite faithfully describes the general tendencies of the data.

The conclusion from the present observations is that in every effort to use odometer reading data, the age of the vehicles must be taken into account because the distribution of odometer readings depends heavily on the distribution of the vehicles by year of manufacture. In practice this means that for any purposes of comparative analysis (e.g., for comparison of two groups of cars), odometer readings must be cross-tabulated with year of manufacture.

5. ANALYSIS OF VIRGINIA ACCIDENTS AND DATE OF INSPECTION

Presumably, the intent of motor vehicle inspection systems is the reduction of accident frequencies by preventing accidents precipitated by mechanical failure. If inspection is effective in this regard, any given vehicle should be less prone to accident involvement immediately after passing inspection, when deficiencies have been corrected, than immediately before inspection. The following discussion presents a means of testing this hypothesis and an application of this procedure to the current data.

Although this description is concerned with accident frequency as a function of elapsed time since inspection, the analysis is not restricted to the study of this relationship. For example, accident frequencies could be studied as a function of vehicle mileage since inspection. Or the analy-

TABLE C-14

CUMULATIVE PERCENT DISTRIBUTIONS OF ODOMETER READINGS IN INJURY-PRODUCING ACCIDENTS, 1965

THOUSANDS OF MILES	YEAR OF MANUFACTURE 1965	1964	1963	1962	1961	1960	1957-59	-1956	TOTAL
UNDER 5	32.9	6.4	-	1.2	-	3.4	1.1	3.9	12.0
10	68.8	17.5	-	1.2	-	3.4	1.1	7.8	25.9
15	86.6	33.9	2.0	3.7	1.9	3.4	5.3	13.0	37.0
20	93.0	51.1	13.7	3.7	5.7	3.4	7.4	13.0	45.3
25	96.0	70.3	31.4	14.8	9.4	3.4	7.4	16.9	54.6
30	97.7	83.2	49.0	28.4	13.2	17.2	8.5	18.2	62.3
35	98.0	90.0	68.6	42.5	18.9	20.7	8.5	19.5	67.9
40	98.3	92.8	82.4	53.1	35.9	31.0	13.8	20.8	72.8
45	98.3	95.7	87.3	65.5	50.9	37.9	18.1	20.8	76.4
50	98.7	98.2	91.2	74.1	67.9	44.8	23.4	22.1	80.0
55	99.0	98.9	92.2	79.0	75.5	51.7	28.1	24.7	82.1
60	99.0	99.3	94.1	85.2	81.1	58.6	39.4	29.9	84.7
65	99.7	99.3	96.1	87.7	86.8	72.4	52.1	39.0	87.9
70	100.0	99.3	100.0	91.4	90.6	82.8	59.6	46.8	90.4
75	-	99.3	-	93.9	92.5	89.6	68.1	54.6	92.3
80	-	99.6	-	95.1	94.4	93.1	76.6	58.5	93.8
85	-	100.0	-	96.3	96.2	96.5	86.2	67.5	95.8
90	-	-	-	97.6	98.1	96.5	91.5	74.0	96.9
95	-	-	-	98.8	98.1	100.0	96.8	83.1	98.3
100	-	-	-	100.0	100.0	-	99.0	94.8	99.6
NO. OF CARS	298	280	102	81	53	29	94	77	1014
MEDIAN MILEAGE 1000 MI. *	7.2	19.5	29.8	38.5	44.8	54.0	64.2	72.0	22.5

*EVALUATED AFTER SOME SMOOTHING.

sis could be applied to a restricted sample including only accidents involving mechanical failure; this approach would be more sensitive if the sample were sufficiently large.

Specifically, the hypothesis of interest is that the probability of accident involvement increases as the number of months since inspection increases. (In Virginia, the source of these data, the time between successive inspections for a given vehicle is six months.) To restate the hypothesis in a more clearly testable form: if the elapsed time since inspection is brief, there are relatively few accident vehicles and relatively many non-accident vehicles; i.e., the ratio of accident to non-accident vehicles is small. As elapsed time increases, the relative number of accident vehicles should increase. Therefore, the ratio of accident to non-accident vehicles increases as the time since inspection increases. This may be written

$$\frac{N(A, T=t)}{N(\bar{A}, T=t)} \text{ increases with } t \qquad \text{(C-11)}$$

where $N(A,\ T=t)$ is the number of accident vehicles whose elapsed time was t.

The difficulty in using this formulation as it stands is the lack of exposure information for non-accident vehicles. (It should be noted that routine collection of inspection information for research purposes could provide some of this information.) It has been determined that in Virginia the number of inspections is more or less equal from month to month. This means that the distribution of elapsed times for randomly sampled non-accident vehicles would be essentially uniform. Inasmuch as vehicles are inspected every six months,

$$P(T=t \mid \bar{A}) = \begin{cases} \frac{1}{6}, \text{ for } t=1, 2, \ldots, 5 \\ \frac{1}{12}, \text{ for } t=0, 6 \end{cases} \qquad \text{(C-12)}$$

where $P(T=t \mid \bar{A})$ is the probability that a non-accident vehicle at any point in time has had T months elapse since inspection. For $T=0$, the probability is 1/12, because this is equivalent to the probability that for any one month inspection preceded the hypothetical random selection of the vehicle; it is thus one-half the probability for $T=1$ of the intermediate values. Essentially the same logic was applied in determining the value of $P(T=6 \mid \bar{A})$.

Because $P(T=t \mid \bar{A})$ is proportional to $N(T=t, \bar{A})$, the hypothesis may be written

$$2N(T=0,\ A) < N(T=1,\ A) < \ldots < N(T=5,\ A) < N(T=6, A) \qquad \text{(C-13)}$$

One more adjustment is necessary in the application of the current data. This is due to the fact that data collection did not start on the first day of the month (April), or end on the last day of the last month (October). The actual data collection period started April 16 and ended October 22; the resultant adjusted final hypothesis is

$$1.97\ N(T=0, A) < N(T=1, A) < \ldots < N(T=5,\ A) < 2.03\ N(T=6,\ A) \qquad \text{(C-14)}$$

Results are given in Table C-17 and the corrected frequencies are plotted in Figure C-6.

Comparing these results with Section 4, it is obvious that the data offer no support for the hypothesis that accidents are more likely to occur as the time since inspection increases. There are many possible reasons for this result:

TABLE C-15

PERCENTAGE OF ODOMETER READINGS UNDER 20,000 MILES

YEAR OF MANUFACTURE	PERCENTAGE UNDER 20,000 MILES
1965	93.0
1964	51.1
1963	13.7
1962	3.7
1961	5.7
1960	3.4
1957-59	7.4
–1956	13.0
All	45.3

TABLE C-16

PERCENTAGE OF CARS WITH ODOMETER READING NOT REPORTED

YEAR OF MANUFACTURE	PERCENT WITH ODOMETER READING NOT REPORTED
1965	11.6
1964	20.8
1963	37.0
1962	38.6
1961	36.9
1960	50.8
1957-59	45.3
–1956	47.6
All	29.9

TABLE C-17

FREQUENCIES OF ELAPSED TIME SINCE INSPECTION

TIME (MONTHS)	FREQUENCY	CORRECTED FREQUENCY
0	100	197
1	186	186
2	192	192
3	165	165
4	180	180
5	165	165
6	99	201

1. Inspection may not be effective in preventing accidents.

2. Inspection may be sufficiently effective so that vehicle deterioration does not precipitate accidents in a period as short as six months. This might suggest that the time between inspections could be increased.

3. Because inspections can be of value only in preventing accidents precipitated by mechanical failure, the inclusion of all accidents in the analysis may have concealed any existing trend. If this were the sole reason for the results, it could be concluded that inspection procedures had a very limited effect upon the total number of accidents.

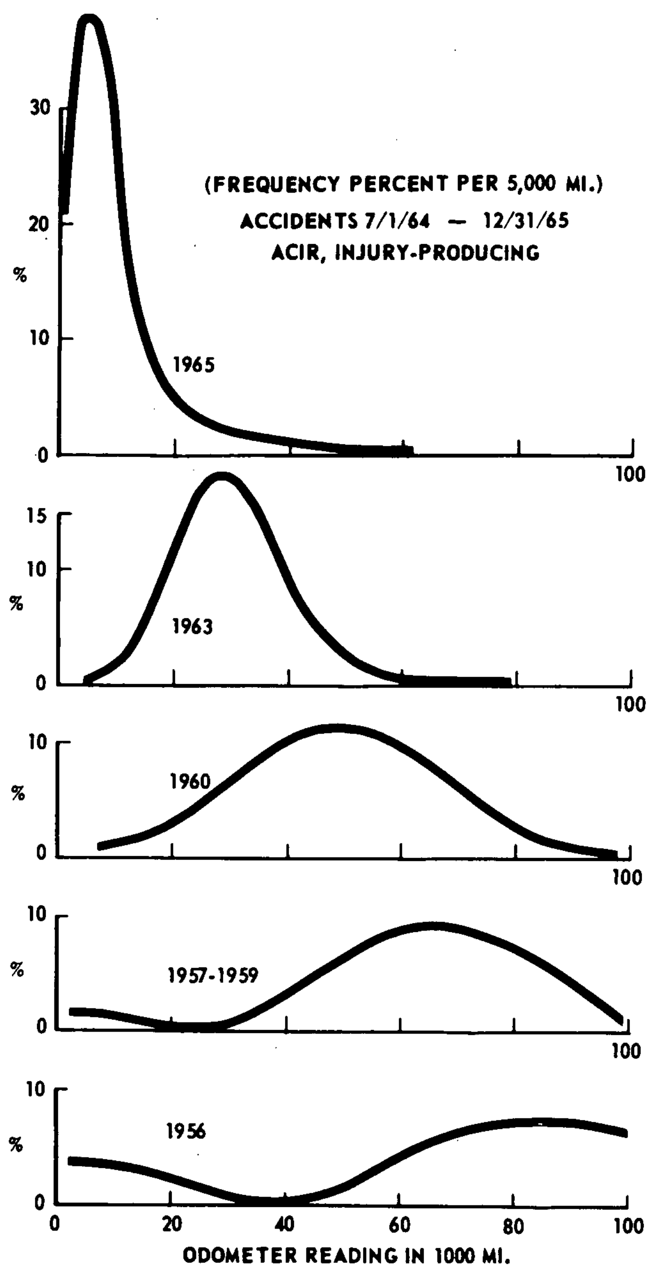


Figure C-5. Smoothed distributions of odometer readings by year of manufacture.

4. Seasonal effects could confound the results. In this case, extension of the data collection period would preclude these extraneous influences.

5. The uniformity assumptions may not be sufficiently accurate. Appropriate data to replace them could be profitably utilized.

6. ANALYSIS OF VIRGINIA INSPECTION DATA, ACCIDENT DRIVER DATA, AND ACCIDENT TIRE DATA

This section contains results of an analysis relating inspection information to data in the driver and tire studies (Figs. D-2 and D-3). For the driver study, two major measures examined are driving intensity, or exposure per unit time, and the number of repairs at inspection. Driving intensity was defined as the odometer reading at the accident minus the odometer reading at the previous inspection, divided by the number of months elapsed between inspection and the accident. Thus, it is the average number of miles per month which the vehicle was

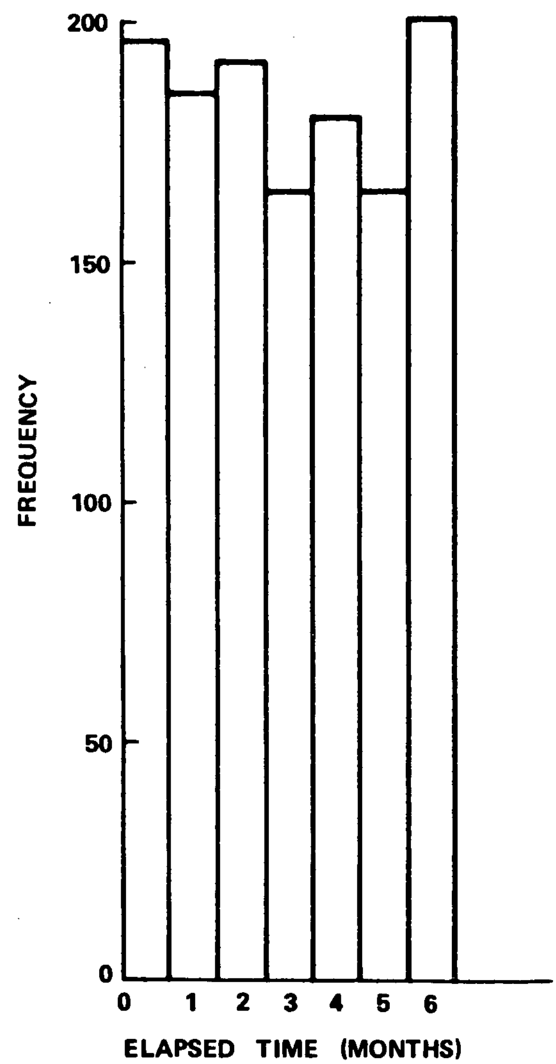


Figure C-6. Corrected frequency of accidents as a function of time since inspection.

driven. It should be noted that it is an imperfect measure of driver behavior, as more than one driver may have driven the vehicle, and that there is some error in this measure due to the measurement of elapsed time. For example, if a driver has an accident in the month immediately following the inspection month, his elapsed time is computed as one month; however, the actual elapsed time could be anywhere from 1 day to 60 days. Of course, this source of error could be obviated by recording the exact day of both events and using them to compute the elapsed time.

Another potential source of error in this driver study is inherent in the fact that the individual whose characteristics are recorded on the accident form may not be the sole driver of the vehicle. The error involved in relating these characteristics to driving intensity and number of repairs increases as other drivers make greater contributions to these variables. Thus, the analysis could have been refined if the accident form included an item describing what proportion of the accident vehicle mileage is attributable to the accident driver. This proportion could have been estimated from data collected in the study, but it was judged that such an estimate itself was not likely to be sufficiently accurate.

The number of repairs at inspection was analyzed in terms of four driver variables: age, sex, culpability, and driver education. Culpability, or responsibility for precipitation of the accident, was determined by analysis of the accident diagram and the accident description. A more complete discussion of its meaning is given in the driver study section. The objective was to determine whether number of repairs, as an inverse measure of the care given to the vehicle, was a function of these driver characteristics.

The analyses showed no significant relationships between number of repairs and any of the four driver attributes. This might result from the relatively short time between inspections. Even the driver who is very conscientious in the care of his vehicle may be willing to wait until inspection time to have repairs made, providing that time is not more than a few months.

Driving intensity was studied in terms of five driver characteristics: age, sex, culpability, distance from home, and frequency of use of the accident road. There was a negative correlation ($r = -0.15$) between age and intensity; however, this correlation is so small as to be of little practical consequence. The average exposure for 384 males was 1,307 miles per month. This was significantly higher than the female average of 1,073, based on 126 observations. When multiplied by 12, these figures represent rather high annual mileages. This could be due to the previously mentioned error in elapsed time, to the fact that the sample included only accident drivers, or to the fact that data were collected in rural areas. In any case, the relative comparison (male vs female) seems valid.

No significant correlations were found between driving intensity and culpability, distance to the accident site, or frequency of use of the accident road. It was noted, however, that those drivers who used the accident road, either daily or rarely as opposed to some intermediate frequency, had the lowest driving intensities.

Certain tire characteristics were also studied in terms of data made available through the use of inspection information. Mileage and number of months elapsed from inspection to accident were the independent variables. The two variables were studied for potential relationships with number of flat tires, frequency of skidding, number of UW (uneven wear) reports, and minimum center tread depth; i.e., the center tread depth of the most worn of the four tires. These analyses are suggestive of possible techniques for evaluating the efficacy of vehicle inspection on absolute grounds or, better, to determine optimal inspection periods.

No significant trends were found between either mileage or time since inspection and any of: number of flat tires, frequency of skidding, or number of UW's. Both mileage and time correlated with minimum center tread depth. As time and mileage since inspection increased, minimum center tread depth decreased. These correlations were extremely weak, however, and of little practical consequence. Descriptive statistics are given in Tables C-18 and C-19. These results indicate that tread wear changes significantly over the months and suggest that inspection may be effective in weeding out those tires with insufficient

TABLE C-18

MEAN MINIMUM CENTER TREAD DEPTH VS MILEAGE

MILES SINCE INSPECTION	NO. OF VEHICLES	MEAN MIN. CENTER TREAD DEPTH (IN.)
0-499	41	0.099
500-999	35	0.120
1000-1999	56	0.119
2000-2999	56	0.107
3000-3999	53	0.103
4000-4999	31	0.101
5000-5999	31	0.097
6000-7999	45	0.088
8000-12999	39	0.077
13000-49999	43	0.080

TABLE C-19

MEAN MINIMUM CENTER TREAD DEPTH VS TIME

TIME SINCE INSPECTION (MONTHS)	NO. OF VEHICLES	MEAN MIN. CENTER TREAD DEPTH (IN.)
0	47	0.097
1	96	0.115
2	84	0.096
3	72	0.096
4	87	0.093
5	83	0.091
6	46	0.078

tread. A study based on a larger sample of data is necessary to determine the full significance of these changes.

The driver and tire data were combined for two further analyses. First, driving intensity was compared to number of repairs. It was thought that if driving intensity during the period from inspection to accident represented an estimate of driving intensity before inspection, one might expect intensity to be correlated with number of repairs at inspection. This was not the case; no trend was found between driving intensity and number of repairs.

The second analysis using the combined driver and tire data involved driving intensity and the year of manufacture of the accident vehicle. The correlation between the two was 0.19, indicating that older vehicles are driven less (Table C-20). This finding may be partly attributable to older vehicles in two-car families being driven less frequently.

7. A TYPICAL INTENSIVE ACCIDENT INVESTIGATION REPORT

CASE 17-1-48 SUMMARY by H. V. Nelson, J. J. Downing, S. N. Lee, October 19, 1967

IDENTIFICATION: Transit and Greiner, Clarence, November 14, 1966, Monday 0910, 1 car and 1 truck, cross intersection, PD.

HIGHWAY: Transit. Straight. 2 lanes, 29-ft asphalt surface good condition, 3-in. crown, 7-ft bituminous shoulder good condition. Commercial area, speed limit 50 mph.

Greiner. Straight, 2 lanes, 20-ft asphalt surface, 3-in. crown, 3-ft dirt shoulder. Commercial area, speed limit 40 mph.

AMBIENCE: Day, temperature 43°, southwest wind at 15 mph, road was dry, shoulders were dry.

TRAFFIC CONTROLS: Transit. Lines—single solid yellow center going north, semi-actuated signal (Greiner) 3A 12G 2 faces.

Greiner. Lines—single solid yellow center going west, semi-actuated signal (Greiner) 12G 3A 2 faces, unusual conditions.

VEHICLES: No. 1. 1964 International, R185, 2 doors, blue silver van, 6-cylinder engine. Standard transmission on floor, power air brakes, no seat belts, damage—1st-19032.

No. 2. 1963 Plymouth, Belvedere, 4 doors, beige sedan, 6-cylinder engine. Push-button automatic transmission on dash, power windows, padded dash, front seat belts, damage—1st-01124.

OCCUPANTS: No. 1. 1. Driver. Male, 35, 5′6″, 130 lb. Driven for 17 years at 100,000 miles per year, operated this vehicle for 2 months at 6,000 miles per month. Seat belts were not used, no injury.

No. 2. 2. Driver. Female, 35, 5′6″, 140 lb. Driven for 19 years at 5,000 miles per year, acquainted with road once a week. Was going from home to shopping, seat belts were worn, no injury.

RF. Female, 26, 5′6″, 135 lb. No injury.

DESCRIPTION: Unit No. 1 was traveling north on Transit at approximately 50 mph. Driver No. 1 saw the traffic light on Greiner change to amber but continued through the intersection. Unit No. 2, traveling west on Greiner, was stopped for the signal. Driver No. 2 started into the intersection as the light changed to her favor. Driver No. 2 had seen unit No. 1 and had assumed that driver No. 1 would stop for the signal. Unit No. 1 struck unit No. 2 in the left front. Unit No. 1's air brake hose was severed by the impact and did not stop until approximately 1,000 ft farther down Transit.

CAUSATION:

1. Human-Experience-Permanent: Driver No. 2 observed that the traffic control favored her direction. She assumed that opposing traffic would respect her right-of-way and that no hazard existed. This action indicated a lack of defensive driving judgment on the part of the driver of unit No. 2.

2. Human-Experience-Permanent: Driver of unit No. 1 saw the amber light and assumed he would have time to clear the intersection before the light turned red in his direction.

3. Environment-Permanent: The 3-sec amber phase on the traffic control device does not provide sufficient time for the driver to undertake proper action when traveling at 50 mph. To stop with a comfortable deceleration force of 0.26*g*, or to safely proceed through the intersection with a 1-sec reaction time would require approximately a 6-sec warning. The 3-sec amber phase was 3 sec short of this suitable time duration.

Evidence indicates that driver No. 1 was the victim of a short amber cycle and had little chance of successfully stopping his vehicle short of the impact point.

RECOMMENDATION: That a 4-sec amber phase followed by a 2-sec all-red phase replace the 3-sec amber phase existing on Transit. This would allow adequate

TABLE C-20

DRIVING INTENSITY AS A FUNCTION OF YEAR OF MANUFACTURE

YEAR OF MANUFACTURE	NO. OF VEHICLES	MEAN MILEAGE PER MONTH
1950-1954	10	839
1955-1959	90	1065
1960	36	1411
1961	38	1132
1962	41	1142
1963	46	1417
1964	67	1251
1965	64	1319
1966	80	1544
1967	24	1652

stopping time for trucks which make frequent use of this highway.

ACCIDENT 17-1-48 DESCRIPTION by S. N. Lee

Location was Transit and Greiner on November 14, 1966, Monday, 9:10 AM. Investigators Lee and McLean. PD accident. The sun was shining, the road was dry, temperature was 43°.

Vehicle No. 1 was a 1964 International box-type truck, color blue in front with a silver bed, New York registration, driven by . . . ., age 35, 5′6″, 130 lb. who was traveling north on Transit approaching the intersection of Maple-Greiner Road. This unit apparently ran a red light. A 1963 Plymouth Belvedere 4-door sedan, beige in color, New York registration, driven by . . . ., age 35, 5′6″, 140 lb. This unit was facing west on Greiner and started across the intersection of Transit. After seeing vehicle No. 1 coming from her left, she stated she had the impression that the truck was going to stop, but as she started up, the truck kept coming and struck the left front of her vehicle with the left side of the truck. During the collision the air hose to the air brakes was broken and the truck continued up the road for many hundred feet before it was able to stop on the opposite side of the road. An independent witness, Mr. . . . ., of Williamsville, who was stopped at Maple, facing east at the intersection of Transit, stated that the light had changed to green, in favor of . . . ., and that to his left on Transit, at least two cars had stopped before the International truck coming from the south entered the intersection.

Driver No. 1 said he attempted to slow his truck by braking, but the load overrode the braking system. The independent witness, ..., stated that the truck did not brake at any time, that rather it appeared to accelerate on entering the intersection. There are traffic-actuated signal controls on Greiner and Maple, approximately 100 ft from the edge of Transit in either direction, east and west. This is an Electro-Matic traffic control from Automatic Signal Division Co., Eastern Industries, Inc., Norwalk, Conn. This intersection signal device was timed by Lee and McLean and was found to have a 3-sec amber light on Transit, which seems to be inadequate for a 50-mph speed limit.

Driver No. 1 was a victim of an inadequate duration of a yellow phase of this signal system. . . . ., driving vehicle No. 2, made the assumption that it was safe to proceed because the light turned in her favor and she assumed that vehicle No. 1 was going to stop even though there was no indication of his slowing down while approaching the intersection.

Both vehicles were examined. Refer to vehicle data information, highway data form, and interviews, also a supplement on signal timing at Transit and Greiner Roads (Figs. C-8, C-9, C-10).

ACCIDENT 17-1-48 IN-DEPTH FOLLOW-UP DATA

An in-depth follow-up examination of the 1964 International truck was not obtainable. The truck was owned by the . . . . Truck Rental Service of Buffalo, but was being operated by a cartage service by whom Mr. . . . . was employed. The truck was hastily repaired and put back into service and the cartage company prevented follow-up on this unit.

The . . . . Truck Rental Service was very cooperative in questioning in regard to upkeep and were very happy to have the truck examined, had not the cartage company refused. The rental service said that the truck was serviced at regular intervals and that the break in the air line fitting was a result of the impact and provided us with the broken fitting. It was determined by Jack McLean, at the scene, that the fitting was broken as a result of the impact and that there did not appear to be a mechanical brake failure. . . . . further stated that the brakes functioned normally after establishing a new air line circuit.

It was felt that to wait until service on the truck at . . . ., at which time is could be examined, would prove of little value. The time element, hasty repair, and further use by the users would render the follow-up invalid.

S. Lee

ACCIDENT 17-1-48 INTERVIEW by S. N. Lee

INTERVIEWEE:

. . . ., driver of International truck.
Age 35, male, height 5′6″, weight 130 lb.

Question: Are there seat belts installed in the truck?

Answer: No.

Question: Can you please describe, in your own words, this accident?

Answer: I was headed north on Transit and approaching the intersection of Maple. The light turned amber about 75 feet back and I depressed the brake, I started to brake, the brake seemed to start to take hold, and then I couldn't stop, the truck kept on going. The other vehicle, the Plymouth, pulled into the intersection and I couldn't stop. I went right through the front of the Plymouth.

Question: How fast were you going?

Answer: About 45 mph. When I tried to brake down hard, the weight of the truck overrode the air brakes and then when I struck the car I lost my air lines and the truck kept on going down the highway. I finally ran off to the side of the road and came to a stop about 1,000 yards away from the accident.

Question: Did you take any evasive action?

Answer: I attempted braking. I swerved to the left, also, and as a result, the car wasn't struck broadside.

Question: Would you please describe the type of day you've had today?

Answer: Well, yesterday I just lounged around the house, watched the football game. I had a good night's sleep last night. Got up this morning, shaved, had breakfast, came to work.

Question: What is the mechanical condition of the truck you were driving?

Answer: Everything seemed all right on the vehicle before the impact. I think the condition of the brakes is a result of the impact, not before. Steering, odometer, everything worked.

TB-31 8/15/63

DIVISION HEADQUARTERS

NEW YORK STATE POLICE

POLICE ACCIDENT REPORT

IF MORE THAN 2 VEHICLES WERE INVOLVED OR MORE THAN 4 PERSONS INJURED, ATTACH ADDITIONAL FORMS.

1. ACCIDENT INVOLVED ☒ Property Damage No. Killed 0 No. Injured 0 No. of Vehicles Involved 2

2. TIME Date of Accident Nov. Mo. 14 Day 66 Year Day of Week MONDAY Hour 9:15 ☒ A.M. ☐ P.M. Investigated at Scene ☒ YES ☐ NO

3. LOCATION
- County: In ERIE
- ☐ City ☐ Village ☒ Township — Give Name of City, Village or Township: CLARENCE
- Give Name of Road, Street or Route No.: On RT. 78
- Intersecting Street or Highway Number: At GREINER RD.
- If not at Intersection ____ Feet or Miles North ☐ S ☐ E ☐ W ☐ of ____ Show nearest Intersecting Street or Highway, Mile post or Landmark
- Give Nearest Pole Number NYSE - 6 - 364
- Check Box if Accident Occurred at: ☐ Underpass ☐ R.R. Crossing ☐ Bridge

4. VEHICLE No. 1
- Driver: ____ Age 35
- Address: ____
- Owner: ____
- Address: ____
- DRIVER INFORMATION: Date of Birth 8/01/31 (Mo. Day Yr.) Sex ☐ Male ☒ Female
- State of License: ☐ N.Y. State ☒ Other WISCONSIN (Give State) ☐ Unlicensed ☐ N.Y. Learner's Permit ☐ N.Y. Interim Permit
- License Ident. No.: ____
- Vehicle Year 1963 Make PLY. Type (Sedan, Bus, Taxi, Truck, etc.) SEDAN License Plate No. ____ State N.Y. Year 1966
- Seat Belts Installed? ☒ Yes ☒ Front ☐ Rear ☐ No
- Circle Positions of Uninjured Wearing Seat Belts → 1 and 3 circled (1 2 3 / 4 5 6)
- Circle Positions of Uninjured Not Wearing Seat Belts → (1 2 3 / 4 5 6)
- Apparent Condition of Driver: ☐ Ill ☐ Physical Defect ☒ Normal ☐ Fell Asleep ☐ Had Been Drinking
- Vehicle was Damaged: ☒ Left Front ☒ Right Front ☐ Left Rear ☐ Right Rear ☐ Left Side ☐ Right Side ☐ Other
- Vehicle Towed Away? ☒ Yes ☐ No By Whom? DADSWELL'S GARAGE, CLARENCE, N.Y.

5. VEHICLE No. 2
- Driver: ____ Age 35
- Address: ____
- Owner: TRUCK RENTAL
- Address: BUFFALO, N.Y.
- DRIVER INFORMATION: Date of Birth 3/09/31 (Mo. Day Yr.) Sex ☒ Male ☐ Female
- State of License: ☒ N.Y. State ☐ Other ____ (Give State) ☐ Unlicensed ☐ N.Y. Learner's Permit ☐ N.Y. Interim Permit
- License Ident. No.: ____
- Vehicle Year 1964 Make INTER. Type (Sedan, Bus, Taxi, Truck, etc.) VAN License Plate No. ____ State N.Y. Year 1966
- Seat Belts Installed? ☐ Yes ☐ Front ☐ Rear ☒ No
- Circle Positions of Uninjured Wearing Seat Belts → (1 2 3 / 4 5 6)
- Circle Positions of Uninjured Not Wearing Seat Belts → 1 circled (1 2 3 / 4 5 6)
- Apparent Condition of Driver: ☐ Ill ☐ Physical Defect ☒ Normal ☐ Fell Asleep ☐ Had Been Drinking
- Vehicle was Damaged: ☐ Left Front ☐ Right Front ☐ Left Rear ☐ Right Rear ☐ Left Side ☒ Right Side ☐ Other
- Vehicle Towed Away? ☒ Yes ☐ No By Whom? TRUCK RENTAL, BUFFALO, N.Y.

6. KILLED OR INJURED

No.	Name	Address	Sex	Age	Injury	Position in Vehicle
1	NONE					1 2 3 / 4 5 6
2						1 2 3 / 4 5 6
3						1 2 3 / 4 5 6
4						1 2 3 / 4 5 6

For each person (1–4): Nature of Injuries ____ Date of Death ____ In Vehicle Number ____ Person Wearing Seat Belt? ☐ Yes ☐ No Injured Taken To Hospital? ☐ Yes ☐ No Name of Hospital ____ Was Person Ejected? ☐ Yes ☐ No ☐ Pedestrian ☐ Bicyclist

MV-104A (3/63)

Figure C-7.

7. ARRESTS Name of Person — Charge

501 - 4A

1111 - D1

8. Give names and addresses of uninjured persons involved or witnesses; specify which (attach separate sheet, if necessary).

— PASSENGER CAR #1

9. TYPE OF ACCIDENT COLLISION WITH:
- [ ] 1. Pedestrian
- [x] 2. Other Motor Vehicle
- [ ] 3. Other MV and Pedestrian
- [ ] 4. Railroad Train
- [ ] 5. Animal or Animal Drawn Vehicle
- [ ] 6. Fixed Object
- [ ] 7. Bicycle
- [ ] 8. Other Object
- [ ] 9. Motorcycle
- [ ] 10. Overturned in Road
- [ ] 11. Ran Off Road
- [ ] 12. Other

10. TRAFFIC CONTROL
- [ ] 1. None
- [ ] 2. Police Officer*
- [x] 3. Signal Light in Operation
- [ ] 4. Signal Light Not in Operation
- [ ] 5. Flashing Light
- [ ] 6. Stop Sign
- [ ] 7. Caution Sign
- [ ] 8. Yield Sign
- [ ] 9. Other (Includes R.R. Crossing)
- [ ] 10. School Crossing Guard*

* Badge or Shield No.

11. LIGHT CONDITION
- [x] 1. Daylight
- [ ] 2. Dawn
- [ ] 3. Dusk
- [ ] 4. Dark, Road Lighted
- [ ] 5. Dark, Road Unlighted

12. WEATHER CONDITION
- [x] 1. Clear
- [ ] 2. Cloudy
- [ ] 3. Rain
- [ ] 4. Snow
- [ ] 5. Sleet
- [ ] 6. Fog

13. ROAD CONDITION
- [x] 1. Dry
- [ ] 2. Wet
- [ ] 3. Ice-Snow
- [ ] 4. Muddy

14. ROAD CHARACTER
- [x] 1. Straight and Level
- [ ] 2. Straight with Grade
- [ ] 3. Straight at Hillcrest
- [ ] 4. Curve and Level
- [ ] 5. Curve with Grade
- [ ] 6. Curve at Hillcrest

15. ROAD SURFACE
- [ ] 1. Concrete
- [x] 2. Blacktop
- [ ] 3. Brick or Block
- [ ] 4. Gravel
- [ ] 5. Dirt or Sand
- [ ] 6. Other Material

16. ROAD TYPE
- [ ] 1. 1 Lane
- [x] 2. 2 Lane
- [ ] 3. 3 Lane
- [ ] 4. 4 Lane
- [ ] 5. 4 Lane Divided
- [ ] 6. 6 Lane
- [ ] 7. 6 Lane Divided
- [ ] 8. One Way Street
- [ ] 9. Unpaved Road
- [ ] 10. Other

17. PAVEMENT MARKINGS
- [x] 1. Lanes Marked
- [ ] 2. Lanes Unmarked

Opposing Lanes Separated by:
- [ ] 3. Curb
- [ ] 4. Mall
- [x] 5. Double Line

18. APPARENT CONTRIBUTING CIRCUMSTANCES
(Check One Box below for each Vehicle)

1	2		1	2	
[ ]	[ ]	1. Speed Too Fast for Conditions	[ ]	[ ]	11. Improper Turning
[ ]	[ ]	2. Failing to Keep Right	[ ]	[ ]	12. Failing to Signal
[ ]	[ ]	3. Failing to Yield Right of Way to Vehicle	[ ]	[ ]	13. Unattended, Rolling Down Hill
[ ]	[ ]	4. Failing to Yield Right of Way to Pedestrian	[ ]	[x]	14. Failing to Obey Signal
[ ]	[ ]	5. Following Too Closely	[ ]	[ ]	15. Disregarded Stop Sign
[ ]	[ ]	6. Backing Unsafely	[ ]	[ ]	16. Dazzling, Improper or No Lights
[ ]	[ ]	7. Reckless Driving	[ ]	[ ]	17. Wrong Way, One-Way Thoroughfare
[ ]	[ ]	8. Driving While Intoxicated	[ ]	[ ]	18. Defective Brakes
[ ]	[ ]	9. Driving While Ability is Impaired	[ ]	[ ]	19. Improper Parking
[ ]	[ ]	10. Improper Passing	[ ]	[ ]	20. Animal on Highway
			[ ]	[ ]	21. Driving Through Play Street
			[ ]	[ ]	22. Pedestrian's Actions
			[ ]	[ ]	23. Unsafe Equipment
			[x]	[ ]	24. Other

19. ACTIONS OF VEHICLE BEFORE ACCIDENT
(Check One Box below for each Vehicle)

1	2	
[ ]	[x]	1. Going Straight Ahead
[ ]	[ ]	2. Overtaking
[ ]	[ ]	3. Making Right Turn
[ ]	[ ]	4. Making Left Turn
[ ]	[ ]	5. Making a "U" Turn
[ ]	[ ]	6. Backing
[x]	[ ]	7. Starting in Traffic Lane
[ ]	[ ]	8. Stopped in Traffic Lane
[ ]	[ ]	9. Starting from Parking
[ ]	[ ]	10. Slowing or Stopping
[ ]	[ ]	11. Skidding
[ ]	[ ]	12. Parked

20. ACTION OF PEDESTRIAN CROSSING AT INTERSECTION
- [ ] 1. With Signal
- [ ] 2. Against Signal
- [ ] 3. No Signal
- [ ] 4. Diagonally

21. ACTION OF PEDESTRIAN CROSSING NOT AT INTERSECTION
- [ ] 1. Walking in road with traffic
- [ ] 2. Walking in road against traffic
- [ ] 3. Standing or Playing in roadway
- [ ] 4. Coming from behind parked vehicle
- [ ] 5. Getting in or off other vehicle
- [ ] 6. Pushing or working on vehicle in roadway
- [ ] 7. Other working in roadway
- [ ] 8. Lying in roadway
- [ ] 9. Not in Trafficway
- [ ] 10. Other

22. DIAGRAM OF ACCIDENT

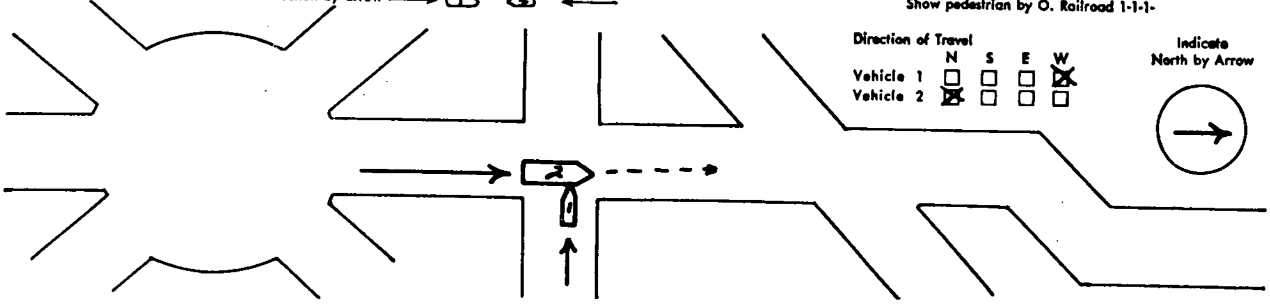
Use solid line to show path of vehicle before accident ——→
Number each vehicle. Show direction by arrow ——→

Dotted after Accident - - - - - - - - - -
Show pedestrian by O. Railroad 1-1-1-

Direction of Travel

	N	S	E	W
Vehicle 1	[ ]	[ ]	[ ]	[x]
Vehicle 2	[x]	[ ]	[ ]	[ ]

Indicate North by Arrow



23. DESCRIPTION OF ACCIDENT

CAR #1 TRAVELING WEST ON GREINER RD; CAR #2 TRAVELING NORTH ON RT. 78; CAR #1 STOPPED AT RED SIGNAL LIGHT AT INTERSECTION OF RT. 78 AND THEN PROCEEDED WHEN LIGHT TURNED GREEN; CAR #2 PASSED RED LIGHT AND WAS STRUCK IN THE RIGHT SIDE BY CAR #1

24. SIGN HERE Officer's Rank and Name — Badge No. — Troop — Initials of Approving Officer

Date and Time of Investigation

Figure C-7 (continued).

Case # 17-1-48
Page 1

PRELIMINARY DATA FORM

LOCATION MAPLE & TRANSIT

DATE 14 NOV 1966 DAY MONDAY

TIME OF CALL 9:10 AM (circled) ~~PM~~

POLICE AGENCY STATE POLICE

INVESTIGATORS LEE & McLEAN

PD ☒ IP ☐ MONITOR ☒ CALL ☐

ATMOSPHERIC CONDITIONS

SUNNY ☒ OVERCAST ☐
HAZY ☐ HEAVY OVERCAST ☐
INTERMITTENT CLOUDS ☐ NIGHT ☐

LIGHT READING f# ____ SEC. ____ ____ @ ASA

TIME OF ARRIVAL 9:21 AM (circled) ~~PM~~ COMMERCIAL ☒

MILEAGE — RESIDENTIAL ☐

TEMPERATURE 43 DEG. F. PERCENT HUMIDITY ____

WIND VELOCITY:

a. AVERAGE 15 MPH c. DIRECTION FROM SOUTHWEST

b. GUSTS — MPH

DESCRIBE MARGINAL DEVELOPMENT ____

NO.	YEAR	MAKE	MODEL	BODY STYLE	COLOR	LIC. NO.	STATE	RE-NEW
1	1964	INTERNATIONAL	2 x 4	BOX	BLK & SILVER		N.Y.	
2	1963	PLYMOUTH	BELVEDERE	4 D. SEDAN	BEIGE	—	N.Y.	
3								
4								

	WRECKER'S NAME	ADDRESS	PHONE
1	DADSWELL'S	MAIN & HARRIS HILL	
2	RELEASED TO OWNER		
3			
4			

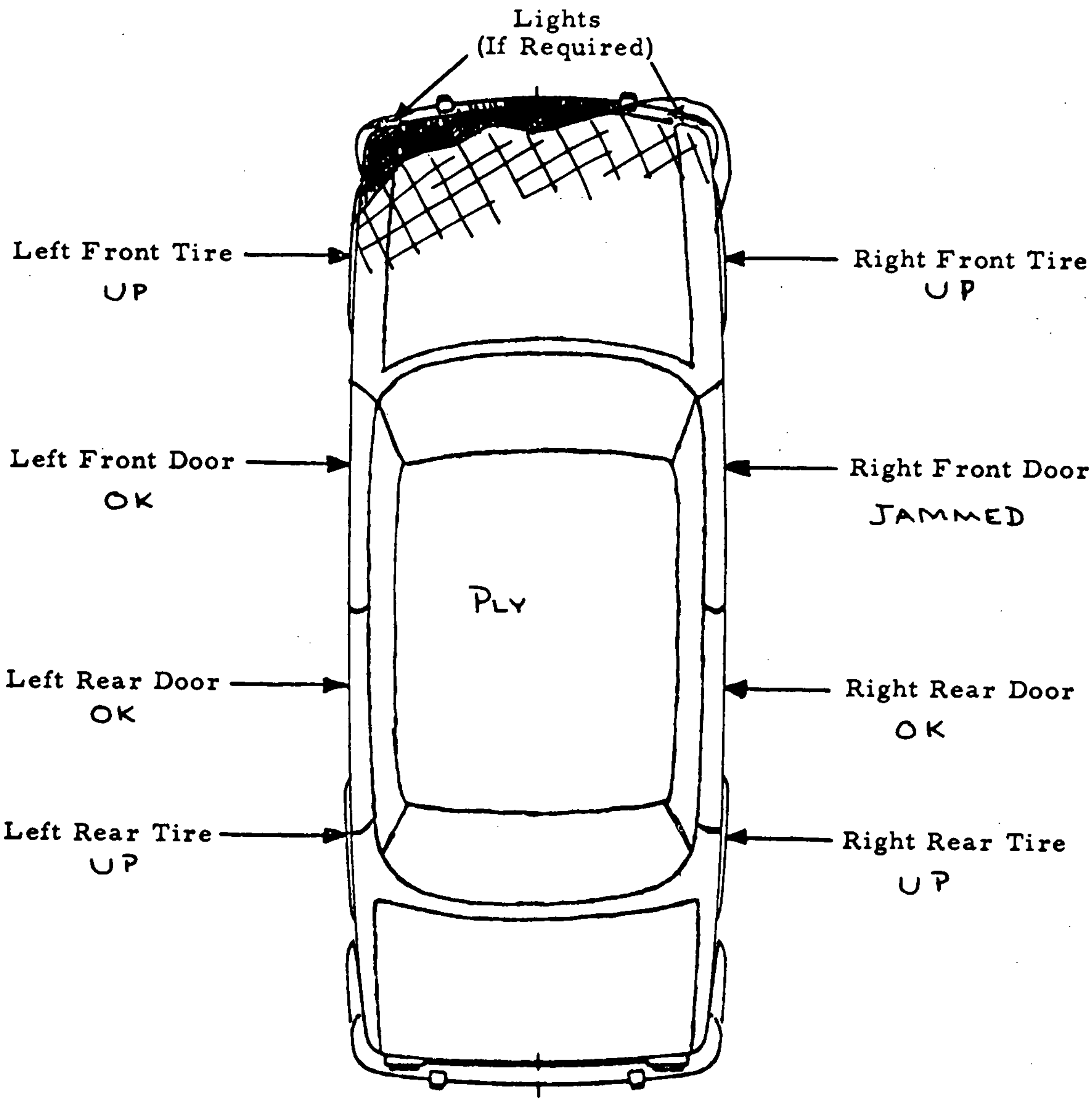
Figure C-8.

CASE NO. 17-1-48

PRELIMINARY VEHICLE DATA

INDICATE DAMAGE TO VEHICLE ON FORM

RECORD DEPTH OF DEFORMATION FROM PRINCIPAL IMPACT(S)



Lights	Tires	Doors
On Operable ✓	Manufacturer Model Type Depth Pressure	Forced Open Jammed Shut Lock Engaged Normal Operation of: Latch Hinges Lock

Accelerator Brakes Steering Wheel Exhaust System

Figure C-8 (continued).

IN-DEPTH VEHICLE FOLLOW-UP DATA

Case No. 17-1-48
Page 1

YEAR	MAKE	SERIES	MODEL	COLOR
1963	PLYMOUTH		BELVEDERE	OFF WHITE
BODY STYLE		LICENSE NO.	MONTH OF ISSUE	STATE
4 DR. SEDAN				N.Y.

VEHICLE IDENTIFICATION NUMBER ____________

LUBRICATION STICKERS (MOST RECENT 3)

	MILEAGE	DATE	ITEMS SERVICED	LOCATION OF GARAGE
1	83,300	4/18/66		PEPPER AUTO SALES
2				1035 W. GENESSEE ST
3				SYRACUSE, N.Y.

VEHICLE INSPECTION STICKER NO. ____________

YEAR 66-67 STATION NO. 1486 MONTH NOT PUNCHED

ODOMETER READING 87155.3 MILES

COMPARTMENT DATA

GLASS DATA

	CLEAN Yes	CLEAN No	TINTED Yes	TINTED No	DAMAGED Yes	DAMAGED No
WINDSHIELD	☒	☐	☐	☒	☐	☒
SIDE WINDOWS	☒	☐	☐	☒	☐	☒
REAR WINDOWS	☒	☐	☐	☒	☐	☒

CAUSE AND LOCATION OF DAMAGED GLASS ——

WIPER BLADES IN ACCEPTABLE CONDITION Left ☒ Right ☒

ARM TENSION OZ. Left ____ Right ____

DOOR DATA

	Open & Close Normally Yes	Open & Close Normally No	Forced Open Yes	Forced Open No	Forced Open ?	Jammed Shut Yes	Jammed Shut No	Latch Operable Yes	Latch Operable No	Hinges Operable Yes	Hinges Operable No	Lock Engaged Yes	Lock Engaged No	Lock Engaged ?	Interior Handle Pull-lb.
LF	X			X			X	X		X				X	
LR	X			X			X	X		X				X	
RR		X		X			X	X		X				X	
RF	X			X			X	X		X		X			

COMMENTS ON OPENED DOORS ——

Figure C-9.

CASE NO. 17-1-48
Page 2

INTERIOR DAMAGE DATA

	Yes	No	If Yes, describe nature and cause
STEERING WHEEL	☐	☒	
STEERING COLUMN	☒	☐	VERY SLIGHT (1/16" AT DASH) TO LEFT INSIDE CAR
SEAT MECHANISM	☐	☒	
CORNER POST AREA	☐	☒	
WINDSHIELD HEADER	☐	☒	
REAR VIEW MIRROR	☐	☒	
DASHBOARD AREA	☐	☒	
DOOR UPHOLSTERY PANELS	☐	☒	

OTHER __________

INTERIOR OPTIONAL EQUIPMENT

	PRESENT
POWER WINDOWS	☐
SEAT BENCH	F ☒ R ☒
BUCKETS	F ☐ R ☐
POWER	☐
RECLINING	☐
HEADRESTS	☐
SEAT BELTS FRONT	☒ NO. 2
REAR	☐ NO. ____
PADDED SUN VISORS	☐
PADDED INSTRUMENT PANEL	☒ OVER INSTRUMENTS ONLY

LIGHTS DATA

	NOT APPLICABLE	OPERABLE LEFT	OPERABLE RIGHT	COMMENTS
HIGH BEAM	☐	☐	☐	
LOW BEAM		☐	☐	DEMOLISHED
PARKING LIGHTS		☐	☐	
FRONT TURN SIGNALS		☐	☐	
REAR TURN SIGNALS		☐ ?	☐ ?	
BRAKE LIGHTS		☒	☒	
TAIL LIGHTS		☒	☒	
BACK-UP LIGHTS		☐ ?	☐ ?	

Figure C-9 (continued).

CASE NO. 17-1-48

Page 3

INTERIOR EQUIPMENT DATA

	PRESENT	OPERABLE	ON	OFF
WINDSHIELD WIPERS				
SINGLE SPEED	☒	☐ ?	☐	☒
VARIABLE SPEED	☐ ?	☐	*☐	☐
WASHERS	☒	☐ ?		
*NOTE SETTING ______				
HEATER	☒		☐	☒
TEMPERATURE CONTROL	☒	☐ ?		
SETTING COOL				
FAN CONTROL	☒	☐ ?		
SETTING OFF				
DEFROSTER	☒	☐ ?	☐	☒
SETTING OFF				
REAR WINDOW DEFROSTER	☐	☐	☐	☐
			Open	Closed
AIR FLOW DOORS	☐	☐	L ☐	☐
SETTINGS ______			R ☐	☐
VENT WINDOWS	☒	☒	L ☐	☒
			R ☐	☒
			On	Off
AIR CONDITIONING	☐		☐	☐
CONTROL SETTINGS ______				
RADIO	☒	☐ ?	☐	☒
AUTOMATIC SPEED CONTROL	☐		☐	☐
SETTING ______				
TRANSMISSION				
MANUAL	☐			
AUTOMATIC	☒			
SELECTOR	☒	☐ ?		
HORN	☒	☒		
POWER STEERING	☐			
ADJUSTABLE STEERING WHEEL	☐	☐		

STEERING WHEEL PLAY (AMOUNT 1/2 IN.)

ACCELERATOR PEDAL ACTION NORMAL ☒

BRAKE PEDAL TRAVEL AFTER 20 SEC. HVY PRES. — IN. NORM. PRES. — IN.

CARGO CHILDREN'S TOYS IN PASSENGER COMPARTMENT

GENERAL INTERIOR CONDITION				
	EXCEPTIONAL	☐	LITTERED	☒
	CLEAN	☒	GROSS	☐
	DUSTY	☐		

Figure C-9 (continued).

CASE NO. 17-1-48

Page 4

RUNNING GEAR DATA

TIRE DATA

	MANUFACTURER	TIRE NAME	STD.	SNOW	STUD	DEPTH*			PRES.
LF	GOODYEAR	POWER CUSHION	X			8	9	10	20
LR	"	SUBURBANITE		X	X	13	13	13	27
RR	"	"		X	X	13	13	13	20
RF	"	POWER CUSHION	X			9	9	10	18

FRONT WHEELS RECENTLY BALANCED

*3 READINGS, INSIDE, CENTER, OUTSIDE

	TIRE SIZE	SIDEWALL CONDITION	ABNORMAL WEAR PATTERN
LF	7.35 x 14		
LR	7.75 x 14		
RR	" "		
RF	7.35 x 14	ABRADED IN ONE PLACE ON OUTER	

FRONT SUSPENSION DATA

	Yes	No
SHOCK ABSORBERS		
ACTION NORMAL	☒	☐
LEAKING	☐	☒
BUSHINGS NORMAL	☒	☐
ANTI-SWAY BAR	☐	☐
BUSHINGS NORMAL	☐	☐
BALL JOINTS		
RECENTLY LUBED	☐ ?	☐
STEERING LINKAGE		
AMOUNT OF PLAY AT FRONT WHEEL (—— IN.)		
STEERING GEARBOX		
DAMAGED	☐	☒
LEAKING	☐	☒
A-ARM AND STRUT BUSHINGS NORMAL	☐	☒
FRONT WHEEL BRAKE CYLINDERS LEAKING	☐	☒
WHEEL BEARING PRELOAD CORRECT	☐	☐ ?

COMMENT ON ANY ABNORMAL CONDITIONS NOTED ABOVE ——

Figure C-9 (continued).

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Page 5

UNDERHOOD DATA

ENGINE: NO. OF CYLINDERS 6

		NORMAL Yes	NORMAL No	
ENGINE OIL LEVEL		☒	☐	
ENGINE MOUNTS		☒	☐	
POWER STEERING FLUID LEVEL	☒ NA	☐	☐	
WINDSHIELD WASHER FLUID LEVEL	☐ NA	☒	☐	
BRAKE FLUID LEVEL		☐ ?	☐	
CONTAMINATION SEAL		☐ ?	☐	
FLUID CONTAMINATED		☐ ?	☐	
SEDIMENT IN RESERVOIR		☐ ?	☐	

POWER ASSISTED BRAKES

4 WHEEL DRUMS	☒	HYBRID	☐
4 WHEEL DISC	☐	DUAL SYSTEM	☐

NOTE ANY FLUID LEAKS —

COMMENTS ON ANY ABNORMAL CONDITIONS —

EXTENT OF FRAME DAMAGE FRONT CROSS MEMBER AND BUMPER ARMS

EXHAUST SYSTEM DATA

	Yes	No
EXHAUST MANIFOLD NORMAL	☒	☐
HEADER PIPES NORMAL	☒	☐
CROSSOVER PIPE NORMAL	☐	☐
MUFFLERS NORMAL	☒	☐
TAIL PIPES NORMAL	☒	☐

COMMENTS —

Figure C-9 (continued).

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Page 6

FUEL SYSTEM DATA		Yes	No
GAS TANK	SUPPORT STRAPS NORMAL	☒	☐
	FILLER PIPE NORMAL	☒	☐
	CAP NORMAL	☒	☐
	LEAKING	☐	☒
FUEL LINES CRACKED		☐	☒
	LEAKING	☐	☒
FLEXIBLE LINE CONDITION NORMAL		☒	☐
REAR SUSPENSION DATA			
SHOCK ABSORBERS			
	ACTION NORMAL	☒	☐
	LEAKING	☐	☒
	BUSHINGS NORMAL	☒	☐
LEAF SPRINGS (IF SO EQUIPPED)			
	BUSHINGS NORMAL	☒	☐
	ANY LEAVES BROKEN	☐	☒
COIL SPRINGS (IF SO EQUIPPED)			
	LOCATING ARM BUSHINGS NORMAL	☐	☐
ANTI-SWAY BAR		☐	☐
	BUSHINGS NORMAL	☐	☐
REAR WHEEL BRAKE CYLINDERS LEAKING		☐	☒

COMMENTS ON ANY ABNORMAL CONDITIONS NOTED ABOVE ______________________

____

____

OVERALL VEHICLE MECHANICAL CONDITION

LIKE NEW	☐
ABOVE AVG.	☐
AVERAGE	☒
BELOW AVG.	☐
POOR	☐

Figure C-9 (continued).

CASE NO. 17-1-48
Page 1

HIGHWAY DATA

ROUGH SKETCH

INDICATE - LANE MARKINGS, SIGNS, ETC.

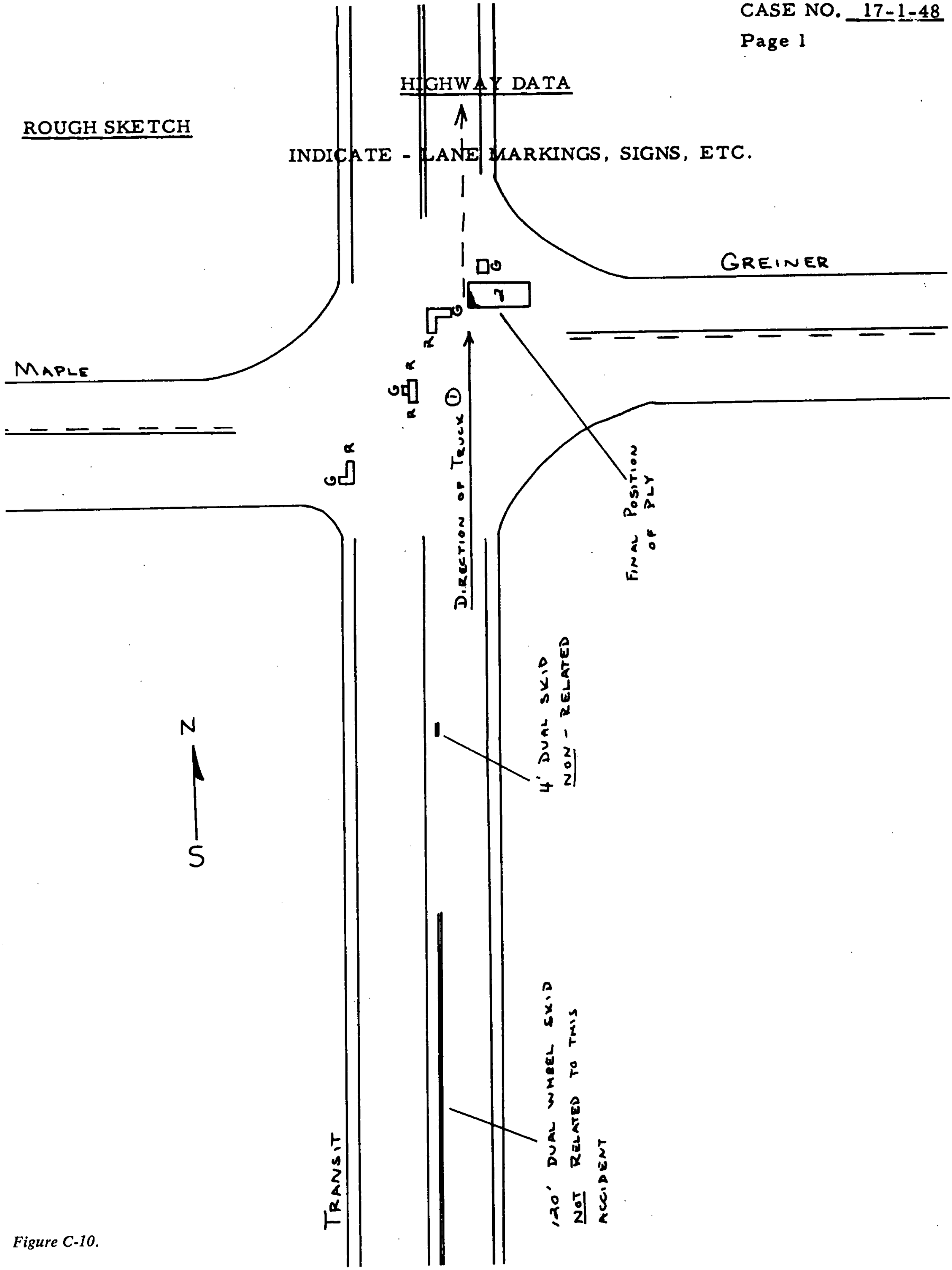


Figure C-10.

CASE NO. 17-1-48
Page 2

HIGHWAY DATA

LOCATION Transit at Maple & Greiner

APPROACH DATA		VEHICLE NO. 1	2	3	4
DIRECTION OF TRAVEL		North	West		
NUMBER OF LANES IN DIR. OF TRAVEL		1	1		
AVERAGE WIDTH OF LANE FEET		12	10		
MEDIAN	TYPE	None	None		
	WIDTH	—	—		
SHOULDER	TYPE	Sealed	Dirt		
	WIDTH	7	3		
GUARDRAIL	TYPE	—	—		
CURB HEIGHT		—	—		
SURFACE	PAVING MATERIAL	Asphalt	Asphalt		
	STATE OF REPAIR	Good	Fair		
	CONDITION (WEATHER)	Dry	Dry		
	FOREIGN MATERIALS	None	None		
	COEFFICIENT OF FRICTION	80 ±	80 ±		
	GRADIENT	0	0		
	CROWN	2 %	2.5 %		
HIGHWAY LIGHTING TYPE		N/A	N/A		
TRAFFIC DENSITY		Moderate	Moderate		
AVERAGE UTILITY POLE SPACING		?	?		

Figure C-10 (continued).

CASE NO. 17-1-48
Page 3

HIGHWAY DATA

CROSS SECTION PROFILES (EACH PERTINENT APPROACH)

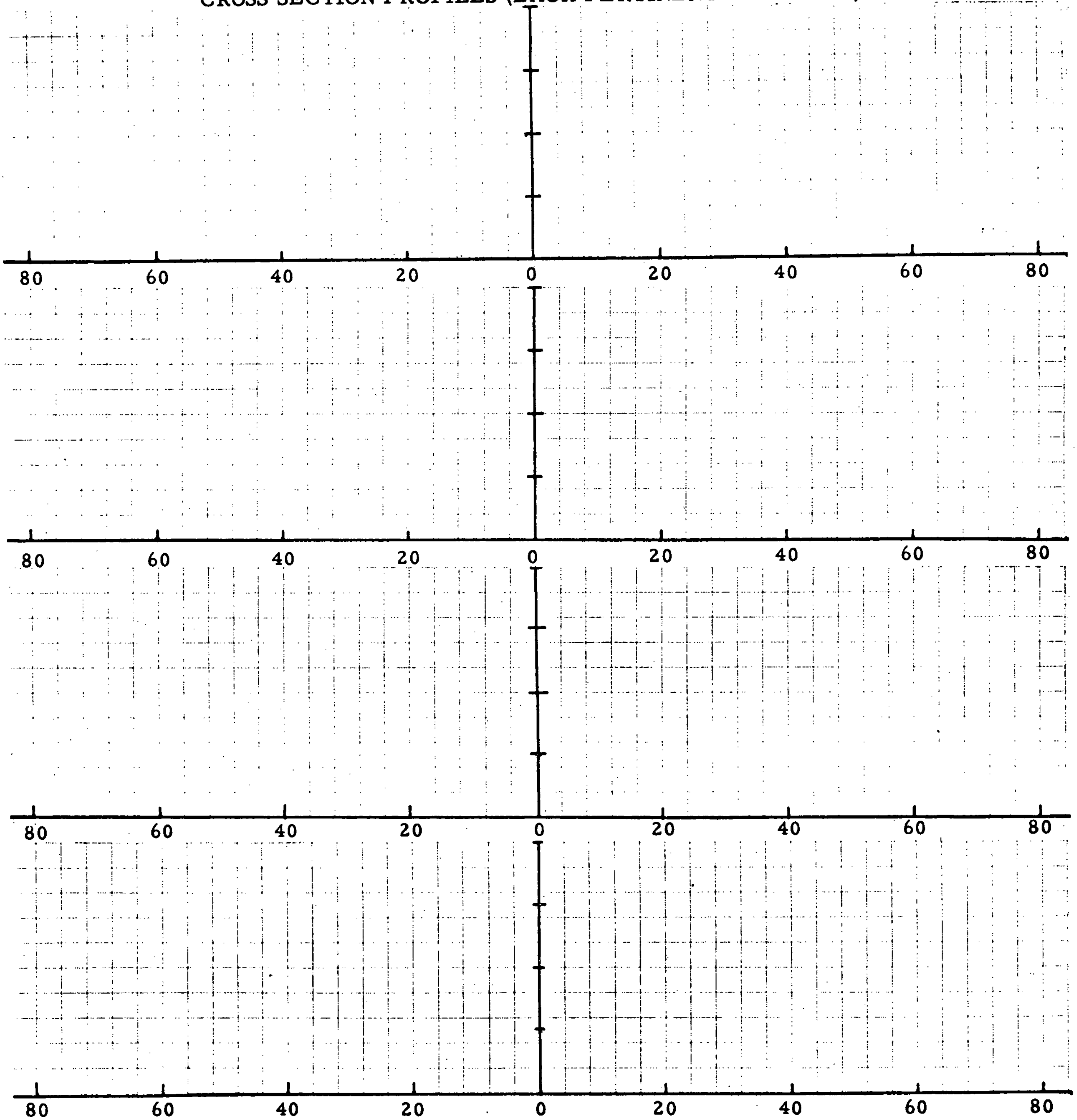


Figure C-10 (continued).

CASE NO. .17-1-48
Page 4

HIGHWAY DATA

AREA OF IMPACT DATA

STRAIGHT ☒ INTERSECTION ☒
CURVE ☐ OFF - ROAD ☐
OFF SET ☒

TRAFFIC CONTROLS NONE ☐

SIGNS ☐ INTERSECTION SIGNAL ☒
OFFICER ☐ OTHER ____________

SIGNAL DATA

	VEHICLE NO.	1	2	3	4
ACTUATION	FIXED TIME	X			
	TIME-OF-DAY CYCLE				
	PEDESTRIAN				
	TRAFFIC DEMAND		X		
	OTHER				
DEMAND ACTIVATOR	OVERHEAD		X		
	PAVEMENT				
	BUTTON				
TIMING SEE ATTACHED SHEET FOR STIPULATED TIMING	DIRECTION MON. ____ RED (SEC)	—	—		
	YELLOW (SEC)	3.1 sec	—		
	*GREEN (SEC)	29 sec	—		

*FOR DEMAND TYPE INDICATE RANGE OF GREEN PHASE (SEC)

STRUCTURAL PERFORMANCE OF HIGHWAY ELEMENTS

DESCRIBE FOR ALL ELEMENTS STRUCK: N/A

TOTAL WARNING TIME ON TRANSIT FOR 0.26G STOP @ 50 MPH
= 6 SECS ALLOWING ONLY 1 SEC EFFECTIVE REACTION TIME
SUGGEST CHANGE TO 4 SEC AMBER 2 SEC ALL RED

Figure C-10 (continued).

S. LEE

Question: How long have you driven and approximately how many miles per year?

Answer: I've driven for 17 years, about 100,000 miles per year.

Question: How often have you driven this particular truck?

Answer: Eight or nine times. I drive this and several other vehicles for my company.

Statement: The truck has a standard 2-speed transmission. Driver has no illness, has not been drinking, or taken any drugs, has no infections. He appears to be in good physical condition.

INTERVIEWER'S OBSERVATIONS:

Mr. . . . . has not been available for a follow-up interview. His employer has defeated efforts for a further interview.

Mr. . . . .'s appraisal of his evasive action, after consideration of other witnesses, seems not to be consistent with other testimony. An independent witness and the people in the other vehicle are in concurrence (independently) that there was no deceleration of the truck . . . . was driving. They further feel that the truck may have been slightly accelerating at the time just prior to impact. It appears likely that this unit was trying to clear the intersection before a red signal, rather than stop for the amber.

ACCIDENT 17-1-48 INTERVIEW by S. N. Lee

INTERVIEWEE:

. . . ., age 35, female, height 5′6″, weight 140 lb.

Occupation, housewife; driver of a 1963 Plymouth Belvedere sedan, New York license plate . . . . , 1966. Seat belts were installed and used (lap belts).

Question: Can you give me a description of the accident?

Answer: I was traveling west on Greiner between 9:10 and 9:15 AM. On approaching the intersection of Transit, headed west, the light had changed to red and I had to wait at Transit for a full cycle of the light to change back to green. As the light changed to green, I saw a truck coming from my left on Transit. He was coming toward me, but I had the impression that this truck was going to stop at that time as it was quite a ways down the road. Then I started up, and as I started up I sensed that the truck was not going to stop. I immediately put on my brakes and attempted to swerve to the right, at which time the truck struck the left front end of my car and damaged the entire front end and went on down the road several hundred feet before he stopped.

Question: Where were you when you first saw the other vehicle?

Answer: I was stopped at the red light on Greiner and Transit, facing west on Greiner.

Question: What were you doing at that moment?

Answer: I was not talking to the passenger in the car at the time, but rather was looking down the road, getting ready to drive across.

Question: Where were you when you first sensed danger?

Answer: Just starting into the intersection.

Question: What were you doing at that moment?

Answer: Driving and looking at where I was going.

Question: Did you take any evasive action?

Answer: Evasive action was in the form of braking and an attempt to turn to the right, away from the direction the impact was coming just as I entered the intersection.

Question: What was your trip plan?

Answer: I just left home 4 or 5 minutes before and I picked up a friend of mine, ... who lives on . . . . and we were going to do some shopping on Niagara Falls Blvd.

Question: What kind of day have you had today?

Answer: I had a good night's sleep last night, about 9 hours, got up this morning, got my kids off to school, got breakfast, and cleaned the house up, called . . . . about going shopping and getting some things that we needed and made arrangements to pick her up about 9:00. Then I had got myself ready to go and that's about all there is.

Question: Do you have any chronic illness?

Answer: No, there is nothing wrong with me.

Question: Do you have any afflictions?

Answer: No.

Question: Had you been drinking or taken any drugs?

Answer: No, nothing.

Question: Do you have a cold, or the flu, or any immediate illness?

Answer: No.

Question: How long have you driven and how many miles per year?

Answer: I've driven for 19 years, about 5,000 miles per year.

Question: What is your opinion of this car's mechanical condition?

Answer: Odometer, lights, steering, brakes, everything is working satisfactorily.

Question: Were you carrying any luggage or cargo?

Answer: No.

Question: Did doors open on impact?

Answer: No.

Question: Was the witness, ..., at the intersection before or after you?

Answer: I don't know.

INTERVIEWER'S OBSERVATIONS:

In summary, ... looked left and saw the truck some distance off and assumed that the truck was going to stop because the light had changed; a normal driver assumption which many drivers make and which is actually a false sense of security.

ACCIDENT 17-1-48 INTERVIEW by S. N. Lee

INTERVIEWEE:

. . . ., age 26, female, ... Clarence, N.Y. Height 5′6″, weight 135 lb. Seated in the right front seat of the 1963 Plymouth driven by . . . .

Question: Can you please give me a description of this accident?

Answer: We were traveling west on Greiner Road, about in the vicinity of Vista Ave. (1 block east of Transit). I noted the light was green at the intersection of Transit and Greiner. As we got closer the light turned yellow. When .... stopped at the intersection, the light was still amber. It was after we came to a full stop that the light changed to red. At that time, I was just watching the traffic go by. The light turned green and I looked to the right, a habit I've developed even when I'm not driving the car myself. I didn't actually see the truck that was coming the other way, opposite to the direction I was looking, until the truck struck the front of the car in which I was a passenger. At the instant of the impact, I saw this faded out turquoise fender and the grille and seeing the height of these I realized that it was a truck that struck us. I looked to the right to see if the truck was going to stop and it didn't, it went on the wrong side of the road and continued on down the road. I then asked .... if she was all right and she said yes, at which time she got out of the car and went across Transit to the other side of Maple to talk to someone in another car, which was facing east. After talking to this person I noticed they both looked in the direction

DAMAGE TO TRUCK FENDER

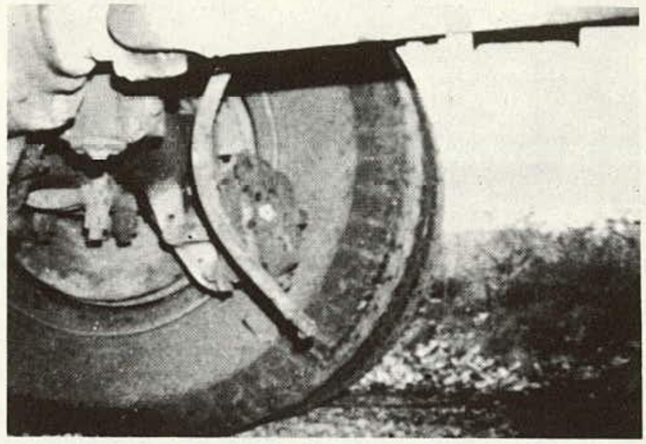
DAMAGE TO PASSENGER CAR

TRUCK RUNNING BOARD BRACKETS

SIDE VIEW OF INVOLVED TRUCK

Figure C-11. Accident No. 17-1-48.

TRUCK'S APPROACH TO ACCIDENT SCENE (SKID MARKS NOT FROM SUBJECT VEHICLE)



BROKEN BRAKE LINE OF TRUCK – LEFT REAR WHEEL

PASSENGER CAR'S APPROACH TO ACCIDENT SCENE (NOTE OFFSET IN CONTINUATION OF ROAD)

Figure C-11 (continued).

the truck was still going. .... then went over to a little store and about that time a lady in a white house at Maple and Transit called over and told me that she had notified the police and they were on their way. The truck continued a long time before he stopped and then finally I could see that he was slowing down and stopping. The truck came to a stop at least two city blocks away from where we had the accident.

Question: Did you hear any squealing of brakes on the truck before the accident occurred?

Answer: No, I just heard the slam as we were struck. It seems as though I was kind of lunged forward and .... had stopped just about the time the accident happened.

Question: What was your trip plan?

Answer: .... came down to my place on .... to pick me up and then we headed west on Greiner and had intentions of going to a milliner for supplies for hats. We weren't in any hurry as we had all morning to do what we were going to do. The milliner is one the other side of Niagara Falls Blvd., in North Tonawanda. It's about three blocks past Melody Fair, the destination of our trip that morning.

Question: Did your car start up immediately after the light turned green?

Answer: No, it turned green and then we started forward, not in a hurry or fast, because we weren't in a hurry.

Question: Was the car facing east on Maple, that .... ran to after the accident for help, at the intersection before or after you?

Answer: About the same time or just before we arrived. There were about three cars behind him. He was first in line.

ACCIDENT 17-1-48 INTERVIEW by S. N. Lee

INTERVIEWEE:

..............., Witness
....
........., New York
Phone ....

POSITION OF WITNESS: .... was in a car facing east on Maple Road (the westward extension of Greiner), first in line at the intersection of Transit, awaiting the change of light. When .... pulled up and stopped at the red light, he had approximately a full cycle of the red light to wait. Two eastbound cars stopped behind him and approximately two westbound cars stopped behind the car driven by . . . . , who subsequently was in the accident. Both . . . . and . . . . awaited the full cycle of the light and had been stopped for some time. . . . . did not see the light change, but was looking to his left watching the cars coming south on Transit and noticed that at least two cars coming south had time to come to a full stop. He looked from his left to the middle of the intersection as his intentions were to go across Maple and continue on Greiner. He looked ahead just in time to see the truck sweep into view from the right and strike the car driven by . . . .

Question: Was there any braking?

Answer: I did not notice the truck brake, it appeared not to brake to me. There was no slowing down whatsoever. No screeching of brakes and the impact itself did not seem to slow the truck down any appreciable amount. The truck continued on north on Transit. The people at the light did not move from their position after the impact for several cycles of the light. I just sat at the intersection and did not step on the gas of my car, and after one change of the light, ... got out of her car. If I had started out with the change of the light, I could have been in the same situation that . . . . found herself in.

Question: Did either vehicle take evasive action?

Answer: Just a moment prior to impact the truck appeared to be bearing to its left slightly toward a position where I was sitting, in an attempt to avoid the car driven by . . . . But he couldn't come too far to the left without coming head on with the cars facing the other direction on Transit at the red light. The truck continued on north beyond my line of vision. After leaving the accident scene and going across Greiner, I noted that there was a truck that appeared to be like the one I saw several hundred feet down the road on the wrong side of the road facing in a northerly direction. I think the truck was about 1/5th of a mile on down the highway from the point of impact.

Question: Then what happened?

Answer: After leaving her car, ... first came over to my car and said "Did you see it, did you see him hit me?" She asked me if I would help her and I advised her that it appeared to be hit and run and asked her if she had seen the car stop. We both looked down the road north and from our location could not see the truck. I advised her to call the police and told her I was in a hurry to keep an important engagement. I gave her my card and told her I would help her, after which I continued on. As I continued on to cross the intersection onto Greiner, I at that point looked down the highway and could see the vehicle, the truck, that I thought had been at the impact scene.

Statement: . . . . further reaffirms that the cars coming south on Transit were fully stopped, awaiting the light before his vision swung back to the right and he saw the truck entering the intersection; therefore, they were barely stopped when the truck had reached the intersection.

Question: Do you have an idea as to the speed of the truck at the time you saw him?

Answer: My best judgment would be about 40 mph. This is only an assumption.

Question: Do you have any observations pertinent to this accident situation?

Answer: Only that . . . . was very fortunate. Had she looked in the direction the truck was coming, of course, I don't think she would have pulled into the path of it. But had she not looked, after she started up, and immediately tried to stop, this truck would have struck her broadside.

Question: Do you know if . . . . did or did not look toward the truck before the impact?

Answer: No, I do not. I did not see her looking in any direction. I didn't notice her until after the impact, except when we were waiting for the light to change, as I stated previously.

INTERVIEWER'S COMMENTS:

. . . . appeared to accurately depict the circumstances surrounding the accident situation. His answers seemed clear, direct and logical. I am impressed in his separation of what he saw and what he assumed. I would judge his testimony as having high creditability.

ACCIDENT 17-1-48 Transit and Greiner S. Lee

Signal Timing and Information:

The overhead, three-phase signal at this intersection is a traffic-demand-type device, regulated by an "Electro-Matic," traffic-actuated traffic control, manufactured by the Automatic Signal Division of Eastern Industries, Inc., Norwalk, Conn.

It is actuated by overhead detectors located on Maple-Greiner on either side of Transit. The Greiner detector is located 106 ft east of the east edge of Transit, suspended at a height of about 17 ft above the road surface in the center of the westbound lane of traffic. The Maple detector is located 96 ft west of the west edge of Transit, suspended at a height of about 17 ft above the surface of the road in the center of the eastbound lane of traffic.

Timing of the signal on Transit with traffic approaching on Greiner:

Amber on Transit	*Green on Transit*
2.9 sec	29 sec
3.1	29.5
3.0	29.5
3.1	29
3.0	29
3.1	29.5
3.1	29

The intended signal timing according to . . . . of the New York State Department of Public Works. Phone no.: . . . .

East-West on Greiner-Maple

Green	Minimum time	12 sec
	Maximum time	22 sec

Dependent on volume of east-west traffic

Yellow	Standard time	3 sec
Red	Minimum time	32 sec

North-South on Transit Road

Green	Standard time	28 sec
Red	Minimum time	15 sec
	Maximum time	25 sec

Timing is variable between the maximum and minimum or point in between and is correlated to the Greiner-Maple signal timing, which is dependent on the volume of traffic East-West.

ACCIDENT 17-1348 Transit and Greiner

CONTRIBUTING FACTORS AND REMEDIAL RECOMMENDATIONS

UNIT No. 1

Causation

This unit was operating on a 50-mph highway and is believed, by weighing circumstances and physical evidence, to have been going near the 50-mph speed limit.

As a recommended *f*-factor of 0.26 *G* based on a 1-sec reaction time, this unit would need 6 sec of warning time to make a normal stop. The amber light was functioning at a 3.1-sec duration, which is 2.9 sec short of the recommended warning (amber) time.

Unit No. 1 was the victim of a short amber cycle and had little chance of making a stop.

Follow-up observations in this area revealed several braking marks by dual-wheel units which were apparently caught by the short amber phase. These observations were made while the road surface was dry. In one hour's observation of the intersection, two trucks and one car were not able to stop and passed through a red light.

The implications of slippery, icy, or snow-packed surface in this area give additional cause for alarm.

Remedy

It has been recommended that a 4-sec amber phase followed by a 2-sec all-red phase replace the 3-sec amber phase now existing on Transit. This would allow adequate time on a 50-mph highway for trucks, which make frequent use of this road.

UNIT No. 2

Causation

This unit operator appears to have made an error in judgment, not regarding skill, but knowledge.

Because the light had changed to green in favor of this unit, the driver made the incorrect assumption that the other would stop. The other driver, being caught in a critical time-distance "squeeze play," could not execute a stop. He apparently chose to try and go through on the amber.

Unit No. 2, in choosing to make an assumption based on right-of-way, has not followed sound defensive driving judgment.

Remedy

A driver education course designed to teach a more defensive type of driving combined with actual driving circumstances in order to demonstrate the many areas critical to this type of problem would be advised.

The unwarranted assumption by this driver appears to be common, and reflects an inadequacy of our present system.

APPENDIX D

SPECIAL FORMS

ACCIDENT NO. ______

ACCIDENT DATA COLLECTION STUDY: PATH OF VEHICLE

OHIO STATE HIGHWAY PATROL

DATE ____________ OFFICER ____________

CORNELL AERONAUTICAL LABORATORY, INC.

TRANSPORTATION RESEARCH DEPARTMENT

VEHICLE DATA YEAR ______ MAKE ____________ MODEL ____________ BODY STYLE ____________

ODOMETER READING ☐☐☐☐☐.■ ESTIMATED SPEED PRIOR TO IMPACT ______ AT IMPACT ______

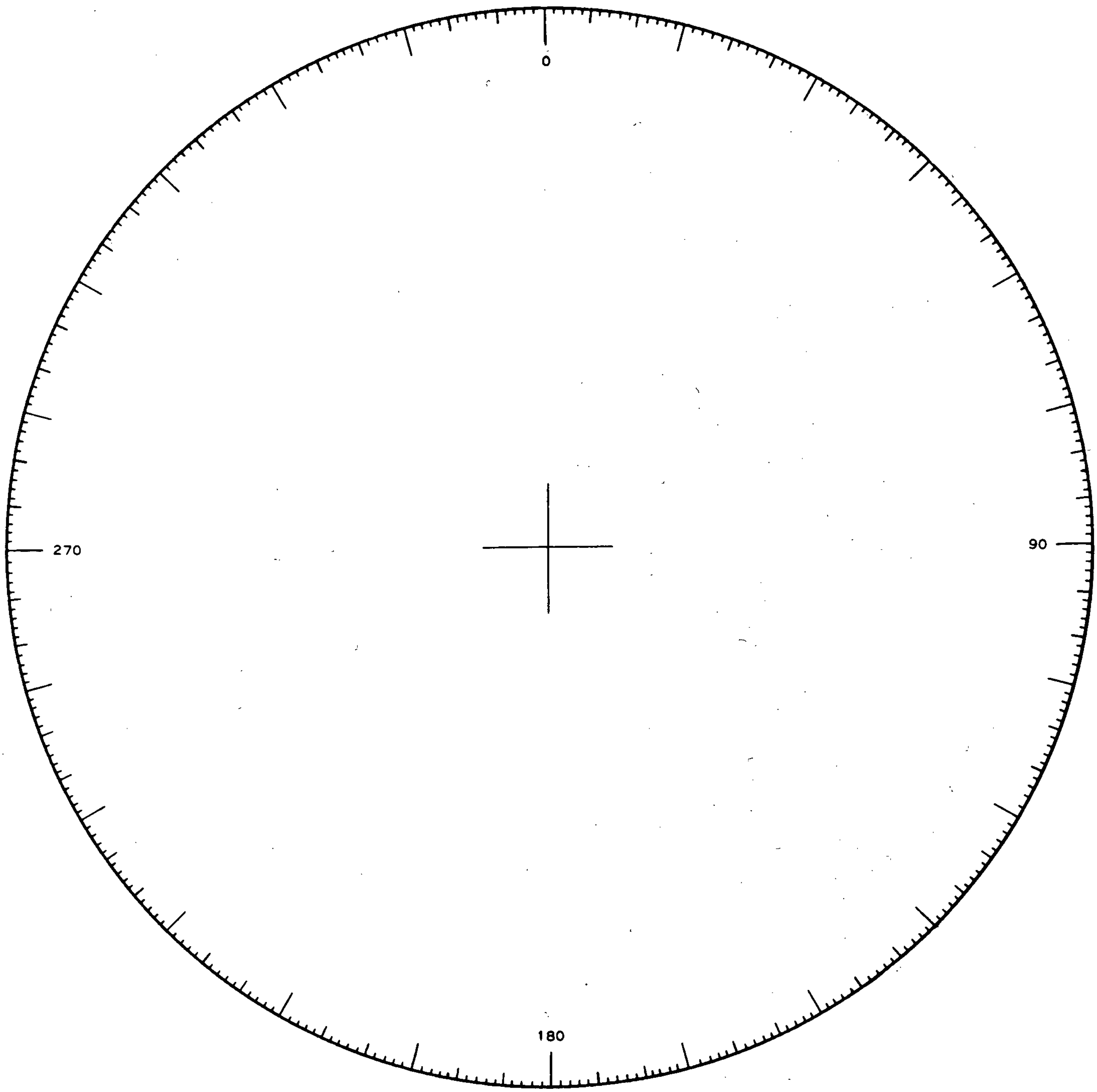


Figure D-1.

SUPPLEMENTAL INSTRUCTIONS FOR COMPLETING PATH OF VEHICLE STUDY

DIAGRAM:

Single vehicle accidents:

1. Locate the point where the vehicle left the surfaced roadway. Place the clipboard parallel with the edge of the road at this point with the top of the clipboard pointing in the direction the vehicle was traveling. Leave in this position until all directions are marked.

2. Aim the pointer at the center of the vehicle. Mark this direction through the arrow on the pointer and label "V" for vehicle. Measure distance from point of departure to vehicle.

3. Aim pointer along path of vehicle departure if different than position at rest. Mark this direction and label "P".

4. Aim pointer at any object (tree, pole, etc.) struck by the vehicle, or any other item (ditch, embankment, etc.) that caused a change in path of vehicle. Measure distance from point of departure to object. Indicate road width. Clipboard may now be picked up.

5. Sketch the general arrangement of the roadway and the accident scene. Show any skid marks or traces of vehicle path as well as the orientation of the vehicle in its final resting place.

PHOTOGRAPHY:

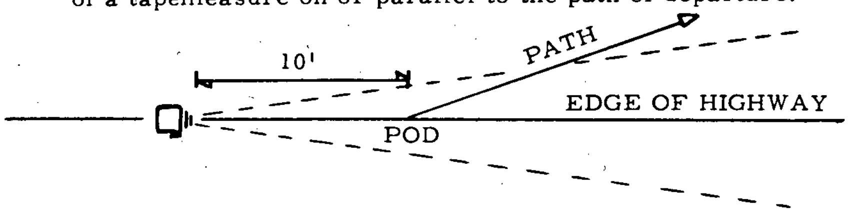
Adequate photographic coverage is essential to this study.

What photographs are required?

Path of Vehicle.

1. From the clipboard at edge of highway take photograph of path of departure and vehicle in final resting position.

2. From a distance of 10 feet from the point of departure (see sketch) take a photograph centering the edge of the highway and point of departure in the view finder. To accentuate the path of departure in the processed photograph, place a yardstick or extended length of a tapemeasure on or parallel to the path of departure.



Highway and Berm. Again from position at clipboard photograph the edge of highway including berm in the direction from which vehicle was traveling.

Vehicle. Photos of the damaged vehicle are necessary. Close-up shots should be included.

Objects struck. Include photos of any or all objects struck by vehicle.

Full photographic coverage should consist of six to eight photos depending on circumstances.

Figure D-1 (continued).

ACCIDENT DATA COLLECTION STUDY: DRIVER

VIRGINIA DEPARTMENT OF STATE POLICE

DIVISION ______ AREA ______ OFFICER ______

CORNELL AERONAUTICAL LABORATORY, INC.

TRANSPORTATION RESEARCH DEPARTMENT

DIAGRAM AND DESCRIPTION OF ACCIDENT:

DATE: ______

TIME: ______

WEATHER: ______

ROAD CONDITION: ______

DRIVER NO. 1 AGE ____ SEX ____ OCCUPATION ______ YEARS OF DRIVING ______

DRIVER EDUCATION ☐ YES ☐ NO ANNUAL MILEAGE DRIVEN ______ DISTANCE FROM HOME ______

USE OF ACCIDENT ROAD: ☐ DAILY; ☐ FEW TIMES PER WEEK; ☐ FEW TIMES PER MONTH; ☐ RARELY

DESTINATION OF TRIP: ☐ HOME; ☐ WORK; ☐ SHOPPING; ☐ BUSINESS; ☐ OTHER (RECREATION, SOCIAL)

ACCIDENT VEHICLE: YEAR ____ MAKE ______ MODEL ______ BODY STYLE ______

LIC. NO. ______ STATE ______ INSPECTION NO. ______ MONTH ______

ODOMETER ☐☐☐☐☐.■ VEHICLE EQUIPPED WITH: ☐ AUTO TRANSMISSION; ☐ POWER STEERING; ☐ POWER BRAKES

DRIVER NO. 1 HAS OPERATED ACCIDENT VEHICLE FOR WHAT PERIOD OF TIME? ______ WITH ANNUAL MILEAGE? ______

DOES DRIVER NO. 1 OPERATE ANOTHER VEHICLE? ☐ YES ☐ NO

IF YES: YEAR ____ MAKE ______ MODEL ______ BODY STYLE ______

OTHER VEHICLE EQUIPPED WITH: ☐ AUTO TRANSMISSION ☐ POWER STEERING ☐ POWER BRAKES

DRIVER NO. 1 HAS OPERATED OTHER VEHICLE FOR WHAT PERIOD OF TIME? ______ WITH ANNUAL MILEAGE? ______

DRIVER NO. 2 AGE ____ SEX ____ OCCUPATION ______ YEARS OF DRIVING ______

DRIVER EDUCATION ☐ YES ☐ NO ANNUAL MILEAGE DRIVEN ______ DISTANCE FROM HOME ______

USE OF ACCIDENT ROAD: ☐ DAILY; ☐ FEW TIMES PER WEEK; ☐ FEW TIMES PER MONTH; ☐ RARELY

DESTINATION OF TRIP: ☐ HOME; ☐ WORK; ☐ SHOPPING; ☐ BUSINESS; ☐ OTHER (RECREATION, SOCIAL)

ACCIDENT VEHICLE: YEAR ____ MAKE ______ MODEL ______ BODY STYLE ______

LIC. NO. ______ STATE ______ INSPECTION NO. ______ MONTH ______

ODOMETER ☐☐☐☐☐.■ VEHICLE EQUIPPED WITH: ☐ AUTO TRANSMISSION; ☐ POWER STEERING; ☐ POWER BRAKES

DRIVER NO. 2 HAS OPERATED ACCIDENT VEHICLE FOR WHAT PERIOD OF TIME? ______ WITH ANNUAL MILEAGE? ______

DOES DRIVER NO. 2 OPERATE ANOTHER VEHICLE? ☐ YES ☐ NO

IF YES: YEAR ____ MAKE ______ MODEL ______ BODY STYLE ______

OTHER VEHICLE EQUIPPED WITH: ☐ AUTO TRANSMISSION ☐ POWER STEERING ☐ POWER BRAKES

DRIVER NO. 2 HAS OPERATED OTHER VEHICLE FOR WHAT PERIOD OF TIME? ______ WITH ANNUAL MILEAGE? ______

Figure D-2.

INSTRUCTIONS - DRIVER STUDY

Accident diagram:

Label vehicles so that the vehicle number agrees with the driver number.

Driver information:

List information only for those accident vehicles which are cars or light trucks.

Occupation. Give job or work type, not name of employer or type of industry.

Years of driving. If possible, give years and months if less than five years; for five or more years, give the nearest year.

Driver education. Check "yes" if driver has had a high school course.

Annual mileage driven. If driver has driven more than one year, use his estimate of his annual mileage. If he has driven less than one year, use estimate of total mileage he has driven.

Distance from home. Give distance between driver's home and accident site to the nearest mile when practical.

Driver's use of accident road. Check frequency with which driver normally uses this road as a driver, not as a passenger.

Driver number x has operated vehicle for what period of time. Give number of full days if less than one week, number of weeks if less than one month, number of years and months if less than five years; beyond that, list to nearest year.

With annual mileage. If driver has operated vehicle more than one year, use his estimated annual mileage for this vehicle. If he has operated this vehicle for less than one year, use estimated total mileage he has driven it.

Does driver number x now operate another vehicle. Check "yes" only if driver has another vehicle currently available; this does not include recently sold vehicles. Include all cars and trucks as vehicles.

Notice that the mileage indicated for individual vehicles need not always add up to the stated "annual mileage driven".

Figure D-2 (continued).

ACCIDENT DATA COLLECTION STUDY: TIRES

VIRGINIA DEPARTMENT OF STATE POLICE

DIVISION________ AREA ________ OFFICER ________________

CORNELL AERONAUTICAL LABORATORY, INC.

TRANSPORTATION RESEARCH DEPARTMENT

DATE: ________________

TIME: ________________

WEATHER: ________________

ROAD SURFACE: ________________

ROAD CONDITION: ________________

DESCRIPTION OF ACCIDENT: ________________

DIAGRAM OF ACCIDENT:

VEHICLE NO. 1 YEAR ______ MAKE ____________ MODEL ____________ STYLE ____________ ODOMETER □□□□□.■

LIC. NO. ____________ STATE ________ IDENT. NO. ____________ INSP. NO. ____________ MONTH ______

TIRE	MANUFACTURER	TIRE NAME	NO. OF PLY	CORD MATERIAL	SIZE	CHECK			TREAD DEPTH (MIN.)		UNEVEN WEAR	AIR PRESSURE (LBS)	IF FLAT, WHY? (BLOWOUT, OFF RIM)
						STUD	SNOW	RECAP	O	C			
L.F.													
L.R.													
R.R.													
R.F.													

NUMBER OF PASSENGERS ______ ADULTS ______ CHILDREN (UNDER 12) ____________

VEHICLE NO. 2 YEAR ______ MAKE ____________ MODEL ____________ STYLE ____________ ODOMETER □□□□□.■

LIC. NO. ____________ STATE ________ IDENT. NO. ____________ INSP. NO. ____________ MONTH ______

TIRE	MANUFACTURER	TIRE NAME	NO. OF PLY	CORD MATERIAL	SIZE	CHECK			TREAD DEPTH (MIN.)		UNEVEN WEAR	AIR PRESSURE (LBS)	IF FLAT, WHY? (BLOWOUT, OFF RIM)
						STUD	SNOW	RECAP	O	C			
L.F.													
L.R.													
R.R.													
R.F.													

NUMBER OF PASSENGERS ______ ADULTS ______ CHILDREN (UNDER 12) ____________

Figure D-3.

INSTRUCTIONS - TIRE STUDY

Manufacturer, Tire Name, Number of Plys, Cord Material, and Size:

Obtain information directly from sidewall. Give actual number of plys, not rating.

Uneven wear:

Write "yes" only if there are visual signs of uneven tread wear, blistering, cupping, etc. Do not write "yes" if the only signs of uneven wear are your tread depth measurements. Remember, this column should be marked "yes" only if uneven wear is apparent upon visual inspection; write "no" otherwise.

Check:

For each tire check one of these headings (standard, snow, stud).

Recap:

Write "yes" if tire has been recapped, "no" otherwise.

Tread depth:

Record two measurements: one at the center tread, "c", and one at the outside shoulder, "o" (not the inside shoulder). Attempt to obtain representative measures avoiding small areas which are obviously high or low. If a measurement is 6/32 of an inch, simply record "6", not "6/32".

Air pressure:

Record to nearest pound. Write "0" if flat.

If flat, why:

Be as specific as possible. Examples are: blowout, puncture, bead separation, cut, torn, off rim, air valve damage, etc.

Figure D-3 (continued).

VIRGINIA DEPARTMENT OF STATE POLICE

DIVISION ______ AREA ______ OFFICER ______

CORNELL AERONAUTICAL LABORATORY, INC.

TRANSPORTATION RESEARCH DEPARTMENT

DATE: ______ TIME: ______ WEATHER: ______

ROAD SURFACE: ______ ROAD CONDITION: ______

VEHICLE YEAR: ______ MAKE ______ MODEL ______ BODY STYLE ______

LIC. NO. ______ STATE ______ INSPECTION NO. ______ MONTH DUE: ______

ODOMETER READING ☐☐☐☐☐.☐ ESTIMATED SPEED PRIOR TO IMPACT ______ AT IMPACT ______

DESCRIPTION OF ACCIDENT: ______

DIAGRAM OF ACCIDENT:

DRIVER

AGE ____ WGT ____ HGT ____ SEX ____

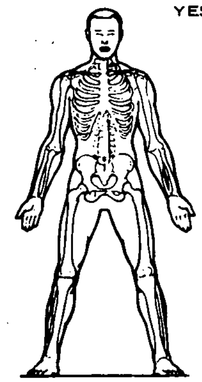
☐ NOT INJURED

☐ INJURED

☐ KILLED

UNCONSCIOUS

YES ☐ NO ☐



INDICATE BODY AREAS INJURED AND CAUSES

SEAT BELT: YES NO

INSTALLED? ☐ ☐

IN USE? ☐ ☐

ADJUSTMENT: LOOSE ☐ SNUG ☐

☐ NOT EJECTED ☐ EJECTED

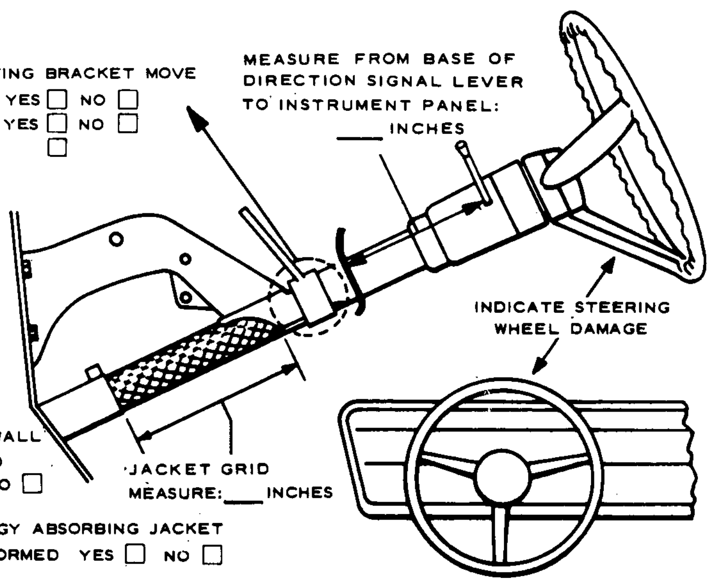
DID MOUNTING BRACKET MOVE

FORWARD YES ☐ NO ☐

BACK YES ☐ NO ☐

UNKNOWN ☐

MEASURE FROM BASE OF DIRECTION SIGNAL LEVER TO INSTRUMENT PANEL: ____ INCHES



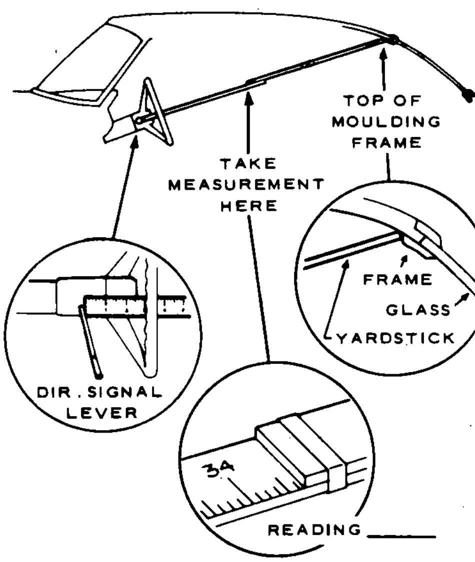
WAS FIREWALL DEFORMED YES ☐ NO ☐

JACKET GRID MEASURE: ____ INCHES

WAS ENERGY ABSORBING JACKET GRID DEFORMED YES ☐ NO ☐

INDICATE INSTRUMENT PANEL DAMAGE

PUSHED FORWARD ☐ BACK ☐ NONE ☐



READING ______

STEERING COLUMN

MOVED YES ☐ NO ☐

STEERING COLUMN DRIVEN

TOWARD OCCUPANT YES ☐ NO ☐

AWAY FROM OCCUPANT YES ☐ NO ☐

IF STEERING COLUMN WAS BENT OUT OF POSITION, CHECK DIRECTION(S) LEFT ☐ RIGHT ☐ UP ☐ DOWN ☐

STEERING WHEEL

DAMAGED YES ☐ NO ☐

	SLIGHTLY DEFORMED	SEVERELY BENT	BROKEN
RIM	☐	☐	☐
SPOKE(S)	☐	☐	☐
HORN RING	☐	☐	☐

Figure D-4.

INSTRUCTIONS FOR STEERING COLUMN STUDY

The purpose of this study is two-fold: First, this is part of a methodology study to determine how certain data for research purposes can best be obtained and reported on a sampling plan basis by police accident investigators. Second, as part of this test, we want to measure the performance, under frontal impact conditions, of the collapsible steering column system introduced in most 1967 model cars. For purposes of comparison, it is considered important to include a control group of cars that are not equipped with this design feature; thus, 1966 cars are included.

What is an applicable or reportable case car? Any 1966 or 1967 model passenger car involved in a frontal impact. Exceptions to this rule involve station wagons and convertibles. These will not be included because of the practical difficulties in obtaining a measurement from the column to a fixed rear point. Also excluded: Foreign make cars (VW's, etc.).

What do we mean by "frontal impact"? For the purpose of this study, a 1966 or 1967 model car sustaining damage at or forward of the front axle, regardless of angle of impact shall be deemed to fall within the scope of the study.

1966 model cars (and 1967 Ford products) 1966 cars are not equipped with steering columns specifically designed to collapse on impact. Therefore some of the questions on the form will not be applicable in reporting these cases. Essentially, only two measurements are required:

1. Measurement of collapse or penetration of the column: Using slide-stick, place one end flush against the ceiling just above the moulding frame of the rear window as indicated in the illustration on the form. Slide the other section forward until the end is butted against the base of the directional signal lever as shown in inset. Take reading and record in the space provided.
2. Measure the distance from the base of the direction signal lever to the point where the column goes through or adjoins the panel.

1967 model cars Include the above two measurements.

In addition: Take the measurement, if possible, of the jacket grid from the lower end to the upper point where the grid is concealed by the bracket or sleeve also noting and checking any deformation to the jacket grid.

Mounting bracket Was there any apparent movement forward or back?

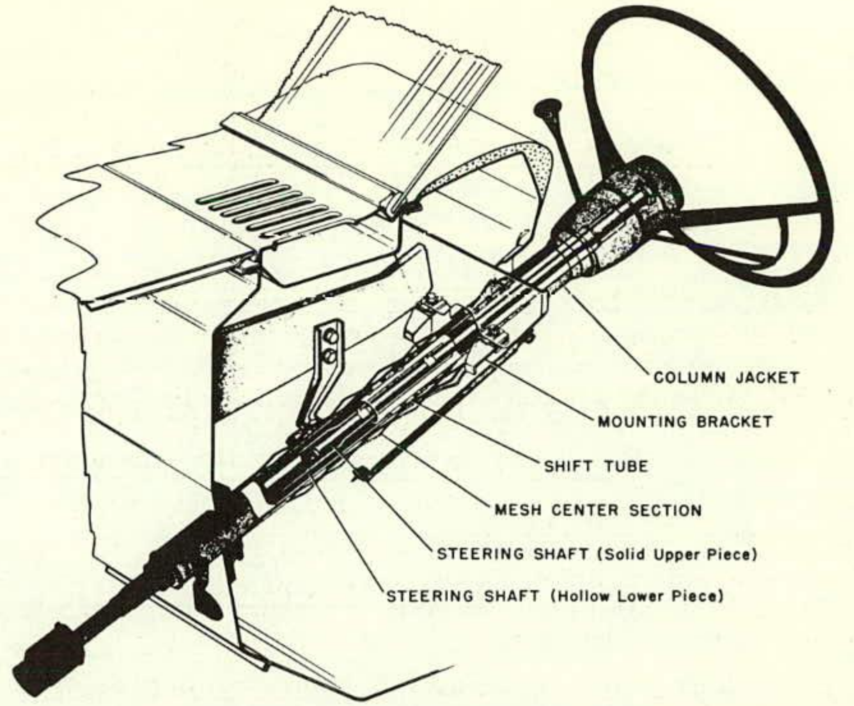
Photography Adequate photographic coverage is essential to this study. The value of the measurements taken is reduced if we don't know whether the column was bent out of position and by how much it was displaced. It is hoped that photographs will provide this evidence. Six to eight photographs will be needed as a minimum.

What photographs are required?

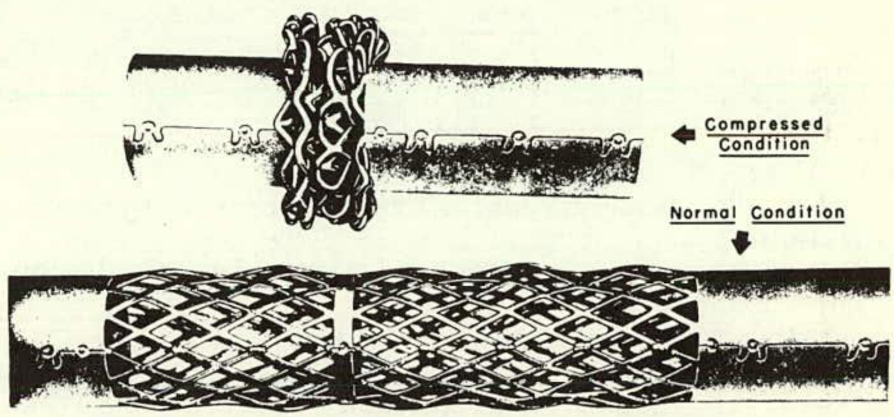
Exterior Damage. To show the extent of frontal damage and direction of impact, photograph "square-on" the front, left and right side. Include view of entire profile of car.

Steering Column. With the camera at approximately instrument panel level take photos of the column and steering wheel, one from the right side and one from the left side. In addition, for more detail, place camera near transmission tunnel and take photos of steering column grid jacket. Caution: All interior pictures should be taken with flash.

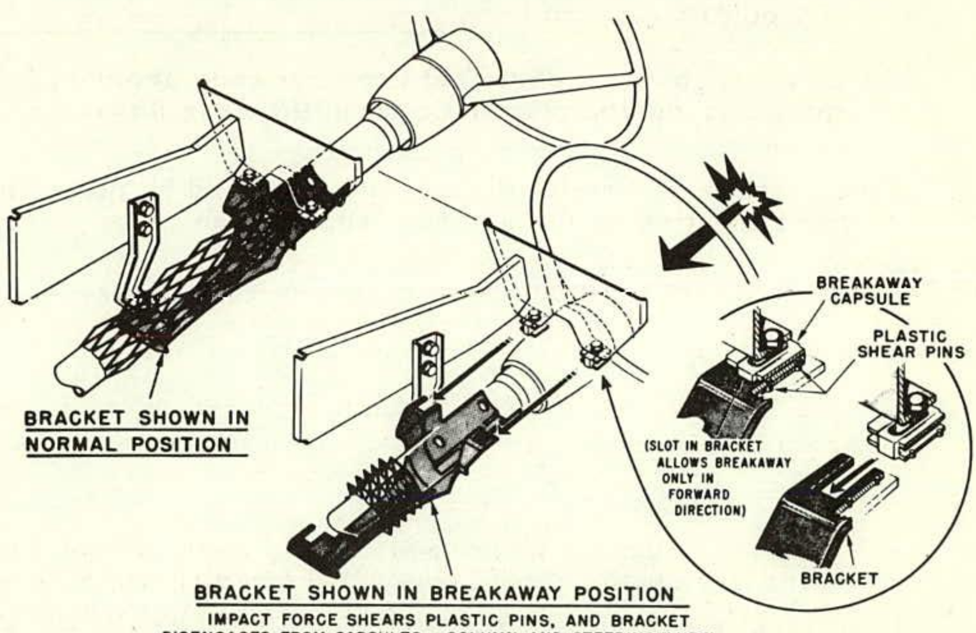
Figure D-4 (continued).



IMPACT-ABSORBING STEERING COLUMN



IMPACT- ABSORBING STEERING COLUMN JACKET



IMPACT-ABSORBING STEERING COLUMN MOUNTING BRACKET

Figure D-4 (continued).

CORNELL AERONAUTICAL LABORATORY, INC.

Survey of Accident Location Criteria

(NCHRP Contract No. HR 17-1)

A. Description of Existing System

1. Does your highway department receive copies of accident reports which occur on state controlled or maintained roads?

(a)	yes	no
routinely	( )	( )
upon request	( )	( )
never	( )	( )

(b)	yes	no
at state level	( )	( )
at district level	( )	( )

2. If you get accident reports are they received from police?

	yes	no
If you get accident reports are they received from police?	( )	( )
Drivers?	( )	( )
From special highway investigations of particular accidents?	( )	( )
Others? (specify) __________		

3. (a) Are accident locations coded onto punch cards or magnetic tape?

	yes	no
Are accident locations coded onto punch cards or magnetic tape?	( )	( )
By the highway department?	( )	( )
By motor vehicle agency?	( )	( )
By other? (specify) __________		

(b) If the highway department does not code accident location at present, do you plan to do so in the near future? yes ( ) no ( )

4. Please describe briefly the method now used by police in the field for reporting accident location on the accident report form.

5. If accident locations are coded for computer analysis, please describe the methods and procedures used in the coding process.

Figure D-5.

B. Location System Criteria

1. In your opinion, is reliable accident location information obtainable from:

	yes (please check)
official police reports	( )
driver reports	( )
both driver and police reports	( )
neither driver nor police reports	( )

2. (a) Please check the portions of the highway system for which you are required to summarize accidents:

( ) a specific curve or other major geometric element
( ) a specific leg of an intersection
( ) a specific interchange ramp
( ) a specific intersection or interchange
( ) a specific routed highway
( ) a specific Federal Aid highway
( ) a specific Federal Aid or State highway subsystem (for example, Federal and Primary, etc.)
( ) a specific city or town
( ) a specific county?

(b) In order to accomplish the above tasks, accidents <u>must</u> be located to nearest:

( ) 0.01 mile
( ) 0.10 mile
( ) 0.25 mile
( ) 0.50 mile
( ) 1.00 mile

3. In your opinion, field markers of some sort are:

( ) necessary in all areas (rural and urban)
( ) necessary in rural areas only
( ) necessary in urban areas only
( ) not necessary at all.

4. The extent to which accident records can and will be automated (i.e., computerized) affects the choice of location method and the detailed operational procedures involved. We have listed below several steps in the process of automation which seem logical in a general sense. Please indicate the present status in your state.

Figure D-5 (continued).

Please check appropriate column:

		CURRENTLY OPERATIONAL	IN PLANNING STAGE	UNDER CONSIDERATION	HAVE NO PLANS
(a)	Accident records data on cards or tape.	☐	☐	☐	☐
(b)	Ability to identify high frequency accident locations on a periodic basis.	☐	☐	☐	☐
(c)	Accident record and highway inventory data on cards or tape with good compatibility of location methods.	☐	☐	☐	☐
(d)	Ability to use accident and inventory data (mechanically) as inputs in formulation of general design and operating policy.	☐	☐	☐	☐
(e)	Ability to make many analyses at specific locations for engineering purposes by computer (few such projects require review of source documents).	☐	☐	☐	☐
(f)	Ability to make all analyses mechanically (by computer) without resorting to accident source documents.	☐	☐	☐	☐
(g)	Ability to mechanically prepare a visual display of accident rates on State highways.	☐	☐	☐	☐
(h)	Ability to mechanically plot collision and condition diagram for a specific location.	☐	☐	☐	☐

Any additional reports, manuals, or opinions regarding any aspect of subject of accident location which you care to submit will be useful and appreciated.

____________________ (Signature)

____________________ (Title)

Figure D-5 (continued).

INSPECTION CERTIFICATE FORM S. P. 131

ISSUED UNDER THE DIRECTION OF

VIRGINIA STATE POLICE

Equipment Inspected	O. K.	Adjust	Install	OCTOBER
BRAKES				
HEADLIGHTS				Date
OTHER LIGHTS				
SIGNAL LIGHTS				Lic. No.
HORN				
STEERING				
MIRROR				Make
WINDSHIELD				
OTHER GLASS				Body Type
WINDSHIELD WIPER				
TAG MOUNTING				Year Built
EXHAUST LINE				Speedometer
TIRES				Reading
SEAT BELTS				
AIR CONDITIONER				Charges $

EQUIPMENT REMOVED ______________ STA. NO. ______________

STATION NAME ______________

INSPECTOR ______________

CARRY THIS RECEIPT WITH YOU AT ALL TIMES WHILE OPERATING THIS VEHICLE (Over)

THIS STICKER EXPIRES APRIL 30

Figure D-6. Virginia inspection certificate.

STATE OF MICHIGAN
OFFICIAL TRAFFIC ACCIDENT REPORT

UD-10C

No. of sheets attached .... Department .... Complaint No. ....

TIME

Date .... 19 .... Day of Week .... at .... A.M. .... P.M. File Class Number ....

LOCATION

County .... City .... Twp. .... Sec. ....

Highway or street on which accident occurred *(Name)* .... Trunkline No. .... County Road No. ....

AT ITS INTERSECTION WITH *(street, highway or R. R. crossing)* ....

OR

IF NOT AT INTERSECTION: *(feet or miles or fractions thereof)* ....

N	S	E	W

of *(intersecting street, highway, city, village, county line or R.R.)* ....

Special reference ....
Use to indicate more precise location: *(alley, house number, stream, milepost, underpass, or other landmark)*

VEHICLE NO. 1

Year .... Make .... Type .... Year, No., & State of Reg .... ICC No. .... MPSC No. ....

Parts of vehicle damaged .... Vehicle removed to: .... By: ....

Owner *(FULL Name)* .... Street or RFD .... City .... State ....

Driver *(FULL Name)* .... Street or RFD .... *City, County, State*

Driver's License .... Regular Operator's License ☐ Other Type License ☐ .... Date of Birth ....
State *Number* *Specify Type and/or Restrictions* *Month, Day, Year*

OCCUPANTS

Front Center .... Address ....
Front Right .... Address ....
Rear Left .... Address ....
Rear Center .... Address ....
Rear Right .... Address ....
Name *Street or RFD* *City and State*

AGE	SEX	INJ	SEAT BELT

Total number vehicles involved ....

VEHICLE NO. 2; Pedestrian or Bicycle

Year .... Make .... Type .... Year, No., & State of Reg .... ICC No. .... MPSC No. ....

Parts of vehicle damaged .... Vehicle removed to: .... By: ....

Owner *(FULL Name)* .... Street or RFD .... City .... State ....

Driver *(FULL Name)* .... Street or RFD .... *City, County, State*

Driver's License .... Regular Operator's License ☐ Other Type License ☐ .... Date of Birth ....
State *Number* *Specify Type and /or Restrictions* *Month, Day, Year*

OCCUPANTS

Front Center .... Address ....
Front Right .... Address ....
Rear Left .... Address ....
Rear Center .... Address ....
Rear Right .... Address ....
Name *Street or RFD* *City and State*

AGE	SEX	INJ	SEAT BELT

Figure D-7. Suggested short accident report form.

DESCRIPTION AND SKETCH OF ACCIDENT

SKETCH POSITION OF CAR(S) BEFORE, AT, AND AFTER IMPACT. RECORD APPROXIMATE DISTANCES, OBJECTS STRUCK, ETC. SHOW ROLLOVER, SKIDMARK DISTANCES. IF OCCUPANTS WERE EJECTED, SHOW WHEN AND WHERE.

1. DRAW HEAVY LINES TO SHOW STREETS
2. NAME STREETS
3. SHOW VEHICLES AND PEDESTRIANS THUS:

   VEHICLES ⟶ [1] [2]

   PEDESTRIANS ○

4. SHOW ANGLE OF COLLISION
5. SPEEDS:

   PRIOR TO IMPACT:

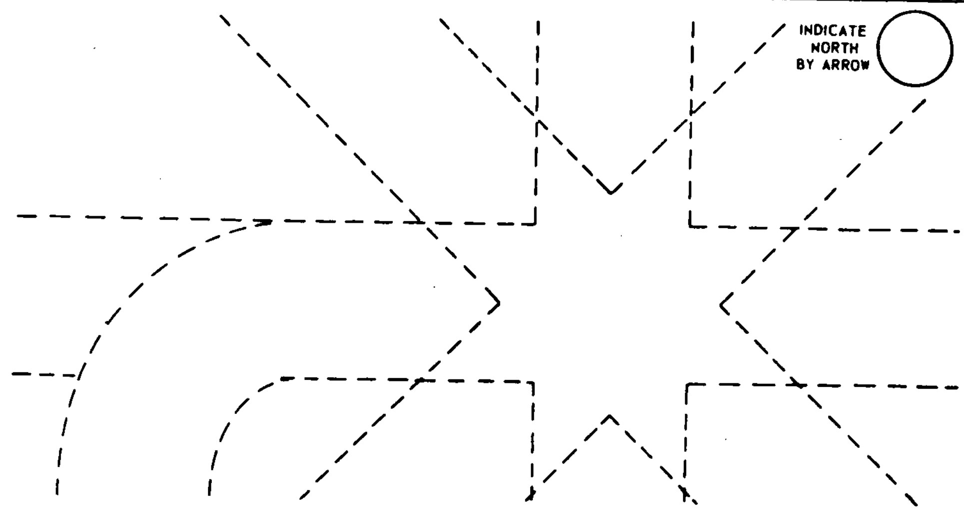
   VEHICLE #1 ____________

   VEHICLE #2 ____________

   AT IMPACT:

   VEHICLE #1 ____________

   VEHICLE #2 ____________



BRIEFLY DESCRIBE CIRCUMSTANCES ____

Injured taken to .... By ....

WITNESSES

Name .... Address .... Age .... Sex ......

Name .... Address .... Age .... Sex ......

Name .... Address .... Age .... Sex ......

POLICE RECORD

Arrest: Name .... Charge ....

Arrest: Name .... Charge ....

Reported by *(name)* .... Address ....

Date received .... Time .... ☐ AM ☐ PM Report received by *(officer)* ....

Investigator.., ..., ...

Signature and Rank *Badge No.* *Station or Department*

Investigated at scene? ☐ Yes ☐ No Photographs taken? ☐ Yes ☐ No Complaint closed by: ☐ Arrest ☐ Other Date .... Post No. ......

Figure D-7 (continued).

STATE OF MICHIGAN
OFFICIAL TRAFFIC ACCIDENT REPORT

No. of sheets attached.................Department.. Complaint No..............................

TIME

Date..............................19........ Day of Week...........................at......................A.M......................P.M.

File Class Number......................

LOCATION

County.................................. City.................................. Twp.................................. Sec.............

Highway or street on which accident occurred *(Name)*.......................... Trunkline No.................... County Road No....................

AT ITS INTERSECTION WITH *(street, highway or R. R. crossing)*..

OR

IF NOT AT INTERSECTION: *(feet or miles or fractions thereof)*.......................... N | S | E | W

of *(intersecting street, highway, city, village, county line or R.R.)*..

Special reference ....

Use to indicate more precise location: *(alley, house number, stream, milepost, underpass, or other landmark)*

Damage to property other than vehicles..

Name object and state nature of damage

In roadway ☐ , or....................feet from N | S | E | W edge of roadway

Name and address of owner of object struck..

....

CODE OF INJURY

(Use only the most serious one in each space for injury.)

K - Dead
A - Visible signs of injury, as bleeding wound or distorted member, or had to be carried from scene.
B - Other visible injury, as bruises, abrasions, swelling, limping, etc.
C - No visible injury but complaint of pain or momentary unconsciousness.
O - No Indication of injury.

VEHICLE NO. 1

Year.................. Make.............................. Type.............................. Year, No., & State of Reg.............................. ICC No.................. MPSC No..................

Parts of vehicle damaged..............................Vehicle removed to:..............................By:..............................

Owner..............................St. or RR.............................. City.............................. State..............................

Driver..............................St. or RR..............................

City, County, State

Driver's License.............................. Reg. Op. Lic. ☐ Other ☐ .... Date of Birth..............................

State *Number* *Specify Type and/or Restrictions* *Month, Day, Year*

OCCUPANTS

Front Center..............................Address..............................

Front Right..............................Address..............................

Rear Left..............................Address..............................

Rear Center..............................Address..............................

Rear Right..............................Address..............................

Name *Street or RR* *City and State*

AGE	SEX	INJURY

Total number vehicles involved ....

VEHICLE NO. 2; Pedestrian or Bicycle

Year.................. Make.............................. Type.............................. Year, No., & State of Reg.............................. ICC No.................. MPSC No..................

Parts of vehicle damaged..............................Vehicle removed to:..............................By:..............................

Owner..............................St. or RR.............................. City.............................. State..............................

Driver..............................St. or RR..............................

City, County, State

Driver's License.............................. Reg. Op. Lic. ☐ Other ☐ .... Date of Birth..............................

State *Number* *Specify Type and/or Restrictions* *Month, Day, Year*

OCCUPANTS

Front Center..............................Address..............................

Front Right..............................Address..............................

Rear Left..............................Address..............................

Rear Center..............................Address..............................

Rear Right..............................Address..............................

Name *Street or RR* *City and State*

AGE	SEX	INJURY

Injured taken to..............................By..............................

WEATHER *(Check one)*
- ☐ Clear or cloudy
- ☐ Raining
- ☐ Snowing
- ☐ Fog
- ☐ Other *(specify)*

LIGHT CONDITION *(Check one)*
- ☐ Daylight
- ☐ Dusk or dawn
- ☐ Darkness

KIND OF LOCALITY *(Check one)*
- ☐ Mfg. or industrial
- ☐ Shopping or business
- ☐ Apartments
- ☐ School or playground
- ☐ One family homes
- ☐ Farms, fields
- ☐ Not developed

ROADWAY

CONSTRUCTION *(Check one)*
- ☐ Concrete
- ☐ Blacktop
- ☐ Gravel
- ☐ Dirt or sand
- ☐ Other *(specify)*

SURFACE *(Check one)*
- ☐ Dry
- ☐ Wet
- ☐ Snowy or icy
- ☐ Other *(specify)*

CHARACTER *(Check two)*
- ☐ Straight road
- ☐ Curve
- ☐ Level
- ☐ On grade
- ☐ Hillcrest

CONDITION *(Check one)*
- ☐ Defect *(describe)*

Low shoulder, slippery when wet, etc.
- ☐ No defect

WITNESSES

Name..............................Address..............................Age..........Sex..........

Name..............................Address..............................Age..........Sex..........

Name..............................Address..............................Age..........Sex..........

This form is prescribed by Commissioner, Michigan State Police pursuant to Section 622, Act 300, P.A. 1949, as amended. 1/63

Figure D-8. A recommended more complete accident report form.

ALL APPLICABLE SCHEDULES MUST BE CHECKED. OFFICER'S CONSIDERED OPINION SHOULD BE GIVEN IF FACTS ARE NOT OBTAINABLE.

WHAT DRIVERS WERE GOING TO DO BEFORE ACCIDENT

Driver No. 1 was headed N | S | E | W on .... at .... MPH
Street or Highway

Driver No. 2 was headed N | S | E | W on .... at .... MPH

DRIVER
1 2 *(Check one for each driver)*

- ☐ ☐ Go straight ahead
- ☐ ☐ Overtake
- ☐ ☐ Make right turn
- ☐ ☐ Make left turn
- ☐ ☐ Make U turn
- ☐ ☐ Slow or stop
- ☐ ☐ Start in traffic lane
- ☐ ☐ Start from parked position
- ☐ ☐ Back
- ☐ ☐ Remain stopped in traffic lane
- ☐ ☐ Remain parked

ROAD TYPE *(Check one or more for each driver)*

DRIVER
1 2

- ☐ ☐ 1 driving lane
- ☐ ☐ 2 driving lanes
- ☐ ☐ 3 driving lanes
- ☐ ☐ 4 or more lanes
- ☐ ☐ Divided roadway *(limited access)*
- ☐ ☐ Divided roadway *(other)*
- ☐ ☐ One way street
- ☐ ☐ Unpaved - any width

WHAT PEDESTRIAN WAS DOING

Pedestrian was going N | S | E | W ☐ Along ☐ Across or into .... From .... To ....
(Check one) *Street Name, Highway No.* *N.E. corner to S.E. corner, or west to east side, etc.*

- ☐ Crossing or entering at intersection
- ☐ Crossing or entering not at intersection
- ☐ Getting on or off vehicle
- ☐ Walking in roadway—with traffic
- ☐ Walking in roadway—against traffic
- ☐ Standing in roadway
- ☐ Pushing or working on vehicle
- ☐ Other working in roadway
- ☐ Playing in roadway
- ☐ Other in roadway
- ☐ Not in roadway

VIOLATION INDICATED *(Check one or more for each driver)*

DRIVER
1 2

- ☐ ☐ Speed too fast
- ☐ ☐ Failed to yield right of way
- ☐ ☐ Drove left of center
- ☐ ☐ Improper overtaking
- ☐ ☐ Passed stop sign
- ☐ ☐ Disregarded traffic signal
- ☐ ☐ Followed too closely
- ☐ ☐ Made improper turn
- ☐ ☐ Improper or no signal
- ☐ ☐ Improper parking location
- ☐ ☐ Other improper driving *(describe)* ________
- ☐ ☐ No violation indicated

APPARENT PHYSICAL CONDITION *(Check one or more as applicable)*

DRIVER
1 2 PED.

- ☐ ☐ ☐ Ill
- ☐ ☐ ☐ Fatigued
- ☐ ☐ ☐ Asleep
- ☐ ☐ ☐ Other impairment *(describe)* ________
- ☐ ☐ ☐ Normal
- ☐ ☐ ☐ Condition not known
- ☐ ☐ Restriction on license complied with
- ☐ ☐ Restriction on license not complied with *(describe)* ________

DRINKING CONDITION *(Check one)*

DRIVER
1 2 PED. HAD BEEN DRINKING:

- ☐ ☐ ☐ Under the influence
- ☐ ☐ ☐ Not under the influence
- ☐ ☐ ☐ Influence not known
- ☐ ☐ ☐ HAD NOT BEEN DRINKING
- ☐ ☐ ☐ NOT KNOWN IF DRINKING

CHECK IF APPLICABLE:

- ☐ ☐ ☐ Chemical test given

VISION OBSTRUCTION

(Check one or more for each driver)
DRIVER
1 2

- ☐ ☐ Windshield or windows *(describe)* ________
- ☐ ☐ Bldgs., signs, bushes, crops, embankment, parked cars, etc. *(describe)* ________
- ☐ ☐ No vision obstruction

VEHICLE CONDITION

(Check one or more)
VEHICLE
1 2

- ☐ ☐ Defective brakes
- ☐ ☐ Defective lights
- ☐ ☐ Defective steering
- ☐ ☐ Defective tires
- ☐ ☐ Other defective equipment *(specify)* ________
- ☐ ☐ Not known if defective
- ☐ ☐ No defect

TRAFFIC CONTROL

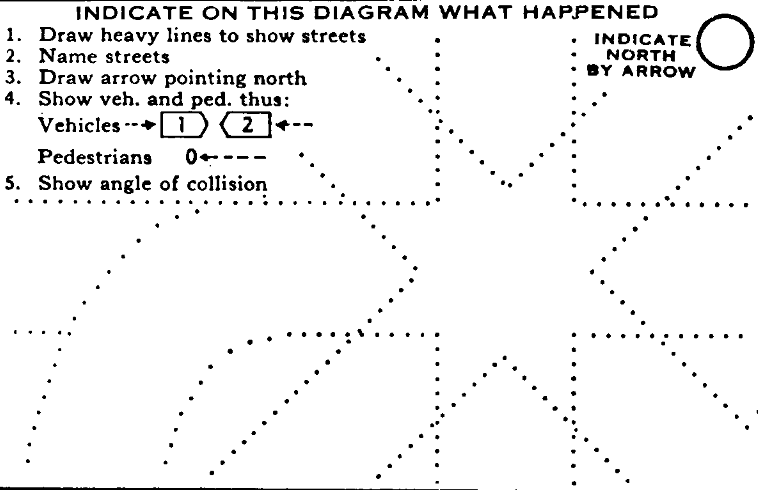
(Check one or more)

- ☐ Stop sign
- ☐ Stop and go signal
- ☐ Officer or watchman
- ☐ R.R. gates or signals
- ☐ Other *(specify)* ________
- ☐ Control not functioning, inadequate or obscured *(describe)* ________
- ☐ No traffic control present

INDICATE ON THIS DIAGRAM WHAT HAPPENED

1. Draw heavy lines to show streets
2. Name streets
3. Draw arrow pointing north
4. Show veh. and ped. thus:
   Vehicles --▸ [1〉 〈2] ◂--
   Pedestrians 0◂----
5. Show angle of collision

INDICATE NORTH BY ARROW



REMARKS AND RECOMMENDATIONS

Inspect scene for need of traffic engineering? ☐ Yes *(explain)*
Re-examine driver for license competency? ☐ #1 ☐ #2 *(explain)*

....

Use complaint form or sheet of paper for more extensive remarks or diagram.

POLICE RECORD

Arrest: Name .... Charge ....
Arrest: Name .... Charge ....
Reported by *(name)* .... Address ....
Date received .... Time .... ☐ AM ☐ PM Report received by *(officer)* ....
Investigator ...., ..., ...
Signature and Rank *Badge No.* *Station or Department*
Investigated at scene? ☐ Yes ☐ No Photographs taken? ☐ Yes ☐ No Complaint closed by: ☐ Arrest ☐ Other Date .... Post No. ....

Figure D-8 (continued).

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Highway Research Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

Rep. No.	*Title*
—*	A Critical Review of Literature Treating Methods of Identifying Aggregates Subject to Destructive Volume Change When Frozen in Concrete and a Proposed Program of Research—Intermediate Report (Proj. 4-3(2)), 81 p., $1.80
1	Evaluation of Methods of Replacement of Deteriorated Concrete in Structures (Proj. 6-8), 56 p., $2.80
2	An Introduction to Guidelines for Satellite Studies of Pavement Performance (Proj. 1-1), 19 p., $1.80
2A	Guidelines for Satellite Studies of Pavement Performance, 85 p.+9 figs., 26 tables, 4 app., $3.00
3	Improved Criteria for Traffic Signals at Individual Intersections—Interim Report (Proj. 3-5), 36 p., $1.60
4	Non-Chemical Methods of Snow and Ice Control on Highway Structures (Proj. 6-2), 74 p., $3.20
5	Effects of Different Methods of Stockpiling Aggregates—Interim Report (Proj. 10-3), 48 p., $2.00
6	Means of Locating and Communicating with Disabled Vehicles—Interim Report (Proj. 3-4), 56 p. $3.20
7	Comparison of Different Methods of Measuring Pavement Condition—Interim Report (Proj. 1-2), 29 p., $1.80
8	Synthetic Aggregates for Highway Construction (Proj. 4-4), 13 p., $1.00
9	Traffic Surveillance and Means of Communicating with Drivers—Interim Report (Proj. 3-2), 28 p., $1.60
10	Theoretical Analysis of Structural Behavior of Road Test Flexible Pavements (Proj. 1-4), 31 p., $2.80
11	Effect of Control Devices on Traffic Operations—Interim Report (Proj. 3-6), 107 p., $5.80
12	Identification of Aggregates Causing Poor Concrete Performance When Frozen—Interim Report (Proj. 4-3(1)), 47 p., $3.00
13	Running Cost of Motor Vehicles as Affected by Highway Design—Interim Report (Proj. 2-5), 43 p., $2.80
14	Density and Moisture Content Measurements by Nuclear Methods—Interim Report (Proj. 10-5), 32 p., $3.00
15	Identification of Concrete Aggregates Exhibiting Frost Susceptibility—Interim Report (Proj. 4-3(2)), 66 p., $4.00
16	Protective Coatings to Prevent Deterioration of Concrete by Deicing Chemicals (Proj. 6-3), 21 p., $1.60
17	Development of Guidelines for Practical and Realistic Construction Specifications (Proj. 10-1), 109 p., $6.00
18	Community Consequences of Highway Improvement (Proj. 2-2), 37 p., $2.80
19	Economical and Effective Deicing Agents for Use on Highway Structures (Proj. 6-1), 19 p., $1.20
20	Economic Study of Roadway Lighting (Proj. 5-4), 77 p., $3.20
21	Detecting Variations in Load-Carrying Capacity of Flexible Pavements (Proj. 1-5), 30 p., $1.40
22	Factors Influencing Flexible Pavement Performance (Proj. 1-3(2)), 69 p., $2.60
23	Methods for Reducing Corrosion of Reinforcing Steel (Proj. 6-4), 22 p., $1.40
24	Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants (Proj. 7-1), 116 p., $5.20
25	Potential Uses of Sonic and Ultrasonic Devices in Highway Construction (Proj. 10-7), 48 p., $2.00
26	Development of Uniform Procedures for Establishing Construction Equipment Rental Rates (Proj. 13-1), 33 p., $1.60
27	Physical Factors Influencing Resistance of Concrete to Deicing Agents (Proj. 6-5), 41 p., $2.00
28	Surveillance Methods and Ways and Means of Communicating with Drivers (Proj. 3-2), 66 p., $2.60
29	Digital-Computer-Controlled Traffic Signal System for a Small City (Proj. 3-2), 82 p., $4.00
30	Extension of AASHO Road Test Performance Concepts (Proj. 1-4(2)), 33 p., $1.60
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* Highway Research Board Special Report 80.

Rep. No.	Title
42	Interstate Highway Maintenance Requirements and Unit Maintenance Expenditure Index (Proj. 14-1), 144 p., $5.60
43	Density and Moisture Content Measurements by Nuclear Methods (Proj. 10-5), 38 p., $2.00
44	Traffic Attraction of Rural Outdoor Recreational Areas (Proj. 7-2), 28 p., $1.40
45	Development of Improved Pavement Marking Materials—Laboratory Phase (Proj. 5-5), 24 p., $1.40
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Rep. No.	Title
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