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Analysis of Methodology for Measuring National Highway Traffic Safety

Robert G. Hendrickson, Alexander R. Craw

Technical Analysis Division
Institute for Applied Technology
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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary

NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

Summary

The objectives of this study were to investigate the current practices of NHTSA in their measuring and reporting on the major variables depicting the national highway traffic safety situation, and to recommend new or improved techniques for a better representation of the national traffic picture.

The current methods of measurement are found to be too restrictive in the scope of description used and as expressed by variables defined at a level too gross to be sensitive to NHTSA vehicle and traffic safety programs.

The following major recommendations are directed to the improvement of measuring traffic safety characteristics:

- Extend the current practice of depicting the National traffic safety situation from fatalities to levels of injury-severity.
- Adopt injury-severity per vehicle-year, injury-severity per driver-year, injury-severity per vehicle-mile and injury-severity per accident as preferred measures of traffic safety over fatalities per miles traveled, fatalities per vehicle-year and fatalities per driver-year.
- Adopt accidents per vehicle-year and injury-severity per accident as preferred measures of traffic safety over fatalities per miles traveled.
- Adopt a level of descriptive capability (detailed in the report) to meet current and future requirements to characterize important factors in the National traffic safety picture.

The following recommendations are directed toward improving program impact and sampling techniques.

- Adopt geographical regions (described in the report) for data collection as a surrogate for National statistics for purposes of projection and estimation.
- Use geographical regions for the location of Alcohol Safety Action Projects to enhance effectiveness and evaluation.
- Improve current data processing techniques to accommodate more descriptors dealing with program impact and to provide facility in retrieving data for reporting and policy purposes.

The study emphasizes the need to standardize the estimation of vehicle-miles traveled and to measure the impact of NHTSA programs by using composite indicators based on registered-vehicles, registered-drivers, vehicle safety systems and miles-traveled. Not only do these variables represent the primary factors of the vehicle-driver-highway mix, but when expanded into important subclassifications they provide a full spectrum of descriptors for analysis, evaluation and reporting.

The complexity of evaluating programs and performing analyses of accident phenomena virtually eliminates the current practice of depicting traffic safety by the use of rates and requires a dimensional structure incorporating as many variables as can be quantified and formulated as indicators for purposes of policy, reporting and evaluation.

<u>Table of Contents</u>

1.0 INTRODUCTION

This report is submitted under a study agreement between the Mathematical Analysis Division, NHTSA and the Technical Analysis Division, NBS. The report covers the investigation of indicators of the National highway traffic safety situation with the intention of developing improvements in the current methodology used for measuring and reporting features of traffic safety as defined herein.

Section 2 covers the general background and situation leading to the research, and Section 3 states the objectives and scope of the study.

Section 4 contains the review of current practice in developing indicators and descriptors, and evaluates the effectiveness of these practices in depicting the National situation. Limitations and gaps in the coverage of these indicators are ascertained, and serve, in part, as the subject of Section 5.

Section 5 deals with the analysis of the problem of measurement, addressing the limitations and gaps in present methods, and, in more general terms, the necessary and desirable structures for measurements to meet the demands of the NHTSA vehicle and traffic safety priority programs.

Section 6 contains recommendations for improving current practice and meeting future requirements for measuring and reporting National highway traffic safety features.

2.0 BACKGROUND AND OVERVIEW

2.1 Background

The growing complexity of today's highway traffic activity has placed an increasing responsibility on the National Highway Traffic Safety Administration. This responsibility takes the form of measuring and reporting on the general character of the driver-vehicle-highway mix, and pursuing programs for effective countermeasures and standards on pre crash accident avoidance, crash injury prevention, and post-crash injury-severity reduction.

The Administration (NHTSA) addresses the gamut of highway-traffic problems through the Motor Vehicle Programs, which concerns standards enforcement, operating systems, crash worthiness, standards for vehicles-in-use, and defects investigation; the Traffic Safety Program, which concerns standards development and implementation, state and community programs, and alcohol countermeasures; and Planning and Programming, which concerns program planning, program evaluation and systems analysis. The Research Institute functions as an investigative unit on the aspects of the vehicle-driver system, and conducts programs concerning experimental safety vehicles, the safety systems laboratory, accident investigation and data analysis, driver performance research, vehicle structures research, and operating systems research.

These activities are enumerated to emphasize the diversity and range of the effort by NHTSA on accident avoidance and injury reduction, and to point out the critical need for appropriate data collection, measurements, evaluation and reporting in order to provide a basis for judging program impact and priority planning. They serve, also, as a functional representation of the major variables in the National highway-traffic picture.

The functions of data collection, measurement, evaluation and reporting lead to requirements, on two separate, but related, levels. On the one level is the description, both qualitatively and quantitatively, of those details dealing with the variables and parameters of occupant safety and vehicle design in a crash scenario. The other level is the description, again qualitatively and quantitatively, of those aspects of highway-traffic activity which describe traffic-safety patterns as seen from the perspective of the Nation as a whole.

These two levels are not exclusive, but they do present a problem in that descriptions at one level may not necessarily supplement the descriptions at the other.

This dichotomy suggests that the functions of data collection, measurement, evaluation and reporting need to be organized in such a way that the contribution of information from each function serves both levels in an optimal sense, and provides a process of data development evolving from detailed accident analysis to the indicators of the National situation.

In summary, then, the need for an adequate and efficient description of the National situation and program impact upon a complex of automobiles, drivers and highways of unparalleled variation, has become an essential concern of NHTSA, and it is to part of this problem that this study is addressed.

2.2 Overview

In this report we discourse on the fact that measuring safety is a difficult task and becomes more difficult (or more ineffectual) as more factors are introduced in time. The faults of several variables that are currently used as indicators will be shown. The use of an economic cost or loss model as an indicator will be discouraged and in its place, indicators that avoid the pitfalls of costing will be recommended. It will be pointed out that the present use of indicators by NHTSA is restricted to those relating to mortality. As such these present at best an incomplete description of the status of safety on the Nation's highways, and are inadequate to measure the effectiveness impact of individual priority programs in improving traffic safety. We will then make recommendations for other indicators that have specifically designated characteristics which better illustrate the National picture and at the same time are sensitive enough to reflect some effects of the NHTSA programs. We will also recommend the use of special regions to assist in the depiction of the National scene and enhance the demonstration of impact of priority programs.

3.0 OBJECTIVES AND SCOPE

3.1 Objectives

The principal objective was to develop measures which adequately portray the overall National highway traffic safety situation. Secondary objectives included an examination of exposure measures, selection of variables sensitive to changes brought about by the Motor Vehicle Programs and the Traffic Safety Programs, an investigation of associated data collection and processing needs appropriate to the desired indexes, and the development of candidate descriptors leading to graduated levels of representing the important variables of the National situation.

The indexes are intended for the assessment of relative trends in injury reduction, to measure shifts in distributions of injury-severity classifications, and reflect the contribution of the occupant-crash protection standard in terms of lives saved or accidents reduced.

3.2 Scope

The study focuses principally on the effectiveness of current practices of NHTSA to measure and present the characteristics of highway traffic safety. The scope includes a critique and analysis of these practices for the purpose of developing new or improved methods for measuring and reporting critical information. The critique is based on an examination of current statistical compilations, data collection systems and files, the utility of basic death and injury data, and an evaluation of the effectiveness of the statistical compilations of the National traffic picture. The analysis is directed toward the development of more comprehensive measures of accident phenomena using a broader base of descriptors and accident criteria.

The perspective of the critique and analysis is primarily that of the Mathematical Analysis Division, Office of Accident Investigation and Data Analysis, in terms of its support function to the NHTSA mission. However, the total, overall requirements for reporting, evaluation, data collection and measurement were retained as a necessary and desirable context in which specific recommendations are made pertaining to a graduated capability in these four areas.

4.0 REVIEW AND CRITIQUE OF CURRENT MEASUREMENT TECHNIQUES

4.1 Introduction

This section summarizes the general goals and perspectives of the NHTSA role in vehicle and traffic safety activities and serves as a background for the critique and evaluation of current practices for measuring accident phenomena.

4.1.1 Major Goals of the NHTSA

The major goals are understood to be the support and promulagation of programs, standards and projects at the National, State and local levels by the NHTSA, to relieve traffic pressures, obtain safer travel over longer distances, reduce the number and severity of injuries, and pursue standards, designs and procedures addressing accident avoidance. The specific goal of the NHTSA is to reduce the national death-rate to 3.7 per 100-million vehicle-miles by 1980. In order to obtain this goal the NHTSA is pointing toward a 14% reduction in total deaths per year as a net effect from its priority programs.

4.1.1.1 Priority Programs

The priority programs are in three categories, Crash Survivability, Alcoholic Abuse, and Experimental Safety Vehicle. Two additional areas, Motor Vehicle Safety and Highway Safety, in coordination with the States, address hazards of defective cars, selective traffic law enforcement, the driver control problem, vehicle inspection programs, traffic engineering and highway safety standards. Progress through research programs involves accident investigations, identifying the important aspects of human factors, vehicle-handling, and highway design.

4.1.1.2 Crash Survivability

This program is divided into two areas, Occupant Packaging and Vehicle Design. Occupant Packaging is further divided into passive measures (automatic protection) and active measures (driver or occupant action). The second lifesaving aspect of Crash Survivability lies in designing the vehicle to absorb and deflect collision forces so that the passenger compartment remains a safety haven.

4.1.1.3 Occupant Packaging - Passive Measures

Passive measures protect automatically in an emergency without volition or action on the part of the occupant. Based on research, numerous standards have been issued which enhance crash survival chances. They specify safety performance criteria for such potentially dangerous features as steering columns, windshields, instrument panels, seat anchorages, door locks, and fuel tanks. About 53% of the cars on the road now contain the basic safety devices which were established as standard during 1968-71. New cars are driven more miles than older ones accounting for nearly 65% of total miles driven.[1/]

4.1.1.4 Occupant Packaging - Active Measures

Lap and shoulder straps are part of the active protection package. Although far more people reject than use them, research and testing have demonstrated their feasibility and effectiveness. In November 1970, NHTSA issued a time-table (1972-1975) for improved seat and shoulder belts and a gradual progression to a completely passive system covering lock-out, compartment protection, and protection for all seat positions against impact and roll-over crashes.

4.1.1.5 Vehicle Design

This priority program covers a wide range of vehicle improvement features addressing energy absorption or deflection. A few of the major developments are (1) front-end, energy absorbing devices, (2) bending beams and crushable sections to distribute forces over the side

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These data are from Traffic Safety, '71: A Report on Activities Under the National Traffic and Motor Vehicle Safety Act.

of the vehicle, (3) energy absorbing structures in the trunk area to increase the sustainable impact force without compartment damage, (4) selective modification of roof pillars, and (5) simulations of occupant kinematics and motions during a crash scenario which are used as a starting point in designing energy - managing structures.

4.1.1.6 Alcoholic Abuse

The Alcohol Safety Countermeasures Program (ASCP) is national in scope and effort. Its primary goal is to identify the heavy-drinking drivers and prevent them from operating vehicles while intoxicated. Its principal operation is to channel as many of these drivers as possible into treatment and rehabilitative programs. The total program embraces (1) financial assistance for increased emphasis on the alcohol aspects of the State highway safety programs, (2) a national campaign of public education, (3) research to produce new or improved methods and devices to reduce the problem, (4) training personnel to carry out the various technical tasks connected with the program, and (5) federal funding of Alcohol Safety Action Projects (ASAP) to demonstrate the feasibility of concentrated effort on selected facets of the program.

4.1.1.7 Experimental Safety Vehicles (ESV)

In the past design changes incorporating safety features were made on a gradual and piecemeal basis. Now, for the first time, whole vehicles are being designed, fabricated, and tested with safety primarily in mind. The ESV program is achieving or contributing to the following: (1) demonstrating the feasibility of advanced automotive safety performance features through the design, fabrication, and testing of experimental vehicles, (2) stimulating public awareness of the safety and economic advantages of advanced designs, (3) encouraging the automobile industry to increase efforts in automotive safety design and to accelerate the introduction of advanced safety features, (4) applying the total systems approach of the program to the development of new and improved Federal Motor Vehicle Safety Standards (FMVSS), (5) permitting the introduction of safety features into production at the least possible cost through advance planning, (6) opening the possibility of International Motor Vehicle Safety Standards being developed with U.S. participation, and (7) making possible the free exchange of safety technology among automobile firms for the first time in history.

4.1.2 MAD Support Function

The Mathematical Analysis Division is responsible, in part, for developing data used in statistical compilations, accident files, ad hoc studies, reports and program impact.

These activities support the mission of the Office of Accident Investigation and Data Analysis and the general requirements of NHTSA to measure the impact of their priority programs and depict, with adequate precision, the major parameters of the National highway traffic safety picture.

In reporting on the National safety situation, the current practice is to present a statistical compilation of the accidents and injuries occurring in the preceding calendar year, which is typified by the data given in Appendix A of Traffic Safety '72: A Report on Activities Under the Highway Safety Act. This Appendix consists of a collection of 25 figures and 15 tables, which are intended to characterize the essential trends in highway-traffic safety.

4.2 Limitations of Statistical Compilations

4.2.1 Annual Report

The information contained in the Appendix of the annual report focuses principally on the use of death statistics to present the national situation to the almost total exclusion of other important descriptors, e.g., injury-severity levels and accident-exposure criteria. An indication of this proclivity has been developed and reported in the appendix to this study. It was obtained by grouping the data into convenient categories and observing the description it provides. Selecting crash and damage (CD), vehicles (V), driver (D) and environment (E) as the working categories, the counts are as follows:

CD -- 18 figures and 5 tables
V -- 9 figures and 6 tables
D -- 8 figures and 5 tables
E -- 3 figures.

Without exception crash and damage deals exclusively with death rates and counts; the vehicle category presents data on registrations, miles-traveled and travel-speed; the driver data addresses only age, sex and rate of driver population growth and environment deals only with vehicle travel on interstate, primary and secondary road systems. The constituents of these categories are given in detail in the Appendix. Included also are the footnotes to these figures and tables. They are interesting in the sense that they often provide a better statement or summary of what is occurring in the National situation than the figure or table to which they are attached.

4.2.2 Measuring Traffic Safety

Both the absence of a good working definition of highway safety and the complexity of describing accident phenomena are major difficulties in developing safety indicators. The range of interacting factors is so large that no single indicator is comprehensive enough to measure and depict all the features of traffic safety of interest to NHTSA.

The three principal variables, registered-vehicles, registered-drivers and miles-traveled have both good and bad features as indicators.

The good features are as follows: registered-vehicles can be expanded into the important subclassifications which cover the vehicle population by type and by safety system; registered-drivers can be expanded into subclassifications which cover driver characteristics and actions; miles-traveled, although it can only be subclassifed into highway systems, is a dynamic measure of the movement of the vehicle population.

The bad features are as follows: registered-vehicles, although accurately measured through registrations, is a static variable, and there is no sure way of knowing the contribution of vehicle-types to miles-traveled; registered-drivers, although accurately measured by registration is also a static variable and there is no sure way of knowing the contribution of driver behavior to accident causation; miles-traveled are based on various estimating schemes of very poor accuracy and its subclassifications are not directly related to the NHTSA safety programs. Lastly, none of the above address in an explicit way the three major causes of accidents: inattention, speeding and alcohol abuse.

However, when the three variables are combined they cover most of the factors in safety analysis and an advantage is obtained which is not achieved otherwise. The disadvantage of a composite indicator, however, still remains, as it does for all indicators, in that the dynamic interaction of factors leading to an accident or increased exposure to an accident are not captured in a predictive model of accident phenomena. An example of this is given in the note to Figure A-12, Traffic Safety 72: "Weekend crashes (4pm Friday-3am Monday) produce many more fatalities in the evening and early morning hours than do weekday crashes. This is primarily a result of increasee recreational driving on weekend nights and associated use of alcohol." This situation clearly depicts the problem as to how to effectively develop these factors into a useful indicator which characterizes and measures these dynamic interactions. The example shows that driver behavior and habits are interacting with a particular vehicle type under conditions of weekend travel. A model of this situation would only be useful if it could predict the reduction in accidents based on changes in driver behavior, vehicle-safety and the distance traveled. Short of having such a model we seek indicators which will serve to measure these conditions and reflect changes in trends as standards and programs bear on safety patterns.

4.2.3 Fatalities Vis-a-Vis Injury Severity

The statistical compilations in the annual reports[1/] present fatalities or fatality-rates by a variety of variables: vehicle miles, registered drivers, licenses in force, population, and State. These basic variables are presented by both tabular and geographical displays, and in many cases materially enhanced by notes attached to the tables or figures. At best, this is depicting only a part of what is happening with regard to safety aspects on the highway system Nationally. For example, in Appendix A of Traffic Safety '72, information is given on vehicle travel on Interstate Highway Systems, Primary Highway Systems and Secondary Highway Systems,

[1/] Safety '71 and Traffic Safety '72, Vol. 2.

by both urban and rural classifications, yet there is no reporting of fatalities incurred on the separate and respective highway systems. Reporting fatalities by highway system would lead to a better "picture" of the safety aspects of the National system.

Other aspects of highway traffic safety are those relating to injury and property damage. In addition to fatalities and injuries, damage to property is important because of its economic impact. For example, Operations Research Inc. (ORI) in their study[1/] have suggested mortality, injury and property damage (M, M, PD) as the primary variables of an accident. There appears to be no difficulty in accessing numbers of fatalities and extent of property damage, however, there is a question on how to represent levels of injury severity. The representation chosen may be helpful in some contexts and useless in others. In a second study (Wisconsin)[2/] ORI used Fatality, a-Injury, b-Injury c-Injury, and Property Damage[3/] There is some possible source of error because the assessment is made visually bya medically lay person. Examinations by the Office of Systems Analysis of NHTSA of the a, b, c code indicate no consistency of measurement. The sources of error lie in the definitions of the levels of severity, a misunderstanding by the recorder of the data, or a misjudgment in the appearance of the severity of the injury.

For the specific purpose of determining 'societal costs'[4/]due to motor vehicle accidents, the Office of Systems Analysis suggests that in addition to a severity measure based on the nature of the injury, some notion of the permanence of the injury is needed. They have used a breakdown of injuries into three severity groupings:

- permanent total disbility,
- permanent partial disability and permanent disfigurement,
- no permanent disability.

Although the a, b, c code is not sufficient for all program areas within NHTSA and recording data in this system may vary in accuracy, it does serve an essential purpose of providing a practical recording scheme. Its shortcomings could be eliminated to a large degree through a coordinated effort by Federal and State governments to improve severity definitions, compliance, standardization, accuracy and implementation.

4.3 Evaluation Summary

4.3.1 Scope of Present Indicators

At present there is no single, explicit set of indicators for the National Highway Traffic Safety "picture." Indicators which are only partially satisfactory are fatalities per 100-million vehicle miles, fatalities per one hundred-thousand population, deaths per one-hundred thousand registered vehicles (or licensed drivers).

4.3.2 Limitations

The current practice of limiting the reporting of annual statistics of the National highway traffic safety situation to fatalities gives an incomplete picture of the National traffic safety situation.

A more complete picture can be obtained by reporting information on the number of injuries incurred, their severity, and information on motor-vehicle related physical damage. The present manner of reporting fatalities, by a variety of tabular, graphical and word summarizations, is inadequate and should be extended to cover the reporting of injuries and their severities as well.

[1/] Operations Research, Inc.: Development of a Cost Effectiveness System for Evaluating Accident Countermeasures, Dec. 1968, PB 183-440.

[2/] Operations Research Inc.: Development of Highway Safety Statistical Indicators, March 1971. DOT HS-800-472.

[3/] Lower-case letters are used to designate levels of injury-severity throughout this report.

[4/] Societal Costs of Motor Vehicle Accidents, Perliminary Report, April, 1972, NHTSA, DOT

With this additional reporting, NHTSA would be in a position to obtain a gross evaluation of shifts in the national highway traffic safety situation over time, say, for example, from more to less serious types of accidents. Hopefully, this could be associated as an impact of the totality of the NHTSA programs. One should not expect to be able to detect impact of individual programs from this gross level of reporting. To accomplish this will require much more elaborate (detailed) reporting or specialized studies.

A more elaborate scale for the classifications of injury severity (CRIS) is in use by the interdisciplinary accident investigation teams. However, this scale does not appear to be useful for easy classification of injury severity by non-specialists.

We again note that one of the listed main goals of NHTSA is to reduce the number and severity of injuries. Thus there is a requirement that the number of injuries as well as some representation of the severity of injuries be included as indicators of progress toward this major goal.

Another listed goal of NHTSA is to obtain safer travel over farther distances. This calls again for a more reliable determination of vehicle miles and for other indications of "safer travel." One indication of "safer travel" might be a shifting from serious to less severe accidents in each severity category.

In particular, there are several measures which do not appear to contribute to the characterization of the traffic-safety picture.

Traffic deaths per 100,000 population attempts to relate two totally different variables and does not connote the same relationship as in measuring natural deaths by population size. In the latter, deaths from all causes are distributed over the total population, but traffic deaths are only taken from the driving population, and then only from a subset of those who are in motion.

To compare deaths from automobile accidents with other causes of death is beside the point and irrelevant to the general objectives of NHTSA. It further implies, somewhat subtly and indirectly, that to get traffic deaths in line with other causes of death makes it more acceptable and suggests progress toward its control. As long as alcohol abuse, speed and driver inattention remain the principal contributors to accidents, all within control to a large degree, deaths from traffic accidents should not be treated in the same way as other sources of deaths where occurrence and control have entirely different features.

The monthly mileage-death rate seems marginal in utility since it obviously reflects seasonal trends. It has an ultimate value in time series analysis and in depicting some features of the National situation, but it is not a critical measure, and is no better than the mileage estimates on which it is based.

The measure, average free-moving travel speeds, is not currently used as an indicator of anything in particular, except perhaps of a combination of vehicle design and posted-speed factors, which does not imply either safety or hazard unless it is related to other elements in the vehicle-driver-roadway mix. However, the recent lowering of highway speed limits has produced a marked influence on fatalities, which suggests that relating this measure to numbers of deaths or accidents is a more meaningful use of this data than reporting travel speeds in absolute terms.

To summarize: the present emphasis of NHTSA indicators is on mortality relative to a set of psuedo-exposure measures that are either poorly determined (as in the case of vehicle-miles) or non-relevant (as is total population) or not used (average free-moving travel speeds). These indicators provide at best only a partial description of National traffic safety. In addition, the current indicators cannot be used to measure the effectiveness of any particular NHTSA priority program.

4.3.3 Economic Loss as a Measure

4.3.3.1 Introduction

A thorough and intensive examination of economic loss models and their use as a measure of program effectiveness is beyond the scope of this report, but economic loss as used by NHTSA does require that some assessment be made of its application. The annual reports refer to, and imply meaning from, economic cost-benefit analysis as an ultimate summing-up of the impact of highway-traffic accident injuries and deaths upon society. Its simplicity, however, does not imply profundity, and its mechanism does not imply integrity, for the evaluation of economic and societal costs is very complex in structure and scope.

4.3.3.2 Evaluation

Economic loss as a measure of program effectiveness or of the overall highway-traffic picture was rejected on three basic points: (1) it is conceptually inadequate, (2) it introduces wide variances into the problem of measurement, and (3) it does not provide additional information beyond that inherent in the data on which it works.

The evaluation of loss does not go much beyond a cost-accounting and earnings-lost concept, and results in converting the physical and property damage associated with an accident into a dollar value. This value, however, does not necessarily represent an economic loss, and certainly does not qualify as a measure of societal loss. In modelling the impact of accidents, the individual and society must be viewed as receivers and investors, and accidents as unforeseen instruments of financial redistribution.

The mechanics of converting the physical and property damage to a dollar-value introduces the wide range of cost estimates as a variance in the dollar-value output of the model. Any indexes based on this output cannot be used without knowing the character of its distribution, and consequently reduces its usefulness.

Since the economic loss calculation is only a conversion of diverse consequences of an accident to a dollar-value, its function is limited to only a mathematical convenience which fails to add to the information available in the input data. The conversion actually obscures rather than clarifies, for it maps many important details of accident causation and consequences into a common but different coordinate.

As a consequence of these three basic issues, it was decided to forego any use of economic loss models as measures, and assume that the objectives of the study can be obtained more effectively by dealing with the basic accident data directly.

4.3.4 Future Requirements

The description of the National highway traffic situation will become increasingly difficult to obtain by using gross or aggregated indicators. The factors of safety now entail human parameters, vehicle safety systems, sophisticated energy absorbing or distributing devices and elaborate traffic control; each of which is difficult to isolate and measure as a separate component.

The methodology for measuring and evaluating safety features will become more intricate than more simple, more detailed than more gross, and require more data on more descriptors; this will require a greater investment of resources to equip NHTSA for its role and responsibility to measure and report on highway safety.

5.0 ANALYSIS OF PROPOSED IMPROVEMENTS TO CURRENT METHODOLOGY

5.1 Introduction

This section relates the work and investigations on those aspects of current practice where limitations and gaps exist, and where new or improved techniques are needed for developing descriptors for measuring National highway traffic safety. These investigations address exposure measures, statistical regions, and structures for descriptor identification for certain levels of measurement and reporting requirements. Special attention is given to descriptors possessing double utility as measures of the National situation and sensing changes brought about by the vehicle and traffic safety priority programs on NHTSA.

5.1.1 Scope of Proposed Improvements

The proposed improvements to the current practice of measuring and reporting on highway-traffic safety are presented in the following sections on safety measures, statistical regions and graduated descriptor arrays.

The current practice of representing exposure by vehicle-miles[1/] traveled or registered vehicles can be improved by the addition of two new measures: accidents per vehicle-year and injury-severity level per accident. These measures relate driver safety more closely to the parameters of accident phenomena and to the performance of the vehicle in protecting occupants after an accident has occurred. These rates shift the emphasis of measurement from fatalities to injury-severity, and from crash damage to accident potential.

The concept of using statistical regions in the place of nationwide data collection is introduced to gain three principal advantages: (1) to obtain a surrogate data-base representing the National situation, (2) to reduce the amount of data needed for projections and estimates, and (3) to serve as locales for concentrated program intensity.

The surrogate data-base would provide a sampling source on the National situation, would be more responsive to reporting requirements because of the smaller number of units, and would provide more consistent and reliable data because of the size and concentration of the effort. Three or four such regions could cover on the order of 50-60% of total fatalities. Data would still be gathered from all 50 States, but policy and program decisions would be based on regional data and activities. Programs, such as the alcohol abuse project (ASAP), would enjoy a higher level of effectiveness if they were concentrated in such regions. An advantage is obtained from covering a larger area, and having more data on which to base evaluations.

In order to measure and report more effectively on the traffic picture, it is necessary to improve on current practices by developing a more sophisticated description of accident data. The approach taken to achieve this was to define sets of descriptors, each set possessing a level of capability to describe accident phenomena, and then to organize these sets from the lowest required level to the highest desired level. This provides a progression of sophistication and relates the level to the NHTSA requirements for measuring and reporting. Each set, or array, is evaluated on its capability, its implementation requirements and its time horizon. Capability is judged on the basis of two criteria: depiction of the National situation, and sensitivity to changes in that depiction brought about by NHTSA priority programs in vehicle and traffic safety standards and design improvements.

5.2 Safety Measures

5.2.1 Difficulties

Although it is one of the basic variables in the depiction of accident phenomena, vehicle-miles traveled has not been completely satisfactory as a measure of safety.

The difficulties are in getting good estimates of miles traveled from the States, whose methods vary (usually based on gasoline sales tax revenue, traffic counts or formula extrapolation) and in the wide variety of highway, turnpike, road and street types, urban and rural. Further, vehicle-miles traveled is not directly related to the three major causes of accidents: speed,

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[1/] Vechicle-miles traveled is retained in this discussion in the event NHTSA prefers it for reasons of tradition and precedence.

alcohol and inattention. It is probably true that most miles traveled are done so safely; it is more likely that the factors leading to an accident are of a particular kind, are not totally random, and occur with a greater probability in certain conditions than in others. On this basis, deaths per vehicle-miles traveled is not a good model for measuring program goals or representing the critical features of traffic safety. Consequently, rates or trends based on the use of vehicle-miles traveled may be highly imprecise and not reflect the inherent factors of accident causation or potential. Exposure is difficult to quantify because it is essentially a non-event; it is rather an expression for the probability that a breakdown will occur in a driver-vehicle-roadway scenario which results in an accident. Exposure is constantly present, but it's materialization into an accident is dependent on many factors not reflected in the simplifying vehicle-miles-traveled variable.

Even if these difficulties could be resolved, the value of using vehicle-miles-traveled is likely to lessen in the future because as cars become safer, and more miles are traveled by more people, the rates per vehicle-miles traveled will decrease. This may divert attention from statistics on factors regarding deaths and injury-severity. Because of the type of motor vehicle and traffic safety programs, the emphasis on measuring safety is likely to shift to evaluations of occupant protection and away from aggregated estimates using miles-traveled.

5.2.2 Candidate Measures

In the following analysis registered-vehicles is used as the basic variable in the formulation because it is accurately measurable and can be subclassified into descriptors which reflect the major objectives of NHTSA safety programs. The results of the analysis may be expressed in terms of vehicle-miles or registered-drivers just as well as by registered-vehicles. An evaluation of national safety using all three, further classified by road system, would present a comprehensive over-view of the major factors in traffic safety analysis. The accuracies of these three variables are not comparable however, but among them their combined subclassifications would cover most of the primary and secondary attributes of interest. The principal superiority which registered-vehicles has over the other two is an advantage of a qualitative nature, which is important to measuring program impact, and lies in the relationship the variable has with the NHTSA priority programs. Changes in vehicular safety design brought about by NHTSA programs will alter the attributes of the automobile population for which the number of registered-vehicles stands as a measure. This permits the use of registered-vehicles in a dual role - to characterize traffic safety and to reflect changes in vehicle design. The former involves counts and distributions, the latter involves descriptors of vehicular attributes for refined presentations of characteristics of the automobile population. This latter advantage is unique among the candidates for measuring traffic safety.

As alternatives to the current practice of representing traffic safety, four measures, days-lost, injury-severity per vehicle-year, injury-severity per accident and injury severity per registered-driver are developed in terms of their attributes and value as formulations of traffic safety and measures of program impact.

5.2.2.1 Days Lost

We define days-lost as the number of productive days which are lost to society because of injury or death. The loss includes days spent away from work under medical care, rehabilitation, or disability, and in the case of death, an estimate of expected balance of days-of-labor not realized. The estimation of days-lost would be modelled in much the same way as economic loss with the important difference lying in the conversion of injury or death to days-lost instead of a dollar value. It has the advantage of being sensitive to motor vehicle and traffic safety programs because it is directly dependent on the medical consequences of injuries sustained, and may be expressed in terms of severity levels, if such an order of resolution is desired. It has a serious disadvantage, however, similar to the cost variability noted in economic loss models in that the number of days-lost could depend on many factors other than the type and degree of injury. This situation precludes the use of days-lost as a preferred indicator despite the advantage cited above. It has been included, however, for completeness, as a possible measure comparable to economic loss but less desirable than the injury-severity per vehicle-year or injury-severity per accident.

5.2.2.2 Injury-Severity per Vehicle-Year

A second alternative is to measure safety as a function of injury-severity and vehicles. This formulation provides a measure based on the driver's exposure to accident, and deals directly with factors not used in current practice. It has the advantage of being formulated without using vehicle-miles traveled, but both derivations are given should NHTSA prefer one to the other for reasons of precedence or content.

The following formulation, proposed as a measure for traffic safety, is based upon the following variables: (1) number of accidents, A, (2) the number of registered-vehicles, V, and (3) the number of injuries per accident by severity class "x" (where "x" stands for either a, b, c), I_x/A.

The driver is essentially concerned with his risk when he travels, so the first value to compute toward this total risk is accidents per vehicle per year which is A/V. His exposure to injury over, say one year, is then given by where "x" is an index of the set of severity

$$H_x = \left(\frac{A}{V}\right)\left(\frac{I_x}{A}\right) = \frac{I_x}{V} \qquad (1)$$

levels. We have expressed two concepts of exposure, one is the accidents per vehicle per year and the other is injury-severity, by class, per vehicle per year. The same equation can be derived as follows: Introduce vehicle-miles-traveled, M, and average miles per vehicle per year, $\frac{M}{V}$; then compute

$$\left(\frac{A}{M}\right)\left(\frac{M}{V}\right) = P \text{ (accidents per vehicle-year)} \qquad (2)$$

and finally

$$\left(\frac{I_x}{A}\right)P = H_x \text{ (injury-severity per vehicle-year)} \qquad (3)$$

Let us now see what this formulation provides in the way of insight and information, which is not given by current measures, on the National situation and the impact of vehicle and safety programs.

Table 1 gives basic data from the State of Michigan from 1964 through 1972, which we shall use for the application of the above proposed measure of safety.

Table 1 - State of Michigan Accident Data, 1964-72

Year	# Killed	# Injured	# Injured, By Severity		
			a	b	c
64	2120	144,623	42,683	35,979	65,961
65	2129	155,258	46,102	37,864	71,292
66	2296	156,694	48,133	38,446	70,115
67	2123	151,297	44,219	36,026	71,052
68	2388	160,413	48,968	38,507	72,938
69	2487	175,400	51,700	40,620	83,080
70	2177	161,719	45,426	37,193	79,100
71	2152	157,664	30,888	42,131	84,645
72	2258	178,929	28,663	49,010	101,256

Using 1964 as a base-year, we construct indexes for Table 1, given in Table 2.

Table 2 - Index Representation, State of Michigan

Year	# Killed	# Injured	# Injured, By Severity		
			a	b	c
64	1.000	1.000	1.000	1.000	1.000
65	1.004	1.074	1.080	1.052	1.081
66	1.083	1.083	1.128	1.069	1.063
67	1.001	1.046	1.036	1.001	1.077
68	1.126	1.109	1.147	1.070	1.106
69	1.173	1.213	1.211	1.129	1.260
70	1.027	1.118	1.064	1.034	1.199
71	1.015	1.090	.724	1.171	1.283
72	1.065	1.237	.672	1.362	1.535

Table 3 provides additional data needed to develop the analysis.

Table 3 - Accident, Vehicle, and Movement Data,
State of Michigan, 1964-72

Year	Average Miles Traveled per Vehicle per year, $\bar{M}$	Vehicle-Miles Traveled per Year, M	Number of Registered Vehicles, V	Total No. Accidents A
64	9,647	38.3×10^9	3970×10^3	284,444
65	10,248	40.9	3991	310,598
66	10,910	43.9	4024	302,880
67	10,912	45.1	4133	299,004
68	11,142	48.1	4317	305,495
69	11,341	50.9	4488	331,223
70	11,644	53.2	4569	313,715
71	11,709	55.5	4740	314,015
72	11,740	58.1	4949	359,745

We now calculate equation (1) and give the results expressed as indexes in Tables 4 and 5.

Table 4 - Injury-Severity Level per Accident, 1964-72

Year	Severity Level - a per Accident		Severity Level - b per Accident		Severity Level - c per Accident	
	Value	Index	Value	Index	Value	Index
64	.150	1.000	.126	1.000	.232	1.000
65	.148	.989	.122	.964	.230	.990
66	.159	1.059	.127	1.004	.231	.998
67	.148	.989	.120	.953	.238	1.025
68	.160	1.068	.126	1.000	.239	1.030
69	.156	1.040	.123	.970	.251	1.082
70	.145	.965	.119	.937	.252	1.087
71	.098	.656	.134	1.061	.270	1.162
72	.080	.531	.136	1.077	.281	1.214

NOTE: Values have been rounded to three places from six.

Table 5 - Exposure Indexes, 1964-72

Year	H_a	H_b	H_c	H_k
64	1.000	1.000	1.000	1.000
65	1.010	.985	1.012	.942
66	.994	.943	.937	.955
67	.890	.861	.926	.861
68	.932	.870	.899	.916
69	.944	.881	.982	.915
70	.807	.783	.909	.778
71	.532	.862	.944	.746
72	.480	.974	1.097	.761

In order to draw contrasts among these formulations it is of interest to examine the amount of information in equation (2), which measures safety as the number of accidents per vehicle per year. This calculation is given in Table 6.

Table 6 - Accidents per Vehicle - Year, State of Michigan, 1964-72

Year	A/M	$\overline{M}$	$P = \left(\frac{\overline{M}}{M}\right) A$
64	7.43×10^{-6}	9,647	71.7×10^{-3}
65	7.59	10,248	77.8
66	6.90	10,910	75.3
67	6.63	10,912	72.3
68	6.35	11.142	70.8
69	6.51	11,341	73.8
70	5.90	11,644	68.7
71	5.66	11,709	66.3
72	6.19	11,740	72.7

The driver's safety is now given as the number of accidents per thousand miles of travel and we can see by Table 6 there has been little change since 1964.

So despite the decline in exposure as given by A/M the increase in $\overline{M}$ offsets this trend. This information is better than that provided by current practice, but not as useful or descriptive as that given by equation (3) where injury-severity is introduced.

In sum, this formulation of safety uses injury-severity, by class per vehicle-year, as an indicator for both the national situation and sensing changes brought about by the impact of vehicle and traffic safety programs. The data of Table 5 are plotted in Figure 1. The lines follow a closely grouped downward trend until 1970 when something of a major impact occurred. After 1970, fatalities remained steady but the spread in injury-severity diverged by large amounts. It follows, for whatever the causes of the change in our example data, that the exposure to injury or death is better portrayed when separated into its components. This separation provides information on the relative frequencies and trends of injury severity, and the shifts in these distributions. This concept can be enlarged to include more descriptors of driver, vehicles and highway variables, making the method applicable for program impact as well as depicting the National situation. As Figure 1 shows, an indicator based on H_K alone would give only a partial account of the situation.

5.2.2.3 Injury-Severity Per Accident

This measure was computed as a part of our analysis above and is given in Table 4. These values permit an evaluation of injury production on a per-accident basis. As such, they include such factors as driving habits, driver conditions, vehicle safety design and occupant protection systems. At this level of measure these factors are not separable, as they are not for the injury-severity per vehicle-year measure. They do permit the inclusion of the additional dimension of accident-injury trends. These, with the other indexes of safety measured on the basis of injury-severity related to movement, provide at least, when coupled with current practices, an improved characterization of the National situation with potential for extension to cover program parameters.

5.2.2.4 Injury-severity per Registered-Driver (per year)

As a measure injury-severity per registered-driver year serves as an extension of the other measures by virtue of the additional descriptors which can be made by subclassification of driver attributes. Since the major causes of accidents are more closely related to driver

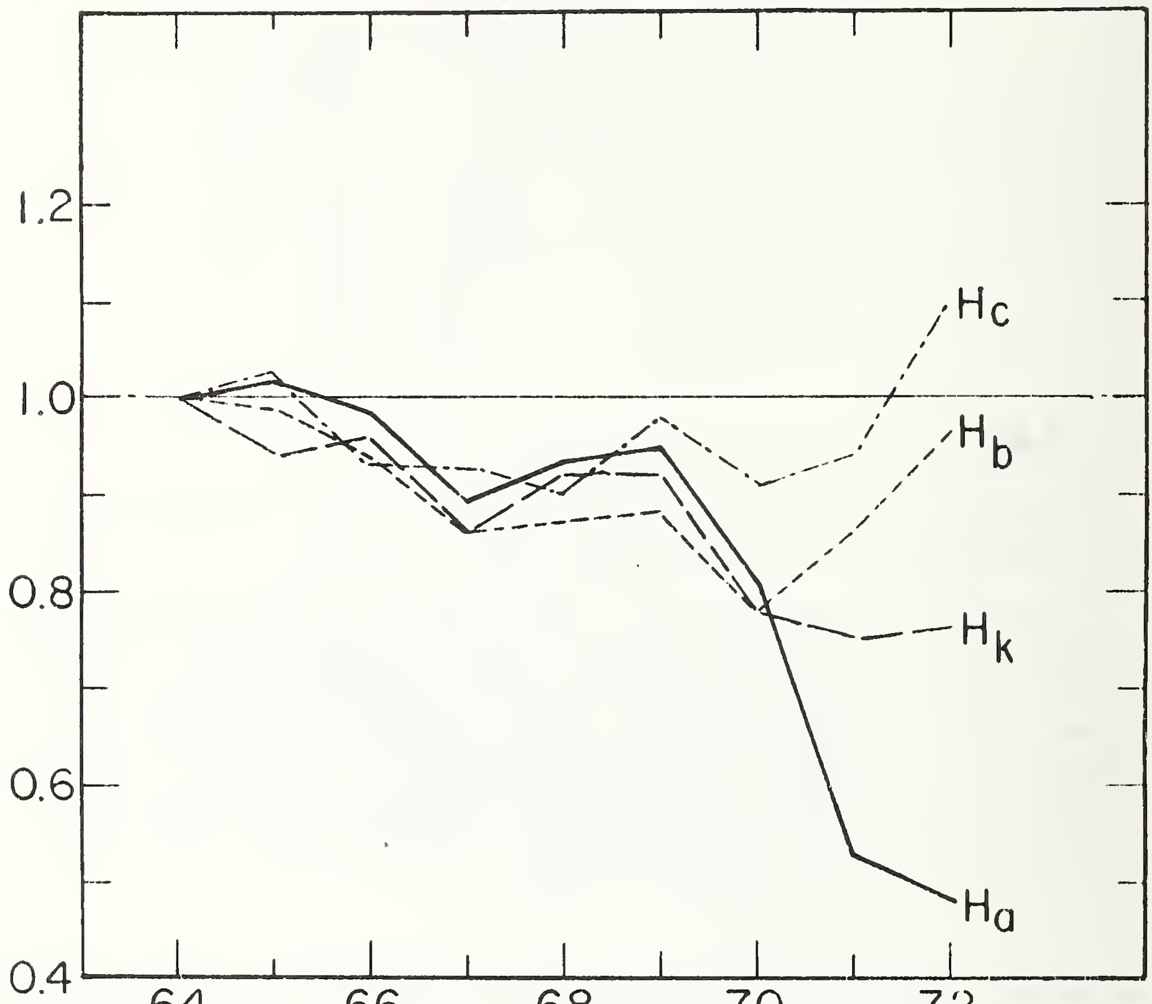

FIGURE 1 INJURY SEVERITY INDEXES

(STATE OF MICHIGAN, 1964-72)

habits or behavior than to the registered-vehicles or vehicle-miles variables, this measure is an important dimension in accident analysis.

In the analysis of Section 5.2.2.2, registered-drivers may be used instead of vehicles and a similar index would result. However, the principal contribution of this measure to analysis is in its subclassifications and their contribution in depicting safety features. Figure A-6, Traffic Safety '72, shows that the ratio, drivers/RV, has a linear, but declining relationship. In 1950 the ratio was 1.25 and in 1971 it was unity. This means that for some kinds of analyses we need only deal with registered-vehicles. But as a principal coordinate in the vehicle-driver-highway mix and the sophisticated safety programs dealing with vehicle safety systems and driver-alcohol and driver-training programs, the registered-driver should be studied at the same level of detail as other measures.

Post accident statistics are essential to the success of index measurements. The two aspects of this phase of accident analyses are the performance of the safety system under the conditions of driver behavior and the extent of injury as a function of driver condition and attributes. These factors interact in the sense of trade-offs between reasonable behavior and reasonable levels of safety equipment to achieve designs and standards for safe driving. Because of these conditions NHTSA safety programs are likely to be evaluated in terms of impact of design-behavior interactions. Consequently measures of driver attributes will increase in importance.

5.2.2.5 Summary

Four measures of safety have been proposed to supplement and extend the current measures of the National traffic picture. If these indicators are refined to include appropriate subclassification of their attributes and supported by the requirements for data collection, they possess the potential for measuring operational impacts of vehicle and traffic safety programs, and provide a basis for depicting national trends. They may be viewed as the principal dimensions for developing different facets of the total picture of traffic safety.

In the driver-vehicle-highway mix the subclassifications of registered-drivers, registered-vehicles and highway systems combine to cover the major indicators of program impact and analysis of trends.

5.3 Statistics Based on Regional Data

5.3.1 Regional Data Base

Since a few States experience a large number of accidents the premise that a sub-set of the forty-eight Continental states could provide data for indicators was studied with very interesting results.

For the period 1965-71 (7 years) the ten States highest in deaths were ranked for each year. These sets, one for each year, had a very stable membership with virtually no significant change over the seven-year period. There were a few displacements of position (but never more than a switching), and only in the second year was there any bumping from the list (and this occurred at the bottom). Table 7 presents these sets by year and rank.

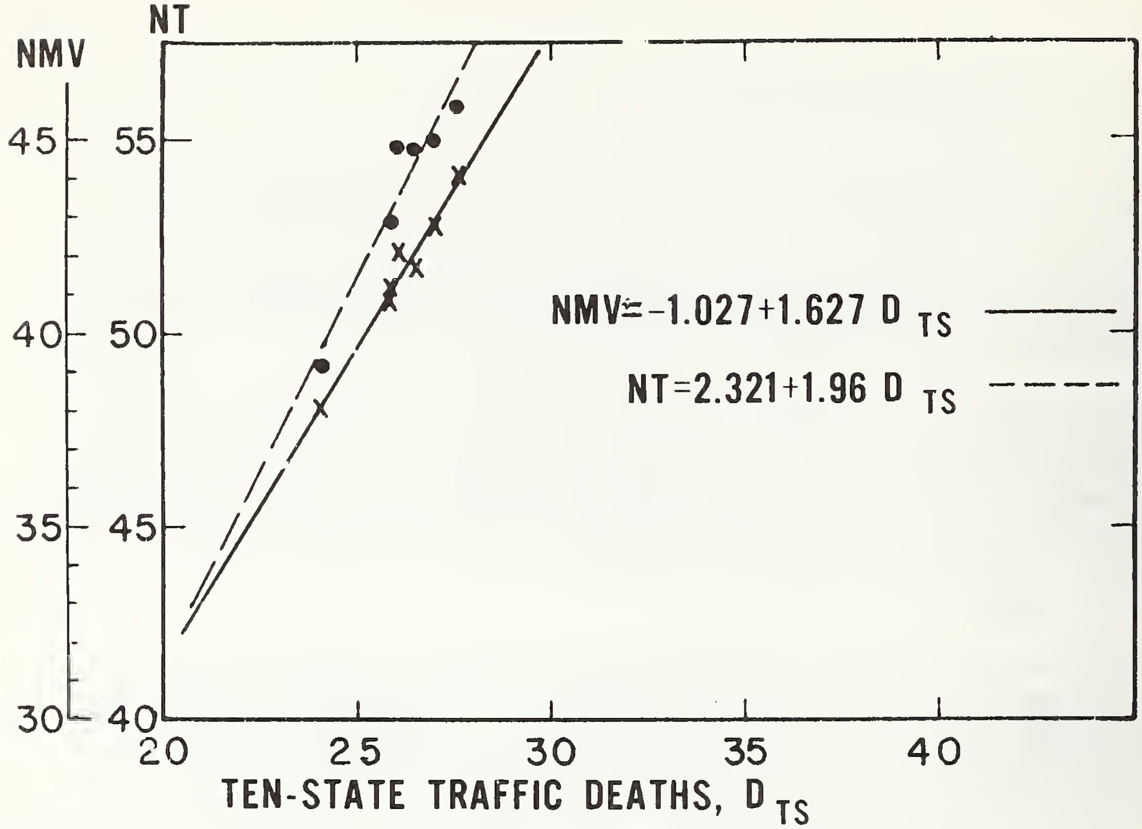

FIGURE 2 REGRESSIONS ON NATIONAL & TEN STATE TRAFFIC DEATHS

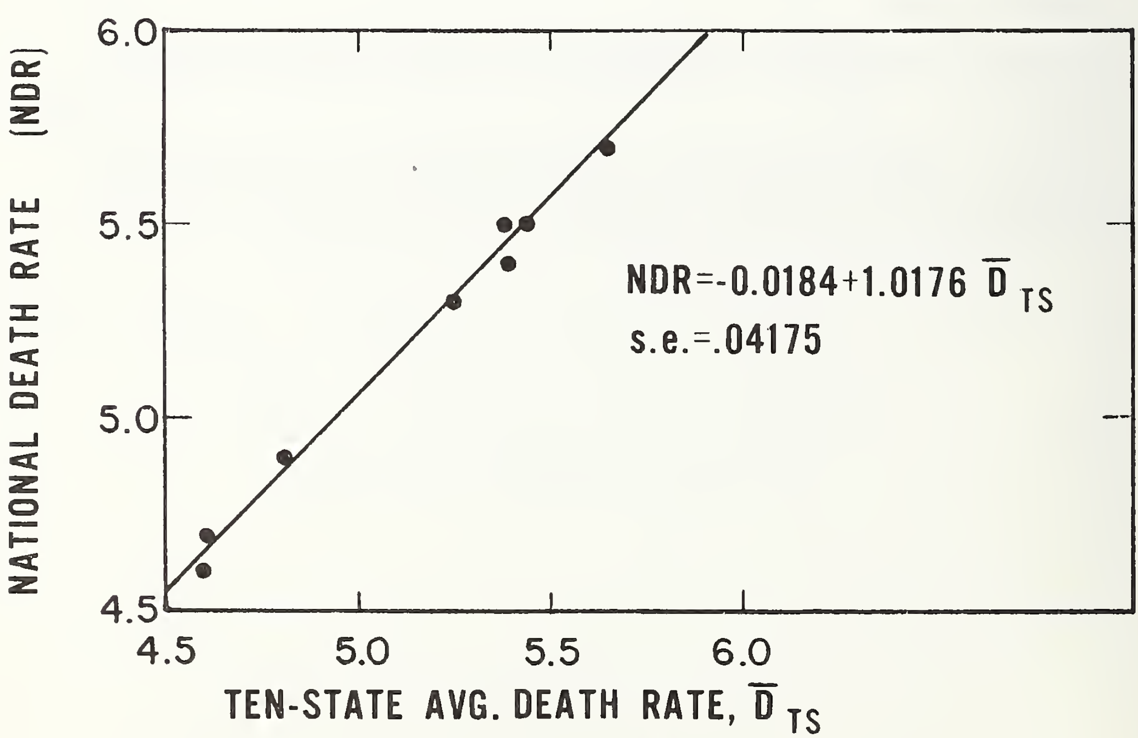

FIGURE 3 REGRESSION ON NATIONAL & TEN STATE TRAFFIC DEATH RATES

Table 7 - Ten State Ranking, by Traffic Deaths; 1965-71

Rank	1965	1966	1967	1968	1969	1970	1971
1	California	California	California	California	California	California	California
2	Texas	Texas	Texas	Texas	Texas	Texas	Texas
3	New York	New York	New York	New York	New York	New York	New York
4	Ohio	Ohio	Ohio	Ohio	Ohio	Ohio	Illinois
5	Illinois	Illinois	Illinois	Illinois	Illinois	Illinois	Ohio
6	Michigan	Michigan	Penn.	Penn.	Michigan	Penn.	Florida
7	Penn.	Penn.	Michigan	Michigan	Penn.	Michigan	Penn.
8	Florida	Florida	Florida	Florida	Florida	Florida	Michigan
9	N. Carolina	N. Carolina	N. Carolina	N. Carolina	N. Carolina	Georgia	N. Carolina
10	Indiana	Georgia	Georgia	Georgia	Georgia	N. Carolina	Georgia

In order for the ten-State data to serve as a surrogate it must be shown to be representative of the National data. The analyses supporting the suggestion are given in Table 8 and Figures 2 and 3.

Table 8 shows a comparison of the product-moment correlations of deaths(D) with deaths per 100-million vehicle units ($D/10^8M$), deaths with registered vehicles (RV), and deaths per 100-million vehicle miles with deaths per ten-thousand registered vehicles ($D/10^4V$), for the ten-State and National data.

Table 8: Correlation Analysis of State Groupings, 1971

Variables	Ten-State	National
$D \sim D/10^8M$	-.38	-.10
$D \sim RV$	.91	.97
$D/10^8M \sim D/10^4V$	.95	.89

Figures 2 and 3 provide additional graphical information on the relationship between the ten-State data and the National data. The data are plotted as coordinate pairs for each year of the period taken in the analysis.

In Figure 2 are the linear regressions of the ten-State total deaths (D_{TS}) versus the National motor-vehicle-deaths- only (NMV) and the National total traffic deaths (NT). The coefficient of correlation between NT and D_{TS} is .96 over the seven year period of the data.

Figure 3 shows the regression for the ten-State death-rate average with the National death rate (deaths per 100 million vehicle miles) over the period '65-'72. The correlation is .99 with a standard error (s.e.) of .04175.

These results suggest the following relationships. Table 8 shows that the two death-rates are strongly correlated but that deaths correlates strongly with registered-vehicles. Since the ten-State data is embedded in the National data the influence of the balance of the States is clearly defined. For the first pair of variables they have a neutralizing effect, for the second a supportive effect and a slight degrading effect on the third. Figure 2 shows the strong linear relationship between the ten-State numbers of deaths and the National numbers of deaths by NMV and NT. The fit with NMV is particular good, which is advantageous to measuring traffic safety since the deaths and injuries associated with motor-vehicles-only are precisely those at which the NHTSA programs are primarily aimed. Figure 3 shows the remarkably good fit between the National death-rate and the average death-rate of the ten-State data. The regression is exceedingly tight with a very small standard error and the slope is very close to unity. Also, the correction term in the regression is quite small.

These relationships suggest the following conclusions. First, death rates tend to be weakly and negatively correlated with numbers of deaths. This implies that death rates are a poor measure of traffic safety at either the state or National level and high numbers of deaths do not necessarily imply high death rates. The importance of this information is that low death rates may mask safety problems which should receive attention. Second, the ten-State data represents the National situation in death-rates, in motor-vehicle-only deaths and between numbers of deaths and registered-vehicles. Third, the death-rates of the ten-States are distributed in the National death-rate data in such a way as to have a lesser range than the National data but have a close approximation to the average of the national death-rate distribution. The weak negative correlation of deaths with death-rate in Table 8, suggests that the ten-State death rates tend to be slightly lower than the death-rates associated with the balance of the States in the National data. It appears that death rates in general are not by themselves reliable measures because they fail to correlate significantly with numbers of deaths.

These results indicate that the ten-State set may be considered as a potential source for projections and estimates of National trends.

Unfortunately, these ten States (Table 7) do not divide well into regions. California stands alone; New York and Pennsylvania are contiguous; Ohio, Michigan and Illinois group well, and Georgia and Florida also make a region. But Texas and North Carolina are isolated, as is California, making it difficult to identify naturally occurring regions which experience a high rate of accidents. North Carolina could be dropped without hurting the statistics since it ranked no higher than ninth (reference Table 7), but Texas, ranking second throughout, should be retained. This would provide five regions: I - California, II - Texas, III - New York and Pennsylvania, IV - Ohio, Michigan and Illinois, and V - Georgia and Florida. All of these States, except Ohio and Pennsylvania, now report injury-severity data in the a, b, c code. If contracts or arrangements could be made with these two States to respond also with a, b, c code, this nine-State data set may have the potential as a data surrogate. A follow-on Phase II of this study, if approved, would examine the potential of this concept and identify its capability to fulfill what appears to be its promise.

Another possible advantage of the regional approach to data collection would be to establish ASAP's[1/] in these regions on a widespread basis. This might improve the sampling base for the evaluation of the program with other vehicle and traffic safety programs in the region. It probably would permit a greater effectiveness of the ASAP since it would now apply to the region rather than to a city or county, and would gain higher visibility with the public.

5.3.2 Evaluation of State-Level Death Rates

In 1971 Nevada had a death rate of 7.3 per 100-million vehicle miles traveled, while California had only 3.9. However, the actual number of deaths in Nevada was 275, while California had 4,777 deaths, a factor of 18 times as great. This suggests that variables other than vehicle-miles traveled should be used to quantify the accident-situation at the State level. Note also the negative or weak correlations given in Table 8 between traffic deaths and traffic death rates. If priorities of funding, resource allocation, or programs were based on mileage death rates only, then, as suggested by the California and Nevada data, inappropriate decisions might result.

Since accidents arise from a complex of factors, often masked by measures based on aggregation, the most effective measures are those which use the essential descriptors of a given situation, are based on an examination of causes of perceived differences between similar conditions, and include a determination of differences derived from the circumstances and specifics contributing to accident phenomena. Rate measurements at the State level are more sensitive to variations in data than identical measurements at the National level, so the integrity of the measurement is correspondingly more critical if it is to be of any use at either level.

[1/] Alcohol Safety Action Projects.

5.3.3 Review of ASAP Effort

As a result of studying the operations and functions of the ASAP program[1/] there appeared to be two aspects of measuring program effectiveness which might be helped by locating ASAP centers within the aforementioned statistical regions. Although the evaluation of program effectiveness examined the residual component in the time-series data, it appears that when the number of fatalities is small in each of the few ASAP groups the residual component does not survive the significance tests. The inherent random error of several, or many isolated and diversely located, data sources is going to be greater than the random error associated with closely grouped data sources, integrated and coordinated within a specified region.

The second aspect of obtaining and measuring effectiveness deals with combining data from isolated and diversely located ASAPs as opposed to data derived on a regional basis. In the former the county and city conditions are likely to vary considerably from location to location, but in the latter, whatever conditions do prevail are consistent for all ASAPs located in the region. This results in the data being more consistent with respect to externalities and more free from the influence of aggregated random error.

5.4 Descriptor Requirements

5.4.1 Objective

In order to develop a scheme or structure for obtaining indicators having the properties we desire, and have stated above it is necessary that the variables selected possess these properties. In addition, these variables should be capable of extended definition into sub-classes, and be measurable and reportable within the context of current practice for data collection.

5.4.2 Variable Selection

The highway-traffic safety activities are organized by categories which are defined by classes of information. The classes may be further divided into subclasses according to the level of complexity and detail desired. The classes and sub-classes become the variables, or descriptors, of the structure; the structure determines the level of detail.

5.4.3 Categories

The highway traffic accident situation is characterized by five major areas: (1) driver, (2) vehicle, (3) environment, (4) accident factors, and (5) injury-severity (includes fatalities). The coverage of each category is determined by the number and type of classes it contains, similarly with subclasses per class. A structure is determined, then, by the quantity and quality of subclasses or classes in the amount of descriptive detail they provide.

5.4.4 Levels of Description

A <u>level</u> is defined as a particular set of descriptors, organized by category, class and subclass, which provides a capability of characterizing accident phenomena. The levels discussed below are focussed principally on the major variables of the driver-vehicle-roadway system. The omission of descriptors for pedestrian accidents and non-vehicle accidents is acknowledged (Levels 3 and 4, do, however, include pedestrians). It is assumed that the currently developed statistics on these, and other secondary features, will be continued as they are, and that any improvement contained in the following levels of descriptive capability that apply to these areas of accidents will be developed and used accordingly.

A first level of description should be no less than that provided by current practice and should be considered a necessary and basic structure upon which more complex structures may be developed. Several levels are constructed below which form a graduated capability for depicting the national traffic safety picture.

[1/] DOT/NHTSA, "Alcohol Safety Action Projects," 1973 Annual Report, Vol. 1, Summary.

Level 1 Descriptor Array

Category	Class	Subclass
Driver	Age Sex	Male Female
Vehicle	Body type	Regular Compact
Environment	Urban Roadway Rural Roadway	I-System I-System
Accident Factors	Manner of Collision Speed Property Damage # of Occupants	Head-on Side Rear-end
Injury Severity	# of Deaths # Injured # Non-injured	

Level 1 provides a necessary minimum of information, and extends current practice only by its inclusion of the number of injured and non-injured in the injury-severity category. This extension, and level 1 in general, does not begin to approach the degree of response desired for program impact or depicting the National traffic picture.

Level 2 provides a considerable advance over Level 1. The Injury-Severity category has been enlarged to include the coded severity levels, the Accident Factors category is more detailed and the Environment category has been augmented by additional detail. Level 2 is not yet sufficient, however, in terms of descriptors which would be sensitive to vehicle and safety programs. For this purpose the Vehicle and Accident Factors categories need additional classes and subclasses. These additions are the basis for the Level 3 capability.

Level 2 Descriptor Array

Category	Class	Subclass
Driver	Age	Over 60 25-59 Under 25
	Sex	Male Female
	Training	None High School Commercial
Vehicle	Body Type	Compact Regular Camper Small Car
	Year	
Environment	Urban Roadway	I-System Freeways
	Rural Roadway	I-System Turnpikes
	Day of Week	Weekday Weekend
	Time	Daylight A.M. Daylight P.M. Night A.M. Night P.M.

Level 2 Descriptor Array (Continued)

Category	Class	Subclass
Accident Factors	Manner of Collision	Head-on Side Rear-end Overturned Struck fixed-object
	Speed	Above posted limit. At posted limit. Under Posted limit.
	Property Damage	
	Number of Occupants	Adults Children
Injury Severity	Number of Deaths Number of Injured Number of Non-injured	K a level b level c level 0 level

Level 3 Descriptor Array

Category	Class	Subclass
Driver	Age	Over 60 25-59 Under 25
	Sex	Male Female
	Training	None Driver Education (H.S.) Commercial
Vehicle	Body Type	2-Door Hardtop 2-Door Sedan 4-Door Hardtop 4-Door Sedan Station Wagon Convertible, Clothtop

Level 3 Descriptor Array (Continued)

Category	Class	Subclass
Vehicle	Body Type	Convertible, Metal Top Van Recreational Small Car (VW, etc.) Compact
	Year	
	Model (Safety System)	None 1 Point (seat) 2 Point (seat and shoulder) 3 Point (seat and shoulder) 4 Point (seat and shoulder) Mod 4 point Air Bag Energy Absorbing Steering Col. Dash padding Bumper Telescoping Device
Environment	Urban Roadways	I-System Freeways Primary Residential
	Rural Roadways	I-System Turnpikes Two and Three lane State Rural
	Month	Weekday Weekend
	Time	Daylight A.M. Daylight P.M. Night A.M. Night P.M.
	Posted Speed	Under 25 M.P.H. 30-40 M.P.H. 50-55 M.P.H. 60 M.P.H. Over 60 M.P.H.

Level 3 Descriptor Array (Continued)

Category	Class	Subclass
Accident Factors	Manner of Collision	• Head-on • Side • Rear • Overturned • Struck fixed object.
	Speed	• Above posted speed • At posted speed. • Under posted speed.
	Driver Condition	BAC ≥ .10 DAC Inattention None Restraint
	Property Damage	
Injury Severity	Number of Occupants	Adults Children
	Number of Pedestrians	
	Occupants Number of Deaths Number of Injured Number of Non-injured	 K a level b level c level 0 level
	Pedestrians Number of Deaths Number of Injured Number of Non-injured	 K a level b level c level 0 level

The highest level of capability is shown as Level 4, and it is identical to Level 3 in all categories except the last, Injury Severity, which is shown here.

Level 4 Descriptor Array

Category	Class	Subclass
Driver	(Same as Level 3)	(Same as Level 3)
Vehicle	(Same as Level 3)	(Same as Level 3)
Environment	(Same as Level 3)	(Same as Level 3)
Accident Factors	(Same as Level 3)	(Same as Level 3)
Injury Severity	Occupants	
	Number of Deaths	K_1 (immediate injuries)
		K_2 (within 24 hours)
		K_3 (immediate fire)
	Number of Injured	a level (critical)
		b_1 (moderate)
		b_2 (Severe)
		b_3 (serious)
		c level (minor)
	Number on Non-injured	0
	Pedestrians*	
	Number of Deaths	K
	Number of Injured	a level
		b level
		c level
	Number on Non-injured	0 level

*To be consistent the pedestrian injury-severity subclasses should be the same as for the motor-vehicle occupants, but it is not mandatory since the intent of the measurement is not the same in both cases.

5.4.5 Evaluation of Levels of Description

It is possible to construct a large number of levels of descriptor arrays by combining the category classes and subclasses from different levels. Our evaluation will be only on the four levels presented above, however. Each level is judged on capability and fulfillment of basic objectives, requirements for implementation, data collection specifications and requirements, and the length of time for development of the level as an operational tool. With respect to this evaluation the basic objectives to be satisfied are: (1) that descriptors be capable of depicting the National traffic safety situation, (2) that selected descriptors have the capability of sensing changes in the National situation brought about by standards and designs derived from NHTSA vehicle and safety programs, (3) selected descriptors have the property of division into subclasses to cover details of interest in the important areas of occupant-packaging systems, injury-severity levels, human parameters, and factors contributing to accident causation, and (4) fulfilling a basic need to measure, via indicators, appropriate specific programs for achieving NHTSA goals of accident avoidance and injury reduction.

5.4.5.1 Level 1 Evaluation

Level 1 consists of twelve classes and nine subclasses, and essentially represents current practice except for the inclusion of two levels of injury severity not presently used in describing the National situation. The evaluation is as follows:

Capability. Equivalent to current practice but extends the emphasis beyond fatalities to include a gross indication of numbers of injured and non-injured.

Objectives. Level 1 is too aggregated to satisfy all of the desired objectives, and certainly does not meet objectives (2), (3) and (4).

Implementation. The only change from current practice is to include the number of injured and non-injured in current statistical compilations. This should require no additional cost to NHTSA and appears immediately obtainable and reportable.

Data Requirements. The data is readily available from all reporting States, and from the data collection system which feeds the SAFE[1/] and FAF[2/] data bases.

Time Horizon. Immediately implementable.

5.4.5.2 Level 2 Evaluation

Level 2 consists of sixteen classes and 36 subclasses, and represents a considerable advance over Level 1. The evaluation is as follows:

Capability. Level 2 contains all of the essential variables needed to provide a good picture of the National situation. The principal advances are in reporting injury-severity in five subclasses, the inclusion of roadway types and the vehicle body-type. If the vehicle safety system is related to injury-severity as an index a new dimension of the National picture should emerge.

Objectives. Level 2 satisfies (1), partially satisfies (2) and (3), but does not fully meet the intent of (4).

Implementation. Some planning and investment are necessary to obtain the data for injury-severity and the speed descriptor. These are available from both the SAFE and FAF reporting forms. Most States provide some information on speeds and all but 15 States now report injury-severity appropriate for Level 2 description. It is desirable to have full participation, so it becomes necessary to get all States up to standard for reporting this data, and in some cases, getting States to start recording at this level of detail on injury levels and accident factors.

Data Requirements. In principal all of the data for Level 2 is accounted for by the SAFE and FAF reporting systems. So no additional requirements are necessary.

Time Horizon. The structure of Level 2 lends itself to an early implementation only if the gaps in data collection from States not reporting on injury severity and accident factors can be filled quickly. If less than 100% reporting is acceptable, Level 2 can be implemented very quickly, otherwise a 6-month to one-year delay should be expected.

5.4.5.3 Level 3 Evaluation

Level 3 consists of 23 classes and 73 subclasses, and attempts to obtain a level of description which begins to reach toward measuring the NHTSA vehicle and traffic safety programs. The evaluation is as follows:

Capability. Level 3 provides for descriptions and measures of driver education, vehicle body-type and safety systems, roadway types, driver condition at time of accident and occupant and pedestrian injury-severity levels. It covers the depiction of the National situation and permits new indicators to be developed, such as safety-system and injury severity, vehicle body-type to safety system, vehicle body-type to injury levels and driver condition to accident causation.

[1/] Standard Accident File Extract

[2/] Fatality Analysis File.

Objectives. Level 3 satisfies (1), serves as a start in obtaining (2), satisfies (3), and should have the potential for supplementing the measurement of programs dealing with specific features of highway traffic safety.

Implementation. The requirements of Level 3 do not differ very much from Level 2, except for the details on vehicle body-type and vehicle safety-systems. Since accident reports give the make, year, model and body-type of vehicles, a data base could be developed from which the particulars of the safety-system would be retrieved. This would require NHTSA to establish a safety-system/vehicle file and integrate its function and operation with the SAFE or FAF systems.

Data Requirements. The principal item, over and above Level 2 data requirements, is the addition of the vehicle safety-system features. This should be made a data reporting requirement by the automobile manufacturers if it is not already in effect. Compliance with standards should be reported, as well as devices exceeding required standards.

Time Horizon. About the same as Level 2. The data on vehicle safety-systems should be currently available. The implementation could be developed in about the same time of six months to one year, and incorporated into current data processing procedures.

5.4.5.4 Level 4 Evaluation

Level 4 has 23 classes and 77 subclasses. It is the same as Level 3 except for the enlarged scope of the injury-severity descriptors. The evaluation is as follows:

Capability. Level 4 extends the capability to a finer resolution of injury-severity reporting. It stops short of the medical categories given in the Collision Analysis Report Form, Dec. 1971, but does extend the a, b, c levels to more refined definitions than now in use. These definitions are still reportable by police officers, paramedics, doctors, firemen, etc., and do not require injury specificity.

Objectives. Objectives (1), (2) and (3) are essentially satisfied; objective (4) must be judged on the basis of application of Level 4 data to specific programs.

Implementation. The success of Level 4 descriptions hinges on the safety-system and injury-severity levels being reported consistently and accurately, at least within acceptable definitions. The investment for its implementation should not be large; coordination and acceptance are the principal problems.

Data Requirements. Same as Level 3. The extension of injury-severity levels from five to nine does require modifying current reporting forms and extending field assignments in computer-file data records.

Time Horizon. On the order of two to three years; this covers implementation of safety-system data file, form changes, data record format changes, and getting the system working smoothly in the field.

5.5 Program Related Descriptors

In Levels 3 and 4, emphasis was placed upon the inclusion of descriptors that would serve to measure, and be sensitive to, the specific NHTSA priority programs on alcohol and drug abuse, occupant-packaging, vehicle safety-systems and, to some extent, human factors. It is important for NHTSA to commence the inclusion of these activities in their statistical compilations since the investment in these programs, and the goals concerning accident avoidance and injury reductions, can only be ascertained by some form of measurement of this kind. When classes of information as described by Levels 3 and 4, which address vehicle safety-system, roadways, injury-severity and vehicle-type, are combined and developed as indicators a much clearer picture of the National situation should emerge. The problem of measurement becomes more difficult, however, when the priority programs take on greater specificity of detail. When this occurs sensitivity of indicators is subject to greater question and some resolution as to measurement and detail must be made.

6.0 RECOMMENDATIONS

The recommendations are given in five areas: which statistical complilations should be dropped, which areas of analysis should be investigated, which level of capability should be implemented, suggestions on data development, and exposure criteria. Text references are provided for each recommendation.

What should be dropped

The following rates or descriptors appear to provide no significant insight into the traffic picture and possess no tangible merit or potential for being useful in measuring program effectiveness.

1. Deaths per 100-million vehicle miles by State (see p. 6-8, 19, 20)
2. Deaths per 100,000 population (see p. 8)
3. Leading causes of deaths (see p. 8)
4. Monthly mileage death rates (see p. 8)

Areas of Analysis

(1) NHTSA should study the potential usefulness of statistical analysis based on a subset of States which correlate closely with National characteristics of traffic behavior. The regional approach has certain advantages of improving responses, reporting standards, a higher level of participation, and a smaller volume of reported data. (See p. 17 et seq)

(2) NHTSA should consider the possible advantages of locating the ASAPs into regional groups consonant with the above proposed statistical regions. This action has the potential for making the program more effective because of concentration, greater visibility with the public, and providing a better basis for statistical calculations. It might be more meaningful to evaluate the ASAPs in conjunction with other traffic safety factors pertaining in the region. (See p. 21)

Levels of Capability

(1) It is recommended that NHTSA implement the capability of the Level 3 Descriptor Array, or its equivalent, as a first step toward a more complete characterization of the National situation and measuring the impact of NHTSA vehicle and safety priority programs. (See p. 24, 25, 26, 28)

Data Development

(1) Since it appears that the SAFE data base is a subset of the FAF data base it is suggested that some resolution of priority and resource allocation should be made, and the surviving data base be organized and developed toward a retrieval and reporting capability for purposes of analysis, statistical compilation and special studies.

(2) The current capability should be expanded to accommodate more descriptors dealing with program impact and provide an efficient data retrieval system responsive to current and future needs.

Traffic Safety

Adopt injury-severity per accident and accidents per vehicle-year, in place of fatalities per vehicle-miles traveled as preferred measures of traffic safety (p. 12-17)

APPENDIX

Classification of Statistics on National Situation

APPENDIX

This Appendix presents a categorical arrangement of the data presented in Appendix A of Annual Report Traffic Safety '72. The notes to the tables and figures are given separately from the tables and figures to emphasize the amount of descriptive information they contain and to suggest comparison as to which supplies more information.

The Figures and Tables of Appendix A of Traffic Safety '72 have been classified by content into four primary categories. Crash and Damage (CD), Vehicle (V), Driver (D) and Environment (E). They have been further classified in some instances by secondary categories. In this case, we have used the additional notation. People (P), Occupant (O), Pedestrian (Ped). In some cases the source of the data has also been indicated, e.g. Federal Highway Administration Statistic (FHWA), the Bureau of Census (Bu. Cen.).

All references to figures and tables are to those in Appendix A of Traffic Safety '72.

Title of Figure or Tables	Figure/ Table	Secondary Category
Motor Vehicle Deaths by States or Occurrence, 1972 and Percent Change from Period 1966-1968.	Fig. A-2	P
Motor Vehicle Mileage Death Rate, 1972 and Percent Change from Period 1966-1968.	Fig. A-3	P,V
Trend in Motor Vehicle Death Rates, 1950-1972.	Fig. A-4	D,V
Deaths per 100,000 Vehicle Miles	Fig. A-10 Table A-2	
Deaths per 100,000 Registered Vehicles	Fig. A-5 Table A-2	D,V
Deaths per 100,000 Driver Licenses in Force	Fig. A-5 Table A-2	D,V
Deaths per 100,000 Population	Fig. A-5	D,E
Index Trend Comparison Motor Vehicle Deaths and Industrial Production (1967 = 100)	Fig. A-7 Note	
Pedestrian Fatalities 1950-1972	Fig. A-8	Ped.
Motor Vehicle Occupant Fatalities, 1950-1972.	Fig. A-8 Table A-4	O,V
Motor Cyclist Fatalities, 1950-1972	Fig. A-9	D,V
Bicyclist Fatalities, 1950-1972	Fig. A-9 Fig. A-11	D,V
Bicycle Population Death Rate, 1950-1972	Fig. A-11	D,V
Weekend - Weekday Contrast in Fatality Rates, 1971	Fig. A-12	P,E
Leading Causes of Death by Age & Sex, 1969	Table A-5	P
Monthly Mileage Death Rates, 1970-1972	Fig. A-13	P,V
Motor Vehicle Fatalities per Day by Month, 1955-1972 1955-1959 1960-1964 1965-1969 1970-1972	Fig. A-14	P,V,E
Leading Causes of Deaths, All Age Groups, Male and Female, Combined United States, 1969.	Fig. A-15	P,E

VEHICLE

Title of Figure/Table	Figure/Table	Secondary Category	Source
Motor Vehicle Registration, 1936-1972	Fig. A-1 Table A-1	-	FHWA Highway Statistics
Estimated Vehicle Miles Traveled, 1936-1972	Fig. A-1 Table A-1		FHWA Statistics
Trend in Ratio of (1950-1972) Licensed Drivers to Registered vehicles.	Fig. A-6 Table A-2	D	(See Table A-2)
Population to Registered Vehicles	Fig. A-6 Table A-2	E	Bu. Cen.
Total Motor Vehicle Travel, 1950-1972 Urban BVM Rural BVM	Fig. A-21 (See note)	E	FHWA
Vehicle Travel on the Interstate Highway System, 1967-1971 Total, Urban, Rural BVM	Fig. A-22	E	FHWA
Vehicle Travel on Primary Highway Systems, 1967-1971 Total, Urban, Rural BVM	Fig. A-23	E	FHWA
Vehicle Travel on Secondary Highway Systems, 1967-1971 Total, Urban, Rural BVM	Fig. A-24	E	FHWA
Average Free-Moving Travel Speed on Main Rural Roads, 1957-1971	Fig. A-25	E	FHWA
Growth in Population and Motor Vehicle Registration (by type of Registered Vehicle)	Table A-13 Note	E	FHWA Bu. Cen.
Average Number of Miles Travelled Annually by Type of Vehicle, 1971	Table A-14	E	Note
*			
Types of Motor Vehicles Involved in Fatal and Injury Accidents, 1971	Table A-15		NHTSA Nat. Accident Summary File

*Note: All the entries above the horizontal line in this table are independent of fatalities and injuries.

The entry below the line relates to fatal and injury accidents.

DRIVER

Title of Figure/Table	Figure/Table
Driver Licenses in Force 1936-1972	Fig. A-1 Table A-1
Distribution of All Drivers Licenses in Force by Age Group, 1972	Fig. A-15
Driver Licenses in Force by Age Group, Male and Female, 1965-1972	Table A-7
Percent Increase in Total Number of Driver Licenses in Force by Age Group, 1965-1972.	Fig. A-16
Distribution of Driver Licenses in Force by Age Group of Men, 1972	Fig. A-17
Percent Increase of Driver Licenses in Force by Age Group of Men, 1965-72	Fig. A-18
Distribution of Driver Licenses in Force by Age Group of Women, 1972	Fig. A-19
Percent Increase of Driver Licenses in Force by Age Group of Women, 1965-1972. *	Fig. A-20
Male and Female Drivers Involved in Fatal non-Pedesterian Accidents, 1971	Table A-10
Percent Distribution by Age of Driver within Accident Type (Estimated) Male, 1971 Female, 1971	 Table A-11 Table A-12

*Note: All the entries above the horizontal line in the table are independent of fatalities and injuries.

The entries below the line relate to fatalities only.

ENVIRONMENT

Title of Figure/Table	Figure/ Table	Secondary Category	Source
Vehicle Travel on the Interstate Highway System, 1967-1970, Total, Urban, Rural	Figure A-22	V	FHWA
(Same) on Primary Highway System, 1967-1971	Figure A-23	V	FHWA
(Same) on Secondary Highway System 1967-1971	Figure A-24	V	FHWA

Fig. A-1 Through 1972 there has been no sign of a slackening in the rapid growth in the use of motor vehicles. Vehicle miles have increased faster than the number of vehicles, and both have increased faster than the number of drivers. Thus, travel per vehicle, travel per driver, and vehicles per driver are still increasing.

Fig. A-2 The pattern of change in motor vehicle deaths since 1966-1969 shows a group of Mountain States with above-average increases in deaths. These States generally showed the smaller decreases in vehicle mileage death rates. The only consistent pattern of decrease over a contiguous area is found as a group of North Central States from Pennsylvania through Illinois.

Fig. A-3 Without exception, the States have reduced their vehicle mileage death rates. The largest reductions have occurred in a broad belt stretching from Appalachia to Minnesota and Iowa. The smallest reductions have occurred mostly in the Mountain States.

Fig. A-4 }
Fig. A-10 } Improvements in vehicles, roads and safety in operation have reduced the death rate per mile of travel by about 40% since 1950, but the rise in travel has more than offset this. Nevertheless, the decline in the mileage death rate means that it is now possible to travel 17,000 miles at the same risk as was attained in driving 10,000 miles in 1950.

Fig. A-7 Increases and decreases in annual highway fatalities have corresponded very closely with changes in economic activity. These cannot be explained by changes in total vehicle-miles of travel because the vehicle mileage continues to rise, even when fatalities declined. Hence the changes must be due to the nature, rather than the quantity, of travel mileage.

Fig. A-10 (Same as A-4).

Fig. A-11 Increasing use of the bicycle has led to higher numbers of deaths and higher death rates. The bicycle is used much more for adult transportation and recreation than it was a few years ago, but bicycle death rates are also related to and, in part, caused by the increasing amount of motor-vehicle traffic mileage.

Fig. A-12 Week-end crashes (4:00 P.M. Friday - 3 A.M. Monday) produce many more fatalities in the evening and early morning hours than do weekday crashes. This is primarily a result of increased recreational driving on weekend nights and associated increased use of alcohol.

Fig. A-13 July through October is the period when the highest absolute number of fatalities occur, and it is also the period when fatalities per vehicle mile of travel are highest. This is probably a result of the large proportion of recreational travel during this period. Vehicle occupancy rates in recreational travel are much higher than for other purposes and so the chance of a fatality per accident is higher.

Fig. A-14 The seasonal pattern of motor vehicle deaths has shifted gradually over the years from a yearly peak in December to a high period that extends from July through October. This most probably reflects the increased amount of recreational travel by the American public during the summer and early fall.

Table A-6 If you survive the hazards of early infancy, but your life ends earlier than it should, there is a great chance that a motor vehicle accident will be the reason than any other major killer. Motor vehicle accidents are the leading cause of death for young people from late childhood to the early thirties. A large group of men the same age will be in their forties before another killer (heart disease) will have killed more of them than died in motor vehicle accidents. A similar group of women will be in their early forties, when cancer overtakes motor vehicle accidents as the biggest total killer of the group.

Fig. A-16 Changes in the age distribution of licensed drivers are an important element of the highway safety problem. In recent years the largest increases have occurred in those age groups when accident rates have been higher than average.

The number of licensed drivers in the youngest and the older age groups have increased much more than those in the middle group, aged 30-59. The total number of drivers increased 20% during the period 1965-1972, but the increase was 36% in the 20-29 age group, and 43% in the over-60 group. There was an increase of 12,194,000 female drivers, or 30%, while (male) drivers increased by only 7,504,000 or 13%, so that in the seven-year period the ratio of male to female drivers declined from 3 to 2 to 5 to 4.

A very large increase occurred in elderly women; the number of female licensed drivers 60 and over increased by 5,360,000 or 80%.

Fig. A-21 Travel in urban areas has been increasing slightly faster than travel in rural areas in recent years, but the proportions vary considerably among major road systems. On the Interstate System there is a nearly equal division between urban and rural travel mileage. On the Primary Systems there is more rural travel, with a 57-43 split in 1971 mileage, while on the Secondary Systems there is more urban travel, the proportion being 42-58 in 1971.

The distribution of the total 1971 travel of 1.19 trillion miles among Interstate, Primary and Secondary Systems was 15%, 34% and 51%.

Table A-10 Males aged under 25 are disproportionately involved in all types of accidents. The over-representation is greatest for single-vehicle accidents, especially "overturn in road." Female drivers in this age group show the same pattern of over representation, although to a lesser degree. Drivers in the age group 25-64 are generally in fewer accidents than would be expected on the basis of their numbers. Drivers over 64 show a mixed pattern, with an over-representation of female and under-representation of males, relative to the number of licensed drivers in that age group.

Fig. A-25 Over the 10 years from 1961-71, the average speed of vehicles on the main rural roads increased about 13%. A corresponding increase in crash speeds occurred. This has been a significant factor in the rise of highway deaths, because high-crash speeds increase the chances that a fatality will occur.

Table A-13 The rate of increase for motor-cycles (registration) continues to be far higher than the growth rates for other vehicles. Numbers of commercial vehicles, such as trucks and buses, are growing relatively faster than passenger cars. The number of commercial buses has begun to increase more rapidly than in the 1960's.

Table A-14 About four miles out of five are driven by passenger cars, and trucks account for almost all the remainder. Travel per passenger car topped 10,000 miles for the first time in 1972. School-bus travel increased only a modest 5%. The basis for estimating motorcycle mileage was changed in 1972, so that a 50% higher estimate resulted. This does not represent a change in the basic trend.

Table A-15 Motor cycles and buses are over-represented in fatal accidents. Motorcyclists in a crash receive essentially no protection from their vehicles. The most probable explanation for the buses over-representation is the larger number of occupants involved per crash.

The ratio of killed to injured in crashes involving trucks is greater than for other motor vehicles, most probably due to the greater weight of trucks.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report covers a critique of current measures used by NHTSA to report and evaluate National Traffic Safety, and presents the development of proposed measures for evaluating the impact of NHTSA priority programs on the vehicle-driver-highway mix. The proposed measures emphasize the use of injury-severity levels and an extended set of driver-vehicle-highway descriptors to depict critical factors in National traffic patterns and trends. The conclusions and recommendations address extensions of current indicators to describe accident phenomena by driver and vehicle attributes, to enlarge the number and detail of descriptors of accident data and accomodate these extensions by more comprehensive data development. Surrogates for National statistics and concentration of certain programs were investigated.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Highway traffic safety; traffic data systems; safety program impact; indicators

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