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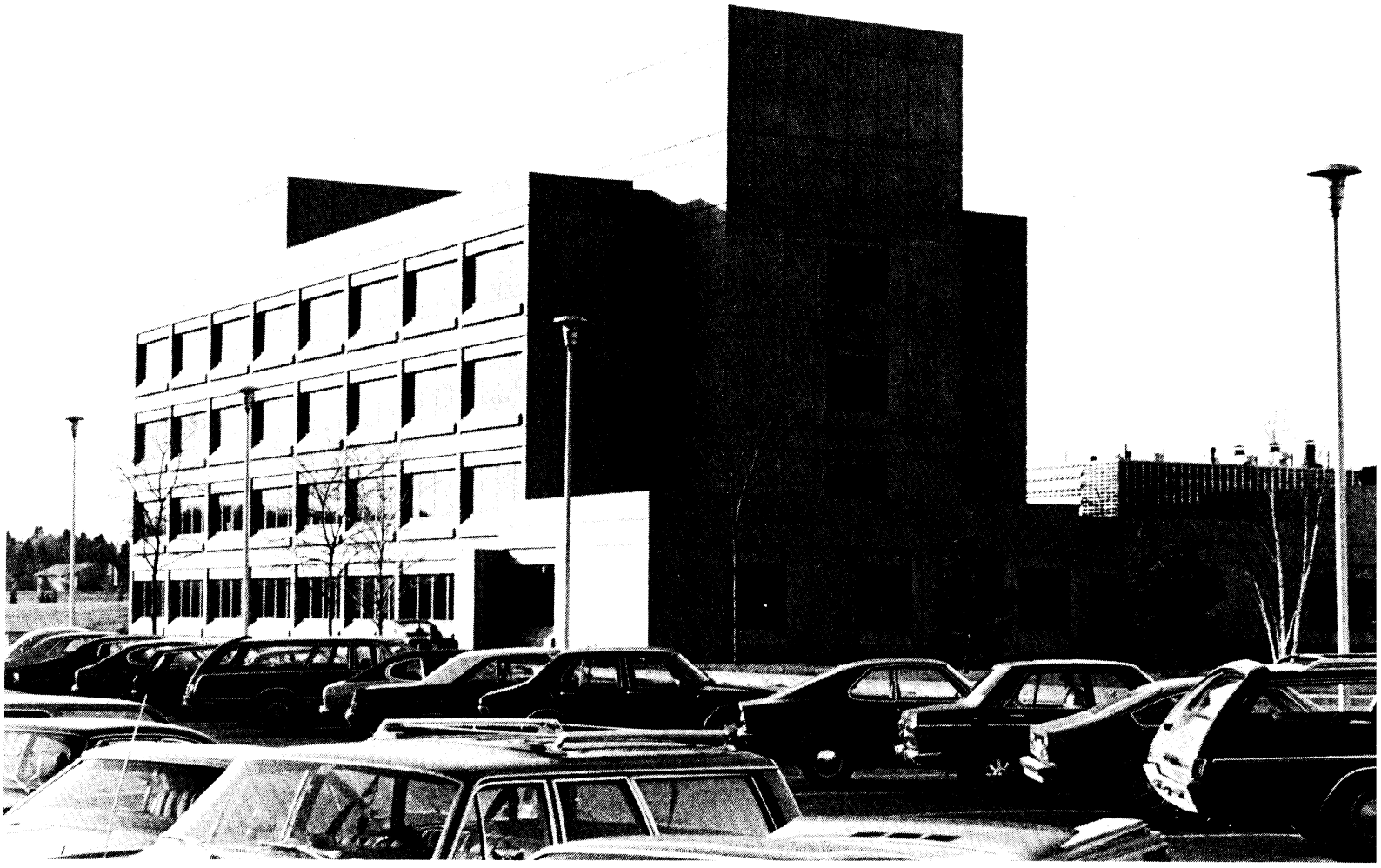

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March, 1978

Further information about HSRI projects and research publications may be obtained from the Highway Safety Research Institute, The University of Michigan, Ann Arbor, Michigan 48109. Telephone: (313) 764-2171

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Introduction

This booklet offers a comprehensive view of current activities, staff, and facilities of The University of Michigan Highway Safety Research Institute. The 77 research programs briefly described here are being conducted by 160 U-M faculty and staff members. The programs, sponsored by 22 different government agencies and private organizations, are creating knowledge essential for improving the nation's transportation systems. With involvement of some 30 academic disciplines in the research programs, a wide range of U-M graduate students are provided opportunities for research experience at HSRI.

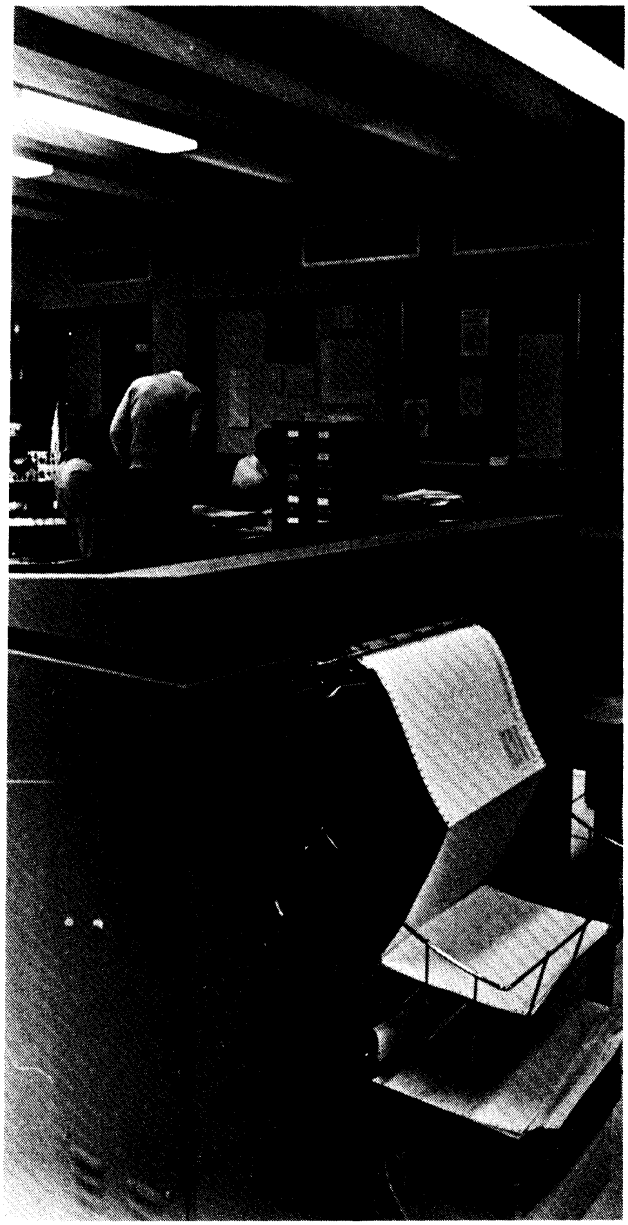
While multidisciplinary studies of transportation problems can be classified in several different ways, the summary descriptions of work underway at HSRI are grouped here under five very general headings:

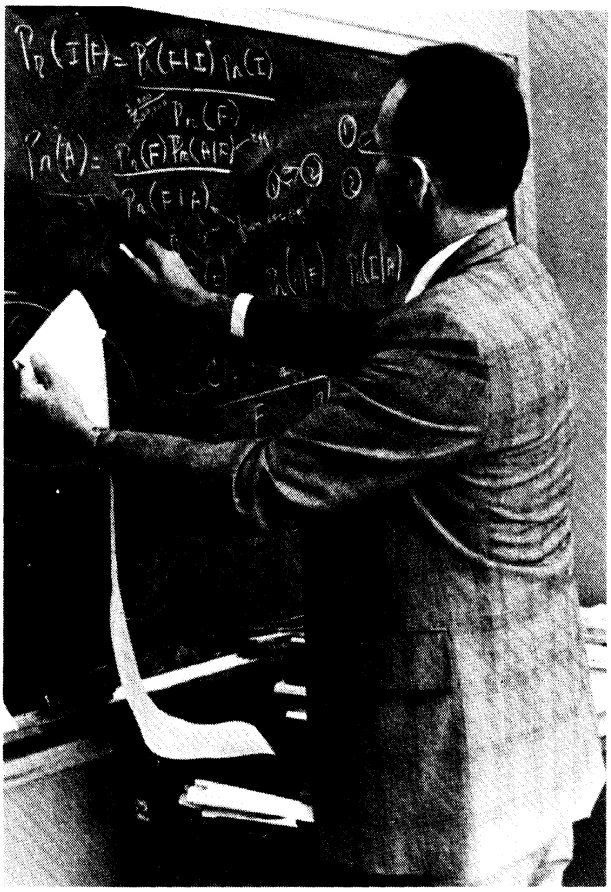
- Accident Data and Systems Studies
- Human Factors Studies
- Injury Protection Studies
- Policy Analysis Studies
- Vehicle and Roadway Studies

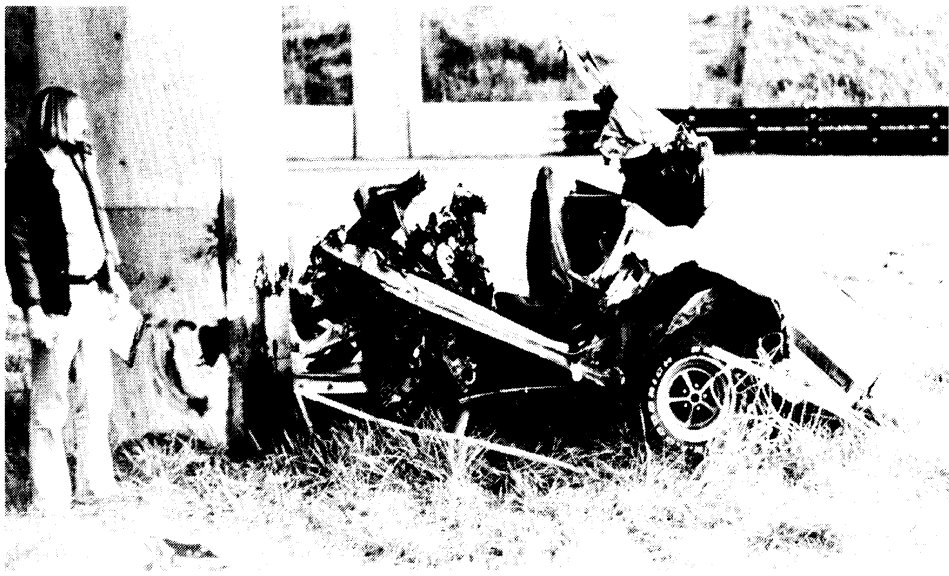
HSRI programs in each of those areas are providing sponsors with the independent research findings each need to make our transportation systems better in several ways—more safe, energy-efficient, economical, convenient, and protective of the environment.

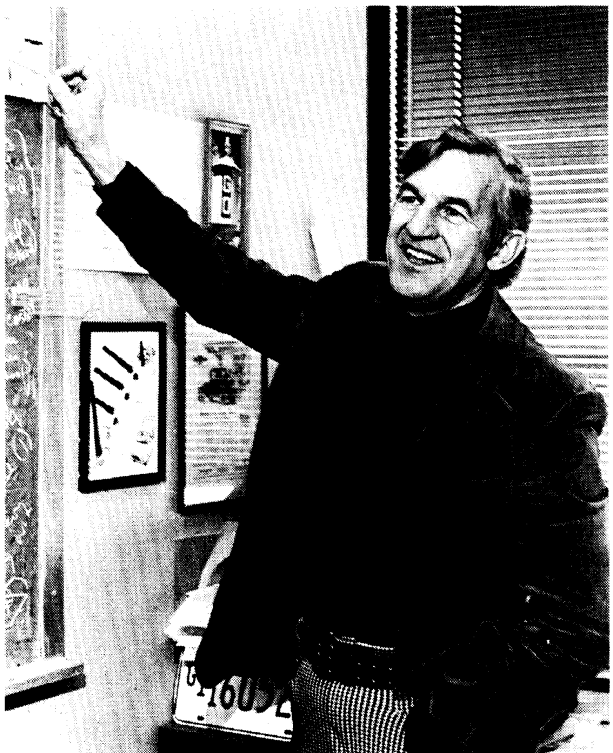
Robert L. Hess
Director, HSRI

Work in Progress









Accident Data and Systems Studies

HSRI research programs in the Accident Data and Systems area are concerned with (1) mathematical modeling and the design of data systems, including data collection systems that provide reliable information on accidents and injuries; (2) the design of methods and techniques to assure the quality of data collected; (3) the design and use of methods of storing, analyzing, and interpreting accident data; and (4) the development of improved means of assisting government and industry policymakers in their efforts to make transportation systems more safe and efficient.

Traffic crashes and injuries resulting from them are the products of multiple factors *combined in a chain or hierarchy of conditions, circumstances, and objects united at particular times and places. Some of those "causal factors" are immediate or proximate, in the sense that one can say of them that "but for the presence of* this *factor, the collision would not have occurred." However, many other "causal factors" are mediative or semi-remote, in the sense that one can say that "this set of factors created conditions that made inevitable the incidence of collisions, given the presence of one or another immediate causal factor."*

That view of traffic crash phenomena engenders many kinds of research studies conducted at HSRI. The studies are designed to obtain better data, organize it for more potent analyses, identify factors that are over-represented in accident-case populations (as compared to the driving populations of which they are a part), assess the significance of those factors as proximate or mediate agents, and recommend to government and industry policymakers various means by which those life-threatening conditions or agents can be removed from or greatly reduced in the transportation system.

Accident Data Storage and Analyses

Investigators: J. A. Green, J. O'Day

Sponsor: Motor Vehicle Manufacturers Association

Objectives: Objectives of these continuing, multi-year programs are to acquire and maintain sets of computerized accident data, conduct analyses of the data to identify and assess causative factors in highway accidents and injuries, and make the accident data files and HSRI-developed computer programs available to analysts at The University of Michigan and other universities, government agencies, and private industry.

Significance: Traffic safety analysts need rapid and economical access to computerized accident data files, not only to identify the most dangerous elements of the U.S. automotive transportation system but to pinpoint the weaknesses in current data-collection programs and design means of collecting better data.

Methods: Answers to particular research questions are sought by the use of univariate or multivariate analyses of combinations of files best suited for a study in terms of the scope, detail, and representativeness of their data. New statistical and analytic techniques are developed and incorporated into the existing methodology.

Results: This program, initiated in 1970, provides quick computerized access to more than 200 general or specialized collections of accident data now regularly used by U-M analysts and more than 10 other research organizations throughout the U.S.

Advanced Accident Investigation Course for Police Officers

Investigators: D. H. Huelke, T. L. McDole

Sponsor: Motor Vehicle Manufacturers Association

Objective: To improve skills of police officers in conducting on-scene accident investigations.

Significance: The quality of accident investigation data depends greatly on the knowledge, skills, and procedures employed by on-scene investigators.

Methods: This course, consisting of 15 weekly meetings, is being offered to 30 police officers invited from six police agencies in Washtenaw County. Topics presented by 13 specialists include on-scene problems, preserving the scene and vehicles, methods of collecting data, highway design factors, role of the forensic pathologist, computer reconstruction of the crash, investigation of aircraft crashes, prosecution in automotive crashes, courtroom procedures, analyses and use of accident data, human factors, and the biomechanics of injuries.

Results: The course is expected to make the participants more expert accident investigators as well as an information source for other police officers in their agencies.

Alcohol-Related Traffic Casualties and Alcohol Availability Policies in Michigan

Investigator: R. L. Douglass

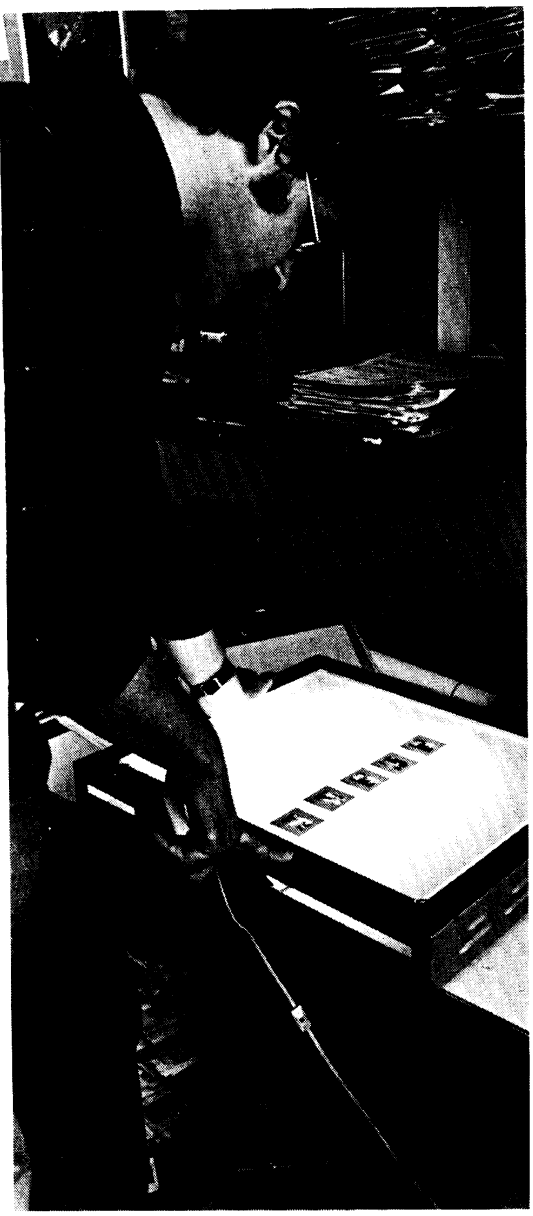
Sponsor: Office of Substance Abuse Services, State of Michigan Department of Public Health

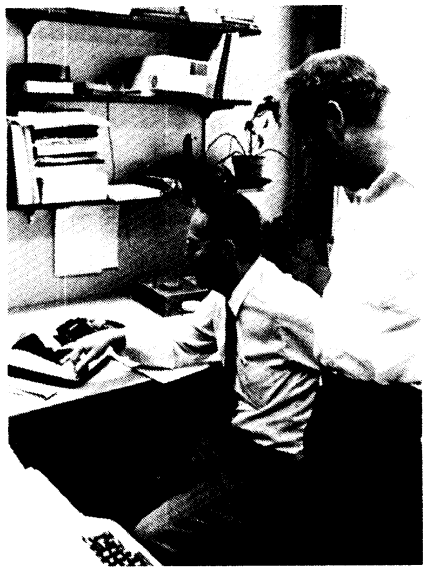
Objective: This study extended previous HSRI research on the effects of the lower legal drinking age on youth crash involvement. It also investigated the influences of increases in the number and locations of liquor license holders since the legal drinking age was reduced from 21 to 18, measuring increases in distribution outlets, beverage alcohol consumption, and the effects of these increases on the 18- to 20-year-old population.

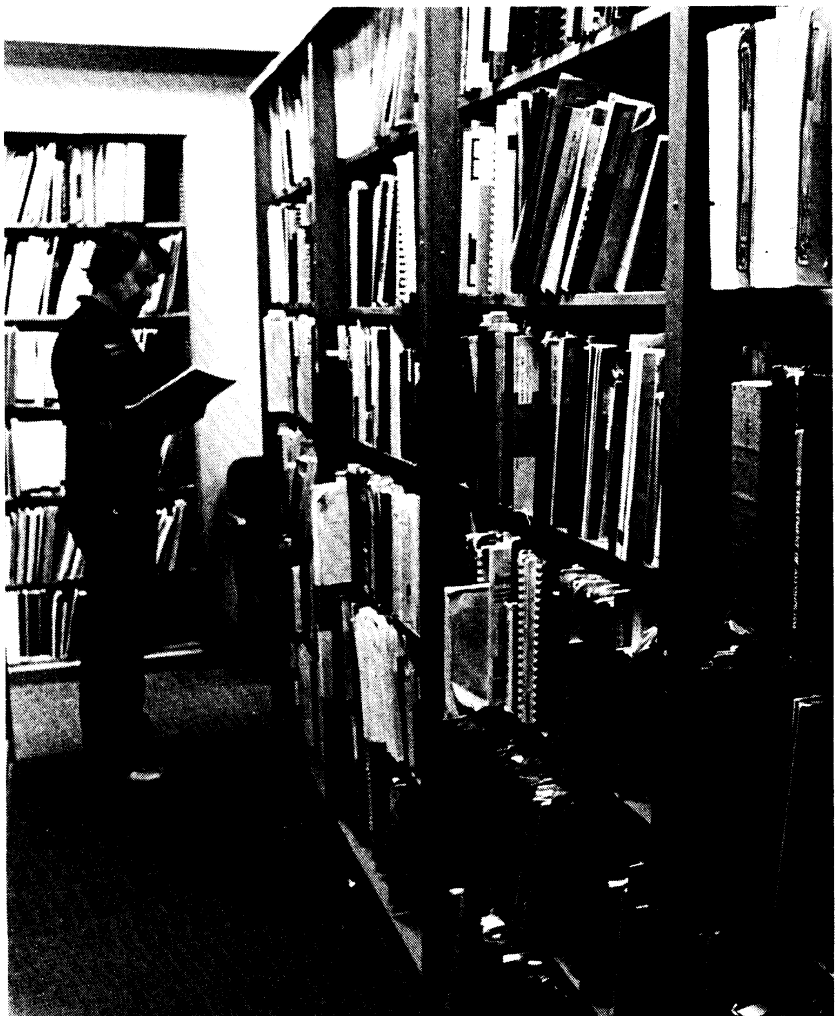
Significance: Several states, including Michigan, have been considering the appropriateness of the 18-year-old legal drinking age. Evidence has linked lowered legal drinking ages with increases in highway casualties.

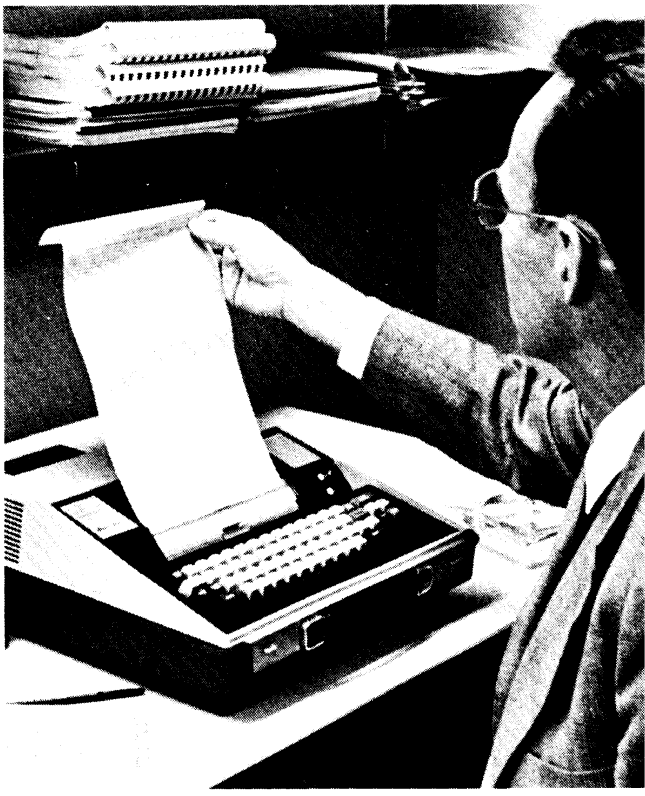
Methods: The study included time-series analyses of Michigan Department of State Police accident data for the 1968-1975 period. Data from the State of Michigan Liquor Control Commission and local governmental units were also analyzed.

Results: The results showed that for the period 1972-1976, the lower legal drinking age, combined with increased availability of alcoholic beverages, produced increases of between 10 and 24 percent in alcohol-related crashes among male drivers aged 18 to 20 in Michigan. Recommendations regarding priorities for state attention to a range of alcohol-related problems have been made.









Analysis of Accidents Involving Car-Into-Truck Underride Collisions

Investigator: J. O'Day

Sponsor: Motor Vehicle Manufacturers Association

Objective: To provide a fuller understanding of the type and extent of car-into-truck underride crashes occurring in the U.S.

Significance: Collisions in which a passenger car strikes a truck are often serious or fatal for car occupants when the front of the car extends beneath the freight bed and much or all of the crash forces are applied at the hood or windshield level of the car. If protective plating were to be attached beneath the freight bed at the rear of trucks and semitrailers, this would help prevent some underride collisions. However, the number of fatalities and serious injuries such a device would prevent each year depends upon how many such collisions occur.

Methods: Computerized accident files on large-truck accidents in the states of Michigan and Texas have been used to identify car-into-truck fatal accidents. The written reports of those accidents are being obtained and reviewed to establish how many of those accidents included rear underrides and side underrides.

Results: The results are expected to provide accurate estimates of the number of rear-end and other underride accidents and fatalities annually in the U.S.

Clinical Case Studies of Selected Collisions

Investigators: D. F. Huelke, H. W. Sherman

Sponsor: Motor Vehicle Manufacturers Association

Objective: To establish the mechanisms of trauma in motor vehicle collisions through intensive study of the relationship of occupant injuries to vehicle components, crash severity, and restraint system effectiveness.

Significance: The emphasis of this continuing program is on establishing precisely how and why the injuries occurred and how they can be prevented or reduced.

Methods: Approximately 135 collisions per year are selected from Washtenaw County crashes for detailed investigation. Only crashes with the following characteristics are selected: The crash has resulted in an injury to at least one occupant of the case vehicle (a late-model passenger car, light-duty truck or van, multipurpose passenger vehicle, large truck or bus); the vehicle was manufactured by an MVMA-member company; the vehicle was towed away from the accident scene; and the vehicles involved can be examined within 48 hours of the collision.

Results: Each clinical case is documented with the Collision Performance and Injury Report long form; a detailed medical report; 35 mm color slides of the accident scene, vehicles, impacted objects, exterior and interior damage; and reporting on other pertinent factors (alcohol, drugs, extrication complications, etc.). Oral case reviews are presented to the sponsor, and scientific papers are prepared for publication in the open literature.

Compilation of Eight Years of Michigan's Alcohol-Related Traffic Accident Experience

Investigator: L. D. Filkins

Sponsor: Office of Highway Safety Planning, Michigan State Police

Objectives: To identify the role of alcohol in 1968-1975 traffic crashes involving drivers in various age groups, and attempt to identify changes in alcohol-related crashes associated with the 1972 lowering of the legal drinking age in Michigan.

Significance: Legislators and other policymakers need to know to what extent regulations concerning sale of alcoholic beverages affect the rate of highway crashes of young drivers.

Methods: The data sets and analytic techniques were chosen to complement those employed in the project entitled "Alcohol-Related Traffic Casualties and Alcohol Availability Policies in Michigan." The research entailed selection of variables to be analyzed, analyses of 1968-1975 accident data, provision of data tabulations and graphs, and interpretive briefing sessions.

Results: The results showed that alcohol continues to play a major role in accidents involving drivers in all age groups, and particularly in fatal accidents. Prior to 1972, 18- to 20-year-old drivers experienced significantly lower proportions of reported alcohol-related accidents, compared to their age 26-45 counterparts, but after 1972 the younger group's involvement increased to the point that it matched or exceeded that of the older group. The proportion of accidents involving male drivers in single-vehicle nighttime accidents also increased more rapidly among the younger drivers after 1972 than did the proportion for the older drivers. Together these results demonstrate that the role of alcohol in accidents involving Michigan's young adults has increased since lowering of the legal drinking age. Data for 1976 will be added in the future.

Data Sources to Support the NHTSA Defects Investigation System

Investigator: J. O'Day

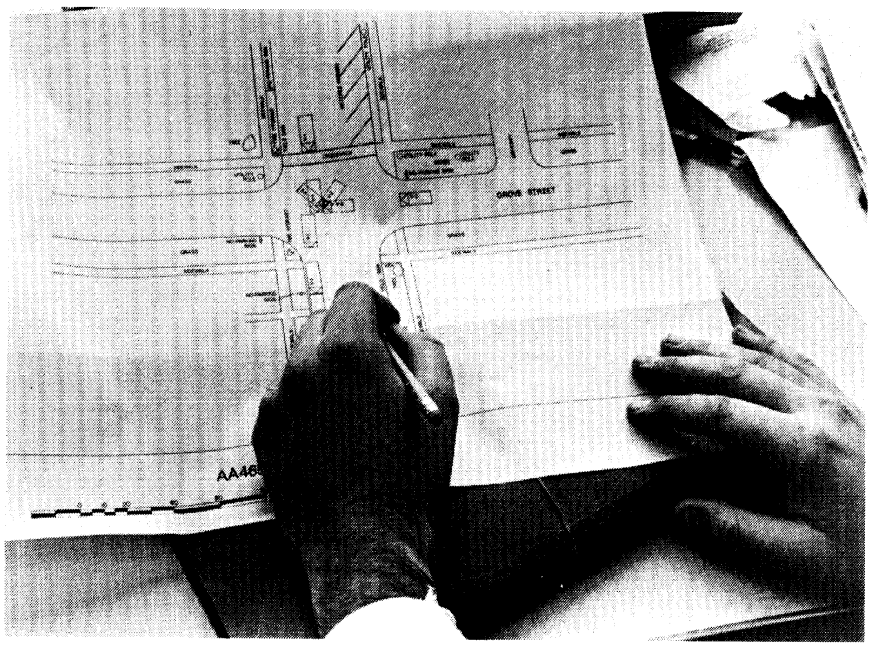
Sponsor: National Highway Traffic Safety Administration

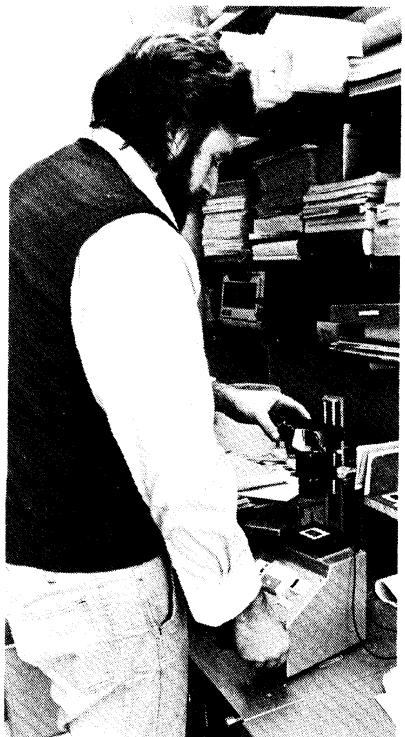
Objectives: To determine what accident data would be useful to the Office of Defects Investigation, NHTSA, and how it may be best utilized in the defects-determination process.

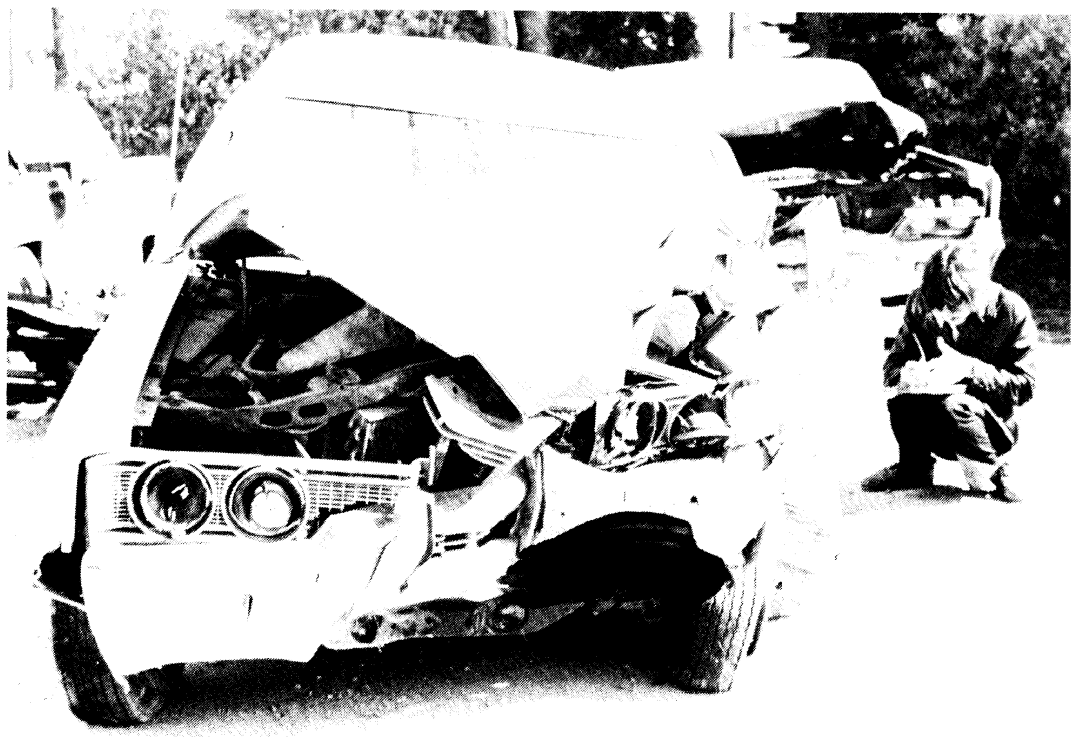
Significance: The NHTSA has authority to require motor vehicle manufacturers to remedy safety-related defects in vehicles they have produced. Accident data are an important means of discovering or confirming the existence of such defects.

Methods: The research includes describing and evaluating data sources currently utilized, identifying and describing unfulfilled data needs, developing specifications for required data items and for data sources to supply those items, and recommending any changes in the system that would improve utilization of current or potential data sources.

Results: The recommendations arising from the study will differentiate between improvements that can be made without changes in the enabling legislation and improvements that would require changes in the law. The findings and recommendations are expected to be used to enhance the analysis and utilization of data sources in the NHTSA defects-investigation process.







Design of National Exposure Data System

Investigator: A. C. Wolfe

Sponsor: National Highway Traffic Safety Administration

Objective: To develop a design for a cost-feasible data collection system that will provide nationally valid exposure information on the nation's motor vehicle travel using such key categories as driver age and sex, vehicle type, road type, light conditions, etc.

Significance: For more effective evaluation of statistics on highway crashes, "exposure" data are needed to show how much various categories of drivers expose themselves to the risk of a crash, in terms of miles traveled, numbers of trips, time of day, day of week, type of roadways, and so forth. This exposure data will be used to provide denominators to accident rates (with numbers of accidents in the numerators) so that meaningful comparisons of under- or over-involvement can be made among various accident and exposure classifications.

Methods: The work entails analyzing and evaluating the various components of potential data collection plans, including exposure data elements, methods of data collection, sampling design, data forms design, data analysis techniques, and required resources in the form of funding, staffing, and facilities.

Results: The best data collection plan at each of three cost levels will be determined and detailed designs for pilot testing these recommended plans will be developed.

Development of Methods for Uniformly Measuring and Coding Occupant Compartment Intrusion in Crashes

Investigator: P. Cooley

Sponsor: National Highway Traffic Safety Administration

Objective: To develop a methodology for assessing crash-induced intrusion into the occupant compartment and expression of this information in codified form for computerized analyses, with particular emphasis on side intrusion with respect to FMVSS 214.

Significance: No methodology presently available permits intrusion to be quantified uniformly and consistently, so that the amount of intrusion can be assessed relative to potential and actual occupant injuries in crashes.

Methods: Tasks in the research include preparing a detailed plan of work, assessing the methodology used by the Canadian Department of Transport, specifying techniques for collection of field data, defining the degree of precision required in measurements of intrusion, developing a method of expressing intrusion measurements in computer-usable form, and conducting training sessions to instruct National Crash Severity Study teams in the measurement/codification methodology.

Results: Application of the methodology developed in this research is expected to produce data useful for improving assessments of the effectiveness of FMVSS 214, Side Door Strength, and FMVSS 216, Roof Crush Resistance. The data will also permit a fuller indirect assessment of FMVSS 208, Occupant Crash Protection, FMVSS 206, Door Lock and Door Retention Components, and FMVSS 204, Steering Control—Rearward Displacement.

Establishment of a National Accident Sampling System Team in Muskegon County, Michigan

Investigators: P. Haseltine (Office of Highway Safety Planning, State of Michigan), P. Cooley (HSRI)

Sponsor: National Highway Traffic Safety Administration (Prime Contractor: OHSP; Subcontractor: HSRI)

Objectives: To establish an accident investigation team in Muskegon County, Michigan, and pilot test data-collection and reporting procedures for the National Accident Sampling System.

Significance: To obtain nationally representative accident data, the NHTSA is developing a sampling system (NASS) that entails placement of some 30 accident teams in randomly selected geographic/populational areas. The data collected in those areas will constitute a statistical microcosm of total U.S. automotive accident phenomena. In this pilot phase of the effort, the Muskegon County team is one of the first 10 teams being established to test accident selection, investigation, and reporting procedures designed into and specified by the NASS plan.

Methods: HSRI is staffing the Muskegon accident investigation team with experienced investigators, providing supervision, and providing supplemental training to assure conformity with the NASS sampling plan.

Results: The program effort is expected to produce a Muskegon County NASS unit prepared to function effectively in the national sampling system.

Evaluation of Effectiveness of FMVSS 301: Integrity of Passenger Car Fuel Systems

Investigators: J. D. Flora, P. Cooley, T. Traux, L. Huang

Sponsor: National Highway Traffic Safety Administration

Objective: To evaluate the effectiveness of Federal Motor Vehicle Safety Standard 301 by collecting and analyzing data on crash-induced vehicle fires.

Significance: FMVSS 301, as amended in 1975 and 1976, contains certain fuel-system performance requirements intended to prevent fuel leakage in passenger cars and school buses as a result of collisions. To establish the extent to which the vehicle standard is reducing the incidence of crash-induced fuel-fed fires in vehicles manufactured before and after the standard was amended, representative high-quality data on such fires need to be obtained and analyzed.

Methods: The research entails obtaining data on post-crash vehicle fires from fire department and police records in jurisdictions throughout the nation where both sets of records contain the detail essential for establishing the causative factors of the fire and relating those to the accident configuration and make and model of vehicles involved. The study tasks include locating and evaluating the data sources, selecting jurisdictions for data collection, verifying the quality of the data, collecting and automating the data, and analyzing it to establish fuel-spill and fire rates per make and model, as well as standard errors for each data set.

Results: The study results are expected to provide a means of evaluating FMVSS 301 by establishing post-crash fire rates for groups of passenger cars meeting different versions of the standard as it was changed over time.

Evaluation of Junior High School Traffic Safety Curriculum

Investigator: T. L. McDole

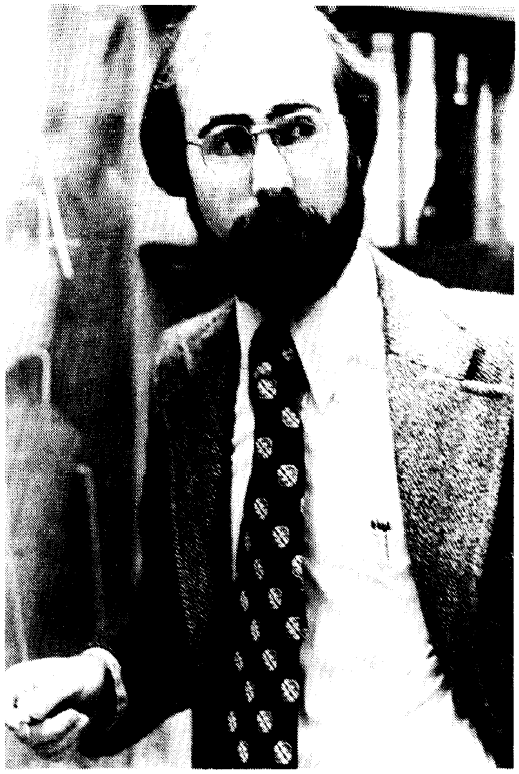
Sponsor: Dickinson County Community Schools

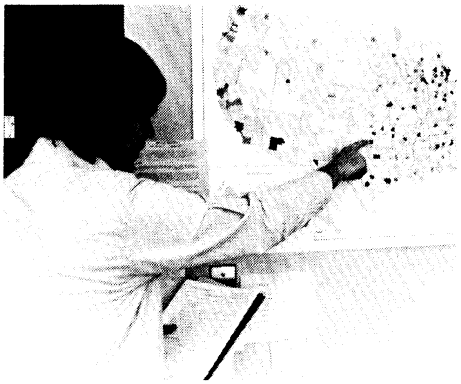
Objective: To determine the effectiveness of a traffic safety education program for grades seven through nine.

Significance: Improvement of public school programs in traffic safety education depends upon effective evaluation of existing programs.

Methods: The research entails consulting with school personnel, assisting with the research design, assessing curriculum materials, conducting workshops with teachers, and providing technical assistance in conducting the evaluation and interpreting test results.

Results: The results of this multi-year project will enable the sponsor to improve the quality of the traffic safety education curriculum.





Fleet Accident Evaluation of FMVSS 121

Investigator: K. L. Campbell

Sponsor: National Highway Traffic Safety Administration

Objective: To determine the effects of Federal Motor Vehicle Safety Standard 121 on the rate of accidents involving air-braked trucks, and the rate of injuries, fatalities, and property damage associated with such accidents.

Significance: FMVSS 121, which went into effect in March of 1975, requires substantial changes in the braking capabilities of newly manufactured air-braked vehicles. This 30-month research program, initiated early in 1976, is the first objective, nationwide, statistically defensible evaluation of a federal motor vehicle safety standard.

Methods: The major effort in this study involves monitoring records maintained by a sample of fleets (truck owners). Information is being gathered on the exposure, accidents, maintenance, and operational experience of these vehicles. The monitored fleets were selected by means of a probability-based sampling technique from a list of purchasers of air-braked vehicles during the period January, 1974, to January, 1976. Some 3,500 vehicles in approximately 500 fleets located in 36 distinct geographic areas of the continental U.S. are being monitored. To supplement the fleet-monitoring activity, information is being collected on a census of fatal accidents involving late-model air-braked trucks for the calendar years 1976-1977. The NHTSA Fatal Accident Reporting System is providing notification of these accidents. Information on injury accidents involving ICC Authorized Carriers is also being obtained from the Bureau of Motor Carrier Safety, processed, and included in the analyses.

Results: Findings will consist of accident rates computed for pre- and post-standard straight trucks and tractor-trailers in several exposure categories, as well as a comparison of the maintenance and operational experiences of pre- and post-standard vehicles monitored.

Improved Methods of Collecting and Analyzing Bicycle Accident and Injury Data

Investigators: J. D. Flora, R. J. Kaplan

Sponsor: Bicycle Manufacturers Association

Objectives: To continue the review and evaluation of accident data gathered by the National Electronic Injury Surveillance System, conduct an independent analysis of bicycle accidents, improve the current methodology of bicycle-accident analyses, investigate time trends in bicycle accidents, and provide an annual summary of the national estimate of bicycle accidents.

Significance: Current methods of collecting and analyzing bicycle-accident data do not provide information sufficiently useful for effective development of several means of making bicycling safer. The study recommendations are expected to improve the NEISS methods. The study is also testing for changes in the rate of bicycle accidents associated with new bicycle standards.

Methods: Feasible data sources have been identified and analyzed, injury scales further developed, and efforts made to develop and incorporate exposure data useful for making the accident data analyses more meaningful. Five and one-half years of NEISS data are being analyzed to assess the sensitivity of measures of hazard currently used by the Consumer Product Safety Commission for ranking products. A computer program has been developed for use in obtaining a rapid and economical standard summary for any given product.

Results: The study has identified several problems with the current sample design and its application. Several recommendations have been made: that a simpler sample design be used; that a CPSC representative be made responsible for basic data collection, so that consistent data can be obtained from all hospital emergency rooms participating in the NEISS system; and that data-based methods of age adjustment be used along with a product-specific exposure measure developed in the study for use in constructing an improved hazard index. Many of the previous recommendations are under consideration or are being implemented by the CPSC.

Industry Responses to Federal Safety Regulations for New Automobiles

Investigators: H. M. Bunch, M. Kubacki

Sponsor: Transportation Systems Center, U.S. Department of Transportation

Objectives: To investigate how the automotive companies have determined their responses to proposed federal safety standards over the past decade, and to describe factors involved in the varied responses to particular proposed standards.

Significance: An understanding of industry reactions to federal rulemaking can suggest ways in which government can more effectively interact with manufacturers in improving the safety of the motor vehicle fleet.

Methods: Three federal motor vehicle safety standards were selected for analysis. For each, an intensive analysis was undertaken of written industry responses to initial rulemaking and subsequent amendments. Industry sources were interviewed to determine the reasoning behind these responses and the extent to which alternative strategies were considered.

Results: The analysis showed that the decision to accept a safety standard is made at the highest levels of a company's management, and, generally, industry is favorably inclined toward the existing standards. Concern remains, however, that the automotive manufacturing process is insufficiently understood by government policymakers. A major industry worry is the problem of increased costs resulting both from a lack of precision in defining standards and from a lack of sensitivity toward industry's design and pre-production planning schedules. The study also revealed that general social attitudes and economic conditions are one of the most important factors in the posture the automotive industry takes toward a proposed new federal standard.

Methodology for Collection of Data on Crash-Induced Fuel Leakage

Investigators: P. Cooley, H. M. Bunch

Sponsor: National Highway Traffic Safety Administration

Objective: To develop a methodology for the detection and measurement of fuel spillage in motor vehicle collisions.

Significance: When fuel-fed fires occur as a result of motor vehicle crashes, they often produce serious or fatal injuries. Because of the potential for such serious consequences, automotive fuel systems need to be designed to minimize crash-induced leakage. To assess the incidence of such leakage and the efectiveness of Federal Motor Vehicle Safety Standard 301-75, accident investigation teams need to employ improved and uniform methods of establishing whether fuel leakage has occurred, the extent of the leakage, and the causes.

Methods: Research tasks include reviewing relevant research literature; developing a methodology for identifying fuel leakage or spillage at the accident scene, along with its source, location, and cause; surveying existing equipment ("sniffers" of unburned hydrocarbons) and assessing its potential use by accident investigation teams; and developing a means of assessing the volume and rate of fuel leakage.

Results: Application of the methodology by accident investigation teams is expected to result in data useful for making improved estimates of the incidence of fuel leakage among groups of vehicles manufactured to comply with the various historical versions of FMVSS 301.

Michigan Driving Characteristics File

Investigator: R. J. Kaplan

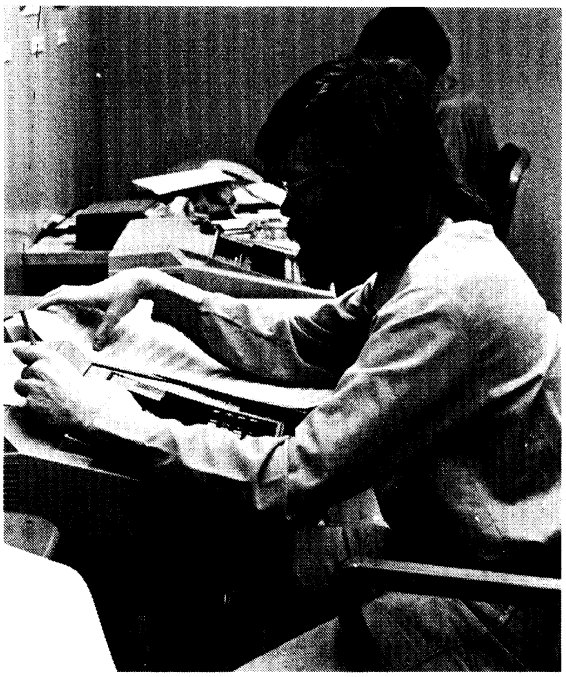
Sponsor: Michigan Department of State

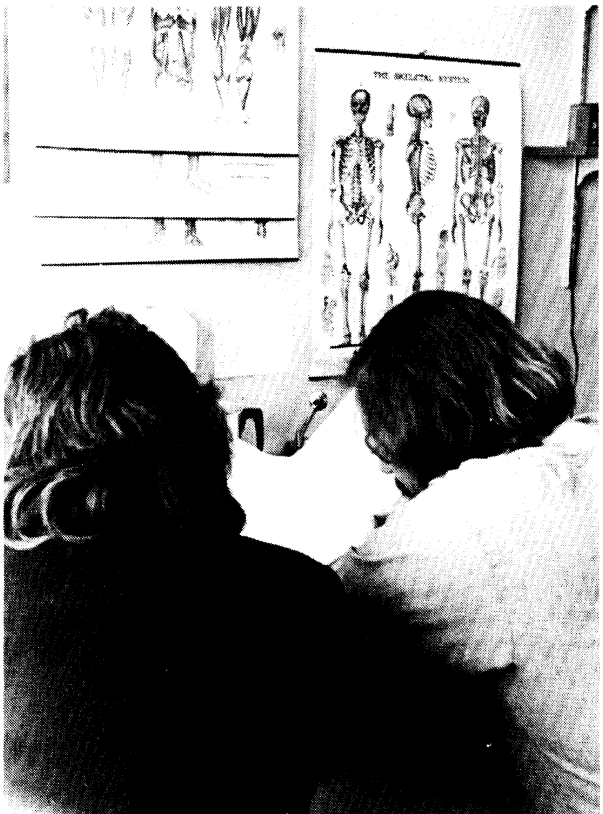
Objective: To obtain a detailed profile of automobile usage and ownership throughout Michigan, and to develop the capability to monitor changes in usage and ownership patterns on a continuous basis.

Significance: Accurate information on changes in the amount and type of automobile exposure is needed to evaluate driver licensing and improvement programs, as well as the consequences of public policy decisions on matters such as overall speed limits and gasoline supply regulation. Hitherto, such information has been available only for limited geographical areas over limited time periods, while larger-scale sources of travel data, such as origin and destination surveys, do not normally permit the study of driver characteristics.

Methods: HSRI has designed and pilot tested an instrument and detailed procedures for approximately 9,000 interviews of Michigan drivers during the license renewal process. Interviewing has been carried out by State personnel over a twelve-month period ending in late 1976. A computer file of survey data has been built at HSRI, and exploratory analyses performed. The survey operation will be scrutinized to aid in the identification of the most efficient methods for monitoring driver exposure on a continuous basis in the future.

Results: The study is expected to provide the Michigan Department of State with the ability to obtain rapid responses to questions about the relationship between individual driver characteristics and patterns of automobile usage, and to ensure that future driver program and policy changes can be related to levels of travel activity.




THE SKELETAL SYSTEM

Multidisciplinary Accident Investigation Files

Investigators: J. Green, J. O'Day

Sponsors: National Highway Traffic Safety Administration, Motor Vehicle Manufacturers Association, and Canadian Department of Transport

Objectives: To collect, computerize, and make available to the research community the accident case data reported by multidisciplinary investigative teams operating throughout North America.

Significance: Accident cases investigated by the multidisciplinary teams provide comprehensive, detailed data derived from the "Collision Performance and Injury Report" long form plus additional variables. These data files provide for the retrieval and analysis of more in-depth, pre-crash, crash, and post-crash accident factors than are available from any other source.

Methods: Case documents are supplied to HSRI by MDAI teams via their respective sponsors. New cases are edited twice to ensure correctness, consistency, and completeness. After computerization they are subjected to extensive consistency checks. The completed cases are made available to users around the continent through the remote-access facilities of The University of Michigan Computing Center and the HSRI-developed Automated Data Access and Analysis System (ADAAS). HSRI also provides field teams and data users with information and training on the data-editing process and contents of the computer files by means of reports and training sessions.

Results: More than 8,500 cases have been computerized. These in-depth files are the most actively used HSRI files, with approximately 50 user accesses per month.

Multilevel Study of Accident Causation and Avoidance

Investigator: L. D. Filkins

Sponsor: National Highway Traffic Safety Administration

Objectives: The long-range objective of the study is to collect and analyze accident data relating to accident causation to identify factors that can be eliminated or reduced through implementation of future countermeasures. The objective of Phase I of this multi-phase study is to provide the conceptual foundation and the experimental design for the study.

Significance: Public- and private-sector efforts to reduce the number of automotive accidents need to be based on accurate knowledge of just what factors in the pre-accident situation function, in combination or sequence with other factors, to make loss of control or a collision inevitable. Those factors need to be identified more precisely by means of accident investigation programs specifically designed to obtain precise information on pre-crash factors and conditions.

Methods: Activities during this Phase I of the study include reviewing the literature on accident causation, selecting and developing accident-causation models, formulating research questions to be addressed, specifying data elements for the collection phase, and selecting analytic techniques to be used in the data analyses.

Results: The Phase-I planning activities will produce a research design for conduct of later phases of the study.

National Crash Severity Study

Investigator: P. Cooley

Sponsor: National Highway Traffic Safety Administration

Objectives: To conduct investigations of a stratified random sample of police-reported injury and towaway accidents in Washtenaw and Lenawee Counties, using sampling, investigative, and analytic techniques employed by other similar NHTSA-sponsored teams operating in other geographic areas of the U.S.

Significance: The purpose of this national program is to obtain needed data on the relationships between crash severity, occupant injuries, and the design of vehicle components, and to test methods for future operation of a statistically valid and reliable national accident sampling system involving careful placement of 25 to 30 teams and construction of a continuing model of nationally representative crash data.

Methods: Data collected on accident cases are obtained from the police report, on-scene investigations, inspection and measurement of vehicle damage, interviews with occupants and witnesses, and medical reports. A specially designed computer program is used to reconstruct each collision so as to arrive at a measure of crash severity.

Results: The study findings are being used by the sponsor to design a crash severity index, assess federal motor vehicle safety standards, and develop a comprehensive national accident sampling system and program.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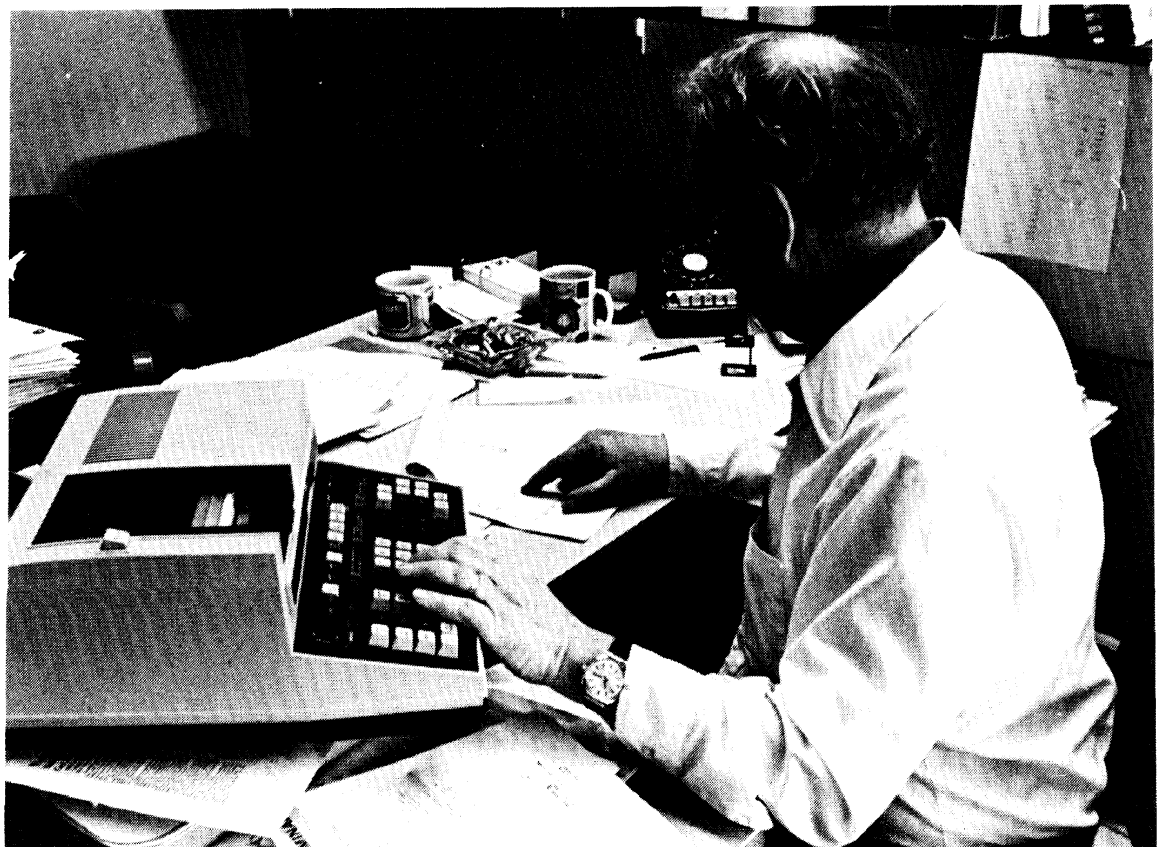

Oakland County Accident Investigations

Investigator: R. E. Scott

Sponsor: Motor Vehicle Manufacturers Association

Objective: To conduct detailed investigations of a sample of Oakland County accidents involving late-model passenger cars towed from the scene.

Significance: Data related to vehicle-handling characteristics, particularly tire characteristics, are being collected to assess their role in accident causation. Data on injuries and restraint system use are also being collected to permit inferences concerning the performance of lap and upper-torso restraint systems in current use.

Methods: The sampling plan is designed for collection of data on approximately 275 accident-involved vehicles per year. Case data are recorded on annotated GM "Collision Performance and Injury Report" long forms with supplements.

Results: The results of this and related programs are expected to contribute to an assessment of the role of vehicle handling in accident causation, particularly as it is affected by the characteristics of tires in use.

Prototype Investigation of Accidents Involving Vehicles Equipped with an Air-Cushion Restraint System

Investigator: P. Cooley

Sponsor: National Highway Traffic Safety Administration

Objectives: To conduct in-depth investigations of automotive crashes involving air-bag-equipped vehicles, as well as school bus crashes and other catastrophic crashes, in the states of Michigan, Ohio, Illinois, Indiana, Kentucky, Minnesota, Wisconsin, and North and South Dakota.

Significance: The HSRI multidisciplinary team is one of five engaged in this nationwide program designed to evaluate the effectiveness of ACRS-equipped cars and the federal motor vehicle safety standards relating to school buses.

Methods: The in-depth case investigations are documented with special forms that record about 800 information items per crash, along with photographs and medical reports. Detailed data on the crash, vehicle damage, and occupant injuries are computerized for use in analyses of causative factors and injury mechanisms. An in-depth report on each case includes conclusions and recommendations.

Results: Since 1974 the HSRI team has investigated more than 140 ACRS crashes and seven school bus crashes. The study results are being used by the sponsor to develop improved safety standards for vehicles and occupant protection systems.

Public Communication on Highway Safety

Investigator: A. C. Grimm

Sponsors: National Highway Traffic Safety Administration, Distilled Spirits Council of the United States

Objective: To increase public understanding of highway-safety-related problems, including alcohol and driving, safety belt use, and the 55 mph speed limit.

Significance: This continuing program is designed to increase the effectiveness of current public information campaigns by encouraging cooperative efforts in planning and evaluation.

Methods: Activities in this program include collection, evaluation, and dissemination of campaign materials (TV and radio spots, print ads, posters, films, as well as survey and research reports and journal articles) through a materials center. A catalog listing these materials is produced and distributed.

Results: The program has collected more than 4,000 campaign items and survey and research reports from more than 300 organizations, and has loaned more than 3,500 items in response to requests. Within the University, the public information materials collection has served as a basic resource for graduate training in the Schools of Public Health, Education, and Social Work. Additionally, graduate students have used the collection as a data base for research projects on alcohol countermeasures and project evaluation methodologies.

Roadside Breathtesting Surveys

Investigator: A. C. Wolfe

Sponsor: National Highway Traffic Safety Administration

Objectives: To obtain nationwide baseline data for comparison with data obtained by local Alcohol Safety Action Project surveys, data obtained in other countries, and data to be obtained in future national surveys; to learn more about characteristics of persons who drive after consuming too much alcohol.

Significance: Information about the distribution and characteristics of alcohol-impaired drivers can assist in formulating effective countermeasures for reducing the number of alcohol-related crashes. Data from a series of roadside surveys over time can be used to monitor the nature and extent of the nation's drinking-driving problem and to assist in a long-term evaluation of national efforts to reduce it.

Methods: A random national sample of 3,698 motorists was obtained in surveys conducted between 10 p.m. and 3 a.m. on eight weekends in the fall of 1973 at 185 roadside locations in 18 states. From among those drivers, 3,358 interviews and 3,192 breath tests were obtained.

Results: In the 1973 national sample, 22.6% of the drivers had a BAC of 0.02% of higher; 13.5% had a BAC of 0.05% or higher; 5.0% had a BAC of 0.10% or higher; and 1.4% had a BAC of 0.15% or higher. In an ongoing study, data from over 100 similar roadside surveys conducted in 27 different ASAPs during the period 1970-1977 are being collected and placed in a single computer file with common format for future comparative analyses.

Special Analysis Topics

Investigator: R. J. Kaplan

Sponsor: Motor Vehicle Manufacturers Association

Objectives: To analyze various sets of motor vehicle accident data stored at HSRI for purposes of answering specific questions about accident causation, crash-induced injury mechanisms, and the effectiveness of injury-preventive measures.

Significance: Such analyses are essential for developing effective countermeasures for reducing the number of automotive accidents and the frequency and severity of injuries.

Methods: Among the topics being pursued in this project are (1) the relationship of passenger car handling elements, particularly tires, and accident causation; (2) the costs of severe, serious, critical, and fatal injuries; and (3) the incidence and effects of occupant compartment intrusion.

Results: The results will be used by the sponsor in understanding design characteristics of vehicles and occupant restraint systems. Recent reports have dealt with the topics of occupant compartment intrusion, vehicle handling, and financial consequences of serious injury.

Stochastic Analysis of Future Vehicle Populations

Investigators: D. H. Golomb, H. M. Bunch

Sponsor: Transportation Systems Center, U.S. Department of Transportation

Objectives: To develop a stochastic model that will forecast distributions of future automobile populations, and to investigate the uncertainties created in those projections by the application of industry and government strategies for introducing new vehicles designed to be safer, cleaner, and more fuel-efficient.

Significance: In light of the recent energy shortages and growing concern for the environment and vehicle crash-protection, federal legislation has been enacted to induce increased technological innovation in the automotive industry. The industry itself has initiated programs to produce more fuel-efficient, cleaner, and safer vehicles. Since it is impossible to predict consumer acceptance, the development of such vehicles poses risks to the industry and the national economy. Most existing predictive models provide little or no information for evaluating these risks.

Methods: The project entails reviewing existing models, compiling relevant data, and constructing two stochastic models—one to generate probability distributions of new car sales, and the other to predict vehicle survival probabilities by type and age.

Results: The models are expected to be used by the sponsor to evaluate the effects of such innovations on industry sales, fuel consumption, emissions, deaths and injuries, and demand for scarce resources.


WASHTENAW COUNTY
MICHIGAN

Washtenaw County Collision Investigations

Investigator: L. D. Filkins

Sponsor: Motor Vehicle Manufacturers Association

Objective: To conduct detailed investigations of a sample of Washtenaw County accidents involving domestic and foreign passenger cars, multiple-purpose vehicles, trucks, and buses.

Significance: Data on injuries and restraint use are being collected to permit inferences concerning the performance of lap and upper-torso restraint systems in current use. Data related to vehicle-handling characteristics, particularly tire characteristics, are concurrently being collected to assess their role in accident causation.

Methods: The sampling plan is designed for collection of approximately 150 accident-involved vehicles per year. Case data are recorded on annotated GM "Collision Performance and Injury Report" long forms with supplements.

Results: The results of this and related programs are expected to determine the effectiveness of current occupant restraint systems in preventing or reducing injuries. Data related to vehicle handling will contribute to an assessment of its role in accident causation. Preliminary analyses suggest that improperly inflated tires, although common in the exposed and accident populations, are not significant causative factors in accidents.


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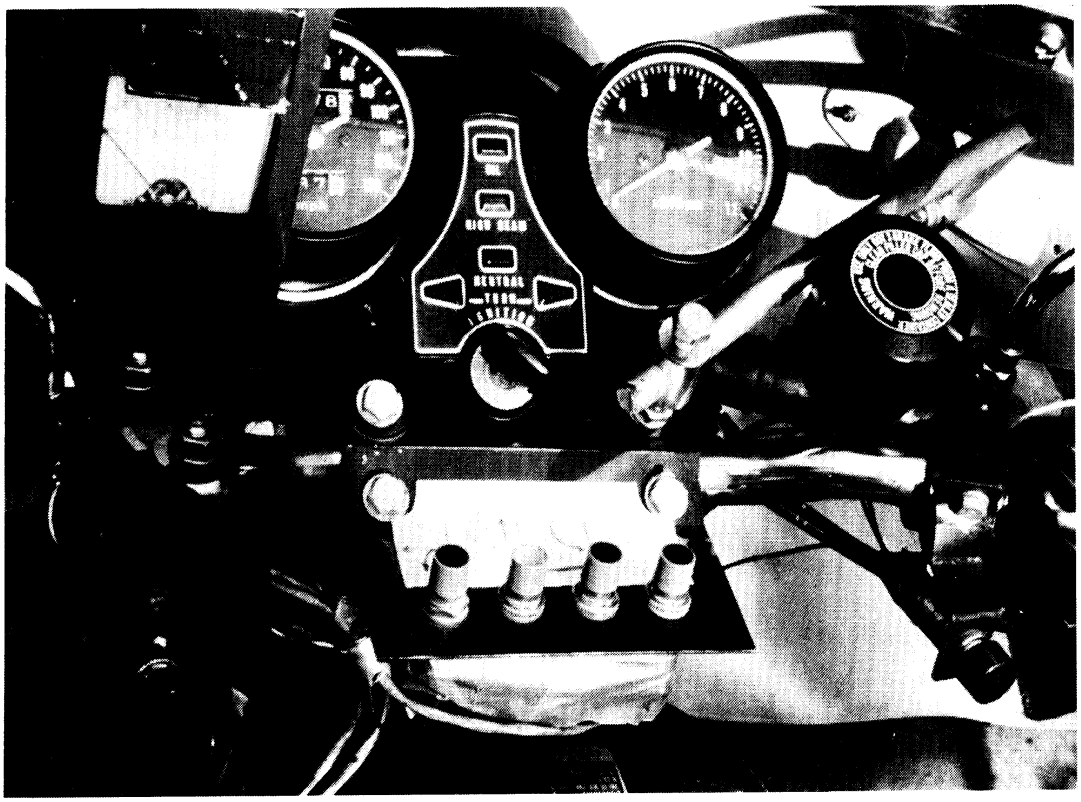

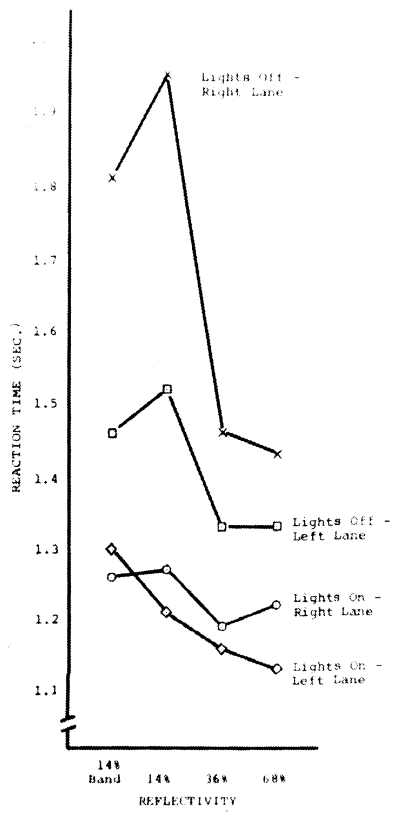
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REACTION TIME (SEC.)
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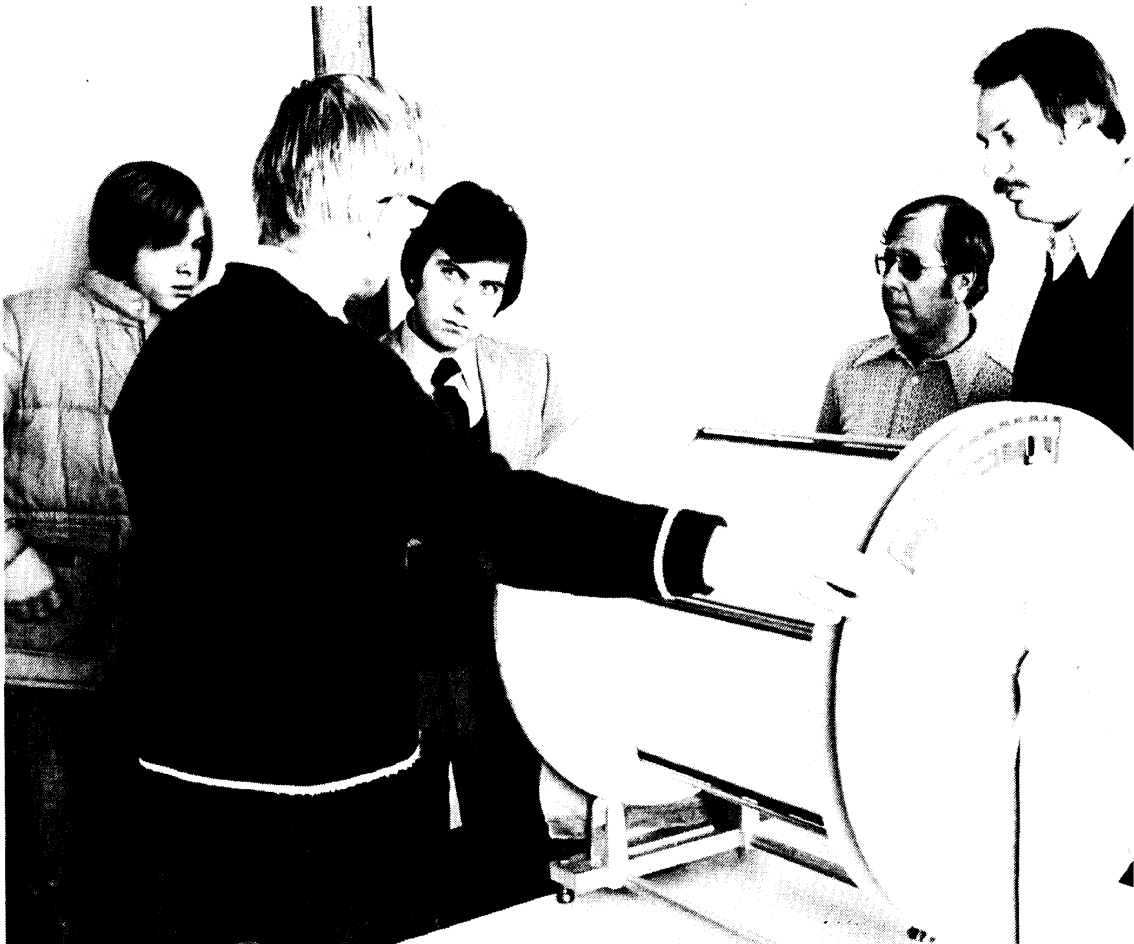


Human Factors Studies

Human factors research at HSRI is concerned with the study of humans acting as control elements in transportation systems. When acting as a controller, a person must adequately conduct such tasks as acquiring and interpreting relevant information, making control inputs and assessing the results, making decisions regarding alternative routes, etc.

Perceptual capabilities are among the most basic skills that affect the ability of a person to act as a controller in a complex system. These capabilities include vision, hearing, and the so-called "space" senses referred to as proprioception. While much research has been conducted in these areas, much remains to be learned. A substantial part of the human factors work at HSRI has been concerned with furthering understanding of relationships between perception and control capabilities.

The dominant perceptual skill in driving is vision. HSRI research in vision has been concerned with fields of view (especially as determined by mirrors), development of improved headlighting systems, the perception of motion of objects in the field of view, the transmission of information between vehicles, and the acquisition of information from the roadway environment, including perceptions of highway signs.

Researchers in human factors have also conducted studies not directly related to perceptual capabilities. Included among these are investigations of the effects of alcohol on driving skills, and a study of ways of involving citizens in the identification and correction of traffic hazards. The results of research on human factors are used by industry and government to improve the 'fit' between human capabilities, vehicles, and the transportation environment.

Citizen Participation to Improve Highway Safety

Investigator: P. L. Olson

Sponsor: National Highway Traffic Safety Administration

Objective: To investigate the potential ways in which participation by citizens can help to reduce or eliminate some kinds of highway safety problems.

Significance: Some highway safety problems such as, for example, delays in communications concerning accident occurrences or stranded motorists, might be effectively reduced through functions performed by community agencies that would encourage citizen participation.

Methods: The study tasks include analyzing current problem areas in terms of their potential for citizen participation, analyzing current practices, developing a research plan involving establishment of an experimental road safety action center, establishing the center in a selected community, and evaluating the effectiveness of the center.

Results: The results are expected to provide valuable information concerning the potential for citizen participation and the efficacy of at least certain forms of road safety action centers.

Evaluation of the Feasibility of a Single-Beam Headlighting System

Investigators: P. L. Olson, R. Halstead-Nussloch

Sponsor: National Highway Traffic Safety Administration

Objectives: To evaluate the beam pattern parameters necessary for developing an optimal single-beam system, and compare them with the conventional dual-beam system to establish the potential for designing a practical system for subsequent on-the-road tests.

Significance: A single-beam system has some obvious benefits, including simplification of the headlighting electrical system and lower headlighting costs. However, a systematic study must be made of the feasibility of developing a single beam that will be as effective at various vehicle speeds and with various roadway geometries in terms of equal illumination distances along with no increased glare for oncoming drivers.

Methods: The work entails a literature review, development of isocandela contours representing the pattern for the single-beam system, procurement of two sets of lamps built to the isocandela curve specifications, and on-the-road tests of the experimental system in comparison with the two-beam system.

Results: The results are expected to include findings and recommendations concerning the utility of a single-beam system, including an assessment of its potential safety benefits when compared with the high percentage of inappropriate use of the present low-beam system.

Evaluation of Position and Spacing of Rear Lamps

Investigators: P. L. Olson, M. Sivak

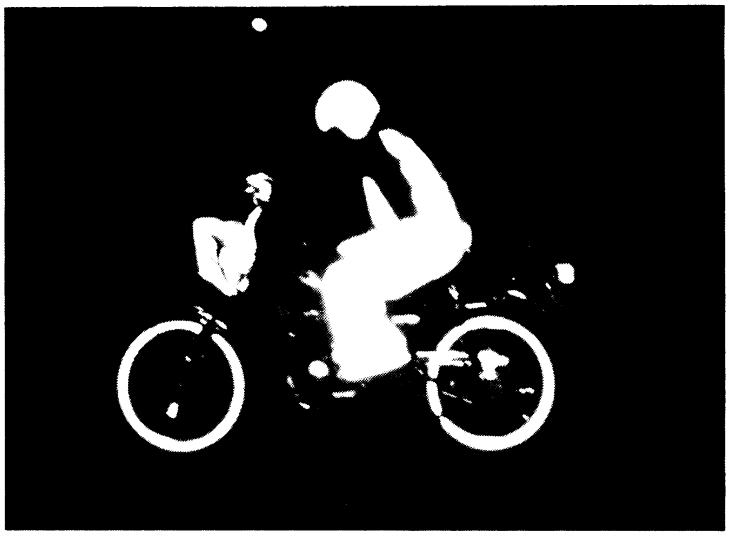
Sponsor: Motor Vehicle Manufacturers Association

Objective: To review and summarize published research findings relating to the position, spacing, color, and intensity of rear signaling and marking systems of passenger cars and trucks.

Significance: Existing signaling and marking systems do not make full use of recent research findings concerning the perceptual capacities and incapacities of motor vehicle drivers.

Methods: The review of the literature includes listing, for each article, the independent variable(s) tested, the range of the independent variable, the dependent variable used, the testing conditions, results, and recommendations of the author.

Results: The work is expected to facilitate a critical analysis of the effectiveness of current and experimental systems with respect to position, spacing, color, and intensity of the lighting and signaling systems.

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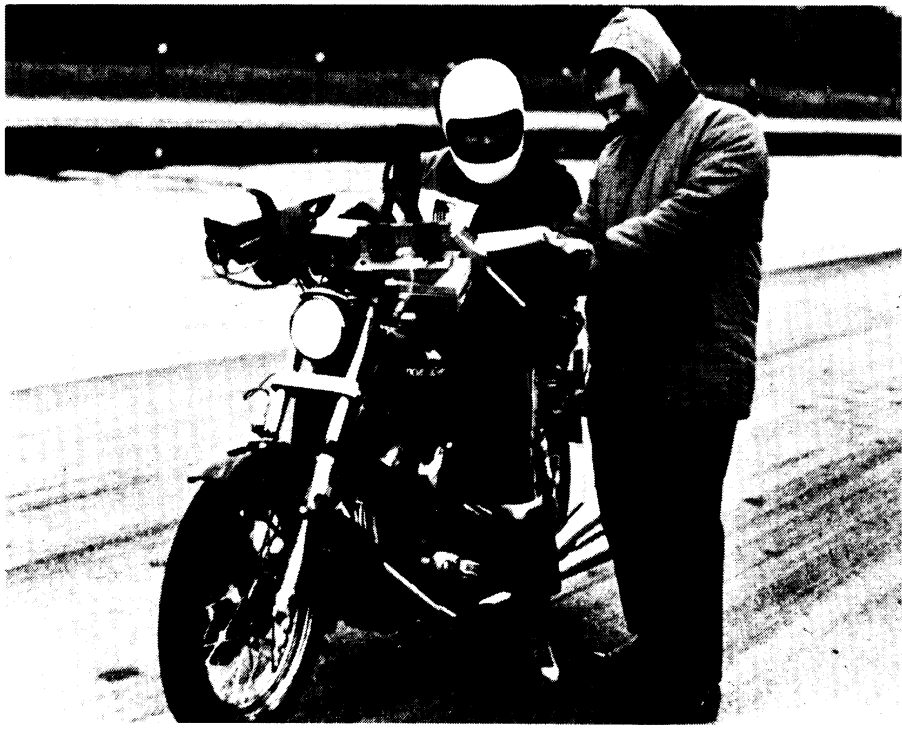


Nighttime Legibility of Highway Signs as a Function of Driver Age and Contrast Ratio

Investigators: M. Sivak, P. L. Olson

Sponsor: National Retired Teachers Association and American Association of Retired Persons

Objectives: To evaluate the nighttime legibility of highway signs as a function of driver age and background/legend luminance contrast.

Significance: This research was conducted in conjunction with The University of Michigan Institute of Gerontology. A recent laboratory study by Olson and Bernstein (1977) had measured nighttime sign legibility as a function of several factors, one of which was subject age. The results had shown that persons over age 65 perform only 65-75 percent as well as persons under age 25, implying that if a young person can read a highway sign at a distance of 800 feet, an older person with the same visual acuity would be able to read the sign at no more than 600 feet. This subsequent study was conducted to determine whether those laboratory findings would be repeated under real-world nighttime field conditions.

Methods: Twelve older and twelve younger subjects, matched on a basis of their daytime visual acuity and color vision, were tested at night on a private, dark road, using special signs that varied in their background colors, specific luminances, and contrast ratios.

Results: The field tests confirmed the laboratory findings. The mean legibility distances for the older subjects were found to be 65-77 percent of those for the younger subjects. The results showed that high-luminance (daytime) acuity is not a reliable predictor for nighttime legibility of signs for different age groups. Furthermore, the results indicate that an intermediate level of contrast ratio yields optimal performance; too low or too high levels of contrast are both detrimental to legibility.

Signal Lighting System Requirements for Emergency, School Bus, and Service Vehicles

Investigator: D. V. Post

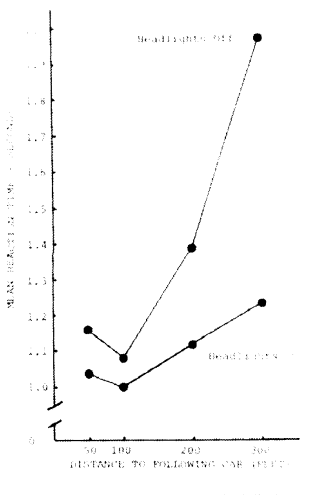
Sponsor: National Highway Traffic Safety Administration

Objective: To analyze vehicle-to-vehicle communication requirements for emergency, school bus, and service vehicles, so that effective signalling systems for these vehicles can be specified to provide nationwide uniform systems.

Significance: Uniformity of message signalling systems for various emergency and service vehicles will result in more adequate communication to drivers of other vehicles, and should reduce the disproportionate number of accidents involving special vehicles. Adequate and consistent school bus signalling systems must also be coupled with standardized operational procedures to protect pedestrians.

Methods: The tasks in the program include analyzing present laws and regulations governing signalling requirements, developing a classification system for categorizing special-purpose vehicles in terms of the information to be signalled, and developing and recommending specifications for uniform signalling systems.

Results: The study results will be used by the sponsor in modifying applicable federal motor vehicle safety standards. Attempts will also be made to modify applicable sections of the Uniform Vehicle Code and to bring state laws into conformity with it. A demonstration will attempt to influence the adoption of a recommended school bus signalling system and uniform laws regarding its use.



MEAN REACTION TIMES AS A FUNCTION OF DISTANCE TO THE FOLLOWING CAR AND

Techniques for Increasing the Conspicuity of Motorcycles and Motorcycle Drivers

Investigators: P. Olson, R. Halstead-Nussloch

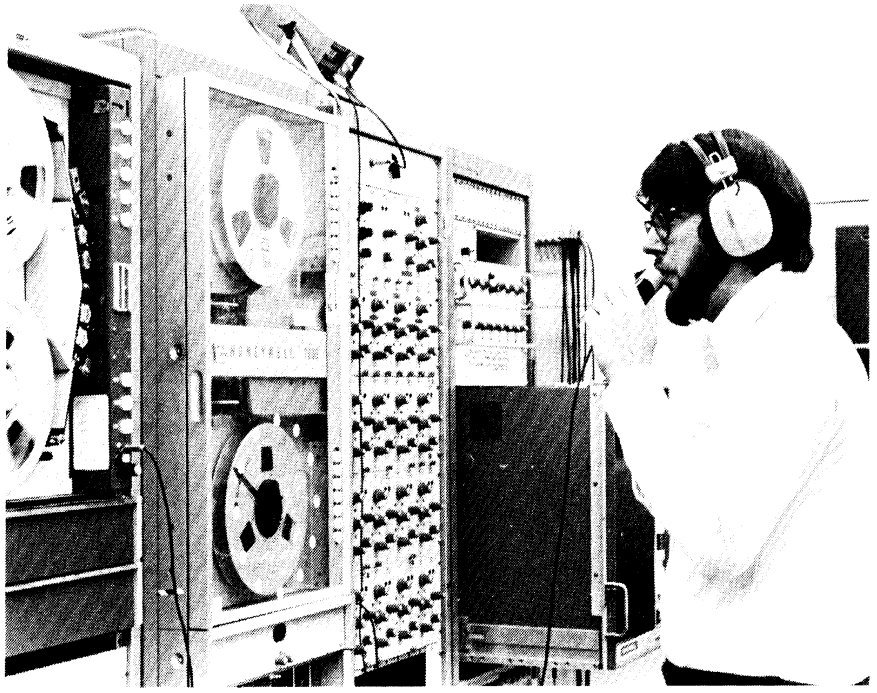
Sponsor: National Highway Traffic Safety Administration

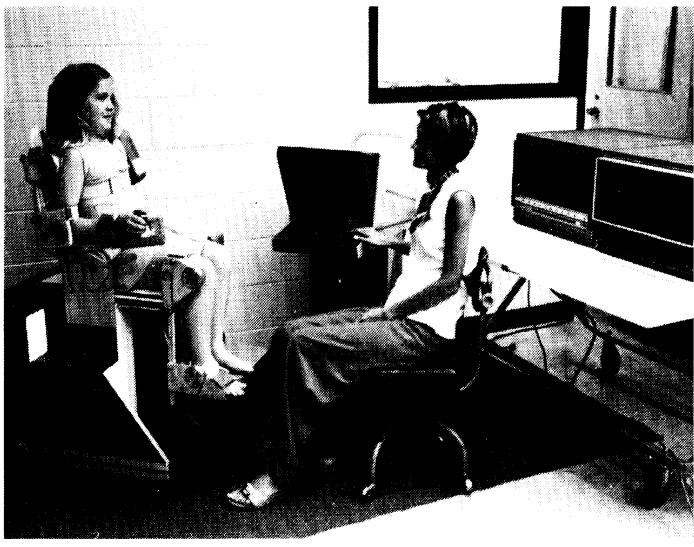
Objective: To develop and evaluate techniques for making motorcycles and motorcycle drivers more conspicuous for drivers of other motor vehicles.

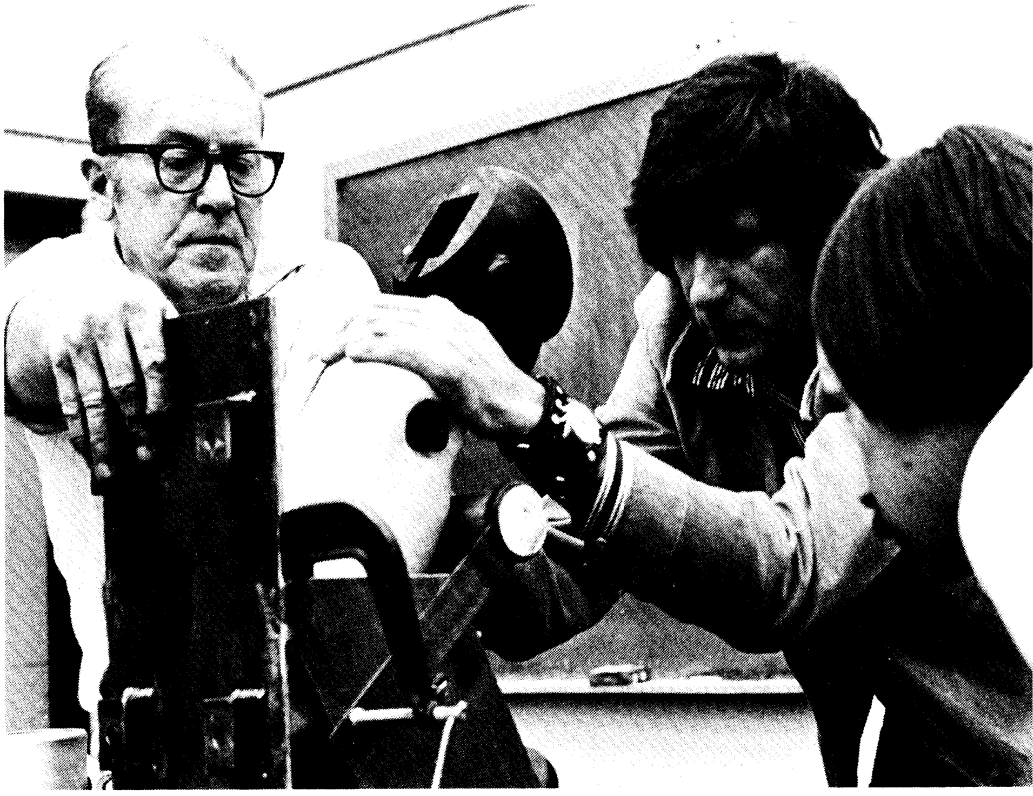
Significance: Several research studies have shown that a high percentage of multi-vehicle traffic accidents involving a motorcycle have resulted partly from the failure of the car or truck driver to see the motorcycle and perceive it immediately as a motor vehicle capable of speeds equal to any four-wheeled vehicle.

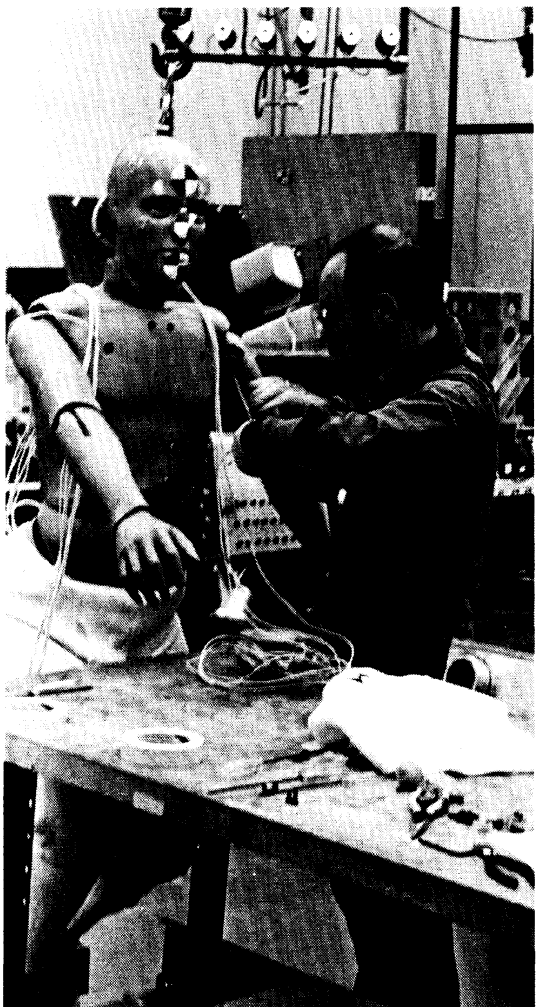
Methods: The study tasks include a critical review of relevant scientific literature, identification and selection of at least six techniques or treatments suited for evaluation, the design and conduct of experimental field tests, assessment of the test results, and development of recommendations concerning the techniques/treatments found to be most effective and feasible in terms of costs and benefits.

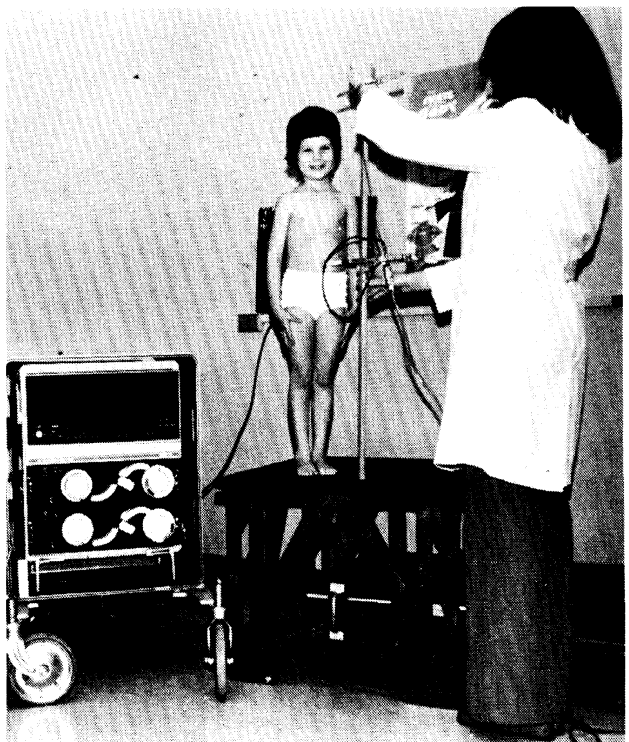
Results: The study results will be used by the sponsor in developing and promoting means of making motorcycles and their drivers more conspicuous.











Injury Protection Studies

HSRI research programs in Injury Protection are concerned with biomechanical, biomathematical, and biomedical problems. All of these efforts are designed to create knowledge and techniques essential for developing better means of protecting humans from injury in accidents, including collisions of vehicles in automotive and other kinds of transportation systems.

The studies are designed to establish a better understanding of what types and levels of impacts various parts of the human body can withstand without serious injury. Designers of vehicles and restraint systems need this information so that they can design vehicles and occupant compartments that keep crash-induced occupant motions down to levels below the threshold of serious injury. This can be accomplished by having a strong occupant compartment or "capsule" that is protected from high decelerations by a vehicle periphery that absorbs crash energy as it crushes. At the same time, a restraint system within the occupant compartment is needed to prevent occupants from colliding with the interior of the decelerating compartment. The more crash energy the vehicle itself and the restraint system can absorb, the greater the chance that occupants can emerge from a severe collision unharmed.

The studies described in the following pages are developing better knowledge of human impact tolerances, energy-absorbing vehicle components, improved restraint systems, and crash-test dummies that are more realistic surrogates for living human adults and children. The efforts include development of computer simulation models that can show the motion and injury effects of particular kinds of crashes. Those computer simulations help the researchers understand the dynamics of crashes. They also speed up the process of obtaining essential information by reducing the extent to which full-scale experimental crash tests must be conducted.

Anthropometry and Biomechanics of Selected Populations

Investigator: R. G. Snyder

Sponsor: National Institute of Occupational Safety and Health

Objectives: To review the state of the art and determine what current data are applicable to biomechanical aspects of occupational work problems and special environments of selected sub-populations.

Significance: The capability of females, pregnant women, the handicapped or disabled, and the elderly to perform certain tasks safely has received little attention from an anthropometric or biomechanical point of view. This study is intended to provide a survey of the state of the art as a basis for determining what available data may be applicable and to identify further occupational safety priorities.

Methods: Pertinent research materials are being collected, listed, and analyzed.

Results: The results of the literature search are expected to be used by the sponsor as a guide to assessing occupational safety problems and requirements for selected sub-populations.

Biomechanics of Cervical Spine Injuries

Investigators: J. W. Melvin, D. H. Robbins

Sponsor: National Institute of Arthritis, Metabolism, and Digestive Diseases

Objectives: To establish the ranges of motion and configuration of the human cervical spine in the principal planes of motion and in coupled combinations of motions; determine the dynamic resistance to motion of the spine under realistic loads; determine its failure characteristics under simple and complex loads; develop a detailed mathematical model of the cervical spine that can assess injury potentials in crash environments; and install the model as a post-processor model for use with computer simulation models of gross vehicle motion.

Significance: Existing biomechanical data on the human cervical spine are specialized and are not well suited to inclusion in a unified analysis of cervical spine injuries.

Methods: The experimental tests are closely coupled with an analytic program to develop a detailed mathematical model that can be used to predict and assess the injury potential of impacts to the cervical spine.

Results: The mathematical model under development, when combined with the experimental injury data and used in conjunction with simulation models of gross vehicle motion, will provide information essential for assessing the extent of spinal injuries in particular simulated collisions.

Biomechanics Research Program

Investigators: J. W. Melvin, R. L. Stalnaker, L. W. Schneider, G. S. Nusholtz

Sponsor: General Motors Research Laboratories

Objectives: To conduct a set of six experimental biomechanical studies: (1) an evaluation of vibratory brain motion through high-speed cineradiography; (2) an evaluation of various energy-absorbing knee restraint structures; (3) an investigation of the response of the neck-shoulder complex to lateral impacts; (4) a study of the effects of vibration on coupling soft tissue of the knee; (5) a study of the responses of leg musculature in jumping impacts; and (6) an assessment of the mechanisms of aortic trauma.

Significance: These studies are designed to create new knowledge of the effects of certain impact motions on the human body, so that vehicles can be designed to protect occupants against serious injury in collisions. Some of the work is being conducted in cooperation with researchers in the U-M Medical School, and some with researchers in the Wayne State Medical School.

Methods: The methods employed in the studies vary, depending on the study objectives, test subjects, and equipment used.

Results: The study findings will contribute to improved designs of occupant compartments in automotive vehicles as well as vehicles in other transport modes.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Computer Model Installation and Training

Investigator: D. H. Robbins

Sponsor: National Highway Traffic Safety Administration

Objectives: To furnish the NHTSA with the MVMA two-dimensional crash victim model, furnish the tutorial package of cassettes and films for self-study of the model, install the 2-D and 3-D models on IBM equipment, and train personnel in their use.

Significance: The two- and three-dimensional computer simulation models of crash-victim motions, developed by HSRI through long-term support by the Motor Vehicle Manufacturers Association, are research tools the NHTSA can use in developing improved standards relating to the design of occupant compartments and occupant restraint systems.

Methods: The work entails considerable travel to NHTSA computer installations to put the models on IBM equipment and train personnel in their use.

Results: On completion of the work, the NHTSA personnel will be prepared and equipped to use the MVMA 2-D and 3-D models.

Crashworthiness and Occupant Protection in General Aviation Aircraft Accidents

Investigator: R. G. Snyder

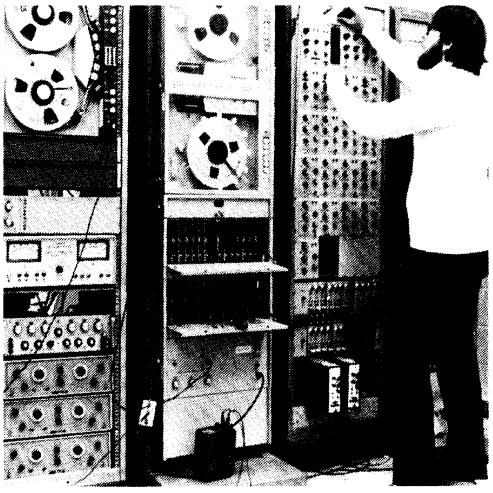
Sponsor: Highway Safety Research Institute

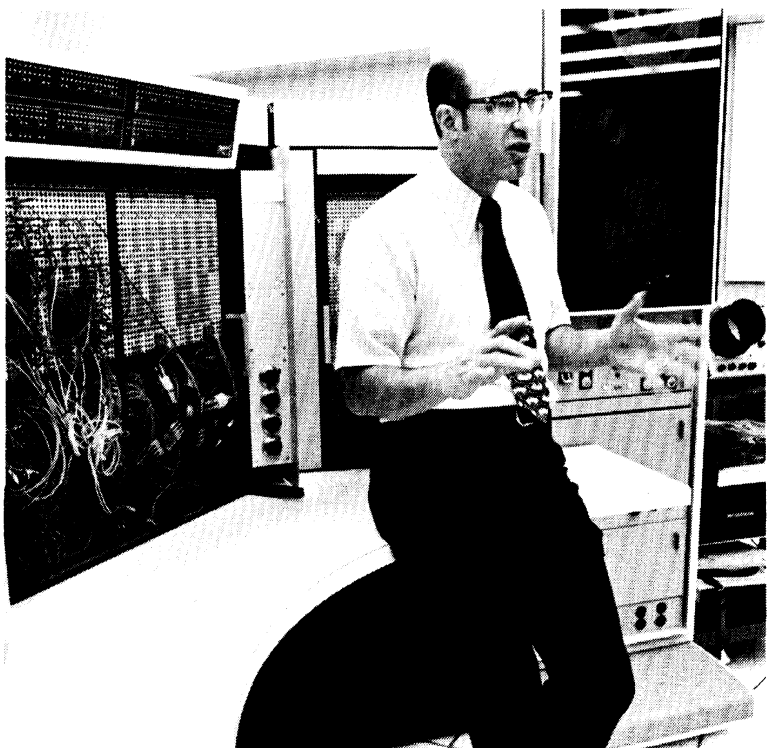
Objective: To determine relationships between injury patterns and crashworthiness design.

Significance: These investigations, conducted since 1970, are being pursued in cooperation with the National Transportation Safety Board, the Federal Aviation Administration, and the Michigan State Police. The on-scene investigations provide biomedical data essential for developing improved aircraft designs, particularly with respect to improved protection during and following a crash.

Methods: In on-scene investigations of survivable crashes, investigators examine and evaluate the performance of cabin structures, instrument panels, restraint systems, seats, and other components related to occupant injury or protection. Analyses of injury causes and occupant impact tolerances include use of FAA, USAF, and NTSB crash reports and studies maintained in the HSRI aircraft safety files, which include some 29,000 documents as well as a magnetic-tape copy of the NTSB accident files for the past 12 years. The tape is being converted to the U-M ADAAS system to permit detailed and rapid computer analyses of aircraft accident variables.

Results: Data collected thus far indicate that even when cabin structures remain intact, occupants often receive serious or fatal injuries from instrument panel projections, inadequate restraint systems, inadequately anchored seats, and other design-related causes. The data show that use of upper-torso restraints could reduce serious and fatal injuries in survivable accidents by an estimated 85 percent. The data also show that emergency general aviation aircraft ditching can be successfully accomplished under adverse conditions, with overall 95 percent survivability found for 315 cases in the past 10 years.





Experimental Data for Validating Finite-Element Models of Thoracic Skeletal Responses

Investigators: J. W. Melvin, N. M. Alem

Sponsor: National Highway Traffic Safety Administration

Objectives: To define, develop, demonstrate, and employ techniques and plans for obtaining experimental data for purposes of supporting and validating finite-element models of thoracic skeletal responses.

Significance: Finite-element computer methods offer the capability of numerically simulating vehicular crashes and predicting significant injuries and internal biodynamic responses of the human body. Models using finite-element techniques require experimental validation to assess their accuracy and provide a basis for further improving them.

Methods: Experimental procedures are being developed to allow the measurement of three-dimensional motions and strains at selected points on the rib cage under static and dynamic loading conditions. These procedures include use of specialized photogrammetry and radiographic anthropometry to describe the global geometry of the thorax, and use of materials testing techniques to provide data on rib hard-tissue failure.

Results: This program is providing extensive experimental information on the details of thoracic skeletal responses to various types and levels of impacts. The information will be used to validate and improve the computer simulation models.

Grip Strength Measurements of Children for Product Safety Design

Investigators: C. L. Owings, R. Norcutt, R. G. Snyder, D. H. Golomb, K. Y. Lloyd

Sponsor: Consumer Product Safety Commission

Objective: To obtain isometric strength measurements of the hand and upper extremity functions of children aged two through ten years.

Significance: This research has collected and evaluated new data related to the elbow and hand strength of children. The safety implications are important, because manufacturers of products used by children lack sufficient information on the strength limitations of the children. The force a child transmits to an object may be sufficient to move it but insufficient for safe control. Data on gripping strength are important for estimating the hazard for injury.

Methods: The study subjects underwent hand strength tests for the three-point pinch, five-point pinch, and squeeze or power grip at different degrees of hand closure, corresponding to exertions on objects ranging in size from two to nine centimeters. The torque capability was measured at joint angles ranging between 67.5° and 180°. A specially designed child "strength chair" fit the child like an exoskeleton for the right half of the body. All electrical signals were amplified and fed via a 12-bit A/D converter to a Nova 1220 digital computer using special data acquisition programs.

Results: Grip strength measurements on more than 350 children and elbow strength measurements on 104 children were obtained and analyzed.

Human Impact Tolerances in Free-Falls

Investigators: R. G. Snyder, D. R. Foust, B. M. Bowman

Sponsor: Insurance Institute for Highway Safety

Objective: To study selected human free-fall impacts and collect impact-tolerance data useful for applications in the design of improved protective systems for occupants of vehicles.

Significance: This study was designed to obtain precise data concerning human tolerance to impact trauma, especially for children and the elderly. Free-fall impacts involving various heights, surfaces, contact sequences, and resulting injuries offer data relevant to impacts occurring to vehicle occupants in collisions, and are easier to reconstruct than occupant motions in an automotive collision.

Methods: One-hundred ten free-falls selected from more than 2,100 cases reported in the U.S. and Canada were investigated on-site. Biomechanical, injury, and environmental data were collected on each case and analyzed. The MVMA Two-Dimensional Crash Victim Simulator was used to simulate seven head-first and three feet-first falls.

Results: The study results showed that when children and adults fall more than 10 feet and land head-first, they normally incur skull fractures. If they fall 10 feet and land in a sitting position, they are likely to incur a lumbar spine fracture. If they fall more than 30 feet and land feet-first, they are likely to incur a pelvic fracture. The computer simulations of six actual head-first falls by children indicated that they can survive peak skull accelerations higher than previously considered survivable; five of the six survived. Survival limits for head impacts of children under age eight were indicated to be as high as 600 G peak acceleration, with rates of onset of up to 300,000 G/sec for durations of up to 3 milliseconds. For the same age group, moderate reversible injury is predicted for peak accelerations as high as 350 G, with onset rates of up to 200,000 G/sec and durations of up to 3 milliseconds. Combining on-site investigations with computer simulations of human free-fall impacts was found to be an effective method of studying impact injury tolerances.

Human Tolerance to Impacts

Investigators: J. W. Melvin, R. L. Stalnaker, G. S. Nusholtz

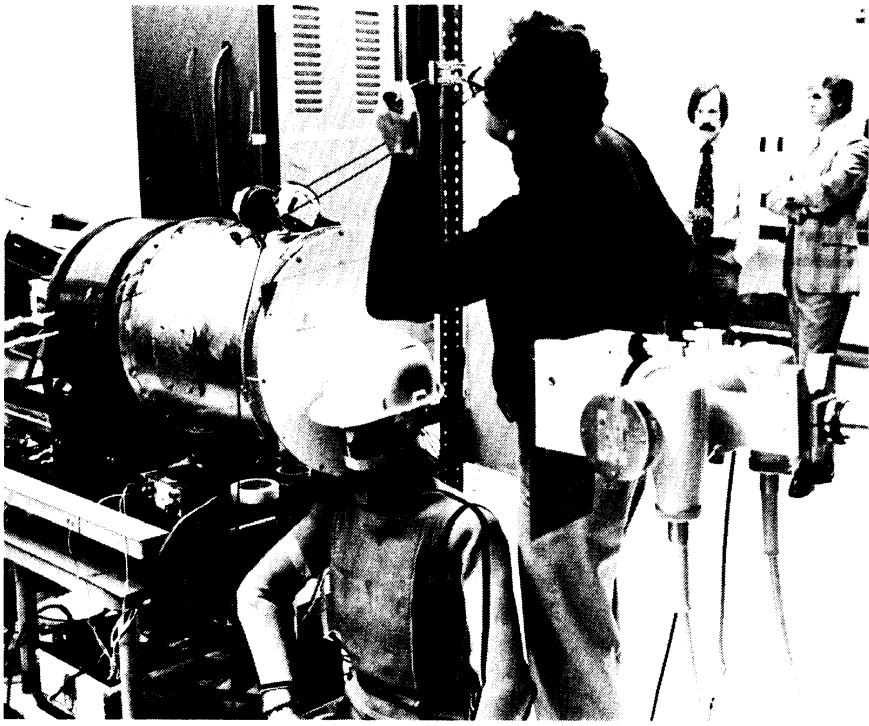
Sponsor: Motor Vehicle Manufacturers Association

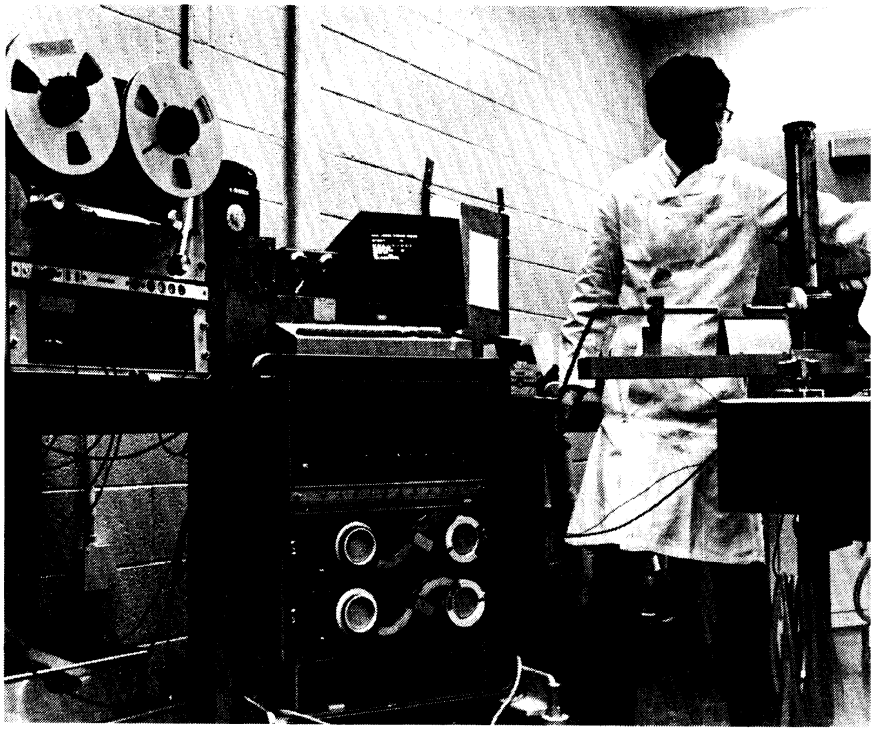
Objective: To extend knowledge of human responses to impact and the tolerance of injury of critical body regions and organs.

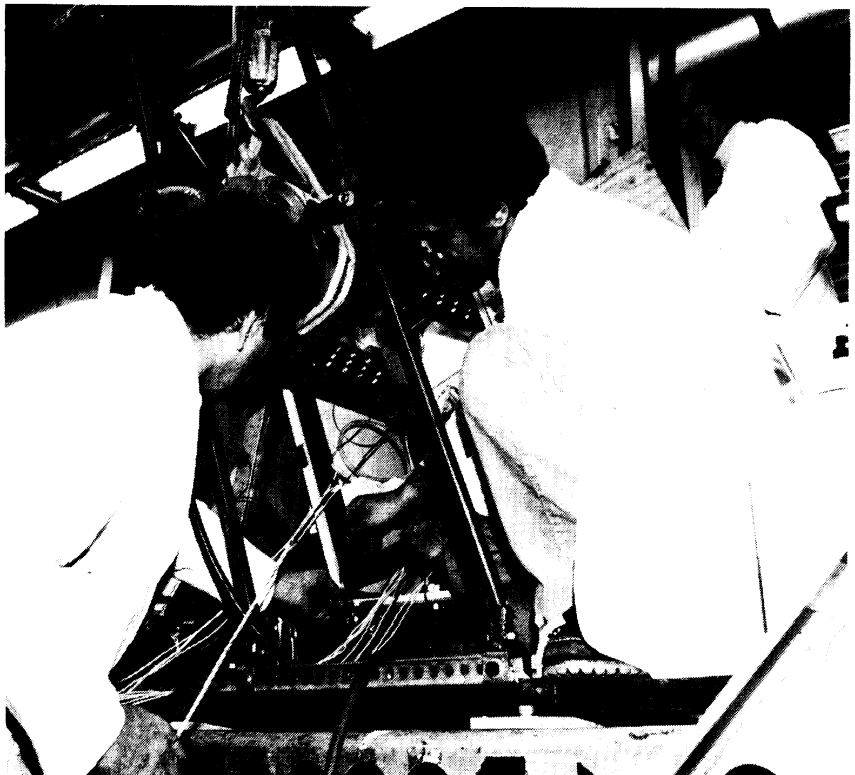
Significance: Knowledge of the tolerance of humans to impacts is essential for developing and evaluating motor vehicle interiors that minimize the likelihood of injuries from a collision. This project is part of the continuing human tolerance research program at HSRI that has developed and applied advanced biomechanical test techniques and instrumentation, anthropometry, computerized data acquisition and analyses, and high-speed-x-ray cineradiographic equipment and techniques.

Methods: Tests are being conducted to study head injury mechanisms, abdominal injury and tolerance mechanisms, and upper leg fracture tolerance.

Results: The experiments are producing data essential for improving anthropomorphic test dummies, occupant restraint systems, and vehicle occupant compartments.





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MVMA Two-Dimensional Man Model Simplification

Investigator: D. H. Robbins

Sponsor: Motor Vehicle Manufacturers Association

Objective: To make the MVMA 2-D Man Model Crash Victim Simulation more efficient by providing selective linking of optional sub-programs to execution.

Significance: Computer simulations of occupant dynamics during crashes, used in conjunction with actual impact testing, are a valuable means of obtaining information essential for developing improved protection for vehicle occupants. The changes being made in the simulation model will reduce computer core space required, execution times, and costs of using the model.

Methods: The computer program is being streamlined by modifying the input processor to produce a small FORTRAN program as part of its output. This "pre-processing" program will provide for the loading of only those options necessary for a given simulation. The program will be debugged and then demonstrated, using a realistic combination of several of the model options.

Results: The project will make the simulation model more efficient and will reduce the cost of using it by about 15 percent.

Occupationally Related Falls

Investigators: R. G. Snyder, E. Umholtz

Sponsor: National Institute of Occupational Safety and Health

Objectives: To investigate occupationally related falls in terms of injury severities, age distributions, geographic and seasonal effects, and changes in trends from 1963 to 1976.

Significance: Falls are exceeded only by motor vehicle accidents as a major cause of accidental death in the U.S. Slips and falls constitute the primary cause of injuries in the work environment. Yet little data are available on the incidence of falls in specific occupations.

Methods: HSRI has accumulated data on approximately 32,000 cases of falls collected in connection with an FAA-sponsored study conducted in 1962-1963 and a 1975-1976 study sponsored by the Insurance Institute for Highway Safety. The data from those two free-fall studies are being individually examined and analyzed to establish age, geographic, and occupation-related injury trends.

Results: The study results are expected to be used as a basis for identifying occupations that may require improved governmental safety standards.

Protection of Child Occupants in Automotive Crashes

Investigators: J. W. Melvin, R. L. Stalnaker

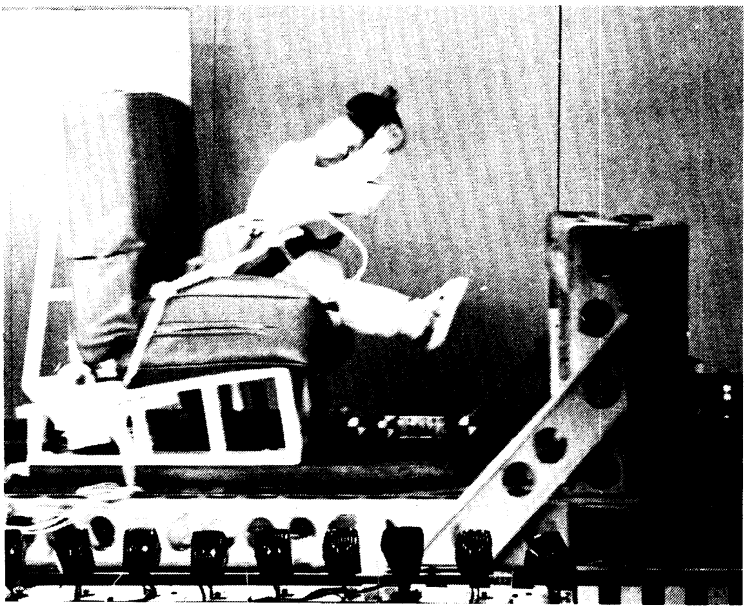
Sponsor: Insurance Institute for Highway Safety

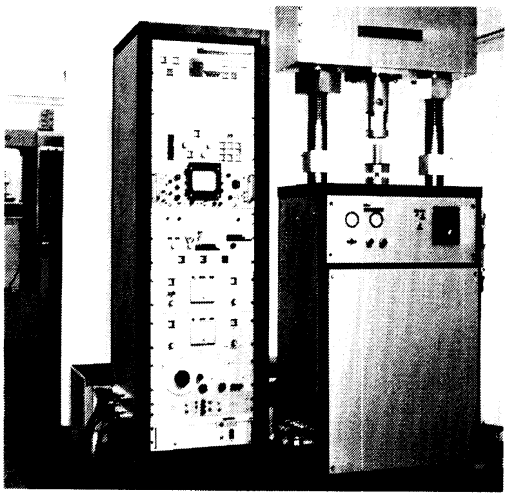
Objectives: To establish injury patterns of restrained and unrestrained child occupants, and assess the effectiveness of child restraint systems in real-world crashes.

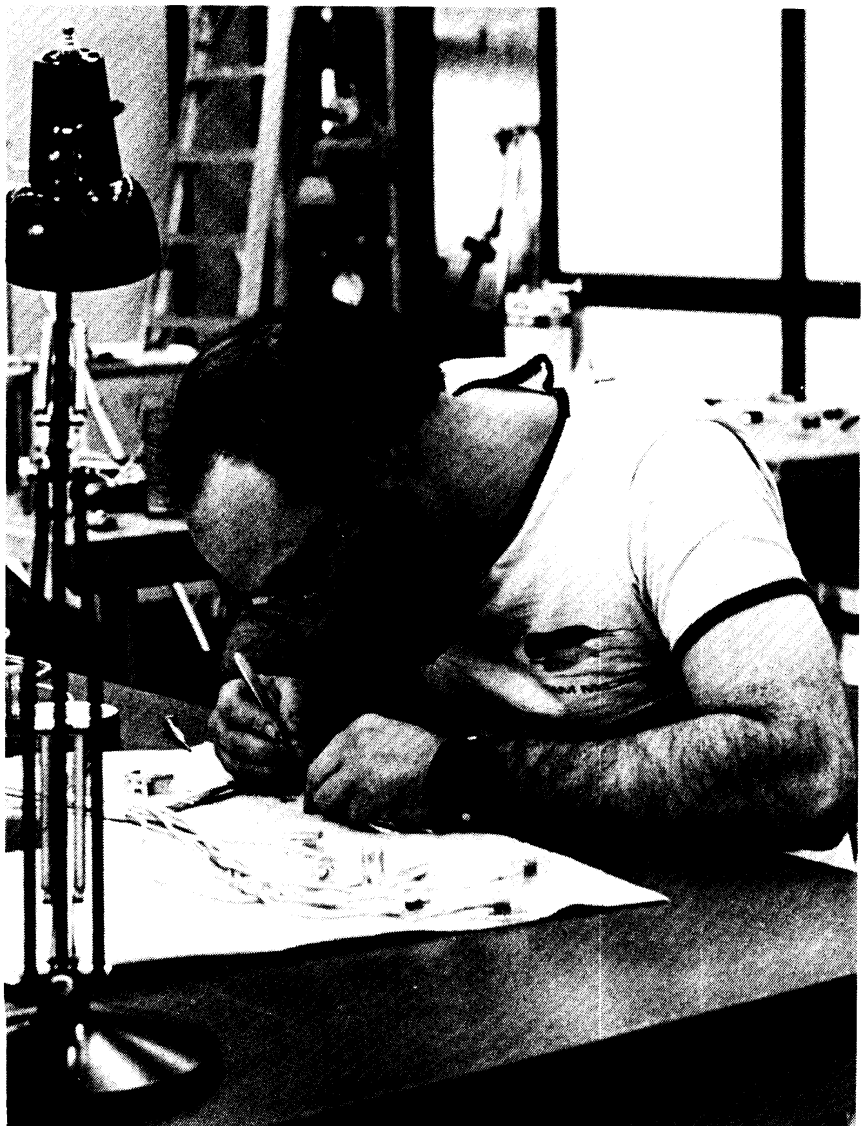
Significance: The data are needed to produce a composite picture of the problems of child occupant protection, so that critical areas that need improvement can be defined.

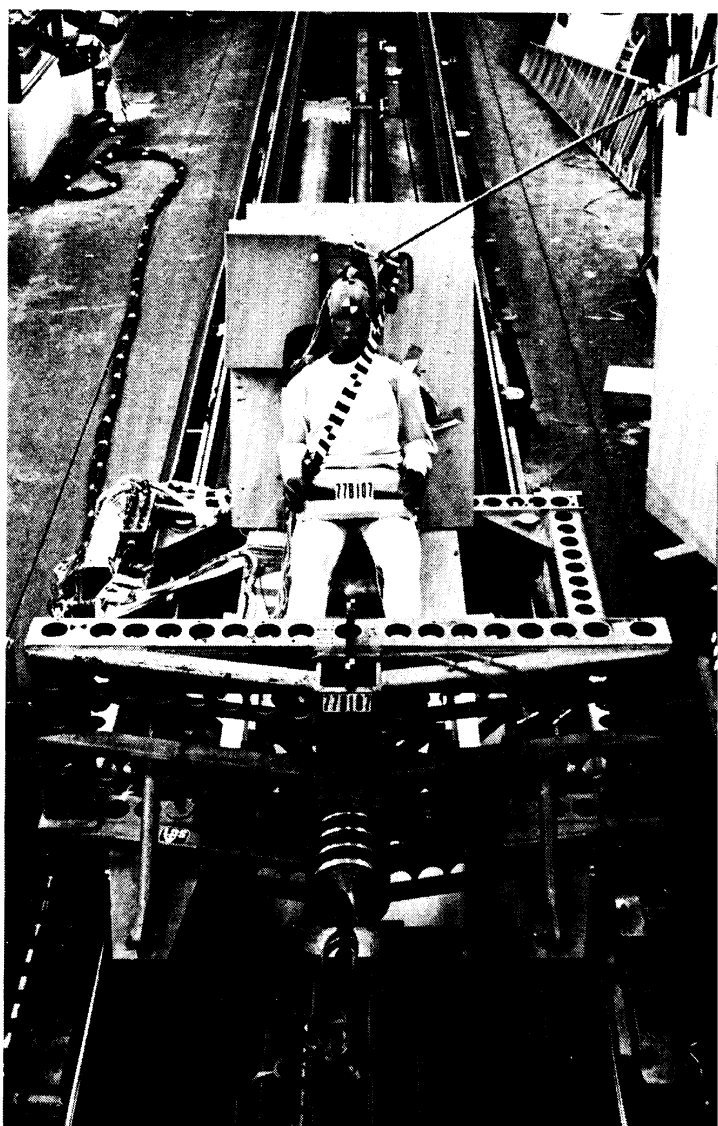
Methods: The research includes investigating crashes in Oakland and Washtenaw Counties, Michigan, in which children eight years of age and under are passengers. The data are being assessed to determine injury patterns of restrained and unrestrained children.

Results: The results will be used in an overall assessment of child restraint effectiveness and performance criteria.









Quantification of Thoracic Impacts and Injuries

Investigator: D. H. Robbins

Sponsor: National Highway Traffic Safety Administration

Objectives: To quantify kinetic and kinematic responses of the human thorax (chest) to impacts, define performance specifications adequate to ensure kinetic and kinematic fidelity of a surrogate thorax to a living human thorax, and compile a compendium of derived predictive functions that relate specific kinematic parameters of a thoracic impact to the probable occurrence of injury.

Significance: Thoracic injuries are prevalent in automotive crashes, but the mechanisms of these injuries are not well understood. This lack of data has hindered development of reliable injury criteria, crash test dummies, and restraint systems.

Methods: Basic data are being obtained through instrumented impact tests. Injury-predictive functions are being developed from the test data.

Results: The injury-criteria information produced in this study will be employed to develop performance specifications for the thorax of an improved crash-test dummy that can be used for evaluating the effectiveness of current and experimental occupant restraint systems.

Viscoelasticity of Soft Tissues and Related Injuries

Investigators: J. W. Melvin, A. S. Wineman

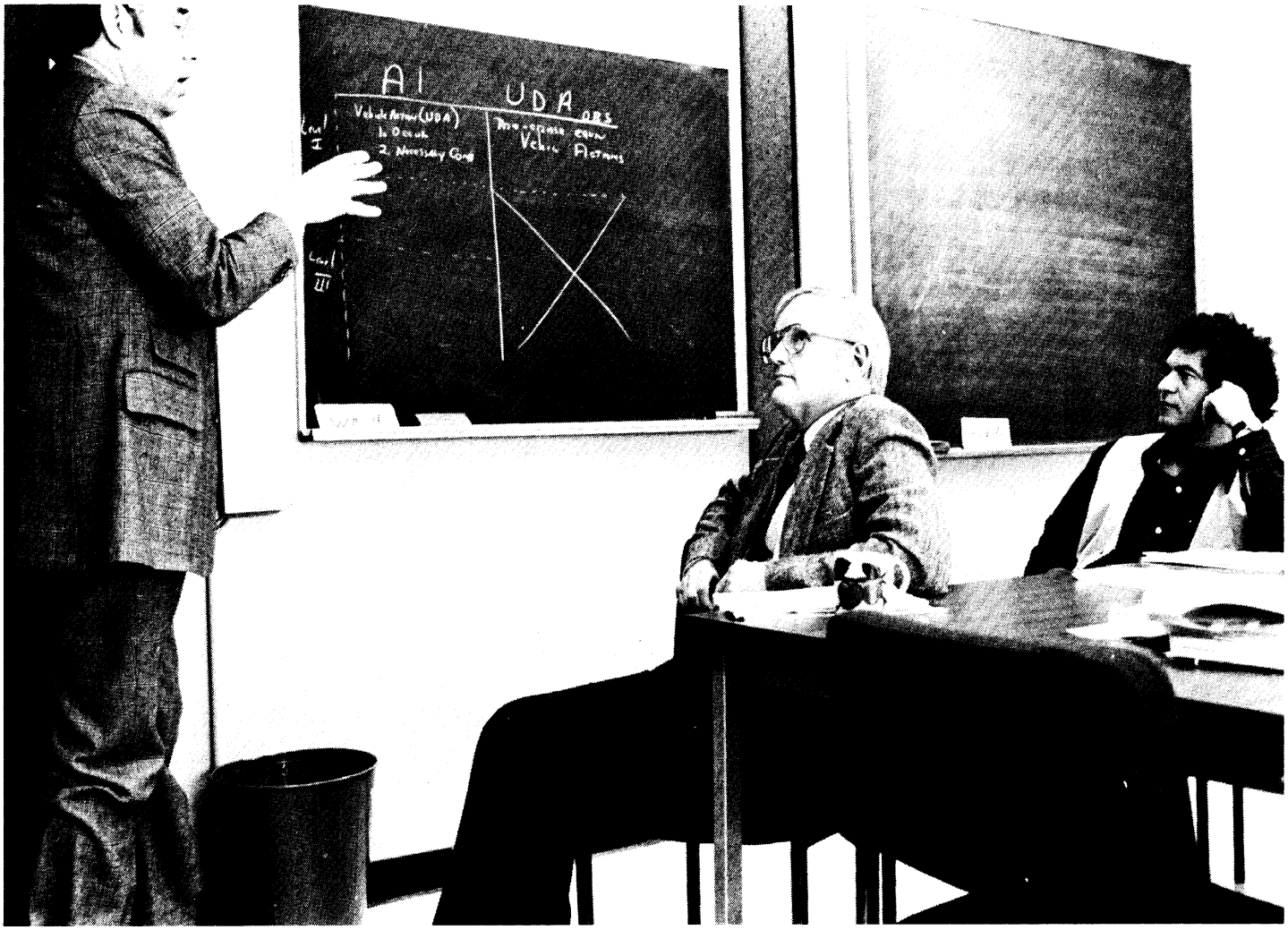
Sponsor: National Science Foundation

Objectives: To study theoretically and experimentally the topics of material anisotropy, rapid loading response, and failure criteria as they apply to the understanding of mechanisms of mechanical trauma to the soft tissue of the human body.

Significance: Intensive efforts are now being made to understand the mechanisms of mechanical trauma in the human body and to mathematically model these mechanisms. It is of great importance to investigate the basic application of nonlinear continuum mechanics to the description of mechanical injury.

Methods: Test methods and constitutive descriptions of material behavior are being based on applications of modern nonlinear continuum mechanics. The program encompasses the study of basic analytic problems in continuum mechanics and the application of such analyses to significant problems in the description and understanding of the mechanical behavior of soft tissue and associated injury mechanisms.

Results: The methods, concepts, and results of this program are expected to improve experimental procedures and constitutive assumptions for understanding mechanical functions and modes of failure in biological tissue. The needs identified in this experimental study will be used to develop special topics in continuum mechanics and solutions to specific problems.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Policy Analysis Studies

Research studies in Policy Analysis are concerned with four program areas: Future Studies, Policy Formulation, Policy Implementation, and Information Utilization.

Projects in the area of Future Studies are examining issues likely to arise more than five years in the future—issues critical to development of public safety and transportation policies.

Projects in the area of Policy Formulation are examining current issues—those now under consideration as public policy questions, or those likely to be considered within the next five years.

Projects in the area of Policy Implementation fall within two broad categories: System Improvement, and Evaluation. The first category, System Improvement, includes projects designed to improve the functioning of federal, state, and local programs. Such studies focus on government operations, system users, or transportation environments. The second category, Evaluation, includes studies that seek to evaluate the effectiveness of programs and identify the collateral impacts of their stated policy objectives.

Projects in the area of Information Utilization are concerned with the dissemination of knowledge for program development, as well as the process by which information is used to make policy decisions.

All of the Policy Analysis studies are concerned with providing information that policymakers, including the public, need for formulating effective policies and programs to increase public safety and develop more effective transportation systems. Such research can help assure policies, laws, and procedures that improve the quality of life by being more efficient yet not unduly restrictive.

Analytic Study of Mathematical Models of the Motor Vehicle System

Investigators: K. B. Joscelyn, B. C. Richardson

Sponsor: Motor Vehicle Manufacturers Association

Objectives: The primary objectives of this study are to inventory, analyze, and describe the use of mathematical models which may be influential in the formulation of policy relating to the motor vehicle transportation system.

Significance: In recent years, numerous mathematical models have been developed which simulate attributes of automobile usage and operation within the motor vehicle transportation system. Increasingly these models are being used in the formulation of policy relating to the motor vehicle system. There is a need to identify and analyze these models and to determine their purposes and uses.

Methods: This study involves five basic tasks: (1) the identification of models; (2) a review of models to obtain a standard set of information pertaining to the models such as structure, sponsor, limitations, use, etc.; (3) computer implementation of selected models; (4) subsequent analysis of these models; and (5) an investigation of the role of models in the formulation of policy relating to the motor vehicle system.

Results: The research results will provide information on the existence, structure, properties, and use of mathematical models in the formulation of policy relating to the motor vehicle transportation system.

Drug Research Methodology

Investigators: K. B. Joscelyn, A. C. Donelson

Sponsor: National Highway Traffic Safety Administration

Objectives: To identify potential solutions to methodological problems that have been identified through prior research and empirical studies of the drug/driving problem. Needed action will be described in operational terms to facilitate implementation.

Significance: Drugs (other than alcohol alone) have been found to be present with increasing frequency in traffic crashes. Experimental laboratory studies have demonstrated that a wide range of frequently prescribed drugs have the potential to impair driving behavior. A precise understanding of the role that drugs play in the causation of traffic crashes is constrained by methodological barriers to inquiry.

Methods: Existing literature will be collected and reviewed, with a focus on major methodogical problems. A series of workshops are being conducted to bring together leading researchers and practitioners to develop specific solutions for the identified methodological problems.

Results: The study will present a series of recommendations and research designs for further study of the drug/driving problem.

Evaluation of the Lansing Youth Driver Enforcement/Information Demonstration Project

Investigators: W. T. Pollock, J. D. Flora

Sponsor: Michigan Office of Highway Safety Planning, and National Highway Traffic Safety Administration

Objective: To provide a quantitative evaluation of the enforcement and public information activities and of the traffic accident reduction impact of a three-year program of publicized selective enforcement by the Lansing (Michigan) Police Department.

Significance: As typical nationally, young drivers (age 15 to 24) consistently show traffic accident over-involvement in the city of Lansing. The demonstration project planned will involve intensive enforcement at times and places statistically associated in the past with high accident involvement by that young driver age group. Accompanied by a broad public information campaign, this special enforcement effort is expected to reduce young-driver accident involvements by a minimum of 15 percent. HSRI will serve as Project Evaluator to document the special enforcement and information activities and to evaluate the impact of those activities on Lansing traffic accident statistics.

Methods: With extensive pre-project measures of enforcement and accidents as baseline data, HSRI will use time series analysis and other sophisticated analytic techniques to identify changes in the Lansing accident experience attributable to the enforcement/information project.

Results: Quantitative expressions of changes in accident experience associated with the intensive enforcement/public information activities will be generated, along with cost/benefit determinations.

Highway Safety Planning Study

Investigator: K. B. Joscelyn, R. K. Jones

Sponsor: Motor Vehicle Manufacturers Association

Objectives: This study is examining the highway safety problem to develop priorities for research and to identify policy actions that should be taken on the basis of existing information.

Significance: The nation's highway safety problem flows from a complex set of interactions of man, machine, and the environment. An equally complex response has evolved from the societal efforts to deal with the problem. The resources available to deal with the problem are limited and must be allocated on a priority basis. This study represents an initial effort to identify priorities for research and policy actions.

Methods: Existing literature that describes the nature and extent of the highway safety problem and present or planned research programs is being examined. Major organizations responsible for research and countermeasure efforts are being visited. The information obtained will be synthesized to develop statements of priority research needs and suggestions for research strategies and designs to meet such needs.

Results: The study will provide information on priorities for highway safety research requirements, research approaches, and policy actions.

Identification of General-Deterrence Countermeasures for Unsafe Driving Actions (Non-Discrete Moving Violations)

Investigators: K. B. Joscelyn, R. K. Jones

Sponsor: National Highway Traffic Safety Administration

Objectives: To identify general risk-management strategies that will reduce the incidence of unsafe driving actions. The focus of the study is on three such high-priority actions: speeding, following too closely, and driving left of center.

Significance: This study will lay the methodological framework for future research and action programs designed to develop and implement countermeasures against unsafe driving actions. The study will provide a broad and rigorous foundation for future programs by identifying a set of general strategies that have their roots in the risk-management systems society uses or can use to reduce traffic crash risk.

Methods: First, potential countermeasures that can be directed at unsafe driving actions are being identified. Ongoing studies and literature on decision-making and proposed countermeasures are being examined, and pertinent results extracted. A list of potential countermeasures will then be developed and subjected to a preliminary assessment by a panel of individuals with expertise in areas critical to the potential countermeasures. Countermeasures that survive this initial screening will be evaluated in detail to determine their technical, social, and legal feasibility. A final set of countermeasures will then be selected for testing and evaluation in a real-world setting. Procedures for experimentally determining the impact of the selected countermeasures will be developed.

Results: The study will provide a framework for development of countermeasure programs for the reduction of unsafe driving actions. Risk-management approaches will be identified as well as the research, demonstration, and evaluation programs necessary for their implementation.

Legal Constraints Relevant to Countermeasure Development

Investigators: K. B. Joscelyn, R. K. Jones

Sponsor: National Highway Traffic Safety Administration

Objectives: The general goal of this study is to identify legal constraints on the development and implementation of countermeasure programs designed to deter unsafe highway behavior. Of equal concern is the identification of methods for the resolution of such problems.

Significance: The last ten years has seen the development of a variety of countermeasure concepts. Scientists have suggested countermeasures that have their roots within the legal system or that raise significant legal issues. Attempts to introduce these countermeasures have sometimes resulted in opposition. The opposition may stem from simple misunderstandings or from perceptions that the countermeasure concept is in direct conflict with existing societal and legal values.

Methods: This study is systematically examining the countermeasure development process from a legal perspective to identify a methodological approach that will allow identification of legal constraints as countermeasures are developed. Next, existing countermeasure concepts will be examined to identify potential legal problems. Finally, the legal system will be examined to identify barriers to innovation that stop the implementation of "legal" countermeasures.

Results: This study will identify the legal constraints that need to be considered when developing countermeasures and methods for resolution of legal issues.

Model Alcohol Safety Health/Legal Delivery Systems

Investigators: K. B. Joscelyn, R. K. Jones

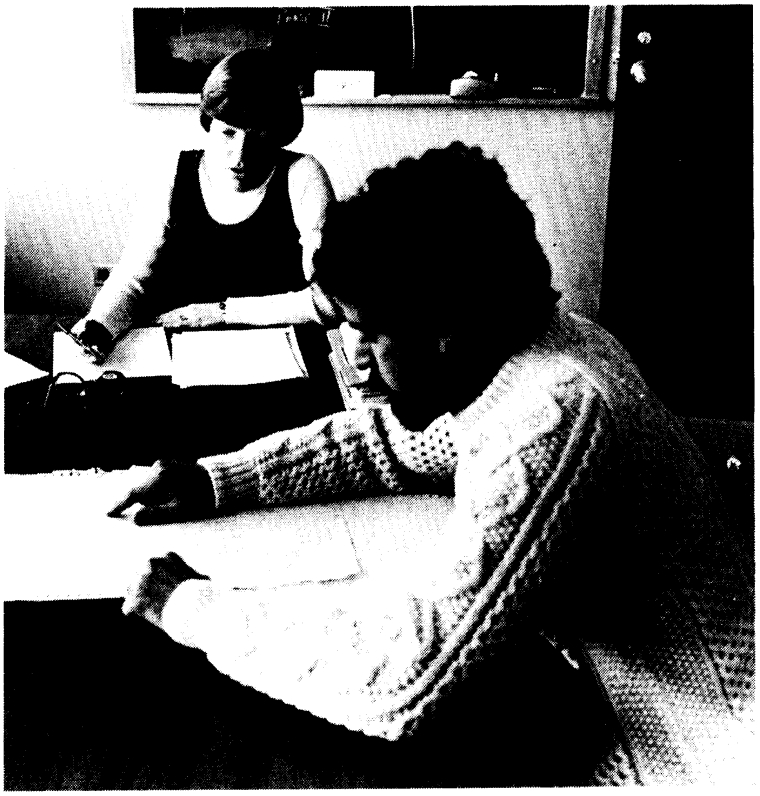
Sponsor: National Highway Traffic Safety Administration

Objectives: To identify and analyze factors that have influenced the evolution of adjudication approaches to the drinking-driving problem, and to prepare several model health/legal adjudication systems.

Significance: During the past decade, many jurisdictions have modified their judicial processes for the drinking driver to include referral to the health care delivery system for treatment. This is often referred to as the health/legal approach. This approach was incorporated within many of the ASAP programs. The effectiveness of the approach is generally unknown. An examination of its effectiveness is complicated by the fact that some jurisdictions that introduced the health/legal approach have now abandoned it or greatly reduced referrals. The study will examine the factors that have led to acceptance and use of a health/legal system. The effectiveness of the approach will be examined and findings presented in a form that judicial and health personnel can use to make their programs more effective.

Methods: Several local jurisdictions having health/legal programs for drinking drivers will be studied to learn how their adjudication systems evolved and the reasons for and effects of changes identified. Both ASAP and non-ASAP programs will be examined through literature surveys and site visits. Case studies emphasizing features of programs that deal effectively with the drinking driver will be prepared, along with descriptive models of generic types of health/legal systems.

Results: The study will provide information to help jurisdictions decide whether to adopt health/legal alternatives and, if so, realistic system objectives, requirements, and management policies. The results will be useful to a wide range of users, from researchers to planners to system operators.



Police Enforcement Procedures for Unsafe Driving Actions (Non-Discrete Moving Violations)

Investigators: K. B. Joscelyn, R. K. Jones

Sponsor: National Highway Traffic Safety Administration

Objectives: To identify and assess police enforcement strategies and tactics that reduce the incidence of unsafe driving acts. While all unsafe driving acts (UDAs) are of concern, priority for this study will be given to three high-risk classes of UDAs. These include: (1) speeding; (2) following too closely; and (3) driving left of the center line.

Significance: Adequate assessment of police traffic enforcement procedures directed at the non-discrete moving violation UDAs will identify which procedures are effective/non-effective in reducing the incidence of violations, allow recommendation of procedures which seem to have the greatest potential benefit, and provide inputs for future research or countermeasure development.

Methods: A literature review of police enforcement strategies, tactics, and procedures will provide current information and documentation of police enforcement activities to reduce the incidence of unsafe driving acts. Contact with operating law enforcement agencies and field assessment of the relative effectiveness of measurement methods will validate information obtained in the literature review and expose the methodological problems—especially those involved with field measurement technology. A final technical report will synthesize and analyze the data and information developed.

Results: A better understanding of the organization of police traffic services, the police traffic function, and enforcement effects on driver behavior and accident reduction will be developed. This study should be used, where appropriate, in the design and execution of new research and development of countermeasures.

Research Information Utilization

Investigator: K. B. Joscelyn

Sponsor: Motor Vehicle Manufacturers Association

Objectives: The goal of this study is to improve the use of existing research information by highway safety program personnel.

Significance: The last ten years has seen the completion of many more research studies on highway safety problems than any previous decade. Examination of current highway program activity reveals that in many cases existing research findings are not being utilized.

Methods: This study is examining the research information needs of practitioners and key decision-makers as well as the usual methods by which they receive information that is used for decision-making. Strategies for the dissemination of information will be developed and evaluated, using selected research findings.

Results: This study is expected to identify methods of enhancing information utilization and improving decision-making in highway safety programs.

State of Knowledge and Information Needs in Alcohol/Drugs and Highway Safety

Investigators: K. B. Joscelyn, R. K. Jones

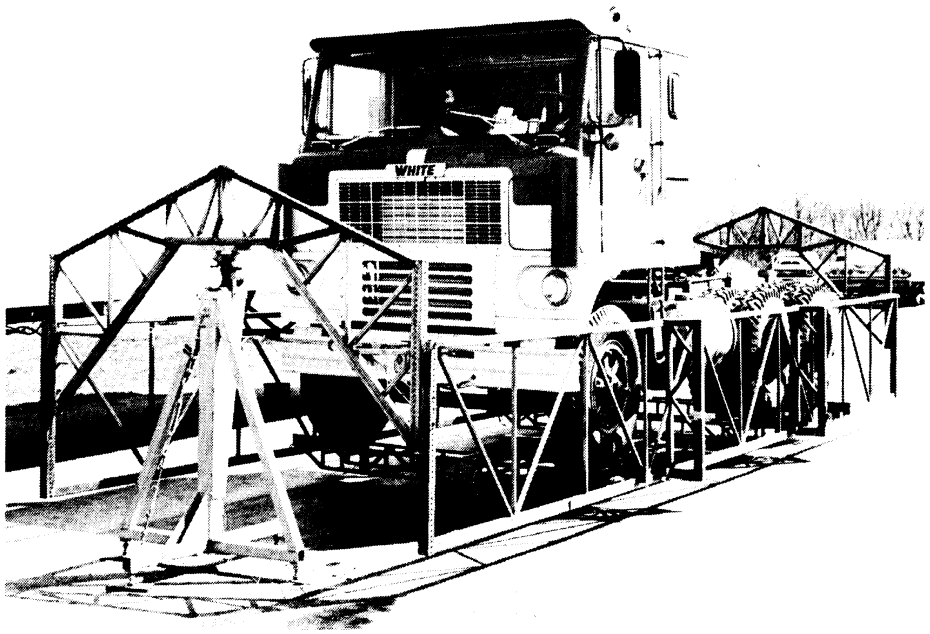
Sponsor: National Highway Traffic Safety Administration

Objectives: The objective of the work related to the problem of alcohol and highway safety is to survey, evaluate, and summarize the research literature and assess the effectiveness of past and present countermeasure programs. The objective of the work related to the broader and less defined problem of drug use and its influence on highway safety is to assess the research literature and specify research questions that must be answered before the question of the influence of drugs on highway safety can be adequately determined.

Significance: The long-term success of public and private efforts to control and reduce highway safety problems stemming from the use of alcohol and other drugs depends on careful, frequent assessments of the problem definitions, the relevance and efficacy of research efforts, and the effects of countermeasure programs.

Methods: The task of surveying the state of knowledge concerning alcohol and highway safety entails assessing the literature on various aspects of the problem (alcohol in crashes and violations, physiological effects of alcohol, laboratory and field research, current countermeasures), organizing a panel of experts to review and evaluate the survey results, and preparing reports and other presentations that can be used by federal, state, and local government agencies as a basis for legislative program planning, etc. The task of identifying requirements for research on the influence of drugs on highway safety entails assessing the state of the art of measuring drug presence and effects, determining the legal and ethical constraints on efforts to establish the extent to which drugs are represented in accident samples, assessing what behaviors related to the driving task are influenced by drug ingestion, and assessing existing and potential countermeasure concepts.

Results: The research results will assist federal, state, and local agencies in developing future programs designed to reduce the frequency of accidents, injuries, and fatalities associated with the use of alcohol and other drugs.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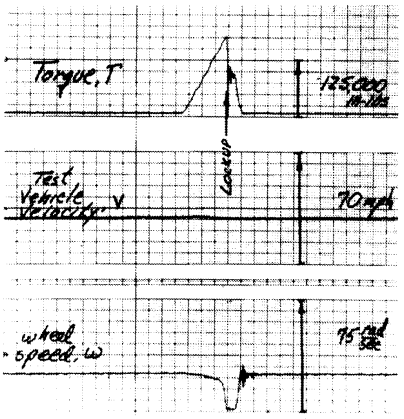
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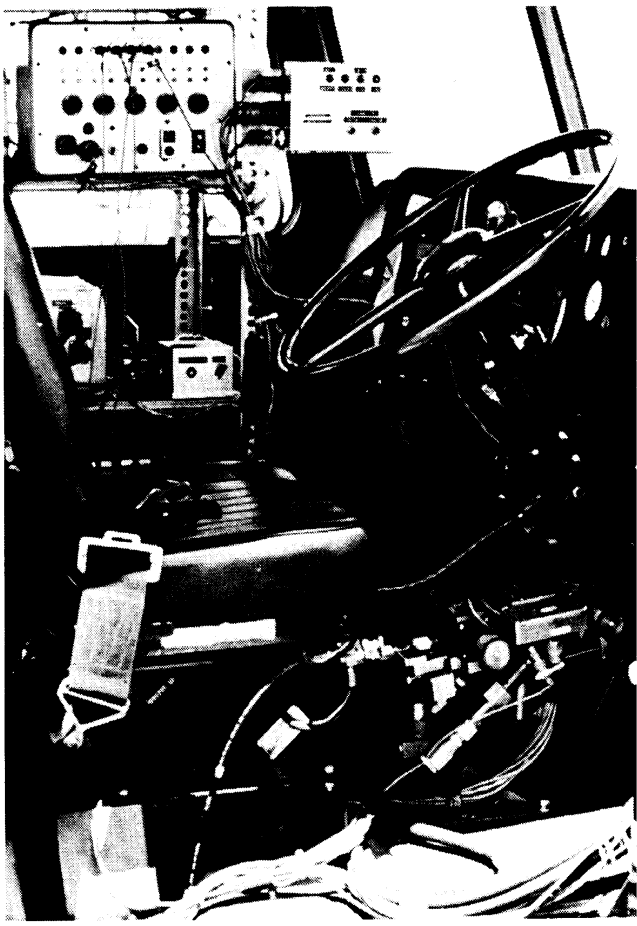


Vehicle and Roadway Studies

Research programs in the Vehicle and Roadways area are concerned with the hardware elements that influence primary (precrash) safety. These studies are both analytic and experimental, in that they include computer simulations of vehicle performance as well as laboratory and over-the-road experiments to evaluate the physical properties of vehicles and their component systems. Insight into accident-causation processes is being obtained by combining information on (1) variations in the performance of vehicle-roadway elements; (2) variations in driver skills and attitudes; and (3) roadway and traffic conditions.

The objectives of current programs are to:

- *Develop performance testing procedures for evaluating the pre-crash safety quality of motor vehicles;*
- *Evaluate the braking performance of existing buses, trucks, and tractor-trailer combinations;*
- *Increase understanding of the steering and braking behavior of the articulated commercial tractor-trailer;*
- *Measure the dynamic characteristics of brakes and brake system components;*
- *Improve current capabilities for analyzing and predicting vehicle behavior near the limits of tire-road friction;*
- *Measure the shear force characteristics of pneumatic tires;*
- *Measure the mechanical properties of suspensions and frames in terms of their influences on handling and braking performance.*

Calibration and Correlation of Response-Type Road Roughness Measuring Systems

Investigator: T. D. Gillespie

Sponsor: National Cooperative Highway Research Program

Objective: To develop and verify relatively rapid and inexpensive methods of calibrating and correlating road roughness measuring systems.

Significance: A major factor determining the service level of a highway (pavement serviceability) and the need for rehabilitation is the roughness scale influencing vehicle ride. The allocation of Highway Trust funds to the various states for road rehabilitation requires comparable means of measuring roughness of highways in the different states. The current road roughness measuring systems in use are difficult to correlate and are susceptible to changes in performance with time. Thus such systems need to be calibrated and correlated to produce a national scale of road roughness measurement.

Methods: Project tasks include (1) evaluating the time stability of various response-type pavement roughness measuring systems in relation to a selected reference or standard; (2) developing methods for calibration of those measuring systems; (3) developing procedures for establishing correlations between similar measuring systems; (4) developing procedures for establishing correlations between dissimilar measuring systems; and (5) demonstrating the practicality of using pavement roughness data from various properly calibrated response-type roughness measuring systems in determining pavement serviceability.

Results: The procedures developed in this research are expected to be used as a means of producing consistent and accurate measurements of road roughness by the various state highway departments and transportation agencies.

Comparison of Vehicle Test Procedures

Investigators: P. S. Fancher, C. B. Winkler, C. C. MacAdam

Sponsor: Ford Motor Company

Objective: To evaluate the advantages and disadvantages of various test procedures for quantifying the directional response of passenger cars.

Significance: A variety of test procedures for establishing the responsiveness (response time) of passenger cars are in use. At present no consensus exists in standards setting organizations as to which procedures are most accurate or easiest to employ.

Methods: Vehicles with widely differing dynamic characteristics will be tested, using several proposed test procedures.

Results: The precision, repeatability, and ease of use will be assessed for the test procedures employed.

Development of Techniques for Establishing the Role of Tire Factors in Accident Causation

Investigator: L. Segel

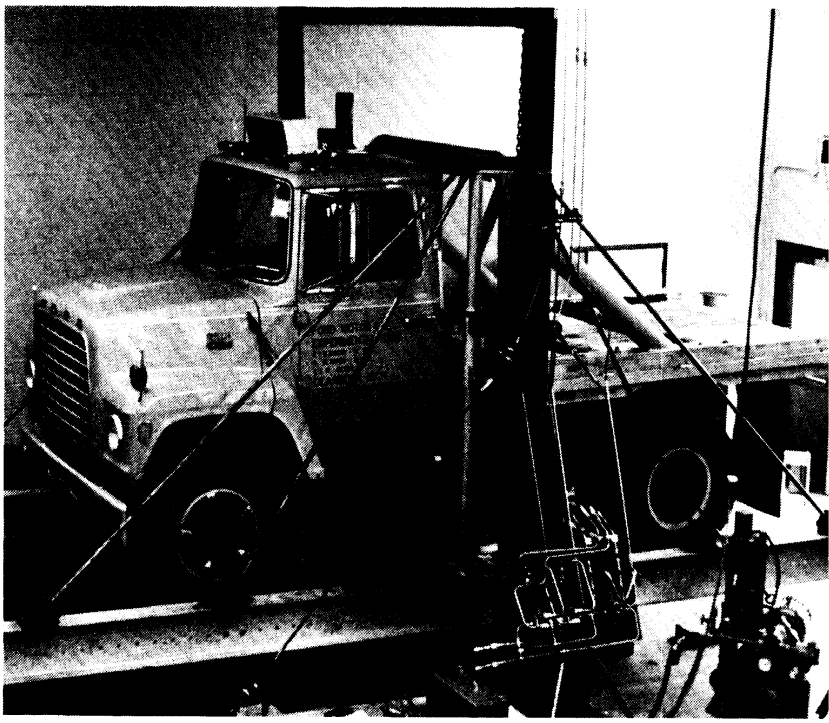
Sponsor: Motor Vehicle Manufacturers Association

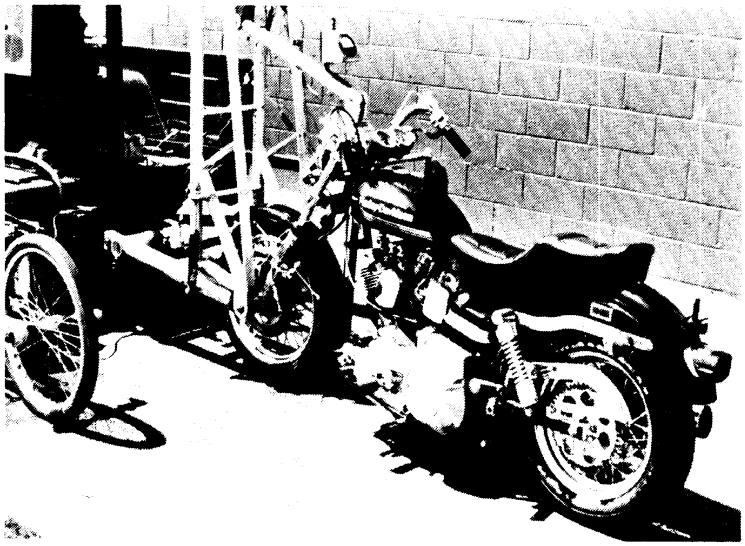
Objective: To determine the feasibility of applying tire and vehicle-loading data to estimates of the response properties of accident-involved vehicles.

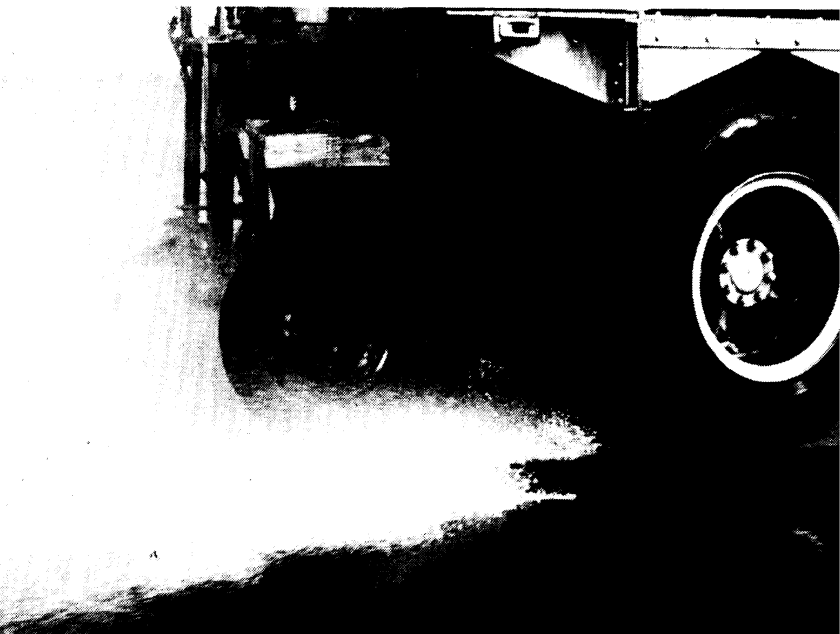
Significance: Although various negative tire factors (mismatching, tread wear, under-inflation, inflation imbalances) are known to degrade the handling performance of motor vehicles, the extent to which these factors contribute to the accident rate is unknown.

Methods: The study involves developing data on the distribution of directional responses in the total in-use car population, developing the same type of data for accident-involved vehicles, and then assessing any significant differences in the two sets of data.

Results: The study results may indicate the extent to which tire-in-use factors contribute to accident causation.







Device for Measuring Traction Fields of Truck Tires

Investigators: P. S. Fancher, R. D. Ervin

Sponsor: Motor Vehicle Manufacturers Association

Objective: To provide a means of measuring the combined longitudinal and lateral force properties of truck tires.

Significance: None of the three current over-the-road devices for testing truck tires has produced data characterizing a tire under combined braking and lateral force conditions. Consequently, current computer simulations of motor truck braking performance must use tire characteristics extrapolated from longitudinal force data, lateral force data, and data on passenger car tires. The new device will provide improved, direct data for use in performance simulations.

Methods: The work entails defining the specifications of a suitable three-axis load cell, purchase of the cell, redesigning of the spindle used in the lateral force dynamometer, installation of the new load cell and a mechanical friction brake, evaluation and calibration of the installed load cell in the laboratory, and field testing of the device, using a standard 10 x 20 truck tire.

Results: The device will provide an improved means of predicting the consequences of braking in a turn, and of studying directional stability under severe braking conditions. The end object of such studies is development of heavy trucks less susceptible to the loss of directional control during braking.

Directional Response Validation for Tractor-Semitrailer Vehicles

Investigators: P. S. Fancher, T. D. Gillespie, C. C. MacAdam

Sponsor: Motor Vehicle Manufacturers Association

Objective: To assess and improve the accuracy with which the Phase-II directional response simulation can predict the directional and roll responses to steering inputs for articulated vehicles.

Significance: A valid computer simulation is a useful tool for evaluating the susceptibility of articulated commercial vehicles to jackknifing, trailer swing, and rollover.

Methods: To obtain actual performance data for use in validating the computer simulation model of tractor-trailer directional responses, the instrumented HSRI straight truck is being converted to a tractor and a trailer is being purchased and instrumented. The research involves conducting preliminary simulation runs, conducting vehicle tests to provide data on the response of the tractor and trailer to steering inputs, operating the Phase-II computer model to establish the ability of the model to predict the dynamic behavior of the combination vehicle, comparing the results, and then improving the simulation model.

Results: The end object of the work is perfection of a simulation model that can effectively predict the influence of design changes on the directional and roll stability of tractor-semitrailers in turning maneuvers.

Facility for Measuring Tandem Suspension Parameters

Investigators: P. S. Fancher, C. B. Winkler

Sponsor: Motor Vehicle Manufacturers Association

Objective: To design and construct a device for measuring the tandem suspension properties required as input to the MVMA computer simulations of truck and tractor-trailer performance dynamics.

Significance: The device, an extension of the single-axle suspension-measurement facility now in operation at HSRI, is expected to increase the level of sophistication of measurements of tandem suspension parameters, making them more efficient and accurate. It is a research tool for examining, in the laboratory, the behavior of heavy truck suspensions.

Methods: The lift cylinders, fluid bearings, control servos, and instrumentation for the second axle are being designed to allow for different distances between axles. They will include the capability for examining spring rates, coulomb friction, deflection steer, and interaxle load transfer.

Results: The device is expected to contribute to development of heavy truck suspensions that provide improved dynamic handling characteristics and stopping performances of heavy trucks.

Improved Passenger Car Braking Performance

Investigators: R. D. Ervin, J. D. Campbell

Sponsor: National Highway Traffic Safety Administration

Objectives: To develop objective test procedures and brake system performance requirements for straight-line braking on surfaces having a low or split coefficient of friction, and develop similar procedures and requirements for braking in a turn on surfaces having high, low, and split coefficients of friction.

Significance: The current Federal Motor Vehicle Safety Standard 105-75 is intended to ensure safe braking performance under normal and emergency conditions. However, its presently defined test conditions measure brake effectiveness only in straight-line stops on surfaces having a high coefficient of friction. Thus the purpose of this research is to provide information to expand the scope of the federal standard to include other braking conditions.

Methods: The work includes experimentally establishing the performance range of current passenger car brake systems in straight-line and turn maneuvers on surfaces having low and split coefficients of friction; developing test procedures, selecting and testing five representative passenger cars, including one equipped with an antilock braking system; evaluating the test results; and recommending expanded procedures to be incorporated in a revised federal standard.

Results: The study results will be used by the sponsor in developing an expanded FMVSS 105 relating to the braking performance of passenger cars.

Improvement of Mathematical Models for Simulation of Vehicle Handling

Investigator: I. McIvor

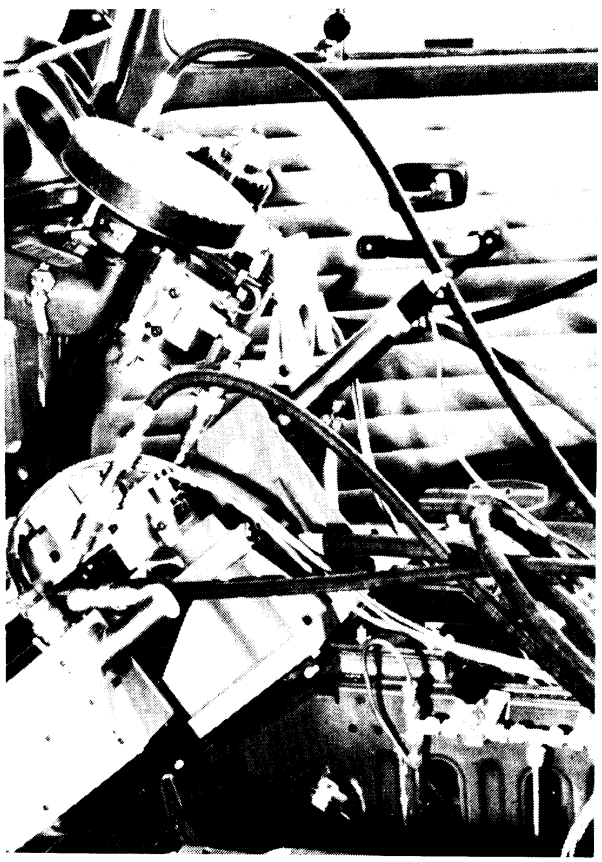
Sponsor: National Highway Traffic Safety Administration

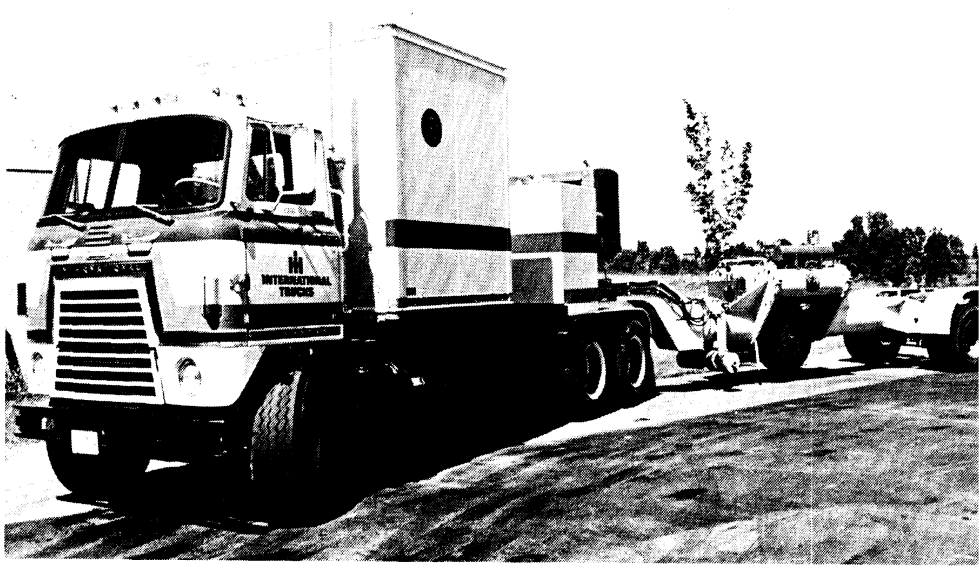
Objectives: To develop analytical concepts for describing the directional stability and control of vehicles applicable to all levels of vehicle behavior from steady state to limit performance. These concepts will be used to establish criteria for evaluating handling quality appropriate for various levels of complexity of vehicle simulation.

Significance: There are currently available a variety of computer simulations with a wide range of complexity and/or realistic modeling capability. In the absence of analytical handling criteria over the entire range of vehicle performance, the use of these simulations to correlate specific design parameters with handling performance is often arbitrary and cost ineffective.

Methods: The research entails extending current handling concepts for linear models to generalized handling criteria applicable to transition and limit maneuvers. Nonlinear analysis methods will be used to develop discriminators of handling quality. Their validity will be verified by comparison with field test data. Various simulation models will be compared for their effectiveness in predicting handling behavior, and optimal models for different performance regimes will be identified.

Results: The results of the study will be a simulation program consisting of a hierarchy of vehicle models appropriate for analyzing the steady state, transition, and nonlinear limit performance of vehicles. The simulation will include algorithms for computation of the discriminators of handling quality.





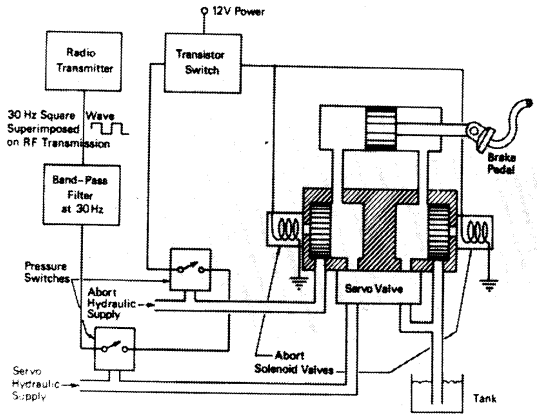
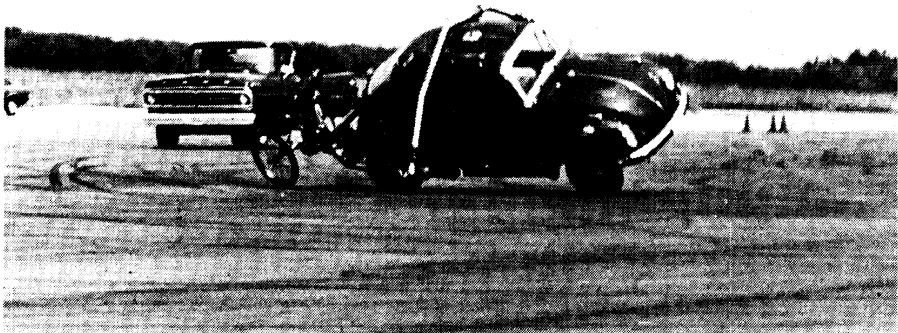


Figure 6. Diagram of Abort Control Circuit



Influences of U.S. and European Braking Regulations on the Accident-Avoidance Performance of Passenger Cars

Investigator: L. Segel

Sponsor: Motor Vehicle Manufacturers Association

Objectives: (1) To quantify the extent of incompatibility of various U.S. and European regulations concerning braking performance; (2) To estimate which regulatory philosophy results in vehicles most capable of avoiding accidents; and (3) To investigate whether additional regulations concerning performance while braking in a turn will result in further restriction of design flexibility.

Significance: Differences in North American and European vehicle performance regulations are partly the result of different opinions concerning what constitutes good braking and handling performance. One effect is that some manufacturers may need to modify brake proportioning on vehicles intended for export. The likelihood that regulations concerning braking-in-a-turn performance will be added to straight-line performance regulations increases the need for analyses that will illustrate the distinctions between braking performances as implied by the various regulations.

Methods: A typical North American and typical European vehicle are being studied by computer simulation of their stopping performances over a broad range of conditions, including brake proportioning, loading, road surface, and types of braking maneuvers.

Results: The results of generalized comparisons of performance, reformulated in terms of impact speeds resulting from real accident situations, will illustrate the more general distinctions between braking regulations in terms of their overall effects on performance under a full range of tire/road friction conditions. The results can be used by regulatory organizations to develop performance regulations that are both more effective and more compatible.

Influences of Brake Lining Properties on Brake Torque

Investigators: P. S. Fancher, L. K. Johnson

Sponsor: Motor Vehicle Manufacturers Association

Objective: To investigate changes in brake effectiveness caused by changes in brake linings, and by changes in frictional properties of linings, with changes in temperature, rate of temperature changes during braking, and wear.

Significance: Past efforts at quantifying the torque outputs of commercial vehicle brakes, using inertial dynamometers and the HSRI mobile dynamometer, have produced disconcerting performance variances most probably attributable to differences in frictional properties of different brake linings and to within-test changes in those frictional properties.

Methods: The work entails selecting and procuring brakes and brake linings, testing them on an inertial dynamometer and on the HSRI Mobile Dynamometer, and analyzing the test data.

Results: The results are expected to establish the extent of variability in brake torque associated with brake lining properties.

Motorcycle Dynamics

Investigator: L. Segel

Sponsor: Honda R & D Company, Ltd.

Objectives: To determine the adequacy of linearized equations of motion to characterize the dynamic behavior of the motorcycle, and to determine specifications for a motorcycle-tire dynamometer.

Significance: An ability to relate design variables to the oscillatory behavior of the motorcycle by methods of linear analysis has great advantages for the motorcycle development engineer. This ability will require that test machines be developed that are particularly suitable for measuring the static and dynamic properties of motorcycle tires.

Methods: Starting with the state of the art in motorcycle dynamics as the point of reference, a linear mathematical model of the constant-speed motorcycle will be developed, using the tools of the vehicle dynamicist. Analytical predictions of dynamic behavior, based on laboratory measurements of the cycle-tire system, will be compared with findings obtained in full-scale experiments. The current understanding of requirements for modeling the static and dynamic behavior of the motorcycle tire will be used to specify a balance system, servos for controlling wheel orientation, and other systems that are a necessary part of a motorcycle-tire dynamometer. Particular emphasis will be given to the need for dynamic test data.

Results: The project is expected to show the extent to which a detailed accounting of the mechanical properties of the tire and structure of the motorcycle will yield an accurate prediction of the oscillatory behavior produced by small disturbances. A conceptual design sufficient to estimate cost and time for constructing a motorcycle-tire dynamometer will be produced.

Safety-Related Characteristics of Double-Bottom Tank Trucks

Investigators: R. D. Ervin, P. S. Fancher, T. D. Gillespie, C. B. Winkler, A. C. Wolfe

Sponsors: Office of Highway Safety Planning, and Department of State Highways and Transportation, State of Michigan

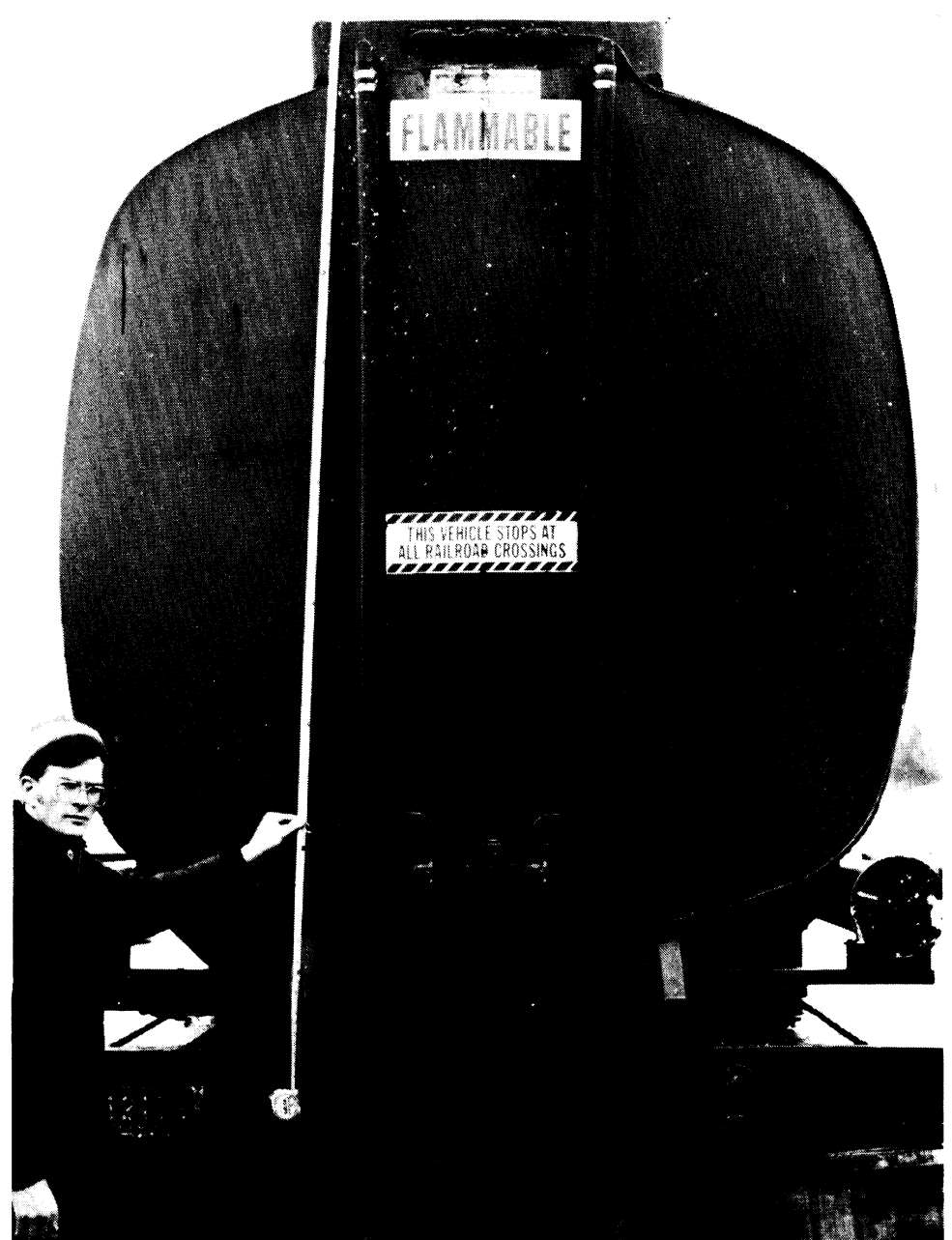
Objectives: To assess the directional and roll stability characteristics of the eleven-axle double-bottom tanker, recommend retrofit changes in vehicle configuration to upgrade the directional and roll stability characteristics, and recommend changes in operational practices by which the directional and roll stability of such vehicles may be improved.

Significance: The research is concerned with developing findings that reduce to a tradeoff between trucking safety and trucking productivity. Double-bottom tankers, with their multiple articulation joints, short-length articulated elements, and high centers of mass relative to track width are susceptible to oscillation, jackknifing during braking and cornering, and rollover. Safety considerations dictate that the vehicles be configured for optimal stability, that drivers be aware of their stability limits, and that operational regulations be designed to ensure optimal practices consistent with trucking productivity.

Methods: In a preliminary short-term study, HSRI is developing vehicle-descriptive parameters, determining the rollover threshold of double-bottom tankers, analyzing their yaw responses to steering inputs, and assessing existing regulations governing the use of double-bottom tankers in the bulk transport of flammable liquids.

Results: The study results will be used as a basis for recommendations to the sponsors concerning actions that would improve the safety of bulk fuel transport. Recommendations that would affect either the configuration or operations of double-bottom tankers will be supported by data obtained in full-scale tests.


Eaton Corporation
Brake Division
Southfield,
Michigan
EATON


FLAMMABLE
THIS VEHICLE STOPS AT
ALL RAILROAD CROSSINGS

Short-Term Research Services in Automotive Engineering

Investigator: H. M. Bunch

Sponsor: International Brotherhood of Teamsters

Objective: To provide short-term research analyses of questions or problems relating to the health and safety of truck drivers.

Significance: Organizations and agencies in the private and public sector frequently are confronted by questions or problems that require a research effort to establish facts and define issues. Organizations that do not maintain a relevant in-house research group opt to set up a quick-response agreement with an independent research organization such as HSRI. Other organizations served in this way by HSRI include the National Highway Traffic Safety Administration, the Motor Vehicle Manufacturers Association, the U.S. Department of Commerce, the Michigan Department of State, and the Michigan State Police.

Methods: As the need arises, HSRI makes available selected staff members for short-term analyses. If those results indicate a need for more indepth, long-term research, the HSRI team prepares a separate proposal and work plan for performing the research on a budget separate from the short-term commitment funds.

Results: Research results are used by the sponsor in formulating policy and developing programs directed toward improving the health and safety of truck drivers.

Simulation of Effects of Increased Truck Size and Weight

Investigator: T. D. Gillespie

Sponsor: Federal Highway Administration

Objective: To develop computer programs simulating the dynamics of heavy trucks and tractor-trailer combinations with appropriate measures of performance by which to assess the effect of size and weight on response to control and disturbance inputs.

Significance: Proposals to increase the allowable size and weight of trucks on the national highway system must be evaluated on a national basis. The FHWA is frequently requested to provide inputs to the evaluation process. Computer simulation has been selected as a means to assess the change in the braking and maneuvering capabilities of such vehicles, and the potential effects on pavement structures and roadway geometric requirements.

Methods: Existing truck and tractor-trailer directional response computer simulation programs will be modified to meet the FHWA requirements. The modified programs will be validated against vehicle tests performed in other FHWA projects. Performance measures will be formulated as criteria for judging the effect of increased truck size and weight on the response to control and disturbance inputs. The simulation programs will be documented and presented to the FHWA in a training seminar. In addition, the programs will be utilized in a parametric study to evaluate some of the changes in performance associated with increased truck size and weight.

Results: The technology developed will be provided to FHWA for use in evaluating the potential consequences on highway safety resulting from relaxation of the current limits on truck size and weight.

State of Knowledge of Relationships Between Truck Tire Design, Traction, and Vehicle Accident Avoidance

Investigator: R. D. Ervin

Sponsor: U.S. Environmental Protection Agency (Prime Contractor: Bolt, Beranek, and Newman, Inc.; Subcontractor: HSRI)

Objective: To review and assess vehicle operating safety as it relates to the properties of tires.

Significance: The extent to which the noise-generating properties of tires can be reduced without reducing traction properties and, in turn, vehicle safety, is unknown. An initial step in this research area involves assessing current knowledge of those tire properties and their interactions.

Methods: The research entails assessing and summarizing existing knowledge relating to these questions: the relationship between traction properties of pneumatic tires and the safety (controllability) of motor vehicles, and the relationship between tire design parameters and tire traction performance.

Results: The research results are expected to be used by the sponsor in planning tire noise control programs.

Steering Controllability Characteristics of Passenger Cars

Investigators: P. S. Fancher, C. B. Winkler

Sponsor: National Highway Traffic Safety Administration

Objectives: To determine methods for modifying passenger cars so that their directional response to steering equals that achieved by certain experimental cars; to fabricate and install the modifications in three selected vehicles (a subcompact, compact, and intermediate); and compare, by means of field demonstrations and simulations, the effects of the modifications relative to standard vehicles.

Significance: The intent of the work is to create a reference base from which design information could be obtained for a possible factory-installed or dealer-installed customer option for purchasing passenger cars possessing the improved steering characteristics.

Methods: The work entails determining the most straightforward methods of altering the selected production vehicles so as to optimize the driver-vehicle system for steering control, modifying one each of the three sets of vehicles selected, and demonstrating the performance differences of the modified and unmodified vehicles, using three experienced and one professional driver in tests performed at the Chrysler Corporation Proving Grounds.

Results: The study findings and their documentation will be used by the sponsor in developing means of integrating research findings into production of passenger cars.

Survey of Antilock System Properties

Investigators: P. S. Fancher, C. C. MacAdam

Sponsor: Motor Vehicle Manufacturers Association

Objective: To perform laboratory tests on vehicles using commercially available antilock braking systems so as to obtain a library of their characteristics for use in computer simulation models of braking performance.

Significance: Although the Phase-II directional response and Phase-III straight-line braking simulations contain comprehensive general-purpose algorithms for simulating antilock systems, the input data needed to use these algorithms is not easily obtained. By linking the braking systems of test vehicles to the HSRI analog computer by means of antilock control modules, data will be gathered and used to determine input-output relationships for describing antilock systems.

Methods: Pressure transducers are installed in the brake chambers and the antilock system is electrically connected to the analog computer. Five vehicles with different types of antilock systems are being tested.

Results: The data obtained are expected to permit generation of representative simulations of the braking performance of vehicles equipped with the various antilock systems tested.

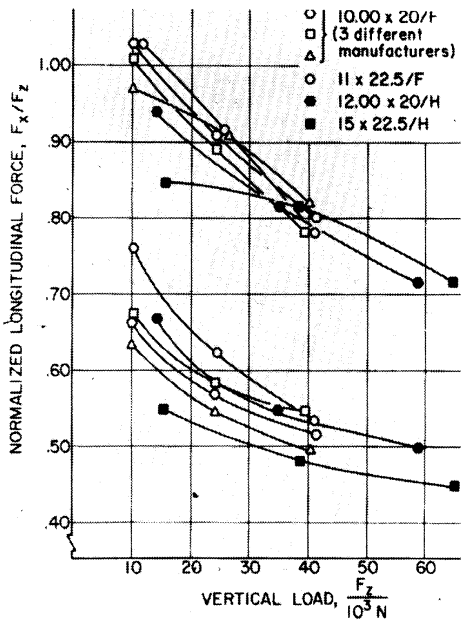
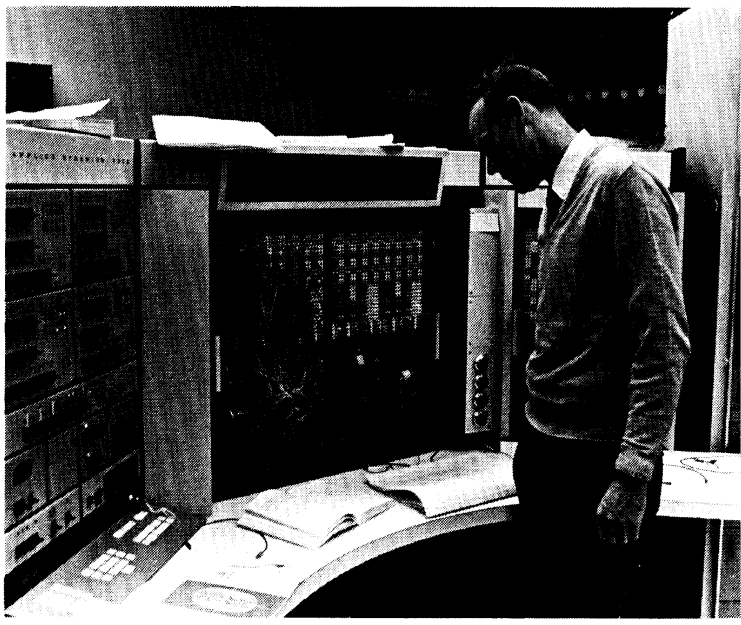
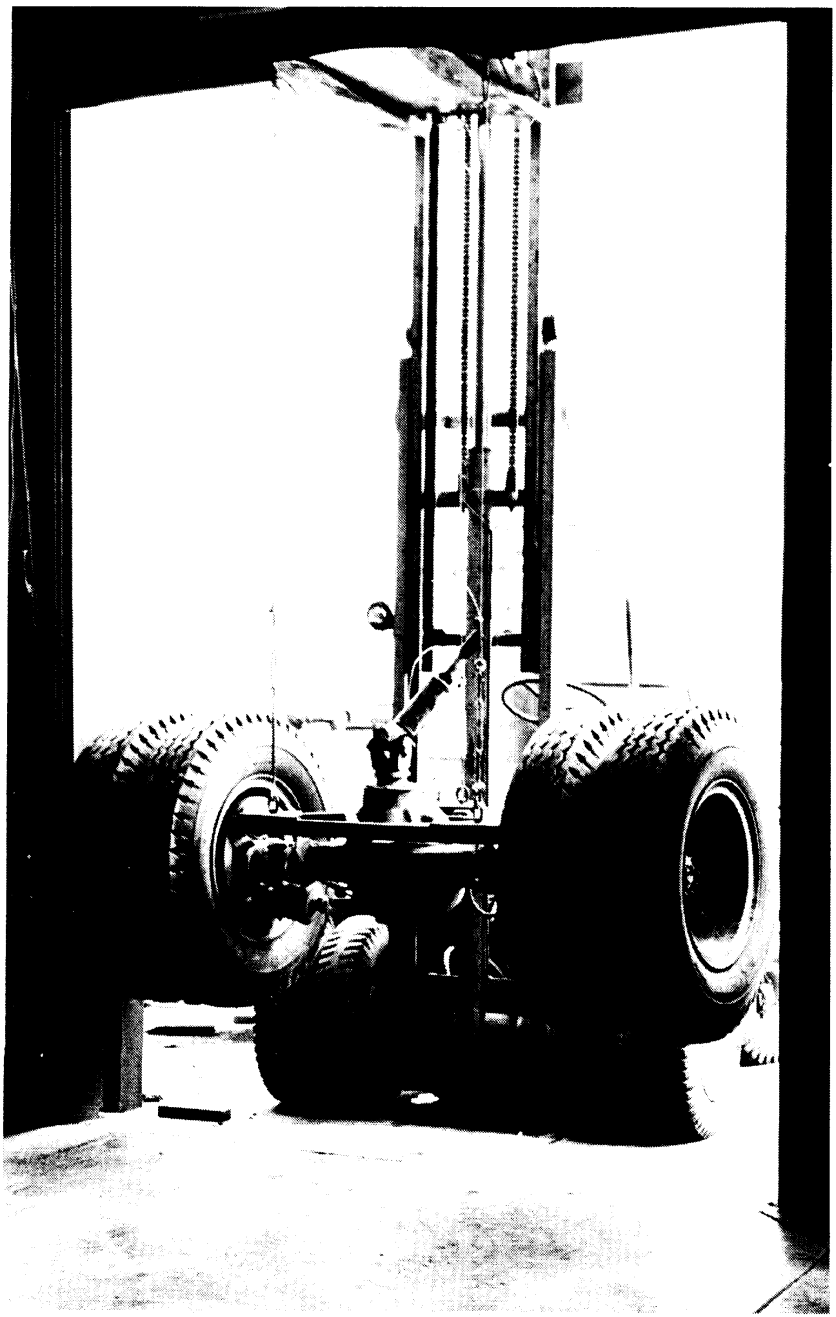
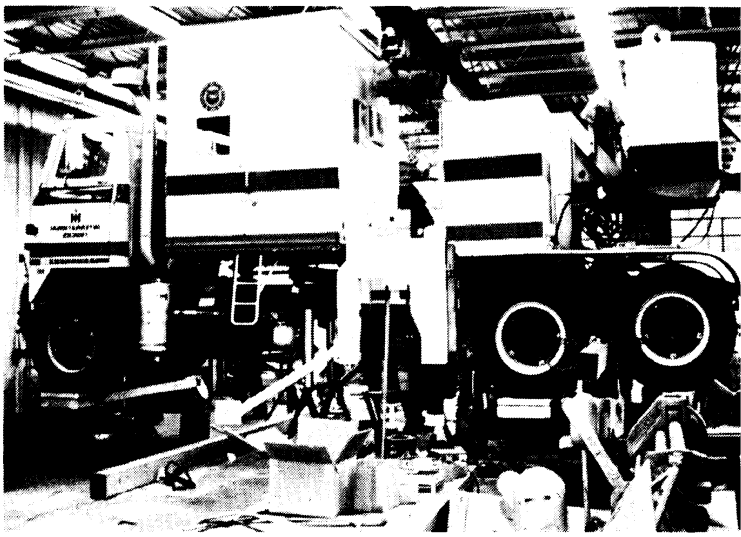


Figure 3. Load sensitivity in the peak and slide traction of a six-tire sample on dry asphalt. Al tests run at 64 km/h.







Survey of Commercial Vehicle Hydraulic Brake System Performance

Investigators: P. S. Fancher, T. D. Gillespie

Sponsor: Motor Vehicle Manufacturers Association

Objective: To develop a model of the single-stop torque-time characteristics of hydraulic brakes, along with means of interpreting the parametric values for the model from inertia dynamometer test results.

Significance: Accurate knowledge of brake torque characteristics is fundamental to predicting the braking performance of hydraulically braked motor vehicles.

Methods: Two typical hydraulic brakes are being burnished and tested on an inertia dynamometer according to FMVSS 105 procedures, then each installed on the Mobile Truck Tire Dynamometer to map its torque-pressure-time characteristics over a range of temperature and speed conditions. The test results will be analyzed to determine parametric relationships as necessary for inputting values into the computer simulation model.

Results: The work is expected to result in a computer model capable of more accurately simulating and predicting the braking performance of commercial vehicles equipped with hydraulic brake systems.

Truck Tire Braking and Cornering Traction

Investigator: R. D. Ervin

Sponsor: National Highway Traffic Safety Administration

Objective: To measure the wet traction performance of heavy truck tires under conditions relevant to the limit braking and cornering of heavy commercial vehicles.

Significance: The body of available data documenting the wet traction behavior of heavy truck tires is very sparse. It has long been suspected that the heavy truck tire is peculiarly deficient in wet traction performance, in comparison to the typical passenger car tire. This study is designed to create a data base to establish the nominal levels of the wet traction performance of truck tires and illustrate the range of performance prevailing in truck tires available on the market.

Methods: The HSRI Mobile Dynamometer is being exercised to measure longitudinal and lateral shear forces at differing velocities on two selected pavements at the Transportation Research Center of Ohio. Measured data are then being processed by computer to generate averaged measures of traction performance at each test condition.

Results: The results will constitute a data base that will assist in development of a NHTSA position on quality grading of heavy truck tires.

Yaw Divergence and Rollover Performance of Tractor-Trailers

Investigator: R. D. Ervin

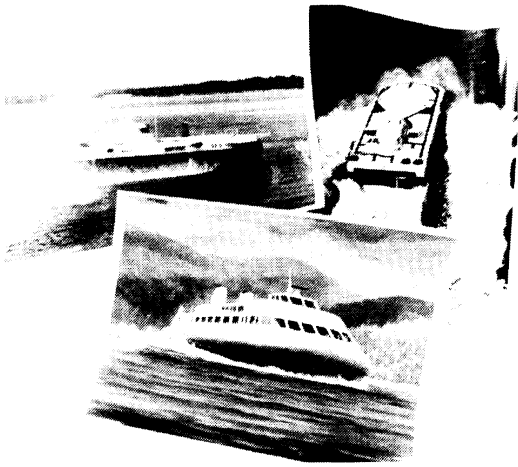
Sponsor: National Highway Traffic Safety Administration

Objectives: (1) Survey the existing tractor-trailer population and select two representative configurations for testing; (2) Measure the suspension and frame properties of the test vehicles before and after modifications; (3) Modify the APL/JHU computer simulation to examine the effects of frame compliance, fifth wheel location, and other factors; (4) Use the simulation to determine the effects of torsional compliance and other factors on handling performance; and (5) Design and execute a full-scale test program to verify the computer simulation results.

Significance: Previous research has shown that suspension and frame compliance properties of tractors and trailers can be influential in producing divergent yaw response in the intermediate level of maneuver safety. This study of truck and trailer directional behavior is intended to produce data essential for improving the dynamic performance and controllability of tractor-trailers.

Methods: Representative trailers and two- and three-axle tractors are being tested and their range of stable yaw behavior measured before and after modifications to alter the distribution of roll stiffness on the tractor. The test program includes trapezoidal steer maneuvers, using a range of fifth-wheel locations. Data from these tests and from computer simulations are being used to derive an improved understanding of tractor-trailer responses to steering.

Results: The research results are expected to be a quantitative expression of the effects of tractor and trailer suspension, frame, and payload location parameters on tractor-trailer directional performance. Recommendations are expected to be based not only on research results but on practical considerations of general tractor-trailer use and construction techniques.



The Michigan Transportation Research Program (MTRP)

The MTRP is a state-supported, multi-sector organization established in 1976 to assist transportation planning efforts in the State of Michigan by integrating research inputs from academic, governmental, industrial, and other private and public sector organizations. It was established as a result of a special message on transportation to the Michigan State Legislature by Governor Milliken in 1975. The Governor proposed that the transportation research expertise in Michigan be organized to assist state government in the development of the Michigan transportation system.

The MTRP is unique in the United States. The federal government is considering ways and means by which the MTRP can be duplicated in other states and regions so that transportation research needs generated on state levels can be brought to the attention of the federal government.

The MTRP is directed by Dr. Charles G. Overberger, Vice-President for Research, The University of Michigan, and members of an Advisory Committee representing five state universities (Michigan, Michigan State, Michigan Tech., Wayne State, Western Michigan), three industrial corporations (Bendix, Ford Motor, Chrysler), and the Environmental Research Institute of Michigan. Dr. Robert L. Hess, Director of HSRI, and Dr. William C. Taylor, Chairperson, Civil Engineering, Michigan State University, are the co-principal investigators of MTRP. The Staff Manager is Mr. Leonard E. Newland. The MTRP Staff, located at HSRI, includes a manager, full-time researchers, and graduate assistants. The MTRP Staff provides support to the committee structure of the organization, and also conducts research and analysis. Consultants and subcontractors are also employed, as appropriate.

The functions of the MTRP are:

- To identify and coordinate transportation research expertise in the academic and private sectors so as to assist the Michigan Department of State Highways and Transportation in its planning of improvements in Michigan transportation systems;
- To increase transportation research, demonstration, and educational activities in Michigan through increased federal and other non-state funding;
- To develop better understanding of relationships between transportation, economic development, and physical and social environments, and to recommend or identify areas for initiative and methods of stimulating development in Michigan through improvement of existing transportation systems and identification of new transportation methods, operations, and products.
- To obtain information and methods of information analysis useful for developing a better understanding of Michigan's future transportation needs, and to project the impacts of proposed actions on the environment, energy supply, safety considerations, public and private costs, and equity.

To explore particular topics, ad hoc committees of experts from the academic and business communities are formed by the MTRP Advisory Committee to formulate research projects and to prepare research proposals. The ad hoc committees and their activities are:

Energy Efficiency Analysis Ad Hoc Committee

(Dr. R. Kaufman, Western Michigan University, Chairperson; Dr. H. Koenig, Michigan State University; Dr. D. Cleveland, The University of Michigan; Mr. R. Larson, Wayne County Road Commission; Mr. H. McKenney, Environmental Research Institute of Michigan; Mr. M. Dewey, Southeast Michigan Transportation Authority.)

A subcontract was awarded for development of a near-term transportation energy contingency plan for the State of Michigan. Given various levels of petroleum shortages (and durations) the plan will recommend actions that can be taken by state government, local governments, transit authorities, firms, and individuals to minimize economic dislocations.

Recent independent MIT and MSU studies project a world petroleum shortfall in the early 1980's, with effects at least as severe as those of the oil embargo of 1973-74. A position paper for public consumption was commissioned which outlines the implications of this projected shortage for Michigan's transportation systems, and suggests alternative actions which can be taken to minimize long-term economic dislocations.

A research project was formulated to develop a long-term energy contingency plan which would relate the transportation energy consumption sectors within the State of Michigan.

Bus Evaluation Ad Hoc Committee

(Mr. H. Wood, Chrysler Corporation, Chairperson; Dr. E. Petrick, U.S. Army Tank Automotive Research and Development Command; Dr. N. Henein, Wayne State University; Mr. K. Guenther, Ann Arbor Transportation Authority; Mr. R. Winston, AM General Corporation.)

To encourage the development of a more durable small bus for transit operations in Michigan, the MTRP is investigating the use of "life-cycle" procurement practices based upon cradle-to-grave costs as calculated through the use of a model developed by the U.S. Army Tank Automotive Research and Development Command (a participant in the MTRP). Use of this technique could provide bus manufacturers with the incentive to make engineering changes that would reduce the overall maintenance and operating costs through the lifetime of the vehicle.

Michigan Regional Car-on-Trains Ad Hoc Committee

(Dr. W. Drake, The University of Michigan, Chairperson; Mr. R. Shackson, Ford Motor Company; Dr. J. Shaffer, Michigan State University; Dr. D. Cortright, The University of Michigan; Mr. G. Butler, Michigan Technological University.)

Under the technical monitoring of this ad hoc committee, the MTRP Staff and consultants are investigating the economic and operational feasibility of providing rail transportation for passengers and their automobiles to the northern vacation areas of Michigan from origins within and outside of Michigan. The purpose of this study is to determine if the provision of such service could expand the market area for tourism in Michigan, and also serve as a hedge against potential severe long-term transportation energy shortages and their impact on Michigan's tourism industry.

Ad Hoc Committee on Transportation of the Mobility-Limited

(Dr. J. Kent, Michigan Technological University, Chairperson; Dr. J. Cohen, The University of Michigan; Dr. T. Datta, Wayne State University; Ms. J. Fitzgerald, Wayne State University; Ms. N. Kidney, Macomb County Essential Transportation Service; Mr. T. McDonald, Chrysler Corporation; Mr. E. McCorkle, Ann Arbor Center for Independent Living; Dr. L. Pastalan, The University of Michigan; Dr. J. Pearson, The University of Michigan; Mr. K. Rajendra, Lansing Planning Department.)

Fixed-route line-haul buses along a major travel corridor in southeastern Michigan are being put into service with lift equipments installed and other improvements which will make them fully accessible to elderly and handicapped persons. This ad hoc committee is developing an evaluation project which would determine the cost-benefit of this "fully accessible" line-haul service as it compares to specialized door-to-door transportation of the elderly and handicapped using dial-a-ride small buses. The project will have significant influence on public policy formation with regard to transportation of mobility-limited persons.

Hybrid-Electric Small Bus Ad Hoc Committee

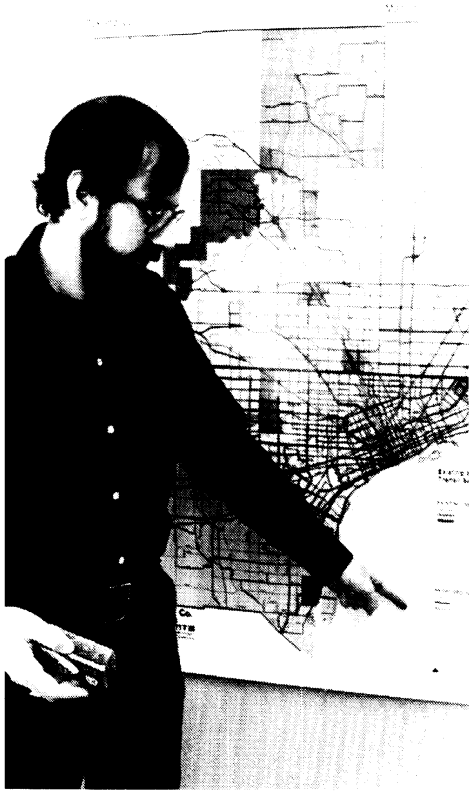
(Dr. J. Kent, Michigan Technological University, Chairperson; Mr. G. Burton, Bendix Research Laboratories; Dr. G. Smith, The University of Michigan.)

In connection with the ERDA-sponsored Electric and Hybrid Vehicle Demonstration Program, the MTRP is developing a small bus demonstration program for Michigan. Michigan firms and individuals who can design and construct such a vehicle have been identified and a demonstration program has been proposed for federal funding.

Transportation and Urban Geography/Demography Ad Hoc Committee

This committee is being formed to develop projects to better understand the relationships between transportation and land use and the implications of demographic changes on transportation needs in Michigan. The scope of inquiry will include major urban areas, small cities, and rural cities and towns.


DICTIONARY



In addition to the ad hoc committee actions, the MTRP Staff and consultants have been involved in the following activities:

Ferry Alternatives for Service Across Lake Michigan

As a result of a request from the Michigan State Legislature, the MTRP Staff commissioned a study which was performed by the Department of Naval Architecture and Marine Engineering, The University of Michigan, and HSRI. The preliminary study assessed the feasibility of using hovercraft or hydrofoil vehicles for passenger and auto ferry service across Lake Michigan. It also examined new hull designs for ferrying railcars and trucks. Initial findings indicated that a hovercraft service could be competitive with existing passenger car fares, would reduce crossing time from 4-1/2 hours to 1 hour, and would require minimal shoreside facilities. It also indicated that an integrated tug-barge service could be competitive and may have a growing market.

Transit Financing Alternatives

As a result of another legislative request, a preliminary study of transit system financing methods used in other states was conducted at Michigan State University, and a transit financing evaluation model is being placed on a computer to provide "quick reaction" answers to subsequent transportation economics questions which may arise in the legislature.

Airport Development Management Data System

The MTRP Staff has assisted the State of Michigan Bureau of Aeronautics in developing a request for proposals for a study to design a data system for the management of aviation facilities planning. This system will assist the Bureau of Aeronautics in determining airport needs and implementing state airport projects.

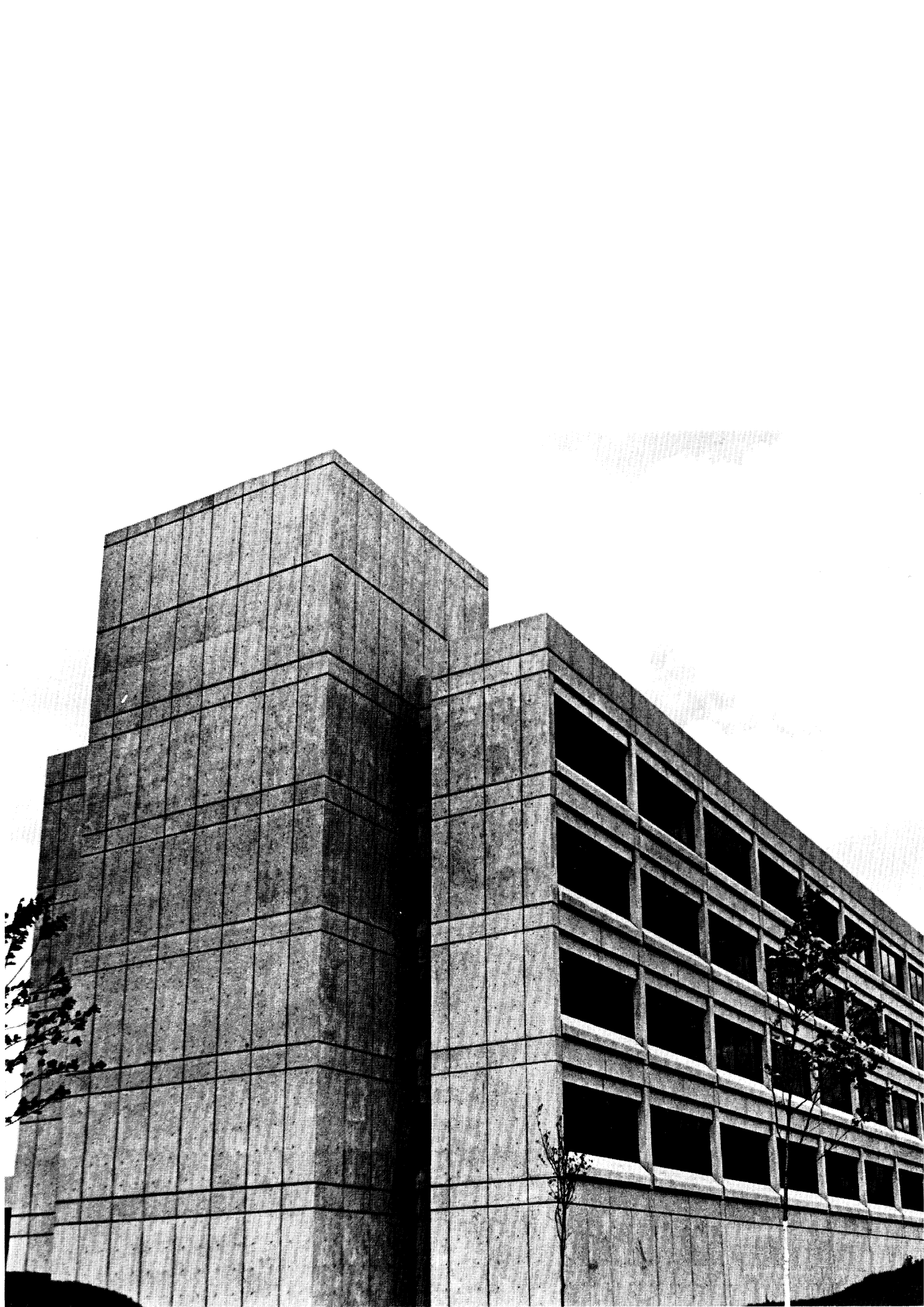
Retro-reflective License Plates

The MTRP Staff commissioned an informational study by HSRI, as requested by the Michigan State Legislature, to examine the cost-effectiveness of requiring retro-reflective license plates on commercial vehicles. The analysis contained observations on the safety implications of retro-reflective license plates and on the practicality of performing evaluations of the ongoing safety aspects of this legislation.

Through its committees and staff activities, the MTRP reviews the annual demonstration and development program of the Bureau of Urban and Public Transportation of the Michigan Department of State Highways and Transportation. The results of these reviews are observations and recommendations to the Department and Bureau concerning changes and additions to the various demonstration and development projects with regard to additional or new research and evaluation which is meaningful to the conduct of these projects as well as the development of results which would be useful in creating federally sponsored projects in Michigan and elsewhere.

The MTRP also functions to communicate to federal agencies Michigan's involvement in transportation research development and demonstration projects.

Such communications have been underway with the U.S. Department of Transportation and, through the Office of the Secretary, with the President's Intergovernmental Science and Technology Advisory Panel. This panel provides recommendations concerning state-level research needs to the President's Scientific Advisor. MTRP has proposed that federal funding be given to the Program in order to expand MTRP's activities, bring MTRP projects to the attention of the Scientific Advisor's Advisory Panel, assist in the transfer of the MTRP experience to other states and regions, and assist in the use of MTRP as a model of how similar organizations might be developed in other states.



HSRI Research Facilities

The HSRI Building

The HSRI Building, constructed in 1969 on the North Campus of The University of Michigan, provides 68,000 square feet of laboratories and other facilities specifically designed to support research on all aspects of transportation systems and their problems. The building contains laboratories for analog and digital computing, vehicle research, impact-sled tests, biomedical studies, and physical and human factors research, as well as a research information/publications center, conference rooms, and office space for U-M and visiting faculty and staff members engaged in the multidisciplinary research programs.

Research Information and Publications Center

This facility provides a specialized information service for the Institute staff and other members of the transportation research community. Its collection includes more than 40,000 cataloged documents and more than 200 periodical titles. The subject areas of the collection reflect the many different ways in which transportation problems can be approached, with materials drawn from the literatures of engineering, physics, medicine, public health, law, economics, psychology, sociology, statistics, computer science, and other fields. The center concentrates on obtaining the most current information on transportation problems and making it readily accessible to the research staff. The center also employs its unique classified subject file to conduct retrospective literature searches, and it provides the HSRI staff with access to all other University of Michigan library resources.

Computer Facilities

The HSRI Computer Laboratory has a Digital Equipment Corporation PDP 11/45 digital computer and an Applied Dynamics AD4 analog computer.

The PDP 11/45 has a 114K-byte memory, two disk drives with a total storage of 5 million bytes, two industry-compatible tape units, floating-point hardware, an analog-to-digital conversion unit, a high-speed printer with upper- and lower-case type, a card reader, and a Calcomp plotter. The PDP 11/45 is used as a stand-alone computer for in-house processing jobs and for digital simulations. It also serves as a real-time process-control system for other analytic devices, including the HSRI rearlighting simulator, and as a remote job station to The University's AMDAHL 470V/6 computer.

The lab also maintains four dial-up terminals for ready access to the AMDAHL.

The AD4 analog computer is used as a stand-alone computer or as a hybrid with the PDP 11/45. In the hybrid mode, data can be transferred back and forth between

computers, and analog programs can be initialized, checked out, and run under complete digital control. The AD4 is also used to convert analog instrumentation tapes to digital form for further processing of the data on the PDP 11/45.

Automated Data Access and Analysis System

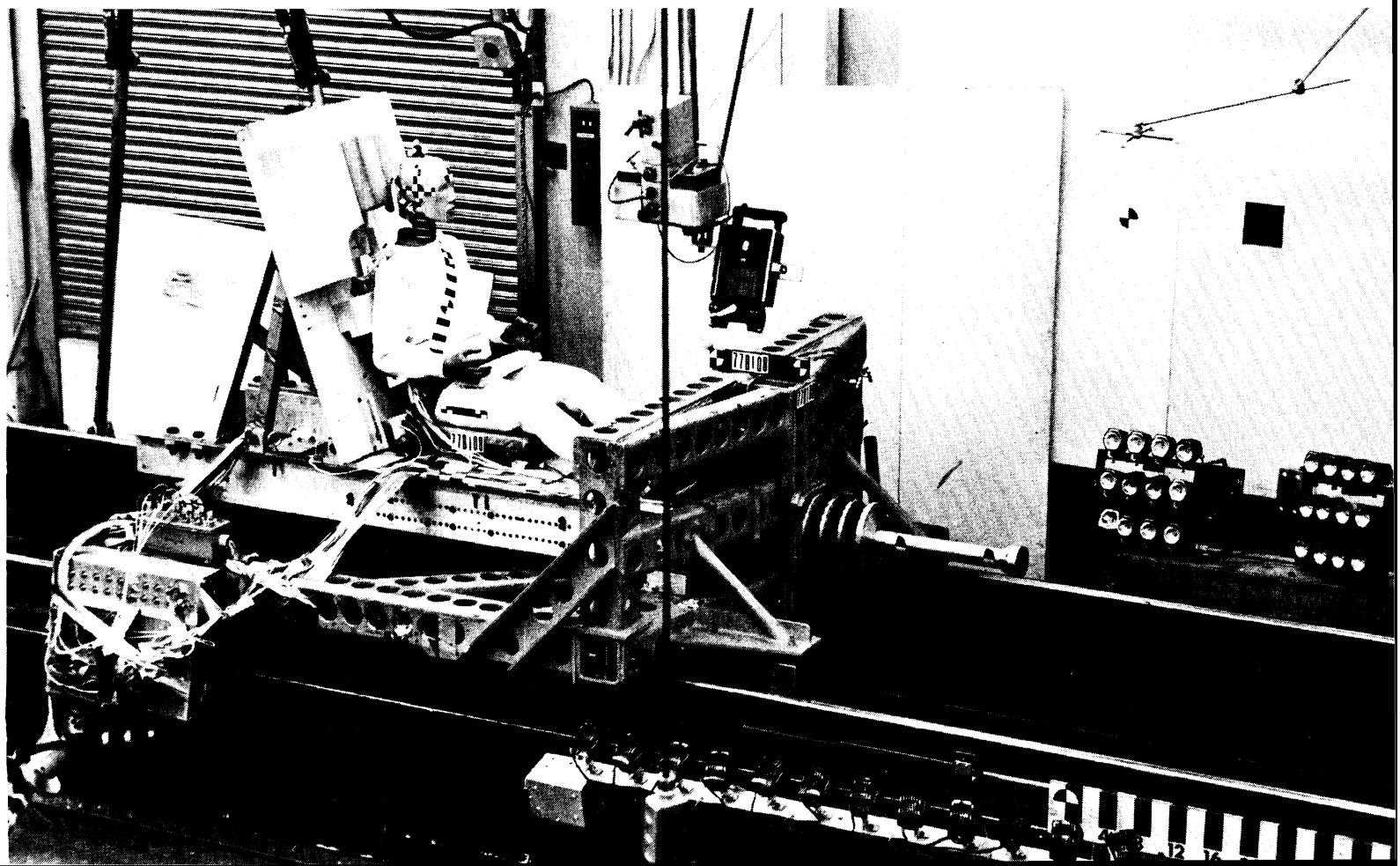
The HSRI Automated Data Access and Analysis System (ADAAS) is an integrated set of computer programs used to access, manipulate, and analyze more than 200 accident-related data sets maintained by HSRI. The system is resident on The University of Michigan's AMDAHL 470V/6 computer, and may be operated in either batch or conversational mode through remote terminals, via a telephone line.

Data access is provided by a keyword unique to each data set. All physical file manipulations (for example, uses of magnetic tapes) are performed by the system. Six simple data manipulation/analysis operations are provided to handle most preliminary data search functions. The data sets can also be accessed by OSIRIS, SPSS, or MIDAS, so that more sophisticated analytic operations may be performed.

The system is largely self-documentary and self-describing, so that novice users can quickly become familiar with its operations. Because the system offers a simple technique for using accident data in important safety-related research questions and decisions, it is employed about 35 times a day by government, industry, and university researchers in the U.S. and Canada. Current users include persons in the NHTSA, the Canadian Ministry of Transport, the Michigan Department of State, Illinois Department of Transportation, member companies of the Motor Vehicle Manufacturers Association, and staff members in several universities and private research organizations.

Impact Sled Laboratory

This HSRI facility has an impact sled that moves on a 45-foot track into a pneumatic decelerator to simulate crashes at equivalent velocities of up to 75 m.p.h. and deceleration forces of up to 75 times the force of gravity. The sled itself is a 975-lb. test platform 6.5-ft. square. The system or device to be tested is bolted directly to the sled or to a structure of steel channels that are then bolted to the sled. The impact sled is driven by a compressed-gas-powered ram, and is stopped abruptly by impacting the adjustable penumatic decelerator. The sled thus operates on the principle of rebound, achieving the desired velocity change by reversing its direction of motion during the impact. The sled payload is 1,225 lbs. Equipment for acquiring and recording data includes high-speed cameras and a 65,000-watt lighting system. Forces and accelerations are transduced and simultaneously recorded on magnetic tape and a light-beam oscillograph. All controls are remotely operated, using safety-interlocked electronic sequences.



Impact Barrier Test Facility

The full-scale impact-barrier test facility developed by HSRI is used to evaluate the crash dynamics of vehicles traveling at velocities of up to 55 m.p.h. The test facility consists of a 70-ton reinforced concrete barrier (similar in function to the SAE J850 barrier), a 100′-by-100′ paved apron in front of the barrier, a 670′ roadway with a guide rail embedded in the road surface, a camera pit below the impact site, and a building that houses the two-cable winch. The versatile continuous-loop method of propelling the test vehicle permits it to be towed at very accurate speeds, either into or away from the barrier. This allows not only precise barrier-impact testing but many other types of accurate "at speed" vehicle tests.

Mathematical Models of Crash Victim Motion

A series of mathematical models of the interaction between a human (vehicle occupant or pedestrian) and a motor vehicle (interior or exterior) has been developed at HSRI. The models are used to analyze the motions of humans during simulated crashes. Two-dimensional models are used to simulate front and rear impacts, including horizontal, vertical, and pitch decelerations. The models have been used to study belt material properties, belt slack, belt geometric configurations, airbag effectiveness, the effect of variations in the properties of the neck on injury susceptibility, advanced automotive interior design concepts, and other topics. Specific sections of the model simulate the real line of the vehicle interior, an inflating airbag, an energy-absorbing steering column, and the most advanced three-point belt system. Three-dimensional models have also been developed to provide insight into the occupant motions during lateral and oblique impacts, rollovers, spinouts, and other forms of crashes that produce three-dimensional occupant motions. Non-symmetric restraint systems are also included. The three-dimensional models incorporate a wide range of moving-contact surfaces used to simulate airbag deployment and occupant-compartment deformations caused by intrusions.

Biomedical Laboratories

HSRI biomedical facilities include animal quarters, a quarantine room, and laboratories for conducting impact studies, radiography, surgery, autopsies, and histology.

The animal quarters consist of interconnected rooms designed for housing, feeding, preparing, and examining animals used in experimental impact studies.

The impact laboratory contains impact-test equipment specially designed for producing controlled impacts in studies of animal and cadaver responses to forces representative of those produced in vehicle crashes. One device uses various-mass pistons operated in velocities ranging from 3 to 120 m.p.h., and can deliver up to 22,000 foot-pounds of energy. An accelerometer and inertia-compensated force transducer are mounted directly behind the striker plate, and piston displacement is recorded by a photo-transistorized optical transducer. A magnetic tape recorder and high-speed cameras record force, acceleration, and motion data.

The radiographic laboratory includes an examination room, a dark room, and a hospital-type Picker radiologic and fluoroscopic unit with a capacity of 300 MA and 140 RvP.

The surgical laboratory, used by HSRI biomedical staff and by U-M Medical School physicians and physiologists conducting cooperative or HSRI-sponsored research studies, contains a preparation room and operating room.

The autopsy laboratory is designed to support gross dissection of cadaver or animal materials. It is equipped with overhead surgical lights, a Lipshaw LM-10 autopsy table that can be rotated 180 degrees, refrigerator and freezer storage units for maintaining tissues under controlled temperature and humidity, and a portable-morgue unit for cadaver storage.

The histology laboratory, designed for microscopic studies of soft and hard tissues, has an AO Spencer Series 10 microscope with a trinocular body and 4X, 10X, and 45X objectives. Specimens are photographed with a Pentex H/a camera. Fresh tissues to be examined are alcohol dehydrated, cleared, infiltrated, embedded in paraffin, sectioned to a thickness of 5 microns with an AO Spencer 820 Microtome, mounted in glass slides, and stained. A large collection of slides of impacted tissues is maintained.

Anthropometric and Bioengineering Facilities

HSRI laboratories and equipment for conducting anthropometric and bioengineering studies include portable NOVA 1220 data acquisition systems and automated measuring devices developed and used in recent studies conducted for the U.S. Air Force, the Consumer Product Safety Commission, the National Highway Traffic Safety Administration, the Office of Naval Research, the Food and Drug Administration, and the Insurance Institute for Highway Safety. The equipment is used in studies of body measurements, physique, and center of gravity, as well as studies of neck range of motion and the biomechanics of "whiplash" injuries. The portable NOVA 1220 systems have 24K of memory, two tape drive units, 16 channels of A/D input, signal conditioning and power supply packages, and interactive display systems consisting of keyboard, terminal, and TV display. Measurement devices include automated calipers that provide electrical readout by means of potentiometers and miniature pressure transducers mounted in the plexiglass blades. The "whiplash" laboratory includes equipment for obtaining orthogonal photographs of head and neck range of motion in three dimensions, and equipment for measuring neck muscle strength and reflex times. A newly developed device for measuring puncture characteristics of human skin and muscle tissue uses a computer-controlled piston for assuring precise low-level impacts.

Materials Testing Laboratory

HSRI facilities for testing the behavior of materials subjected to various loading conditions and speeds include a Plastechon high-speed universal testing machine, an Instron low-speed universal testing machine, an MTS torsional actuator, and an Unholtz-Dickie electromagnetic linear shaker system.

The Plastechon uses a closed-loop ram system to test materials in compression or tension under loads of up to 12,000 lbs., applied at velocities of from 20 to 30,000 inches per minute. A servo-control mechanism ensures constant ram speed regardless of load variations, and the machine can apply cyclic deformation ranging from sinusoidal, triangular, and

square waves to random inputs.

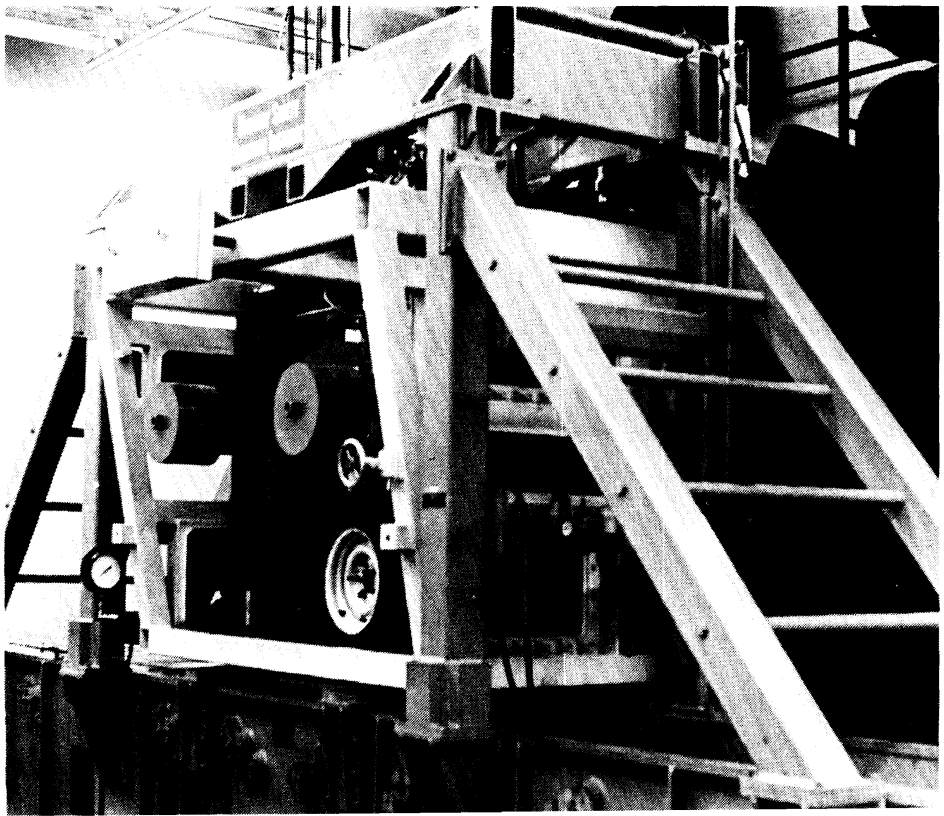
The Instron machine can supply loads of up to 10,000 lbs. at speeds ranging from .02 to 20 inches per minute. It has a moving crosshead operated by two vertical drive screws, and a positional servomechanism for precise control of the crosshead movement.

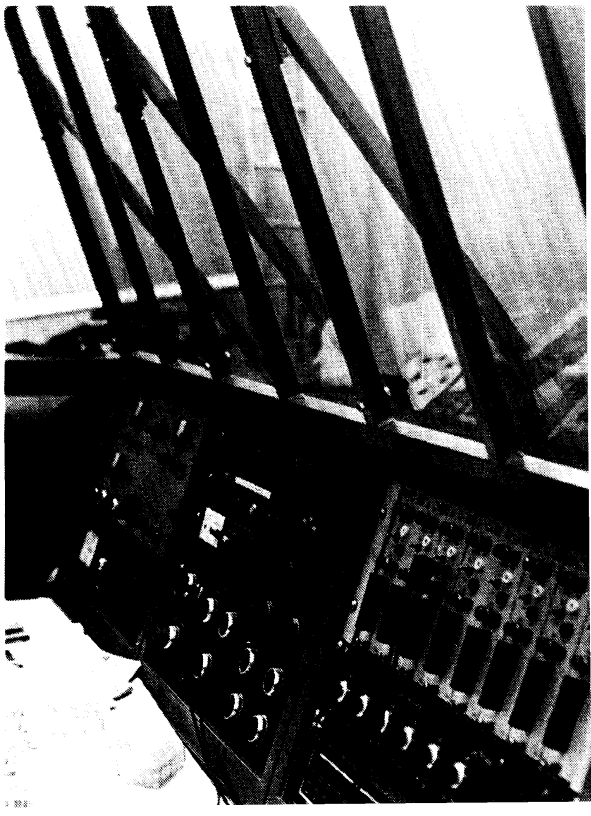
The MTS torsional machine is a hydraulic servocontrolled rotary actuator that can produce up to 280° rotation with a torque capability of up to 7,000 in. lbs. The system can be cycled dynamically up to 100 Hz.

The Unholtz-Dickie shaker has a peak sine-wave force rating of 300 lbs. and a frequency range of from 0 to 8,000 Hz. The shaker is coupled to a Spectral Dynamics automatic mechanical impedence analysis system.

Flat-Bed Tire Tester

The flat-bed tester is used to obtain precise measurements of the mechanical characteristics of rolling and standing tires. It accommodates passenger-car and truck tires ranging from 24 to 44 inches in diameter and can apply vertical loads of up to 10,000 lbs. The device is designed for low-speed tests at steer angles between ±90° and camber angles between ±20° and is instrumented to measure the three forces and three moments developed by the tire. Automatic data scanning and logging by on-line analog-to-digital converters and digital tape-recording equipment provide efficient data recording for rapid processing to the HSRI PDP 11/45 computer.





Mobile Truck Tire-Brake Tester

Constructed by HSRI under MVMA sponsorship, this over-the-road apparatus is a semitrailer towed by an instrumented highway tractor. Its function is to measure the longitudinal and lateral shear-force properties of truck tires ranging in size from 6.50-20 to 18-22.5 inches. Test tires are mounted either on the semi-trailer for measurement of braking traction or on the tractor-situated assembly for measurement of cornering traction. Both trailer- and tractor-located test stations permit the attainment of realistic tire operating conditions while the total rig travels over test pavements of interest.

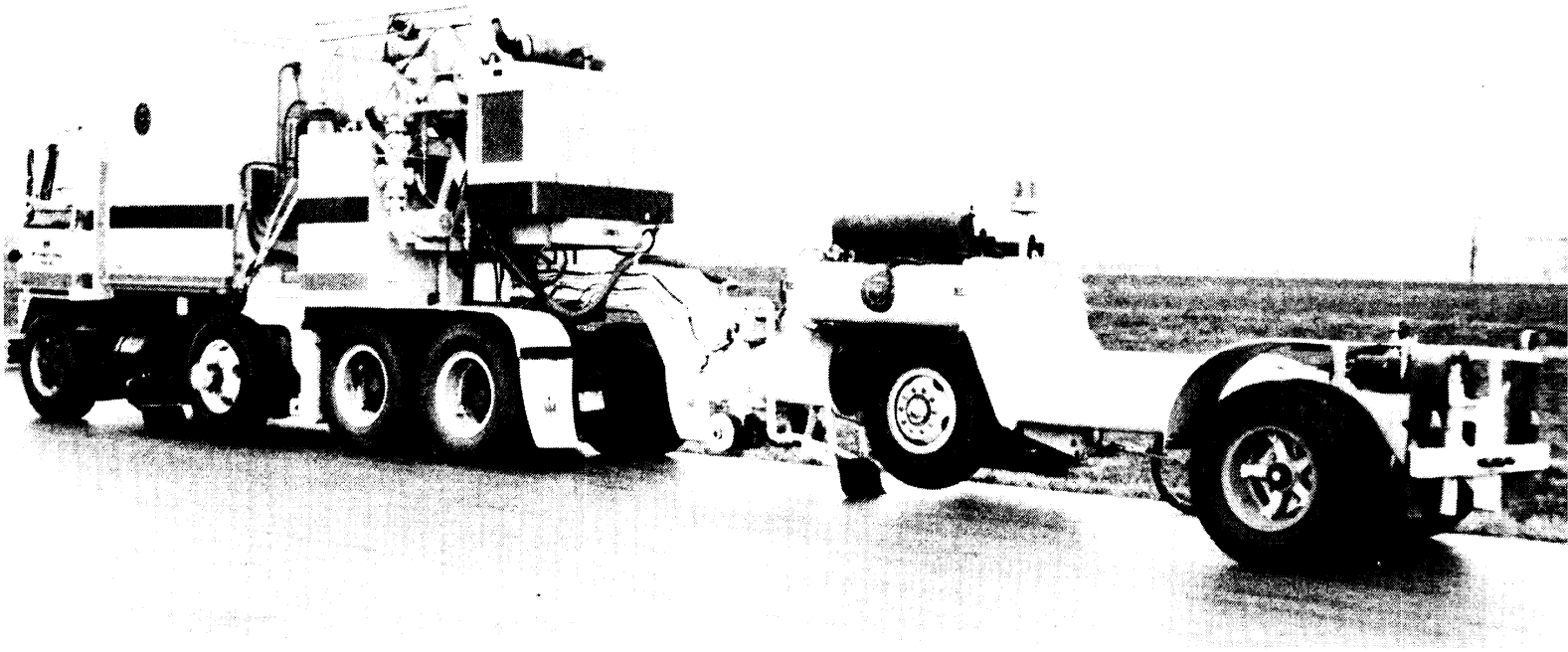
The braking and cornering traction behavior of tire specimens is then measured and recorded at an on-board operator's module. The mobile system carries its own hydraulic, pneumatic, and electrical power services and also provides a water delivery capability for simulating wet roadways.

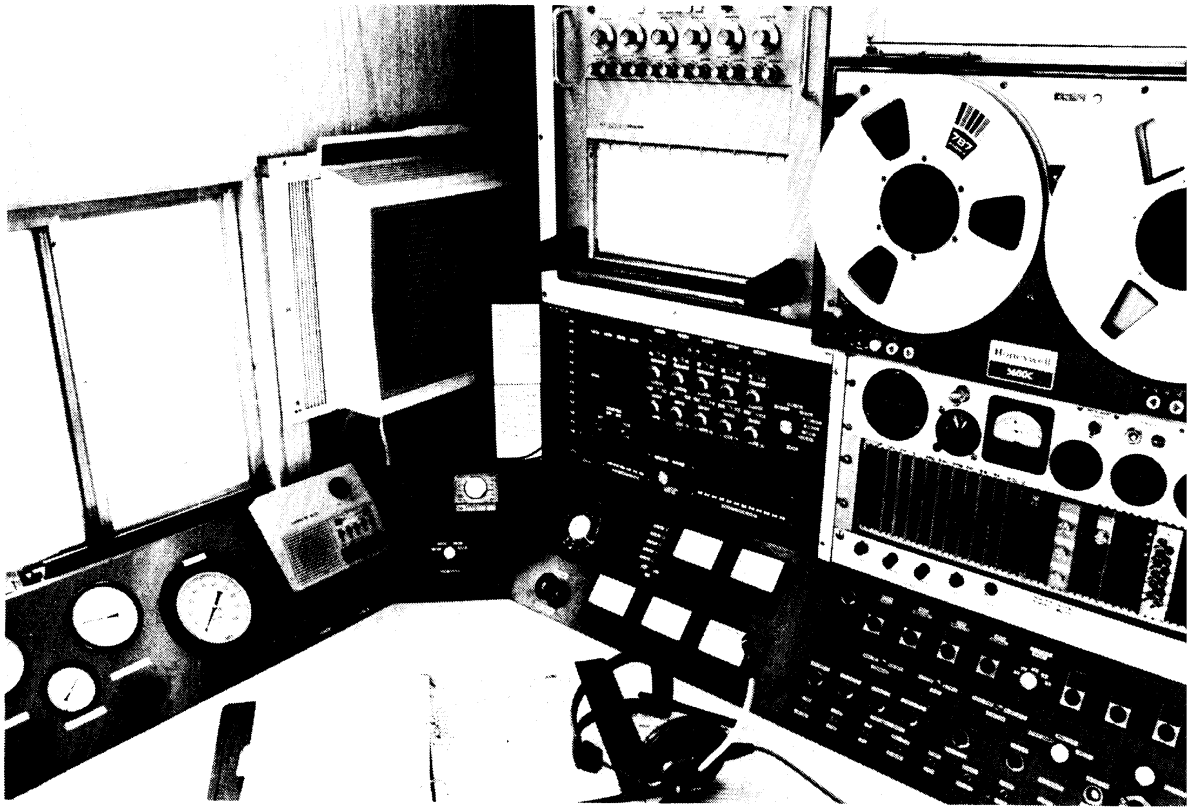
Vehicle Dynamics Simulation Programs

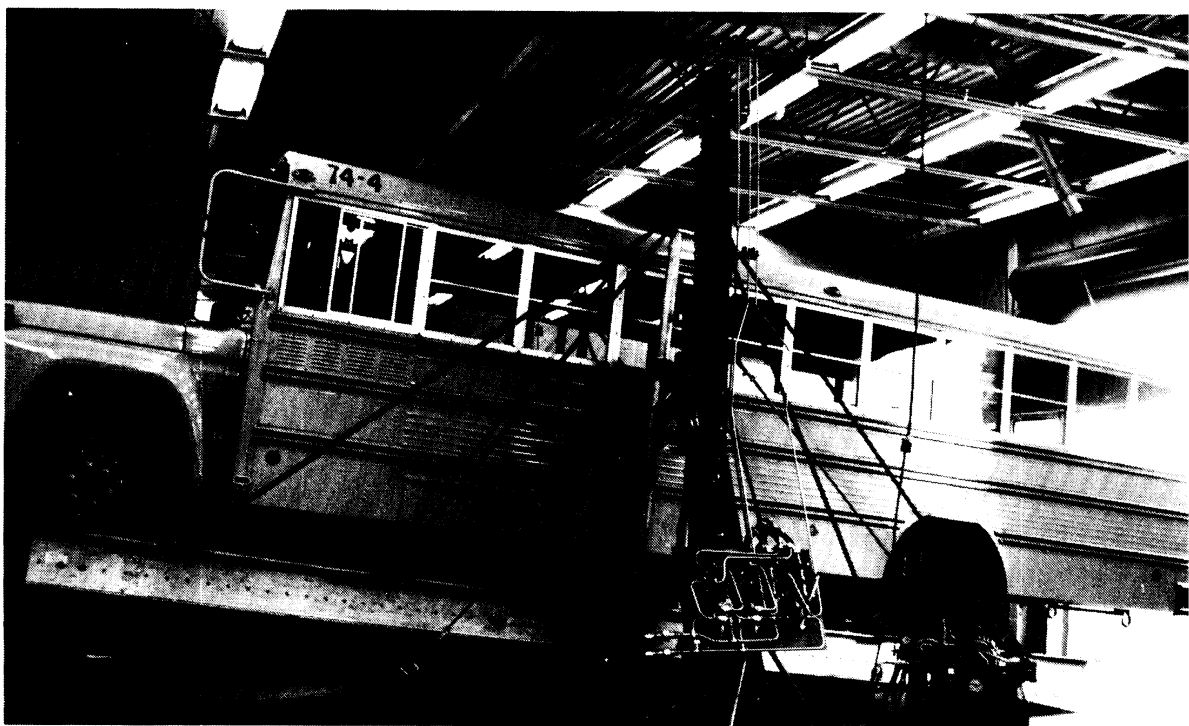
HSRI has developed several computer simulation programs for predicting the longitudinal and directional responses of passenger cars, trucks, tractor-semitrailer vehicles, and passenger-car/trailer combinations. These programs contain provisions for representing various tandem suspensions, brake systems, anti-lock systems, tire shear-force characteristics, steering system compliance and kinematics, and fifth-wheel or hitch designs. The programs compute load transfer during dynamic maneuvers. Though the programs contain many degrees of freedom, including wheel-rotation dyamics, special techniques have been developed to make them economical to run.

Pitch-Plane Inertial Properties Tester

The HSRI Pitch-Plane Inertial Properties swing is used to measure the pitch moment of inertia and center-of-gravity position in the pitch plane (i.e., side view) of motor vehicles. The tester, designed primarily for heavy vehicles, can handle two- and three-axle trucks weighing up to 30,000 lbs. The



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properties measured by use of the tester have important effects on the vehicle's response during braking.

Driver Performance Research Instruments

HSRI resources for research on driver performance include a TV-display driving simulator and an eye-mark recorder. The closed-loop TV-display driving simulator consists of a road path on a 40-ft. continuous motor-driven belt, with a TV camera mounted above the belt. The test subject views the camera image in a TV monitor through a simulated windshield frame, and operates a steering wheel and braking and acceleration controls in response to yaw and lateral camera movements introduced by the experimenters. The input disturbances and the subject's responses are recorded on magnetic tapes for subsequent analyses. The eye-mark recorder is an optical headgear device worn by test subjects to measure and record how they use their eyes during driving. The headgear positions a lens between the driver's eyes and projects a light spot on the cornea of one eye. The road scene viewed by the lens, along with the light spot reflected by the cornea, is imaged on the face of a small TV camera tube. These are recorded on video-tape for later analyses of the frequency and duration of eye glances at various points ahead of the vehicle under various light conditions and driving situations.

Vehicle Lighting Research Instruments

These HSRI resources include automobile and motorcycle headlighting test vehicles, three computer programs for simulating the night performance of headlighting systems, two rearlighting test vehicles, and a rearlighting simulator.

The headlighting test automobile is equipped to control up to 14 headlamps operated in various combinations of number, aim, beam patterns, and intensities. It also carries devices for sensing targets and recording target location and visibility distance. The headlighting test motorcycle is equipped to allow rapid change of one or two pre-aimed headlamps or the use of headlamps whose aim is adjustable while the motorcycle is in motion. Its capabilities include target sensing and the recording of visibility distances and analog data such

as roll angle or yaw rate.

The headlighting-vision model consists of computer programs that compute driver-visibility distances and glare values during simulated meetings between vehicles equipped with various headlighting systems. The topography-vision model also computes driver-visibility and glare values, but takes into account complex topography. It can produce a plot of the scene along with distances at which targets become visible. The sign-vision model computes the legibility distance of roadway signs as a function of legend and background brightness, derived from the reflectivity of the material, the headlamp system parameters and values, and the location and orientation of the sign.

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1977 HSRI Bibliography

This bibliography includes publications, contract reports, dissertations, and conference presentations produced by members of the HSRI research staff as well as by members of other academic departments and research units of the University of Michigan whose work has been associated with HSRI.

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