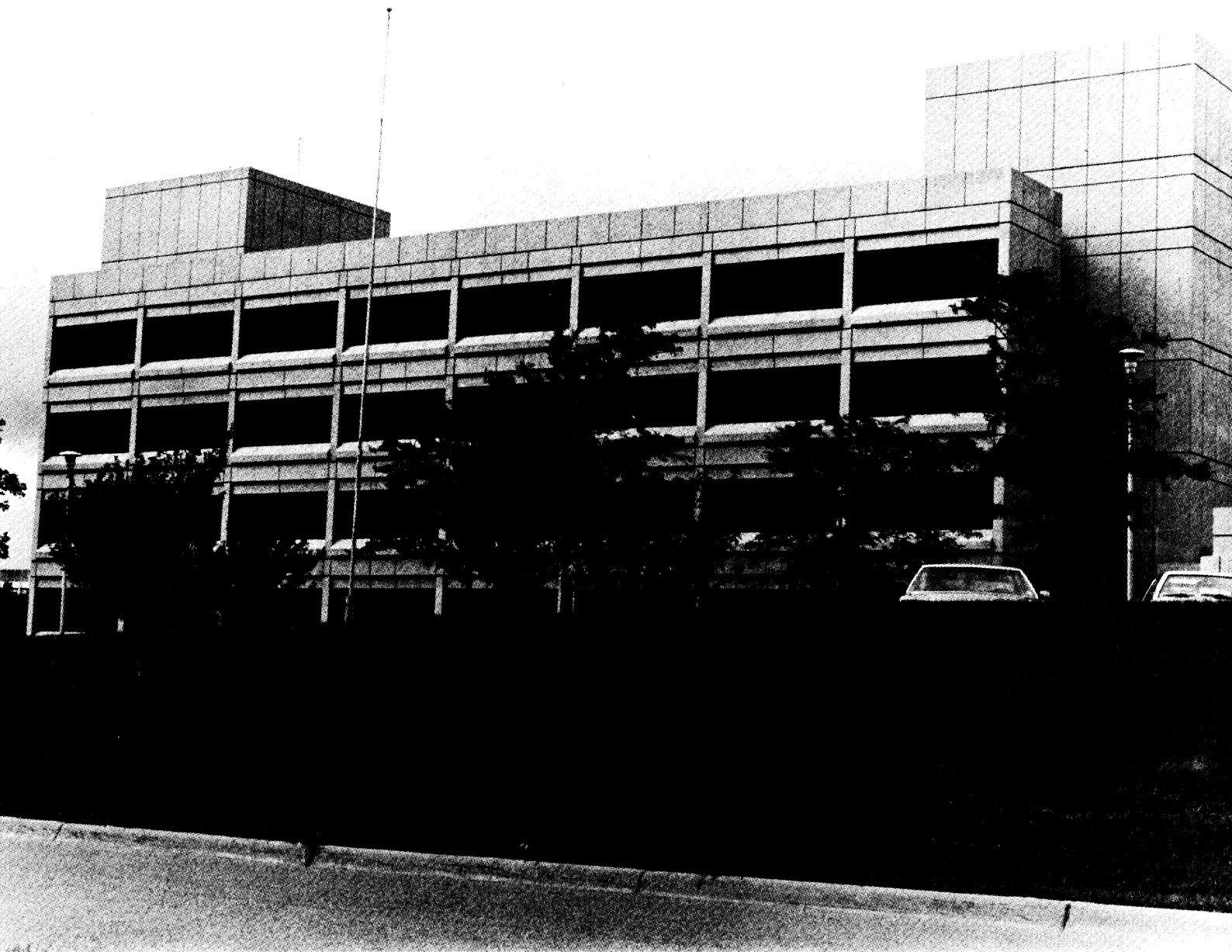


WORK IN PROGRESS

Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48109





UM—HSRI—77—1
January, 1977

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

Contents

Introduction/1

Work in Progress/3-99

Public Policies and Program Planning

Alcohol-Related Casualties and Alcohol Beverage Market Response to Public Policies in Michigan/5

Drug Research Methodology/6

Public Factors Planning Study/7

Legal Constraints Relevant to Countermeasure Development/8

Michigan Transportation Research Program/9

Public Communication on Alcohol and Highway Safety/10

Sanctions Imposed upon At-Fault Drivers Involved in Severe Crashes/13

Research Information Utilization/14

State of Knowledge and Information Needs in Alcohol/Drugs and Highway Safety/15

Accident Data

- Car and Truck Crash Experience on Toll Roads During the Energy Crisis/19
- Clinical Case Studies of Selected Collisions/20
- Accident Data Storage and Analyses/22
- Development of Methodology for Making National Estimates of Fire Data in the U.S./23
- Fleet Accident Evaluation of FMVSS 121/25
- Multidisciplinary Accident Investigation Files/27
- National Crash Severity Study/28
- Oakland County Accident Investigations/30
- Prototype Investigation of Accidents Involving Vehicles Equipped with an Air-Cushion Restraint System/31
- Special Analysis Topics/33
- Washtenaw County Collision Investigations/34
- Improved Methods of Collecting and Analyzing Bicycle Accident and Injury Data/36

Drivers

- Citizen Participation to Improve Highway Safety/39
- Driver Record Data Analysis File/40
- Evaluation of Junior High School Traffic Safety Curriculum/41
- Licensing Tests for English-Deficient Driver License Applicants/42
- Michigan Driving Characteristics File/43
- Publication of "Michigan Driver Profile"/44
- Revision of Michigan Original Operator Written Licensing Test/45
- Roadside Breathtesting Surveys/46
- Trends in Alcohol/Safety Public Information Campaigns, 1970-1976/47

Vehicles and Roadways

- Development of Techniques for Establishing the Role of Tire Factors in Accident Causation/51
- Evaluation of Phase-II Computer Simulations of Directional and Roll Responses to Steering Inputs/52
- Improved Passenger Car Braking Performance/54
- Factors Influencing the Efficiency of Antilock Systems/56
- Influence of Loading and Roll Stiffness on Directional Response/57
- Luminous Requirements of Retroreflective Highway Signing/58
- Michigan Checklane Evaluation/59
- Motorcycle Braking Performance/60
- Motorcycle Dynamics/61
- Signal Lighting System Requirements for Emergency, School Bus, and Service Vehicles/63
- Survey of State of the Art of Vehicle Dynamics and Handling/64
- Steering Controllability Characteristics of Passenger Cars/65
- Survey of Single-Axle Steering and Suspension Properties/66
- Techniques for Increasing the Conspicuity of Motorcycles and Motorcycle Drivers/67
- Testing of Hydraulic Brake Systems for Light-Heavy Vehicles/68
- Tire Factors Influencing the Braking Performance of Trucks/69
- Torque Characteristics of Commercial Vehicle Brakes/70
- Traction Properties of Radial-Ply Tires for Heavy-Duty Trucks/71
- Trailer Braking Performance/72
- Visibility Distance Through Heat-Absorbing Glass/73

Injury Protection

- Anthropometry of Infants, Children, and Youths to Age 18 for Product Safety Design/76
- Biomechanics of Cervical Spine Injuries/79
- MVMA 2-D Man Model Simplification/80
- Calibration of Test Dummies for Side-Impact Tests/81
- Crashworthiness and Occupant Protection in General Aviation Aircraft Accidents/82
- Developing a Foundation for Systems Anthropometry/84
- Human Impact Tolerances in Free Falls/86
- Development of Calibration and Testing Procedures for Three-Year-Old-Child Dummies/87
- High-Speed Cineradiographic System/89
- Modular Program Development for Vehicle Crash Simulation/90
- Human Tolerance to Impacts/92
- Prediction of Head and Neck Response to Impact Acceleration/95
- Quantification of Thoracic Impacts and Injuries/96
- Uses of Anthropometric Test Dummies in Building Standards Development/97
- Viscoelasticity of Soft Tissues and Related Injury/98
- Whole-Body Kinematic Responses to Crashes/99

HSRI Professional Staff and Participating Faculty Members/101-106

HSRI Research Facilities/107-123

The HSRI Building/109
Research Information and Publications
Center/111
Computer Facilities/111
Automated Data Access and Analysis System/112
Impact Sled Laboratory/113
Mathematical Models of Crash Victim
Motion/114
Impact Barrier Test Facility/114
Biomedical Laboratories/115
Materials Testing Laboratory/116
Mobile Truck Tire-Brake Tester/117
Mobile Tire Tester/118
Flat-Bed Tire Tester/119
Variable Braking Vehicle/121
Pitch-Plane Inertial Properties Tester/121
Driver Performance Research Instruments/122
Vehicle Dynamics Simulation Programs/122
Vehicle Lighting Research Instruments/123



Robert L. Hess, Director

Introduction

This booklet offers general readers a comprehensive view of current HSRI research programs, staff, and facilities. The 66 research programs involving 150 U-M faculty and staff members are creating knowledge essential for improving transportation systems.

While multidisciplinary studies of transportation problems can be classified in several different ways, the work underway at HSRI can be very broadly described within five general categories:

- Public Policies and Program Planning
- Accident Data
- Drivers
- Vehicles and Roadways
- Injury Protection

HSRI programs in each of those areas are providing sponsors from federal and state agencies, industrial organizations, and various societies and institutes with the independent research and information each of them need to make our transportation systems better in several respects—more safe, energy-efficient, economical, convenient, and protective of the environment.

Robert L. Hess
Director, HSRI

1977
Work in Progress

Public Policies
and
Program Planning



Alcohol-Related Casualties and Alcohol Beverage Market Response to Public Policies in Michigan

Investigator: R. L. Douglass (at left)

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

Objective: This study is an extension of previous HSRI research on the effects of the lower legal drinking age on youth crash involvement. The present study includes extended analyses of the duration of the increase in alcohol-related crashes among 18- to 21-year-olds in Michigan, reported by HSRI in 1974. This study will also investigate the influences of increases in the number and locations of liquor license holders since the legal drinking age was reduced from 20 to 18. The study will measure increases in distribution outlets, new products, and the age-specificity of these increases to the 18- to 20-year-old population.

In addition the study will review and make recommendations regarding methods of assigning priorities for research and state programming of alcohol-related social problems on the basis of relative social cost.

Significance: Several states have pending legislation regarding the appropriateness of the 18-year-old legal drinking age. Early evidence has linked lowered legal drinking ages and increases of highway casualties in some states.

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

Results: The final report will provide answers to the central question of the permanence of the immediate impact of the 18-year-old legal drinking age on highway safety in Michigan. Also the relationship of the beverage alcohol market to the impact on Michigan's roadways will be assessed. Recommendations will be made regarding the most feasible methods of assigning priorities for state attention on the basis of social costs of a range of alcohol-related problems.

Drug Research Methodology

Investigators: K. B. Joscelyn, E. F. Domino

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 methodological problems. A series of workshops will be 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.

Public Factors Planning Study

Investigator: K. B. Joscelyn

Sponsor: Motor Vehicle Manufacturers Association

Objectives: This study will examine 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 will be examined. Major organizations responsible for research and countermeasure efforts will be 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.

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 will first systematically examine the countermeasure development process from a legal perspective to identify a methodological approach that will allow the 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.

Michigan Transportation Research Program

Investigators: C. G. Overberger, Research Advisory Committee

Sponsor: State of Michigan Department of State Highways and Transportation

Objectives: To assess transportation research needs, stimulate research proposals, and recommend to the State government prospective research efforts most promising in terms of their potential contribution to improvement of public and private transportation systems in the State of Michigan.

Significance: The effective assessment of statewide research needs and the pre-evaluation of proposed research and demonstration efforts requires inputs from a broad array of governmental, academic, industrial, and other private- or public-sector organizations concerned with improving transportation systems in Michigan. The Transportation Research Advisory Committee established as an integral part of this program is designed to assure this broad participation in the evaluation of programs, recommendation of research projects, and assessment of research findings.

Methods: The membership of the Advisory Committee and procedures for assuring effective interactions among Committee members and program staff are being developed.

Results: The program is expected to assist State government in the development of its research plans by organizing the transportation expertise in the State of Michigan. It is also expected to expand the transportation research base in Michigan through federal funding.

Public Communication on Alcohol and Highway Safety

Investigators: R. L. Douglass, A.C. Grimm (at right)

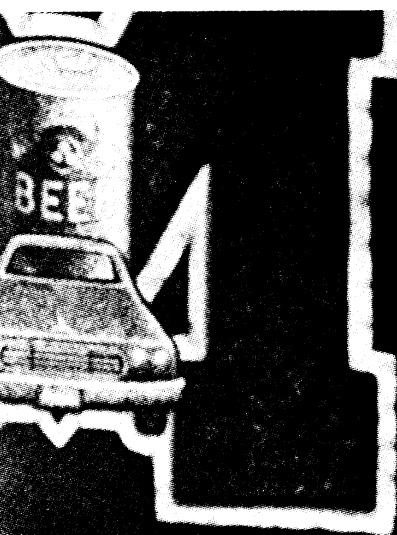
Sponsors: Distilled Spirits Council of the United States, National Highway Traffic Safety Administration, and Wine Institute of California

Objectives: To increase public understanding of the problem of alcohol in relation to highway safety.

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. Seminars for representatives of governmental, commercial, and voluntary agencies engaged in information campaigns on alcohol and highway safety are held semiannually.

Results: The program has collected more than 3000 campaign items and survey and research reports from over 300 organizations, has loaned more than 2800 items in response to requests, has conducted eight peer review seminars, and published their proceedings. Within the University, the public communication 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.



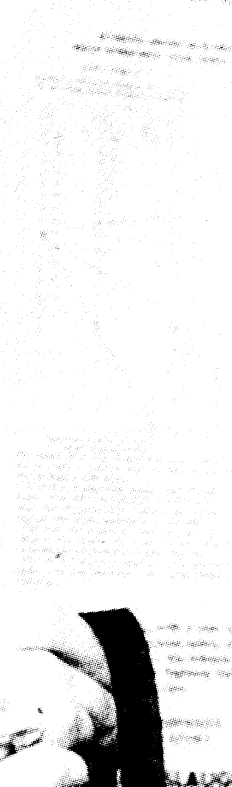
HIGH SCHOOL SPORT AND TRAINED STUDENTS LAST YEAR.

LET FRIENDS DRIVE DRUNK.

WHAT KIND OF DRINKER ARE YOU?



HOW MUCH IS TO... THESE CHARTS HELP DRAW TH...





Sanctions Imposed Upon At-Fault Drivers Involved in Severe Traffic Crashes

Investigators: K. B. Joscelyn, W. T. Pollock (at left)

Sponsor: National Highway Traffic Safety Administration

Objective: To develop an estimate of the frequency and severity of sanctions imposed by courts and driver licensing agencies upon at-fault drivers involved in fatal or severe crashes.

Significance: Society relies heavily upon the traffic law system as a general deterrent to unsafe driving actions. Yet, little objective information is available to assess the actual performance of the legal and administrative agencies in dealing with drivers who commit unsafe driving acts that cause severe accidents.

Methods: The basic data files of the Institute and the public records of legal and administrative agencies will be examined to determine what sanctions were imposed upon a sample of drivers who were responsible for causing death or serious injury.

Results: The study will provide an initial estimate of the nature of sanction practices in several jurisdictions and delineate a methodology for broader examination of the issue.

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 safety program activity reveals that in many cases existing research findings are not being utilized.

Methods: This study will examine 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 to enhance information utilization and improve 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, traffic regulation development, enforcement 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.

Accident Data



Car and Truck Crash Experience on Toll Roads During the Energy Crisis

Investigators: R. E. Scott (at left), K. L. Campbell

Sponsor: National Highway Traffic Safety Administration

Objectives: This study will examine characteristics of truck and car crashes that occurred on toll roads during the 1973 and 1974 calendar years.

Significance: The energy crisis produced significant changes in driving patterns and traffic flow behavior, partly in response to the 55 mph speed limit and partly because of other factors. This study, a continuation of prior work conducted under NHTSA sponsorship, seeks to identify in greater detail characteristics associated with car and truck crashes.

Methods: Accident data from toll roads and corresponding traffic data files for the 1973-74 time period will be examined to determine if different characteristics are associated with cars than trucks and if variances among trucks of different configurations can be detected.

Results: The findings will provide greater insight into accident characteristics of large trucks.

Clinical Case Studies of Selected Collisions

Investigators: D. F. Huelke (at right), 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; the vehicle (a late-model passenger car, pickup truck, van, recreational vehicle, or large truck) 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; 35mm color slides of the accident scene, vehicles, impacted object, 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.



Accident Data Storage and Analyses

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

Sponsor: Motor Vehicle Manufacturers Association

Objectives: The 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 analytical 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.

Development of Methodology for Making National Estimates of Fire Data in the U.S.

Investigators: J. D. Flora, P. Cooley

Sponsor: National Fire Prevention and Control Administration

Objectives: To consolidate and extend existing methods of constructing national estimates of the incidence of fires, related injuries, and attendant losses, and to assist the National Fire Data Center in applying the methodology.

Significance: Accurate national estimates of the frequency of various types of fires, along with injuries, fatalities, and property-damage losses associated with them, are difficult and costly to make because of the diversity of data sources and the lack of common data elements. Uncertainty concerning the scope of certain fire problems prevents an accurate assessment of the potential effectiveness of intervention measures and proposed countermeasure programs.

Methods: The project entails reviewing and summarizing recent relevant research, evaluating existing data sources, assessing potential additional data sources, selecting appropriate methods and data sources, identifying gaps in the methodology and data, developing and extending the methodology, and assisting the FDC to develop the best currently available national estimates of fire-related problems.

Results: The study results are expected to be used by the sponsor in developing improved estimates of fires and fire-related problems. The methodological results will also aid research in other areas,—e.g., in accident data analyses where definitive data sources are lacking.



Fleet Accident Evaluation of FMVSS 121

Investigator: K. L. Campbell (at left)

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 improvements in the braking capabilities of newly manufactured air-braked vehicles. This 27-month research program 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 5,000 vehicles in approximately 550 fleets located in 36 distinct geographic areas of the continental U.S. have been selected for monitoring, although not all fleets are expected to participate. 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 will also be obtained from the Bureau of Motor Carrier Safety, processed, and included in the analysis.

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.



Multidisciplinary Accident Investigation Files

Investigators: J. Green, J. O'Day (at left)

Sponsors: National Highway Traffic Safety Administration, Motor Vehicle Manufacturers Association, and Canadian Ministry 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 on more than 800 variables per case, 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 do files based upon police-reported data.

Methods: Case documents are supplied to HSRI by MDAI teams via their respective sponsors. New cases are logged in and the data coding is edited to ensure correctness, consistency, and completeness. Data coding must be internally consistent within the coding form and consistent with the full-text description of the collision. After added variables are coded, the case is edited a second time before key-punching, and computer checks for over 400 codes and internal consistencies are made before the case is added to the time-shared computer files. Once cases are on-line, any coding problems discovered are corrected. HSRI 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 8,000 cases have been computerized. Special files concerning vehicle malfunctions, injuries, and fatalities have been constructed for passenger cars, trucks, buses, motorcycles, and pedestrians. These in-depth files are the most actively used HSRI files, with approximately 50 user accesses per month.

National Crash Severity Study

Investigator: P. Cooley (at right)

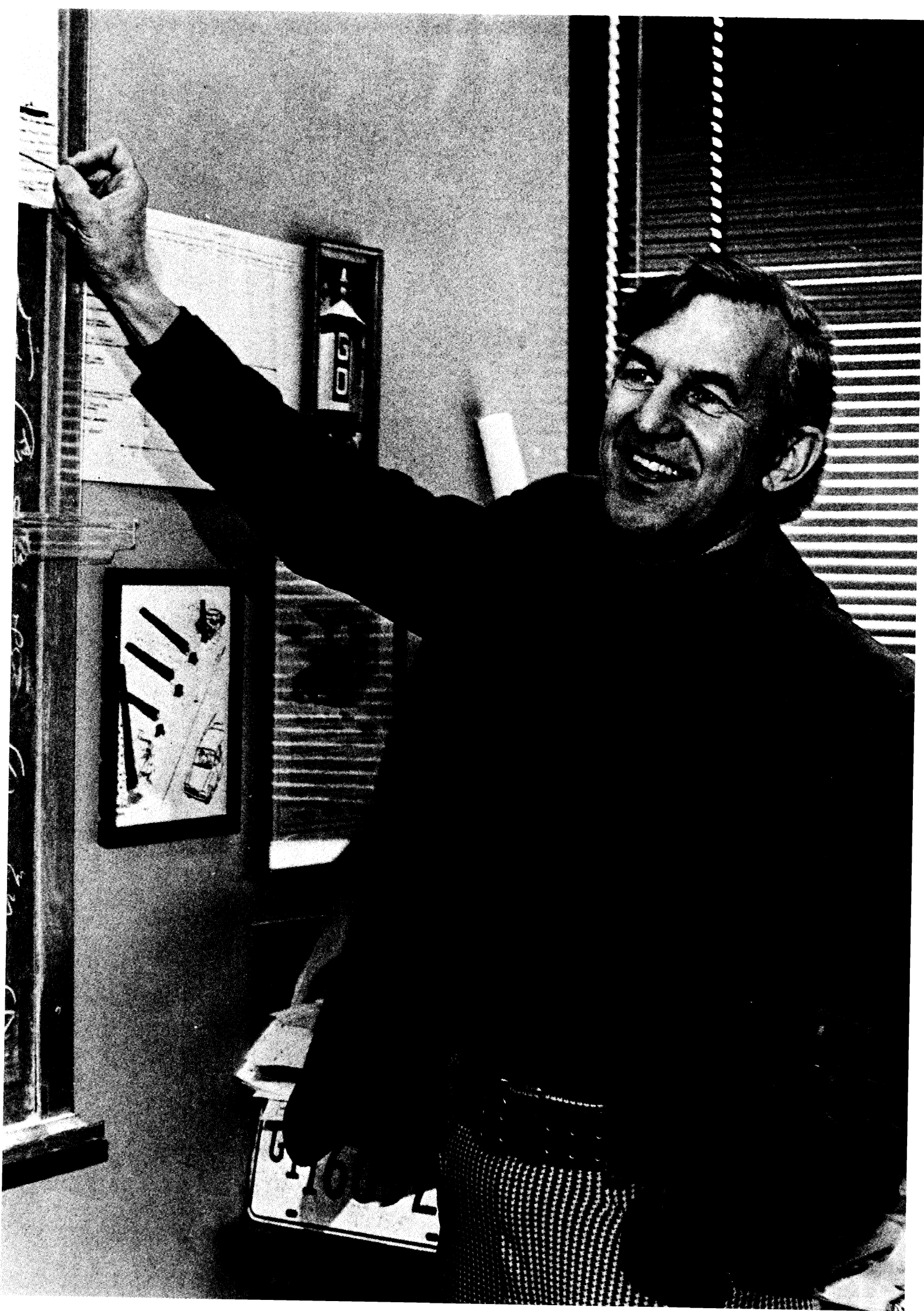
Sponsor: National Highway Traffic Safety Administration

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 objectives of this national program are 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 visits, 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.

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



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 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 standard relating to the design of 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 is produced on each case study.

Results: Since 1974 the HSRI team has investigated some 35 ACRS crashes per year and two or three school bus crashes per year. The study findings are being used by the sponsor to develop improved safety standards for vehicles and occupant protection systems.



Special Analysis Topics

Investigator: R. J. Kaplan (at left)

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 numbers 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.

Washtenaw County Collision Investigations

Investigator: L. D. Filkins (at right)

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.



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 will also test for changes in the rate of bicycle accidents concerned 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. Four and one-half years of NEISS data will be 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 analysis for any given product. A detailed analysis of data collected on 650 in-depth investigations of bicycle accidents will also be performed.

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.

Drivers



Citizen Participation to Improve Highway Safety

Investigator: P. L. Olson (at left)

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.

Driver Record Data Analysis File

Investigator: R. J. Kaplan

Sponsor: Michigan Department of State

Objectives: To maintain and update sample files of Driver Record data, and to facilitate rapid response to queries involving these and other data bases.

Significance: Data normally maintained for identification and enforcement purposes frequently need to be restructured to permit use of sophisticated analytic computer packages, such as those developed by HSRI. Supporting analyses of these and other data sources are needed to aid policy-making in Michigan's driver licensing and improvement programs.

Methods: The computer programming necessary to translate individual driver records into fixed-format analytic files is periodically reviewed by the users and applied to revised sample data tapes furnished by the Department of State.

Results: The sponsor is provided periodic documentation of file updates and modifications as well as reports on the results of analyses.

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: The improvement of public school programs in traffic safety education depends upon effective evaluation of existing programs.

Methods: The project entails consulting with school personnel, assisting with the research design, assessing curriculum materials, conducting a workshop 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.

Licensing Tests for English-Deficient Driver License Applicants

Investigator: W. T. Pollock

Sponsor: Michigan Department of State

Objective: To provide driving knowledge test questions in a format suitable for combination tape recorded/pictorial licensing tests for English-reading-deficient applicants.

Significance: An increasing volume of non-English-speaking applicants and the constant flow of English-reading-deficient applicants has suggested to the sponsor the practical feasibility of tape recorded (in English and various other languages) and pictorial testing and education of some driver license applicants. If successful, this automation of testing will help reduce license examiner contact time and eliminate the uncertainties found with transient use of foreign language interpreters.

Methods: Subject matter for these tests, consisting of one-fourth sign and three-fourths general driving knowledge material, was selected primarily from the Michigan driver manual, "What Every Driver Must Know," and from the HSRI Driver Knowledge Item Test Bank. Criteria for subject matter inclusion included documented highway sign confusion, unique features of U.S. and Michigan traffic law, and critical knowledge components of driving from highway safety literature. A pool of some 80 candidate test items was constructed by HSRI, consisting of 20 sign pairs and 60 true/false questions. This item pool, prepared on display boards and tape recordings, will be pre-tested on a group of English-deficient applicants, with the data from that exercise on item comprehensibility and difficulty then used to form a final test of 10 sign and 30 true/false questions for full field evaluation.

Results: This pilot test is expected to result in a considerably more equitable, cost-effective technique for knowledge testing of English-deficient driver license applicants.

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 will be 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.

Publication of "Michigan Driver Profile"

Investigator: R. J. Kaplan

Sponsor: Michigan Department of State

Objective: To publish summary information describing the distribution of demerit points for traffic offenses and accidents among Michigan drivers.

Significance: The publication is intended to serve as a reference document for State and local government officials and legislators.

Methods: Analyses have been completed of random samples of Michigan Department of State driving records to establish the distribution of points, accidents, and driver-improvement actions (warning letters, suspensions, revocations) by age, sex, and degree of urbanization.

Results: A publication that graphically illustrates the results of the analyses is being prepared for broad distribution in the State of Michigan.

Revision of Michigan Original Operator Written Licensing Test

Investigator: W. T. Pollock

Sponsor: Michigan Department of State

Objective: To revise, update, and expand the knowledge content of the Michigan written test for original license applicants to reflect the best available information on safe, efficient legal vehicle operation.

Significance: The licensing tests to be developed, using accepted psychometric procedures, will include recent research and operational findings on driving principles and test construction, and will serve as an incremental improvement in the educational and testing characteristics of the Michigan Original Operator Test.

Methods: A pool of 268 multiple-choice items was developed using knowledge elements for emphasis drawn from accident and violation data files, recent traffic law legislation, new highway signing practices, the Michigan Driver Manual, and research literature on significant, persistent driving problems. In concert with sponsor staff, this pool was reduced to four 40-item forms for pilot use. A total of 600 original license applicants took these tests as part of their application process at three state licensing offices selected to represent three applicant groups—inner city, suburban, and rural. Data from the pilot test, coupled with review comments from all licensing offices, will be used to form two 40-item forms equivalent in content and difficulty for subsequent use by the state in its original driver license test operations.

Results: These new test forms will represent the periodic updating of written tests intended for Department of State use in educating and testing new applicants, and will serve in tandem with similar renewal applicant tests previously developed for the state by HSRI.

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 numbers 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% or 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.

Trends in Alcohol/Safety Public Information Campaigns, 1970-1976

Investigators: R. L. Douglass, A. C. Grimm

Sponsor: National Highway Traffic Safety Administration

Objective: To review and report on trends in alcohol/safety public information campaigns during the 1970s, concentrating on a consistent set of comparative variables in major national campaigns and noteworthy smaller campaigns.

Significance: Development of improved public information campaigns depends upon effective assessment of past campaigns.

Methods: The work entails assessment of such positive trends as cooperation among government and non-government agencies, indications of increased production of responsible-drinking campaigns, increased consistency in campaign themes, and documentation of behavioral/change/intervention themes. A structured content analysis of campaign materials will provide the means of objective assessment.

Results: The report of the study will include a discussion of the role of increased communication among sponsors, producers, and researchers in improving campaigns, and the benefits involved for all public and private participants in the process.

Vehicles and Roadways



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

Investigator: L. Segel (at left)

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.

Evaluation of Phase-II Computer Simulations of Directional and Roll Responses to Steering Inputs

Investigator: P. S. Fancher (at right)

Sponsor: Motor Vehicle Manufacturers Association

Objective: To assess how accurately the Phase-II computer program can predict directional and roll responses to steering inputs.

Significance: The ultimate objective in development of the HSRI Phase-II computer simulation program is to make it capable of accurately predicting a vehicle's responses during combined braking and turning maneuvers. This project addresses turning maneuvers, thereby providing a foundation for attacking more complex maneuvers involving both braking and turning. The use of a valid computer tool for studying directional responses can also significantly aid in the evaluation and development of new vehicle designs.

Methods: The project tasks include selecting and obtaining the use of an appropriate straight truck, measuring the parameters of the truck and incorporating them in the Phase-II simulation program, instrumenting the truck for road testing of its directional and roll responses, simulating the vehicle performance in directional response tests, testing the vehicle in directional response maneuvers, and assessing the simulations by comparing their results with the physical test results.

Results: Information gained through this assessment of the Phase-II simulation program will be used to improve it.



Improved Passenger Car Braking Performance

Investigators: R. D. Ervin (at right), J. D. Campbell

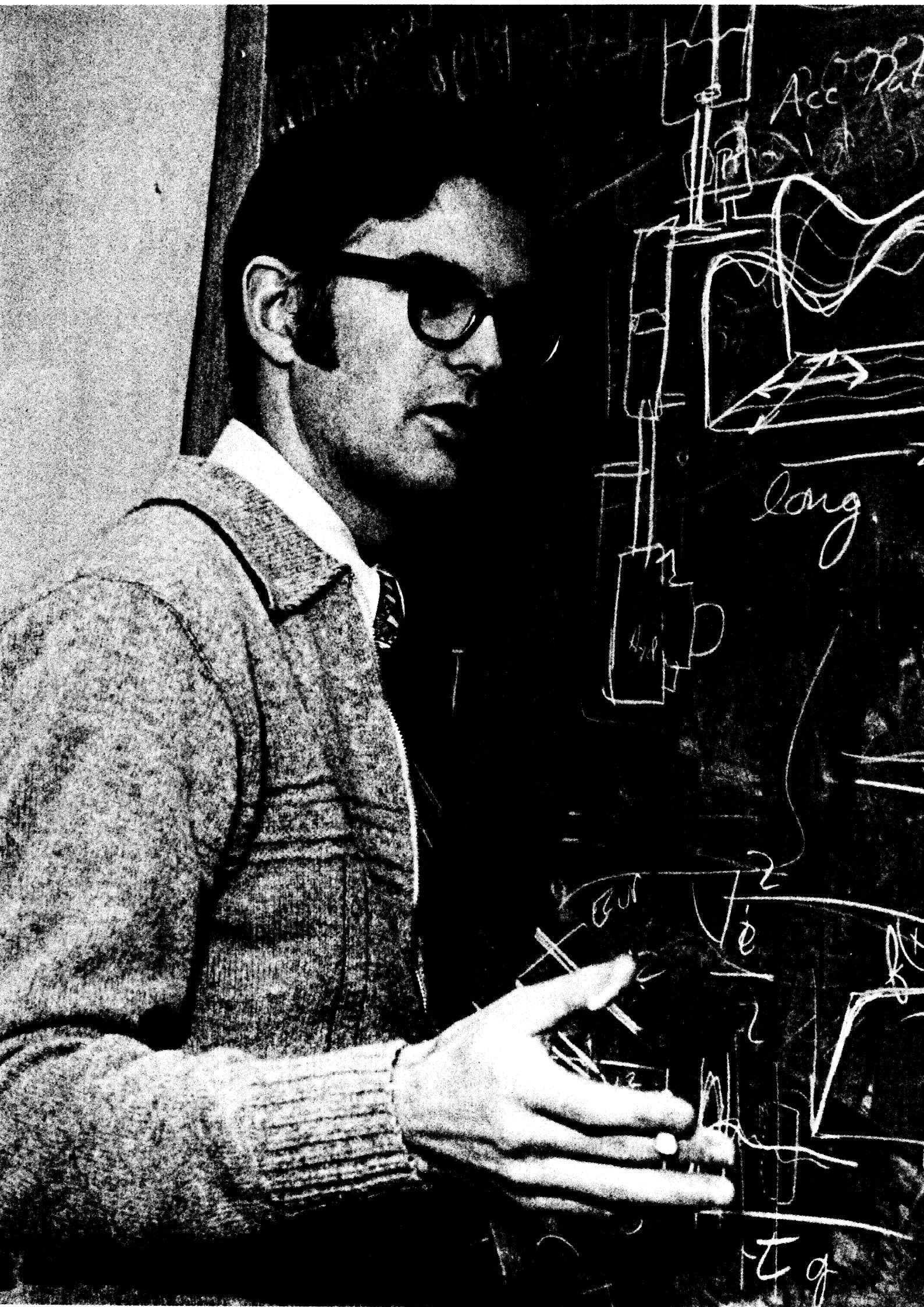
Sponsor: National Highway Traffic Safety Administration

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.



Factors Influencing the Efficiency of Antilock Systems

Investigator: P. S. Fancher

Sponsor: Motor Vehicle Manufacturers Association

Objectives: To assess the relative importance of factors influencing the performance of antilock systems, and identify the operating conditions in which these factors become important.

Significance: The performance of antilock systems for air-braked trucks is influenced by a complex set of factors, including air system dynamics, pressure loss during antilock cycling, brake fade effects, variations in tire loads due to vehicle pitching and bouncing, side-to-side brake imbalance, front-to-rear brake proportioning, and tire shear force characteristics. Unfavorable combinations of these factors can greatly reduce the efficiency with which antilock systems utilize the available tire/road friction. Accordingly, the identification of conditions which will lead to inefficient braking is extremely important in the evaluation of vehicles.

Methods: The Phase-III simulation is being used to make a parameter sensitivity study for assessing the relative importance of the factors influencing antilock system performance. The antilock test devices developed during the past two years are being used with antilock system hardware to aid in verifying and to supplement the results from the Phase-III simulation.

Results: The study will provide vehicle manufacturers and other users of the Phase-II and -III computer simulations with information they need for making critical evaluations of the braking performance of trucks equipped with antilock devices.

Influence of Loading and Roll Stiffness on Directional Response

Investigator: P. S. Fancher

Sponsor: Motor Vehicle Manufacturers Association

Objective: To assess how the directional responses of commercial vehicles may be influenced by lateral offsets of the center of gravity or by torsional properties of the frame, the suspension system, and the fifth wheel.

Significance: It is important to determine if the HSRI Phase-II simulation programs need to be extended to account for the influence of center-of-gravity offsets and torsional properties. In some cases these properties may contribute to making a vehicle directionally unstable and difficult to drive.

Methods: The work involves estimating inertial parameters, measuring torsional characteristics, performing mathematical analyses, operating the simulation, and, if necessary, refining the simulation programs.

Results: The study results are expected to improve the accuracy of the Phase-II simulation in predicting over-the-road directional responses of trucks to steering inputs.

Luminous Requirements of Retroreflective Highway Signing

Investigators: P. L. Olson, A. Bernstein

Sponsor: National Cooperative Highway Research Program

Objective: To define the lower and upper limits of luminosity for retroreflective road signs, including those composed of retroreflective sheeting as well as reflector buttons.

Significance: The research is designed to produce guidelines for engineers and manufacturers in selecting, maintaining, and replacing retroreflective highway signs.

Methods: The work includes a literature review, a survey of current practices and materials used by traffic engineering agencies, and laboratory and field experiments to develop an analytical model of sign performances under varied conditions.

Results: A laboratory investigation has been conducted to define and quantify key variables influencing sign legibility distances. A computer model developed uses the laboratory and photometric data and takes into account sign position and roadway geometry. This model was used to predict the legibility distance of a large number of highway signs. A study was conducted to measure the actual legibility distance of the same signs. In general the model predicts legibility distance within 10%.

The last step of this program is to convert the available data into a form which will enable traffic engineers to make cost-effective decisions regarding highway sign materials.

Michigan Checklane Evaluation

Investigator: J. D. Flora

Sponsor: Michigan State Police

Objectives: To assist the Michigan State Police in planning, conducting, and evaluating a program of selective vehicle inspections and driver interviews on highways in the State of Michigan. The main objective of the program is to assess the effectiveness of a random-checklane vehicle-inspection program that provides checks of about 15% of the vehicles in the area per year, as compared to a periodic inspection of all vehicles. The different programs are being conducted in two different counties in Michigan.

Significance: The comparison will provide a means of assessing the relative effectiveness of the two types of programs for reducing vehicle defects. The observed benefits from the programs in terms of reduced defects of various types, considered along with the estimated cost of each program statewide, will enable the State of Michigan to decide whether to implement a full, statewide program of periodic vehicle inspection. The study will also provide the first comparative evaluation of the two vehicle inspection systems in an actual population, using a quasi-experimental design.

Methods: As a subcontractor to the Michigan State Police under a grant from the NHTSA, HSRI is assisting in the site selection and scheduling of checklane operations, providing mechanics for the special brake inspections to be performed, interviewing drivers and analyzing the interview data, and ensuring adherence to the design, proper randomization, and the overall quality control of data.

Results: The results of this two-year study will include estimates of the extent of reductions in vehicle defects achievable under the two systems of vehicle inspection, along with driver-interview data on driver knowledge, attitudes, trip purposes, and other driver behavior factors. The data from the first year showed that the moving stopping task is a more effective measure of a vehicle's stopping capability than is a wheel pull and inspection of the brake components.

Motorcycle Braking Performance

Investigators: R. D. Ervin, C. C. MacAdam

Sponsor: National Highway Traffic Safety Administration

Objectives: To determine the braking capabilities of motorcycles in terms of Federal Motor Vehicle Safety Standard 122, examine current test performance standards and recommend changes, examine the evolution of motorcycle brake systems and determine their rate of progress, recommend modifications to current standards or propose new standards, and recommend a timetable for upgrading motorcycle brake system performance requirements.

Significance: Federal Standard 122, originally based on passenger car braking test procedures, is in need of a major revision. An objective format must be established and the motorcycle must be treated as a unique transportation machine.

Methods: Methods include a survey of braking capabilities of U.S.-marketed motorcycles, use of the HSRI flat-bed tire tester for braking-in-a-turn tests of motorcycle tires, and full-scale braking tests conducted on a sample of motorcycles.

Results: The study is expected to produce a new set of test procedures and recommendations for improved safety standards for motorcycles.

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.



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

Investigator: D. V. Post (at left)

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.

Survey of the State of the Art in Vehicle Dynamics and Handling

Investigator: L. Segel

Sponsor: Motor Vehicle Manufacturers Association

Objective: To conduct a critical review of the literature dealing with motor vehicle performance and its relationship to driver-vehicle performance, as viewed in a traffic safety context.

Significance: It is difficult to plan and execute research designed to improve understanding of the pre-crash (or primary) safety of the vehicle-driver system. Part of this difficulty derives from the inadequacy of existing concepts, such as those ordinarily referred to by the term "safety." Another source of difficulty is the complexity and cost of required experiments. Therefore, the relevance and cost/effectiveness of future "safety" research can be improved by a critical assessment of existing knowledge concerning vehicle capacities and performance, driver capacities and performance, and the consequences of interactions of those capacities and performances.

Methods: The research is directed toward the following questions: (1) From a research viewpoint, what are the more useful and fruitful definitions of driver performance, vehicle performance, and driver-vehicle performance? (2) What are the more useful definitions of a driver-vehicle system in a "safe" set of operating conditions? (3) Does the objective of designing a vehicle that is appealing to the user-customer coincide with the objective of maximizing its potential for safe operation? If not, in what ways do those objectives conflict with each other? (4) To what extent can the user-customer defeat the safety-potential features designed into a passenger vehicle, and how can design practice be modified to protect against operator practices or in-use degradations that eliminate or negate those safety-potential features?

Results: The research is expected to produce a definitive and exhaustive report on driver-vehicle interactions and the relationship of driver-vehicle performance to primary safety. The report will identify important knowledge gaps and contain recommendations for appropriate further research.

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 Single-Axle Steering and Suspension Properties

Investigator: C. B. Winkler

Sponsor: Motor Vehicle Manufacturers Association

Objective: To conduct laboratory measurements of the single-axle steering and suspension parameters of five selected, representative vehicles.

Significance: These data are needed for predicting directional responses caused by suspension design factors and brake imbalances during severe braking maneuvers.

Methods: The study entails using an HSRI-developed test device to measure the steering and suspension properties of a representative sample of vehicles (axles) to complete a baseline survey of (a) the brake, deflection, and compliance steer properties, and (b) the spring rates and coulomb friction properties of single-axle suspensions.

Results: The study findings will describe the differences in suspension and steering properties of the vehicles, and will be used to improve the Phase-II simulation of directional responses of steering/braking inputs.

Techniques for Increasing the Conspicuity of Motorcycles and Motorcycle Drivers

Investigators: P. Olson, R. Halsted-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.

Testing of Hydraulic Brake Systems for Light-Heavy Vehicles

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

Sponsor: Motor Vehicle Manufacturers Association

Objective: To design, construct, and test fixtures for the HSRI mobile brake and tire tester that will permit evaluation of the performance of hydraulic braking systems on light-heavy trucks and other vehicles.

Significance: The HSRI mobile brake and tire tester (dynamometer) has previously been used for testing pneumatically actuated braking systems. However, many trucks in the light-heavy class (20,000 to 26,000 lbs. gross vehicle weight) use hydraulic brakes, for which no mobile-test data are available.

Methods: The project involves designing and building the fixtures for the mobile dynamometer, and testing the capabilities of the new system by measuring the brake torque characteristics of a sample of hydraulic brakes for light-heavy vehicles.

Results: The work is extending current HSRI capabilities in the measurement of brake parameters and providing representative sets of data for hydraulic brake performance.

Tire Factors Influencing the Braking Performance of Trucks

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

Sponsor: Motor Vehicle Manufacturers Association

Objectives: To evaluate the influence of oscillating vertical loads on tire traction, and the influence of braking force on rolling radius.

Significance: These data are needed to understand and predict the braking performance of trucks during emergency stops.

Methods: The work entails (1) testing a sample of truck tires at very light vertical loads (corresponding to tire conditions on the rear axle of a lightly loaded truck); (2) modifying the HSRI truck tire tester to apply an oscillating vertical load, and conducting tire tests with combined oscillating load and braking slip; and (3) conducting tire tests to study how various combinations of braking force and vertical load affect the radius of rolling truck tires.

Results: The study findings will be used to improve HSRI computer simulation models of truck braking performance and evaluations of antilock devices used in the braking systems of heavy trucks.

Torque Characteristics of Commercial Vehicle Brakes

Investigator: P. S. Fancher

Sponsor: Motor Vehicle Manufacturers Association

Objective: To identify and perfect methods for obtaining brake torque data accurate enough for use in predicting the braking performance of commercial vehicles.

Significance: The accurate representation of brake torque is fundamental to predicting stopping performance. However, dynamometer data currently employed in predictive models are somewhat inadequate. The predictive capabilities of the models can be significantly improved by using more comprehensive sets of brake torque data.

Methods: Inertial dynamometer and over-the-road tests are being used to assess variations in torque attributable to the fade process that occurs during a single stop. The resulting data will be evaluated and arranged so as to represent brake torque as a function of pressure, temperature, and sliding velocity. The developed function will be incorporated in the Phase-II and Phase-III computer simulation programs.

Results: The study findings will be used to determine the type and quality of brake test data necessary for accurately predicting the braking performance of heavy commercial vehicles, using the HSRI Phase-II and Phase-III computer simulation models.

Traction Properties of Radial-Ply Tires for Heavy-Duty Trucks

Investigator: R. D. Ervin

Sponsor: Office of Noise Abatement, U.S. Department of Transportation

Objective: To test the braking and cornering traction properties of six types of radial-ply truck tires.

Significance: Measurements of the traction properties of heavy truck radials are needed in considering the noise vs. safety trade-offs of commercial vehicle tires.

Methods: The work entails conducting laboratory and mobile dynamometer tests of the longitudinal and lateral traction properties of radial-ply truck tires with rib or cross-bar treads, on wet and dry surfaces, at various loads and velocities.

Results: The study results are expected to be used by the sponsor in establishing policies concerning tire noise emission.

Trailer Braking Performance

Investigator: C. B. Winkler

Sponsor: National Highway Traffic Safety Administration

Objectives: To clarify the mechanics involved in combination-vehicle braking, develop a rational method for measuring trailer braking, and establish guidelines by which the towing and towed vehicles can be properly matched to provide acceptable combination-vehicle braking performance.

Significance: No adequate standards exist for matching passenger cars and trailers to assure safe braking performance.

Methods: The project tasks include making parameter measurements of five sample trailers; with the aid of dynamic simulations, analyzing the braking performance of combination vehicles under various conditions; conducting full-scale braking performance tests with various combinations of tow and trailer vehicles; and reporting conclusions and recommendations concerning test procedures, trailer brake standards, and parameters for effective matching of tow vehicles and trailers.

Results: The study results include recommendations for appropriate trailer brake test procedures and guidelines for the matching of towing and towed vehicles, as well as conclusions regarding the utility of implementing the results in the form of performance standards and/or consumer information guidelines explaining tow-vehicle-and-trailer braking performance.

Visibility Distance through Heat-Absorbing Glass

Investigators: A. Bernstein, P. Olson

Sponsor: P. P. G. Industries

Objective: To determine distances at which pedestrians standing in the roadway at night are visible to drivers viewing them through clear and heat-absorbing windshield glass, as a function of pedestrian reflectance, headlamp misaim, headlamp dirt, pavement type and condition, horizontal and vertical road curvature, and oncoming glare.

Significance: A parametric study of nighttime visibility distances allows safety planners to determine which parameters most strongly affect visibility distance and to develop meaningful and cost-effective standards for increasing visibility distance.

Method: An analytic computer model of drivers' visibility distances has been used in this parametric analysis. The Headlight Visibility Program determines the effects of many vehicle and environmental factors by carefully modeling the human visual detection process, the illumination provided by vehicle headlamps, pavement reflectivity, the disabling effects of glare on target detection, windshield transmissivity, headlamp misaim, and headlamp dirt.

Results: The decrement in distance at which a pedestrian is visible through heat-absorbing glass, compared to clear glass, varies from a low of 0% under certain glare conditions to a high of 12% when the pedestrian has a low reflectance, the most intense headlamp illumination is directed at the pedestrian's feet, and there is no glare. Under most circumstances the decrement in visibility distance due to heat-absorbing glass is 6%.



Injury Protection

Anthropometry of Infants, Children, and Youths to Age 18 for Product Safety Design

Investigators: R. G. Snyder, C. L. Owings, L. W. Schneider, H. M. Reynolds

Sponsor: Consumer Product Safety Commission

Objectives: To conduct a nationwide survey of basic and functional measurements of infants and children, from newborn to age 18, and make the data available to product designers, writers of government safety standards, and others needing such information.

Significance: More than 4,000,000 children are injured each year in accidents involving toys, furniture, playground equipment, and bicycles, often because those products were designed without adequate knowledge or consideration of the physical characteristics of the intended users. This study is the first to obtain measurements applicable to the current population of U.S. children.

Methods: A total of 80 measurements are being taken on a representative sample of infants, children, and youths to age 18 throughout the United States. The measurements are taken by two measuring teams using specially designed mini-computer systems and instrumentation for automatic data acquisition and storage. Special devices for measuring centers of gravity in three dimensions have also been designed and are interfaced with the computer for automatic data retrieval and calculations.

Results: This study is a continuation of a previous effort in which 40 measurements were obtained on over 4,000 infants and children to 12 years. These results were published in a final report to the Consumer Product Safety Commission in May of 1975. The results of the new study will be published in April, 1977.





Biomechanics of Cervical Spine Injuries

Investigators: J. W. Melvin, D. H. Robbins (at left)

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 models of gross vehicle motion.

Significance: Existing biomechanical data on the human cervical spine are specialized and are not well suited to inclusion to 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 accidental impacts of 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.

MVMA 2-D 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 subprograms prior 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.

Calibration of Test Dummies for Side-Impact Tests

Investigator: J. W. Melvin

Sponsor: National Highway Traffic Safety Administration

Objective: To develop procedures and criteria for calibration of Part 572 test dummies for use in side-impact compliance testing.

Significance: The need to assess occupant protection in impacts other than frontal impacts makes necessary the development of procedures and methods for assessing the capability of dummies to make consistent responses in, for example, repeated side-impact crash tests. This requires specifying the performance characteristics of various dummy parts as well as the assembled dummies.

Methods: The work includes reviewing biomechanical data pertaining to actual or simulated side impacts, including tests with human volunteers, cadavers, primates, and other animals; reviewing test and calibration procedures employed by various organizations; determining and verifying the response characteristics of the Part 572 test dummy in side impacts; and establishing test procedures and calibration criteria by which test dummies will be qualified for side-impact compliance testing.

Results: The procedures and calibration data produced in this project are expected to be used by the sponsor in development of a revised federal safety standard relating to occupant protection.

Crashworthiness and Occupant Protection in General Aviation Aircraft Accidents

Investigator: R. G. Snyder (at right)

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 the kind of biomedical data essential for safer designs or aircraft, 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 relative to occupant injury or protection.

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%. The data also show that emergency general aviation aircraft ditching can be successfully accomplished under adverse conditions, with overall 95% survivability found for 315 cases in the past 10 years.



Developing a Foundation for Systems Anthropometry

Investigators: H. M. Reynolds (at right), H. Golomb, M. Bender

Sponsor: USAF Office of Scientific Research

Objective: To conduct basic research that will lay the foundation for a new three-dimensional anthropometry to measure the size and shape of the body for both workspace and acceleration/deceleration problems.

Significance: The classical measurement techniques of traditional anthropometry were originally devised to describe variations in human morphology. However, these techniques provide static dimensions unsuited for use by analysts concerned with dynamic interactions among body segments, such as those that occur with a vehicle occupant during a collision. Therefore the linkage system must be defined three-dimensionally, and the inertial properties of the body segments must be known relative to the same linkage system.

Methods: The research program addresses several questions with respect to what is to be measured, how it is to be measured, and how the data are to be analyzed. This includes close scrutiny of past measurement efforts, using descriptive and statistical techniques in both traditional and three-dimensional anthropometry to determine accuracy requirements, compatibility of the new systems anthropometry with current and future math and/or statistical models, and the possible relationships between the old and new anthropometry. In addition, some cadavers will be studied, using quantitative stereo-radiographic techniques to analyze the lumbar/pelvic/femur linkage system in terms of landmark definition, skeletal geometry, and mobility relationships. A major portion of the research effort will be directed towards describing the relationship between the exterior surface and internal links of the body.

Results: The study will result in the development and validation of a methodology that describes mass distribution relative to a linkage system located and oriented in 3-D space. No population data will be collected, but small-sample estimates will be provided to demonstrate data collection, analysis, and presentation methods for future systems-anthropometry population studies.



Human Impact Tolerances in Free Falls

Investigator: R. G. Snyder

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 involved in collisions.

Significance: This investigation is designed to reduce the serious lack of 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 can simulate many collision situations, and are easier to reconstruct than an auto crash.

Methods: Data are gathered through investigation of selected reported falls within a 600-mile radius of Ann Arbor by means of on-site visits, interviews with survivors and other appropriate persons, and study of injuries and their relation to the fall environment. Certain falls are then reconstructed mathematically, using a computerized crash-victim simulator.

Results: More than 100 falls have been investigated, mostly of children and older adults. Good cooperation has been obtained from the persons involved, and new data have been obtained concerning the capacity of the human body to tolerate impacts to various body regions. Computer simulations are producing more detailed data for selected falls.

Development of Calibration and Testing Procedures for Three-Year-Old-Child Dummies

Investigator: R. L. Stalnaker

Sponsor: National Highway Traffic Safety Administration

Objectives: To develop calibration and test procedures for using a dummy of a three-year-old child in evaluations of child restraint systems, and develop a test protocol that can be used with minimal variations in any crash test facility.

Significance: Presently proposed revisions to FMVSS 213 include simulated dynamic crash tests for all child restraint systems in frontal, lateral, and rearward modes. Many factors in child seat testing can influence the performance of such a system and produce variability in test results. To ensure objective, repeatable tests, those factors must be quantified and limits set on allowable ranges of variation in test procedures.

Methods: The project entails identifying dummy components that affect dummy responses; developing an objective calibration procedure and a simple, low-cost dynamic test fixture; developing standardized setup procedures; and demonstrating the procedures by conducting impact sled tests of representative child restraint systems.

Results: The procedures and data produced in this project are expected to provide the sponsor with standards and specifications that will be incorporated in the revised federal safety standard.



High-Speed Cineradiographic System

Investigators: J. W. Melvin, M. Bender (at left)

Sponsor: National Science Foundation

Objective: To develop a high-speed X-ray cineradiographic system that will photographically record radiologic data during impact studies at a rate of at least 1,000 frames per second.

Significance: The system will significantly improve the quality of data obtainable from HSRI biomechanical studies of brain motion, other critical body organ motion, neck motion, and other biomechanical parameters during collision impacts.

Methods: Components of the system include (1) a continuous-potential thermionic-emission X-ray source; (2) two X-ray-to-light fluorescent conversion screens; (3) an objective lens; (4) a magnetically focused three-stage image-intensifier tube; (5) transfer optics; (6) a high-speed motion picture camera; and (7) control and timing circuits, and associated power supplies.

Results: The components have been constructed and assembled, and the system is being used in current biomechanical studies underway at HSRI.

Modular Program Development for Vehicle Crash Simulation

Investigators: I. K. McIvor (at right), D. H. Robbins

Sponsor: National Highway Traffic Safety Administration

Objective: To develop a vehicle-impact simulation program possessing the following: (1) the ability to compute three-dimensional structural responses under general crash conditions; (2) flexibility for the user to specify arbitrary structural configurations using modeling elements appropriate for realistic vehicle structures; (3) a modular structure for input data representing actual sub-assemblies of the vehicle; (4) the capability of predicting appropriate crashworthiness variables, including energy dissipation, impact forces, relative displacement of components, and acceleration and velocity time histories of all significant points; (5) a cost-effective numerical integration procedure.

Significance: Knowledge of the structural behavior of vehicles during impact is essential for crashworthy design. To date, crash testing is the principal source of such information. The simulation program under development will significantly reduce the need for crash testing in the design process.

Methods: The simulation program is based on a modular structure that provides the user with maximum flexibility in specifying a vehicle model appropriate for the given crash conditions. Each module represents a specific sub-assembly of the vehicle.

Results: In analytic studies, a new structural theory for dynamic large plastic deformations of three-dimensional frame structures was derived, based on the concept of a plastic hinge. A nonlinear constitutive theory for generalized plastic hinges, including the effect of localized deformation, was developed. An incremental form of the equations of motion for general rigid bodies was derived. The concept of generalized springs used in one-dimensional mechanical simulations was extended to three dimensions. A computer program based on the above studies (UMVCS-1) was developed to meet the specified criteria. Its executive system has an open-end design, so that additional modeling elements can be added without any structural changes in the simulation program. In validation studies, two dynamic validation tests in-



volving symmetric and asymmetric configurations were conducted on the HSRI Impact Sled. The structure was a combination of a space frame and rigid body masses similar to those used in previous scale modeling vehicle impact tests. The results validated the predictive capability of the simulation program for such structures under conditions characteristic of vehicle impact.

Human Tolerance to Impacts

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

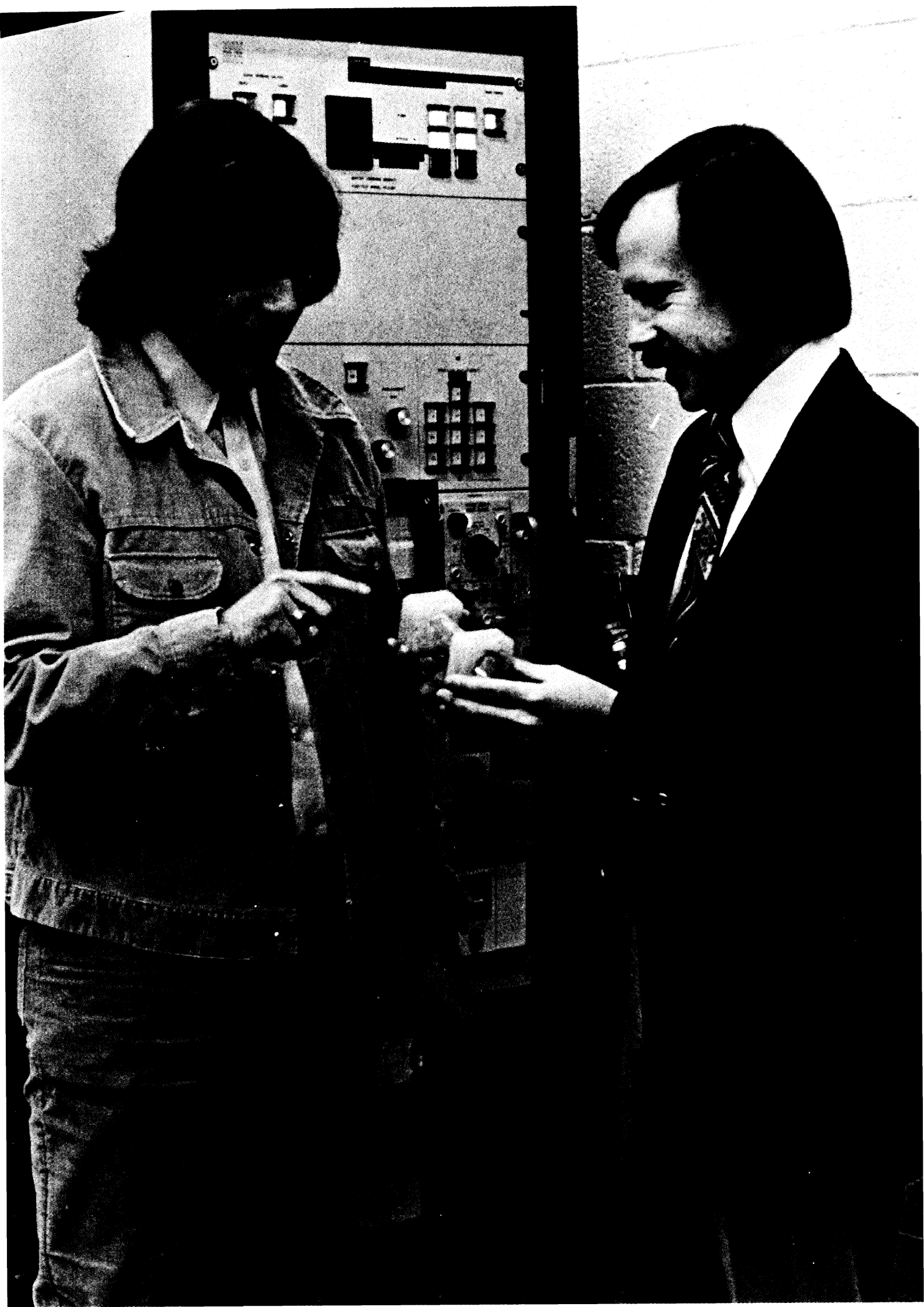
Sponsor: Motor Vehicle Manufacturers Association

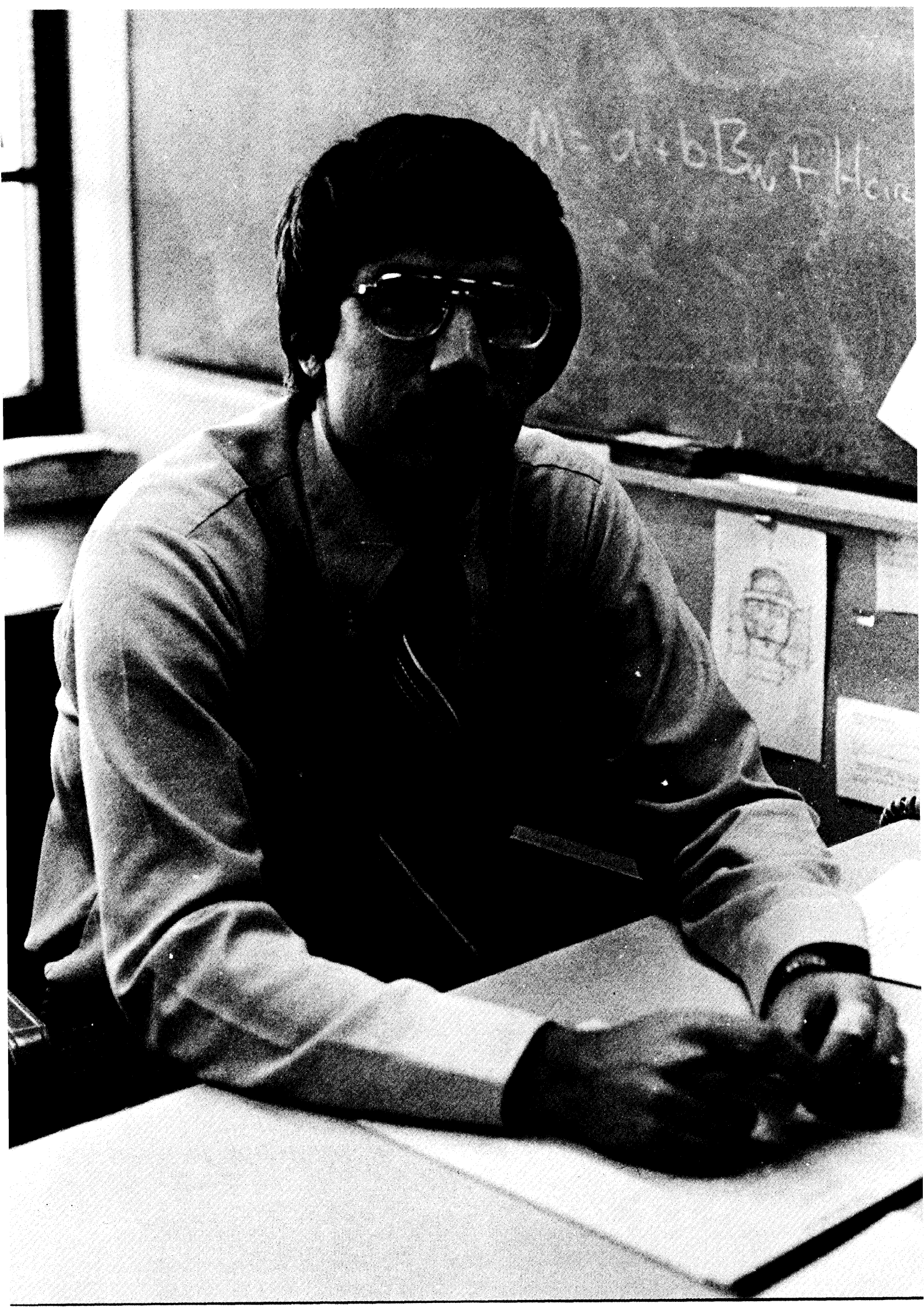
Objective: To extend knowledge of human impact response and injury tolerance of critical body regions and organs.

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

Methods: Unembalmed human cadavers are being used in instrumented impact tests involving head, abdominal, clavicular, and eccentric knee impact tolerances. The rate of onset of loads and/or acceleration is being monitored to determine whether injuries are related to this parameter.

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





Prediction of Head and Neck Response to Impact Acceleration

Investigators: L. W. Schneider (at left), B. M. Bowman

Sponsor: U.S. Naval Aerospace Medical Research Lab

Objectives: To measure physical and biomechanical properties of the human head and neck and its components and to utilize these experimental data in computer models to (1) understand the effects of different physiological mechanisms on the dynamic response of the head and neck during impact, and (2) improve the capability of computer models to predict the dynamic behavior and injury tolerance levels of humans in various crash conditions.

Methods: Properties of the human neck, including anthropometry, neck muscle strength, range of motion, and neck muscle reflex times, have been measured on 18 male Navy sled test volunteers. These data have been utilized in the MVMA 2-D Crash Victim Simulator to simulate the head/neck response of these subjects to sled tests at 6 and 15 g's. Additional experiments are being conducted to investigate more closely the role of muscles, joint stops, and passive tissue resistance. These new data will be used to improve the model performance and capabilities.

Results: Good agreement between simulation and experimental results has been obtained, using averaged data for five of the 18 Navy subjects and comparing head angular acceleration, head angular velocity, head angular position, resultant head acceleration, and T_1 resultant acceleration curves during the initial 300 msec of the sled runs. However, differences between experimental and simulation curves exist. It is expected that the simulations can be improved with additional experimental and modeling work.

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 probably 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.

Uses of Anthropometric Test Dummies in Building Standards Development

Investigator: D. H. Robbins

Sponsor: National Bureau of Standards

Objective: To determine the applicability of anthropometric test devices to various problems of building and construction safety.

Significance: Anthropometric dummies can be used to develop building design standards and safe procedures for constructing, using, and maintaining buildings.

Methods: The project entails surveying the state of the art of anthropometric test devices and the range of safety problems associated with the construction and use of buildings, then producing a guidebook for use by persons responsible for standards development.

Results: The guidebook and project report resulting from the study are expected to present and document for building standards developers a discussion of the development and use of anthropometric test devices, a description of existing hardware, discussions of how and when dummy hardware should be used, and various procedures for tests involving use of partial dummies or simulated body segments.

Viscoelasticity of Soft Tissues and Related Injury

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: Testing methods and constitutive descriptions of material behavior will be used which are justified by results from modern nonlinear continuum mechanics. The program encompasses the study of basic analytical problems in continuum mechanics and the application of such analyses to significant problems in the characterization and understanding of the mechanical behavior and associated injury mechanisms of soft tissue through experimental studies of tissue response.

Results: In this program, methods, concepts, and results based on modern continuum mechanics will be developed to improve experimental procedures and constitutive assumptions to improve understanding of mechanical function and modes of failure in biological tissues. Similarly, the needs identified in the experimental study will be used in development of special topics in continuum mechanics and the solution of specific problems.

Whole-Body Kinematic Responses to Crashes

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

Sponsor: General Motors Research Laboratories

Objective: To obtain detailed measurements of whole-body kinematic responses in a crash environment.

Significance: To end purpose of the work is to provide data essential for improving the designs of variously sized anthropomorphic test dummies—a critical need in the development of advanced occupant protection systems.

Methods: Unembalmed human cadavers are being used as test subjects in simulated crashes on the HSRI Impact Sled at various levels of severity. Extensive instrumentation techniques are used to allow detailed three-dimensional motion measurement of critical body components.

Results: The study findings are being used in development of scaling laws and performance requirements for different sizes of anthropomorphic test dummies.

**HSRI
Professional Staff
and
Participating
Faculty Members**

Alem, Nabih M.
Ph.D., Mechanical Engineering
Assistant Research Scientist

Barhydt, Wendy H.
B.S., Special Education
Research Assistant

Bender, Max
M.S., Physics
Associate Research Scientist

Bennett, Robert O.
M.S., Physics
Senior Research Associate

Benson, Joseph B.
M.S., Bioengineering
Senior Research Associate

Bernstein, Arthur
M.S., Physics
Senior Research Associate

Boissonneault, Joseph F.
Foremen

Bowman, Bruce M.
Ph.D., Engineering Mechanics
Associate Research Scientist

Brown, Douglas E.
Engineer

Bunch, Howard M.
M.B.A., Marketing and Transportation
Transportation Research Program Mgr.

Campbell, John D.
M.S., Information & Control
Engineering
Senior Research Associate

Campbell, Kenneth L.
Ph.D., Mechanical Engineering
Assistant Research Scientist

Cassells, Joyce V.
B.A., Sociology
Research Assistant

Chaffin, Don B.
Ph.D., Industrial & Operations
Engineering
Professor of Industrial &
Operations Engineering

Cleveland, Donald E.
Ph.D., Civil Engineering
Professor of Civil Engineering

Compton, Lois S.
B.A., Psychology
Research Assistant

Compton, Marion J.
Research Associate

Cooley, Peter
B.S., Electrical Engineering
Research Scientist

Davis, Rollin A.
B.S., Physical Education
Research Assistant

Deering, Michael G.
B.S., Zoology
Research Assistant

Domino, Edward F.
M.D.
Professor of Pharmacology

Douglass, Richard L.
Ph.D., Public Health Administration
Assistant Research Scientist
Assistant Professor, School of
Social Work

Dunne, Seymour J.
B.S., Mining Engineering
Senior Programmer Analyst

Ervin, Robert D.
M.S., Mechanical Engineering
Associate Research Scientist

Fancher, Paul S.
M.S., Instrumentation Engineering
Research Scientist

Ferris, Leona E.
Supervisor, Data Entry

Filkins, Lyle D.
M.S., Industrial Engineering
Research Scientist

Flora, Jairus D.
Ph.D., Statistics
Associate Research Scientist
Associate Professor, Biostatistics

Ford, Christopher R.

B.A., Geography
Research Assistant

Foust, David R.

M.S., Bioengineering
Ph.D. Candidate, Bioengineering
Senior Research Associate

Freeman, James

B.S., Zoology
Research Assistant

Gendel, Terri

A.B., English, Anthropology
Research Assistant

Gillespie, Thomas D.

Ph.D., Mechanical Engineering
Associate Research Scientist

Golomb, Dan H.

M.S., Industrial & Operations
Engineering
Programmer Analyst

Green, John A.

Ph.D., Physics
Research Scientist

Grimm, Ann C.

M.A., Library Science
Research Associate

Haney, James E.

M.A., English
Program Representative

Hess, Robert L.

Ph.D., Engineering Mechanics
Director, HSRI
Professor, Applied Mechanics &
Engineering Science

Huber, Mark A.

B.S., Mechanical Engineering
Research Assistant

Huelke, Donald F.

Ph.D., Anatomy
Professor, Anatomy

Jones, Ralph K.

B.S., Mathematics
Consultant

Joscelyn, Kent B.

J.D., Law
Research Scientist and
Head, Public Factors

Kaplan, Richard J.

Ph.D., Experimental Psychology
Research Scientist and
Acting Head, Systems Analysis

Kay, Robert D.

B.A., Psychology
Research Assistant

Kim, Tae Moon

M.S., Industrial & Operations
Engineering
Programmer

Kornfield, Susan M.

A.B., Education
Research Assistant

Lawson, Thomas E.

B.A., English
Research Assistant

Lehman, Richard J.

B.A., Psychology
Research Associate

MacAdam, Charles C.

M.S., Vehicle Dynamics & Control
Systems
Research Associate

Mangus, David J.

Research Assistant

Marsh, Joseph C.

M.S., Electrical Engineering
Assistant Research Scientist

McCormick, William E.

B.A., Psychology
Assistant Director, HSRI

McDole, Thomas L.

Ph.D., Education/Traffic Safety
Senior Research Associate

McIvor, Ivor K.

Ph.D., Engineering Mechanics
Professor & Chairman, Applied
Mechanics & Engineering Science

Melvin, John W.

Ph.D., Theoretical & Applied
Mechanics
Research Scientist and Head,
Biomechanics

Minahan, Daniel J.

B.S., Civil Engineering
Research Associate

Moore, Joseph

Administrative Associate

Murphy, Michael J.

B.S., Electrical Engineering
Research Assistant

Newland, Leonard E.

B.A., Economics
Transportation Research Program Mgr.

Nusholtz, Guy S.

M.S., Bioengineering
Research Associate

O'Day, James

M.S., Physics
Research Scientist & Head
Systems Analysis

Olson, Paul L.

Ph.D., Industrial/Experimental
Psychology
Research Scientist and Head,
Human Factors

Owings, Clyde L.

M.D., Ph.D., Bioengineering
Associate Professor, Pediatrics &
Communicable Diseases
Associate Professor, Electrical &
Computer Engineering

Peck, Leigh S.

B.S., Engineering
Research Assistant

Pettis, Leslie C.

B.S., History, English
Research Assistant

Pollock, William T.

Ph.D., Psychology
Research Scientist

Post, David V.

M.S., Psychology
Research Associate

Post, Thomas M.

M.S., Engineering Mechanics
Research Associate

Prince, Robert M.

B.A., Psychology
Research Assistant

Read, Elizabeth

B.A., Psychology
Research Assistant

Reynolds, Herbert M.

Ph.D., Physical Anthropology
Assistant Research Scientist
Asst. Professor of Anthropology

Ricci, Leda L.

B.A., English, Sociology
Research Assistant

Richardson, Barbara C.

M.S., Civil Engineering
Research Associate

Robbins, D. Hurley

Ph.D., Engineering Mechanics
Research Scientist and Head,
Biomathematics

Sayenga, Eric

M.S., Counseling
A.M., Psychology
Research Assistant

Sayers, Michael W.

M.S., Mechanical Engineering
Research Associate

Schick, Cheri

Research Assistant

Schneider, Lawrence W.

Ph.D., Bioengineering
Associate Research Scientist

Scott, Robert E.

M.S., Electrical Engineering
Research Scientist

Segel, Leonard

M.S., Engineering
Research Scientist and Head,
Physical Factors
Professor, Mechanical Engineering

Sherman, Harold W.

B.S., Electrical Engineering
Senior Research Associate

Snyder, Richard G.

Ph.D., Physical Anthropology,
Zoology
Research Scientist and Head,
Biomedical
Professor, Anthropology

Stalnaker, Richard L.

Ph.D., Engineering
Associate Research Scientist

Tann, Thomas A.

Research Assistant

Truax, Terry D.

M.A., Physiology, Psychology
Research Associate

Vanderburg, Douglas G.

B.S., Zoology
Research Assistant

Verma, Mukul K.

M.S., Aeronautical Engineering
Research Associate

Wakefield, Ronald R.

B.S., Sociology, Psychology
Research Assistant

Weber, Kathleen B.

M.A., Library Science
Coordinator, Research Information
& Publications

Whitney, Carol S.

Research Assistant

Winkler, Christopher B.

M.S., Mechanical Engineering
Senior Research Associate

Wolfe, Arthur C.

Ph.D., Political Science
Senior Research Associate

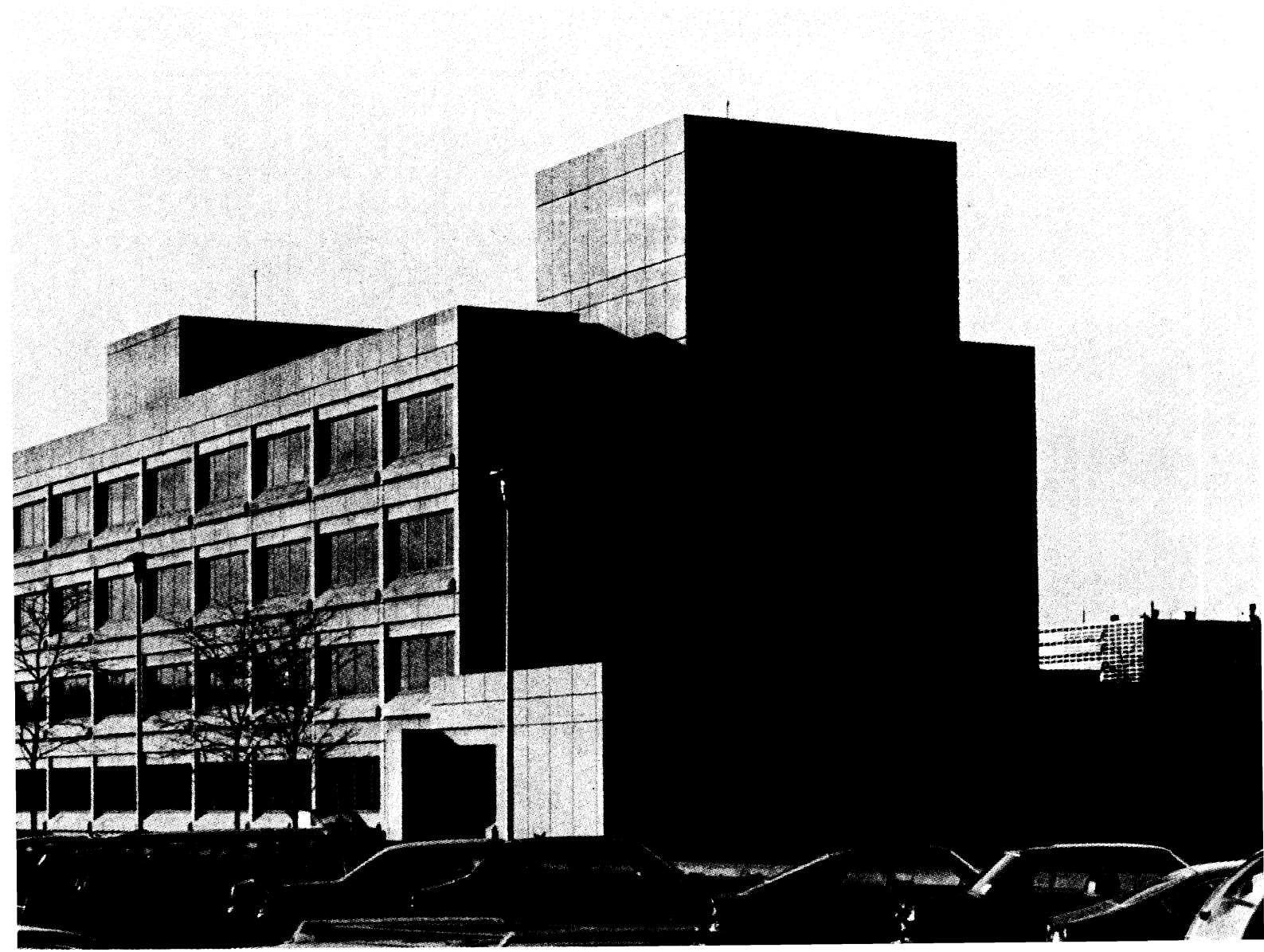
Young, Wendell E.

B.S., Mechanical Engineering
Research Associate

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 approximately 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 144K-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

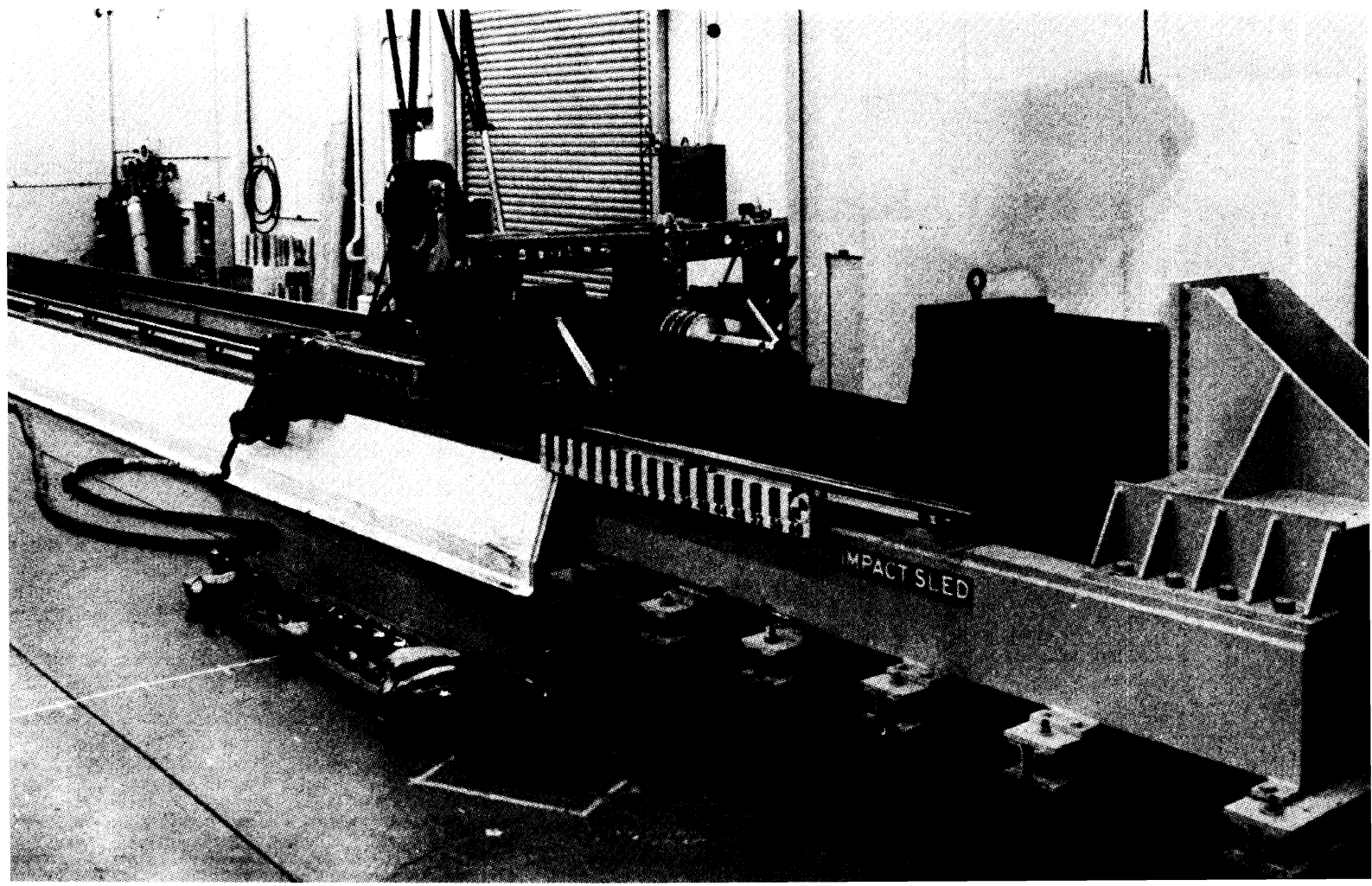
The HSRI Automated Data Access and Analysis System (ADAAS) is an integrated set of computer programs used to access, manipulate, and analyze more than 200 accident-related data sets maintained by HSRI. The system is resident on the University of Michigan's AMDAHL 470V/6 computer, and may be operated 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 pneumatic 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.



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.

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.

Biomedical Laboratories

HSRI biomedical facilities include animal quarters, a quarantine room, an impact lab, radiographic lab, surgical lab, and autopsy lab. The animal quarters consist of interconnected rooms specifically designed for housing, feeding, preparing, and examining animals used in experimental impact studies. The impact laboratory contains an impact-test machine specially designed for biomedical impact studies at HSRI. It produces controlled impacts in studies of animal and human cadaver responses to forces associated with vehicle crashes. The machine 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 facility, 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 an operating room. The autopsy laboratory is designed to support gross dissection of either cadaver or primate 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.

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.

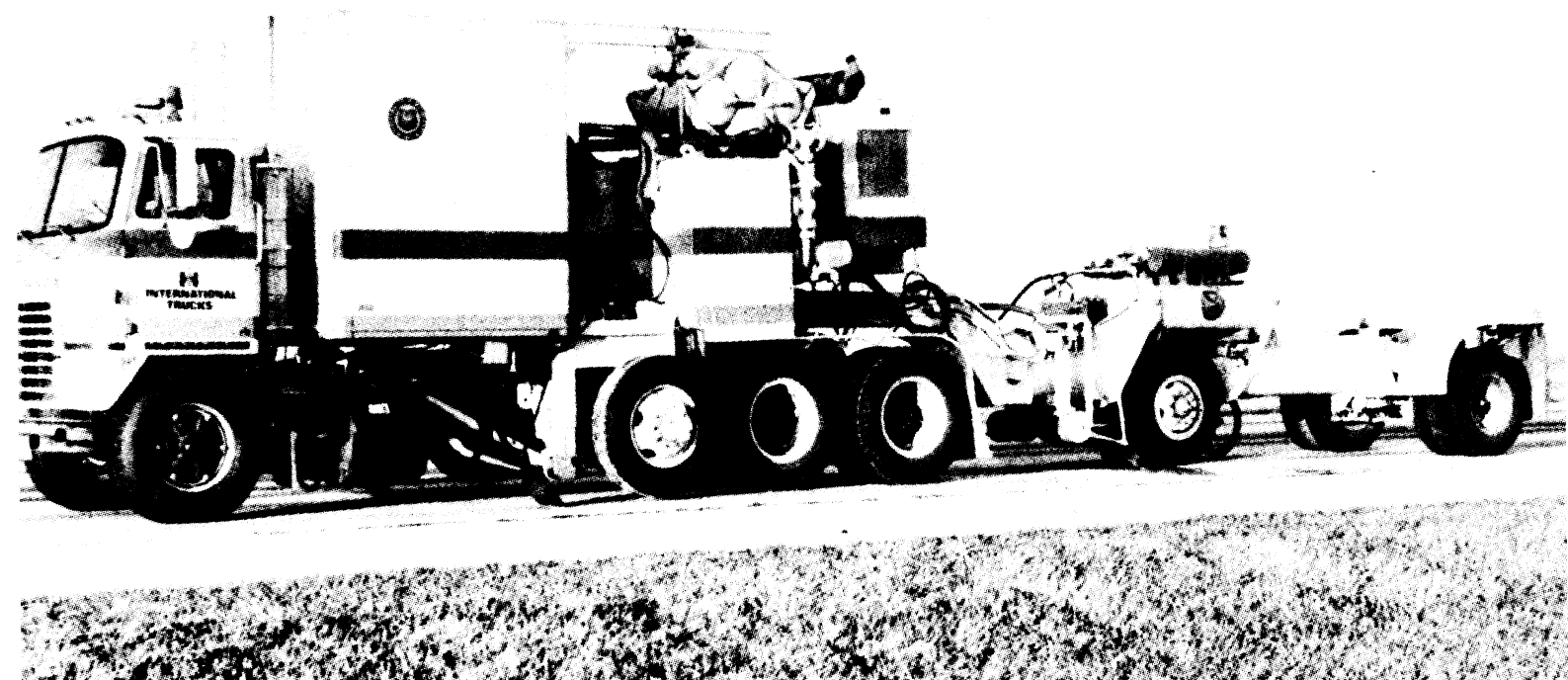
The MTS torsional machine is a hydraulic servocontrolled rotary actuator that can produce up to 280° rotation with a torque capability of up to 7,000 in. lbs. The system can be cycled dynamically up to 100 Hz.

The Unholtz-Dickie shaker system 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 impedance analysis system.

Mobile Truck Tire-Brake Tester

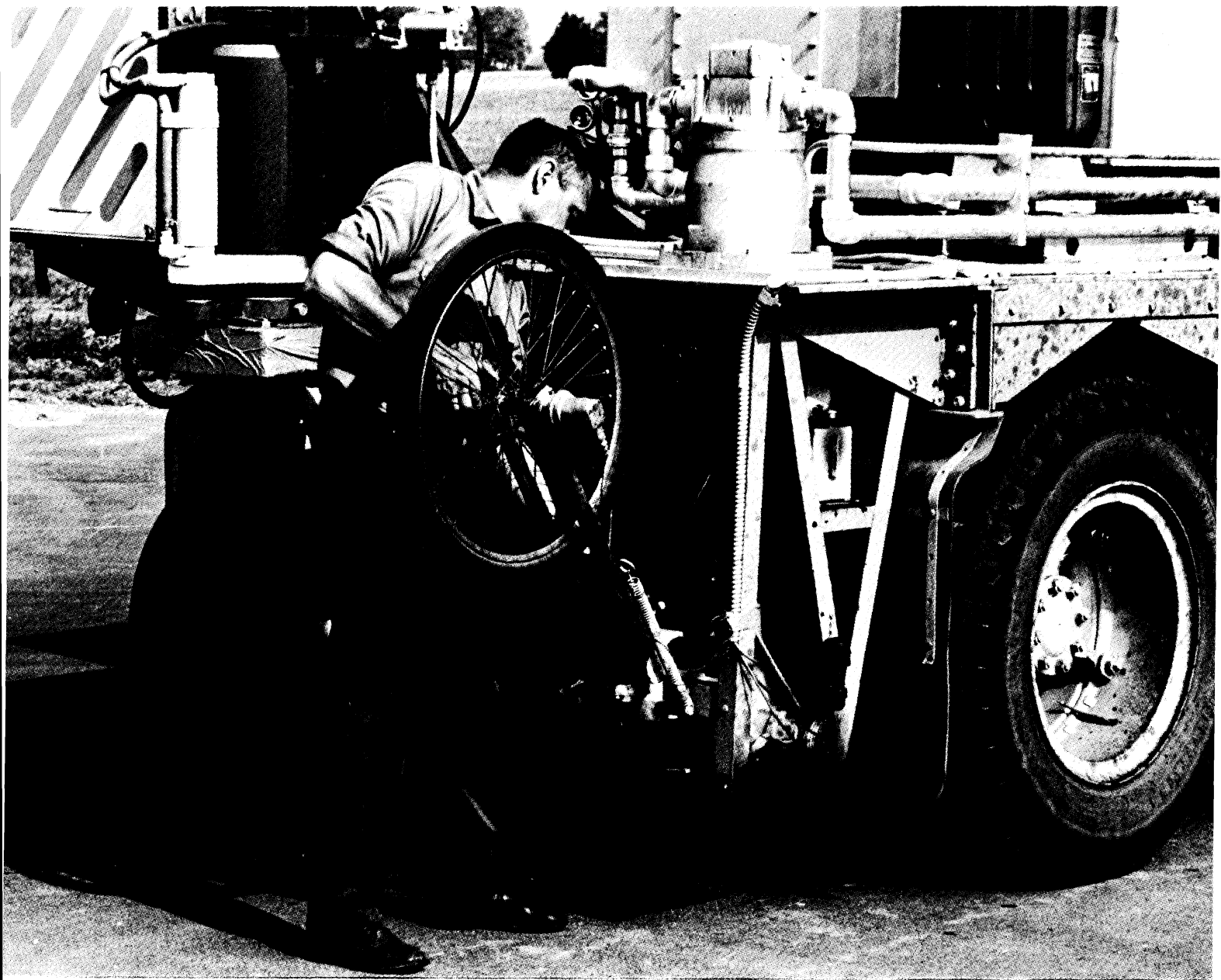
Constructed by HSRI under MVMA sponsorship, this over-the-road apparatus is a semitrailer towed by an instrumented highway tractor. Its function is to measure the longitudinal and lateral shear-force properties of truck tires ranging in size from 6.50-20 to 18-22.5 inches. Test tires are mounted either on the semitrailer 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.



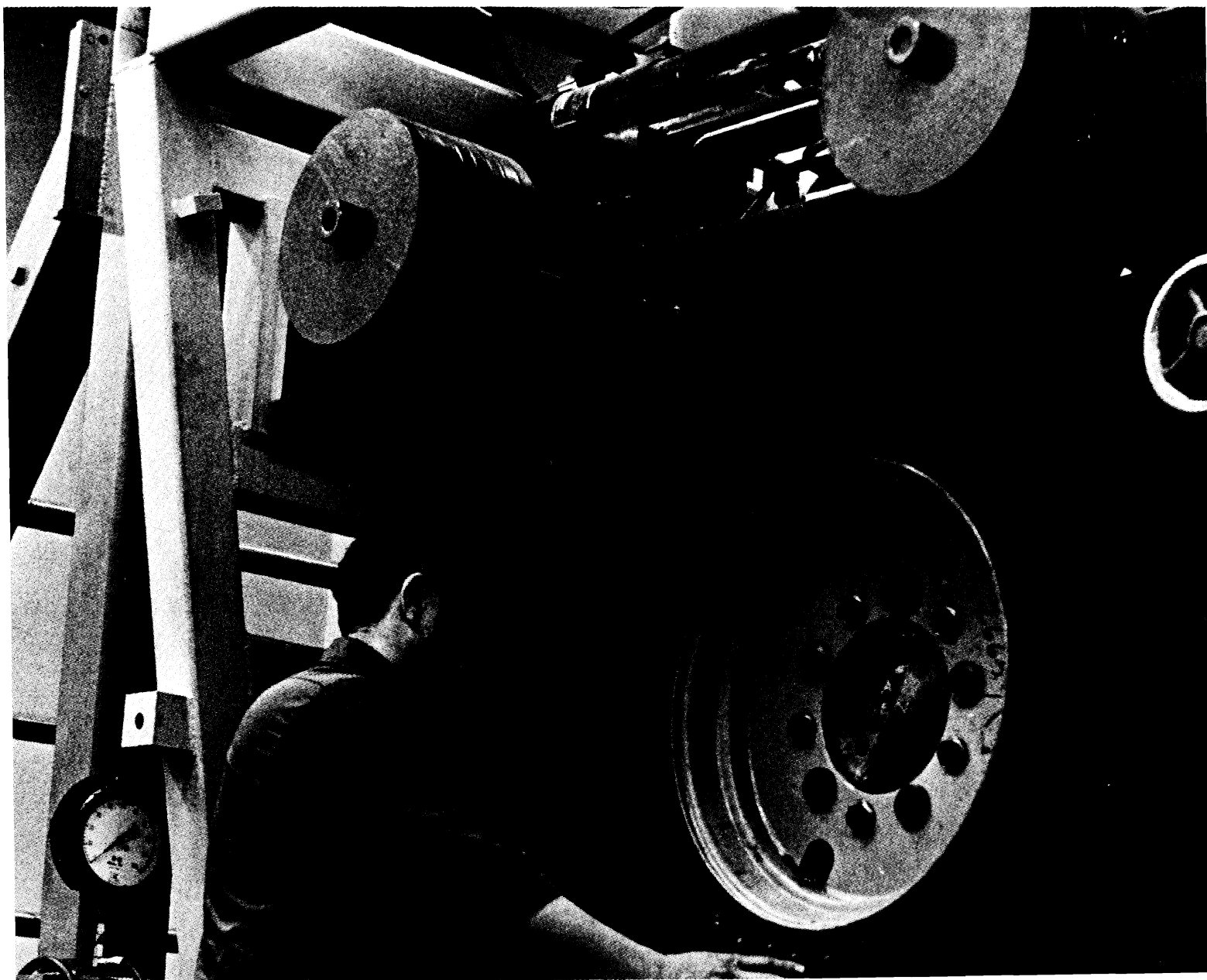
Mobile Tire Tester

The HSRI mobile tire tester, consisting of a retractable test wheel mounted on a modified tandem-axle commercial tractor, is used to measure tire braking, driving, and cornering forces on public roads or specially prepared surfaces. The test wheel accommodates any size passenger-car tire and can apply vertical loads of between 600 and 2,000 lbs. at road speeds of up to 55 m.p.h. The test tire is driven by an independent motor at programmed speed variations, from locked wheel to a speed exceeding the road speed of the tractor. The test tire may also be steered at angles of up to 18° to study the influence of driving or braking on tire cornering. For wet testing, an on-board watering system deposits a uniform layer of water on the test road. The tester is instrumented for measurement of the longitudinal and lateral forces produced by particular tire-road combinations.



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 $\pm 90^\circ$ and camber angles between $\pm 20^\circ$ 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.





74-4

Variable Braking Vehicle

This research tool was designed and constructed at HSRI to study human factors in man-machine interactions during braking, to conduct engineering evaluations of innovative brake system configurations, and to determine the ability of diagnostic devices to detect degradations in vehicle braking performance. The vehicle has a control and instrumentation system for programming, controlling, and monitoring the braking action at each rear wheel. The central component of the system is a special-purpose analog computer that serves as an electronic analog of brake system performance. The computer commands two electro-hydraulic control systems that independently actuate the left and right rear brakes of the vehicle.

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 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 tape 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 videotape 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 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 dynamics, special techniques have been developed to make them economical to run.

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 distances 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.



