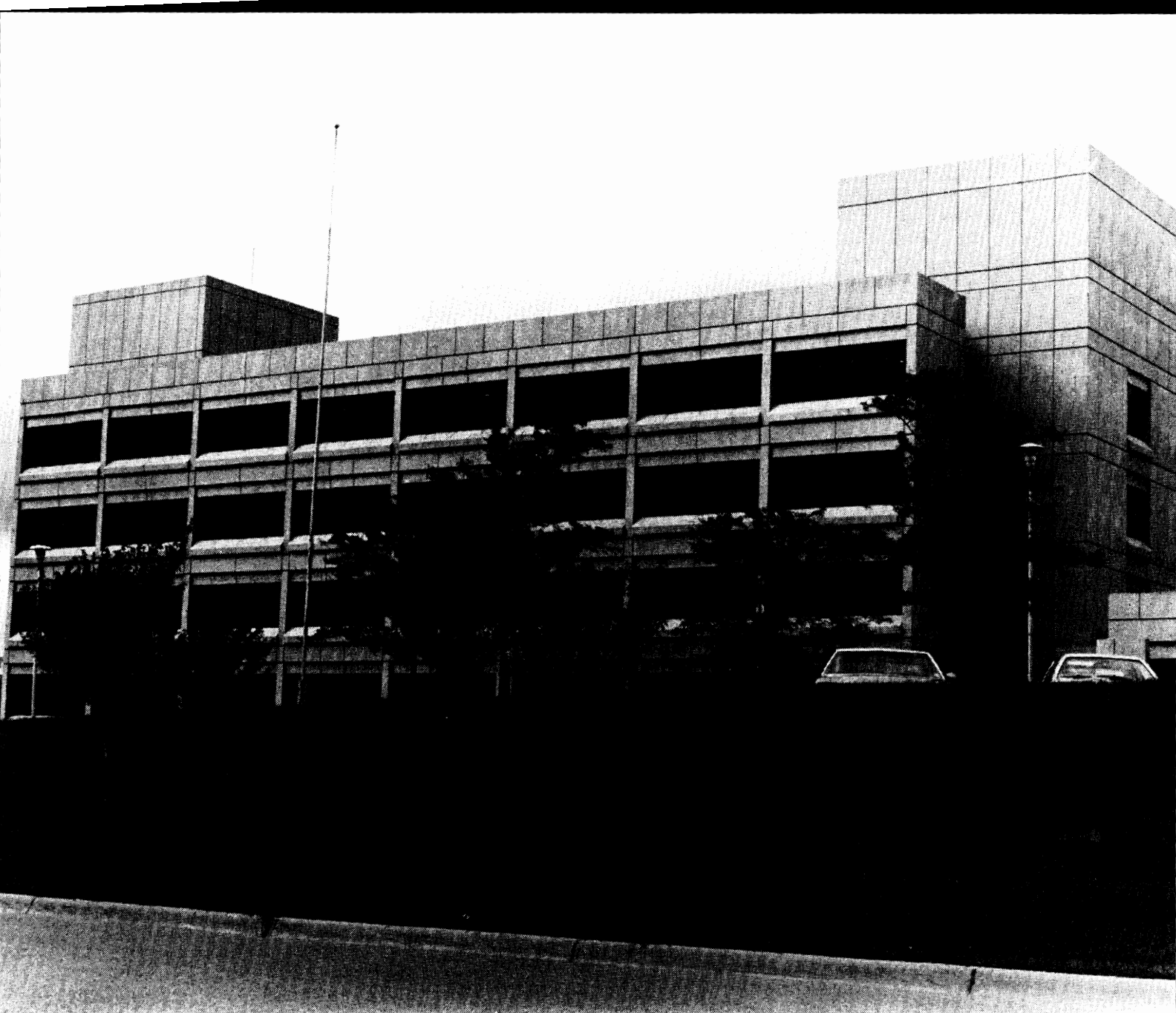


Work in Progress 1976

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



UM-HSRI-76-1
January, 1976

Copies of this publication and additional information about HSRI projects and research publications may be obtained from Kathleen Weber, Coordinator, Research Information, at (313) 764-2171, or by writing the University of Michigan Highway Safety Research Institute, Ann Arbor, Michigan 48109.

Contents

Introduction

Work in Progress

Accident Investigations and Data Analysis/9-22

Clinical Case Studies of Selected Collisions/11

Design of a National Accident Sampling System/12

Effects of the Energy Crisis on the Safety of U.S.
Toll Roads/13

Exploratory Data Analyses/14

Highway Incident Textures Laboratory (HIT-Lab)/16

Improved Methods of Collecting and Analyzing
Bicycle Accident and Injury Data/17

Multidisciplinary Accident Investigation Files/18

Oakland County Accident Investigations/20

Special Collision Data Analysis Topics/21

Washtenaw County Accident Investigations/22

**Driver-Vehicle Interactions and Performance of
Vehicle Components/25-34**

Effects of Tire Properties on Truck and Bus
Handling/27

Methodology for Determining the Role of
Vehicle Handling in Accident Causation/28

Motorcycle Braking Performance/29

Trailer Braking Performance/30

Tire Involvement in Highway Traffic Crashes/31

Truck Braking and Handling/32

Truck Tire Noise and Traction/34

Occupant Protection and Human Tolerance to Impacts/37-55

- Anthropometry of U.S. Children to Age 18 for Improving Safety of Consumer Product Designs/39
- Basic Biomechanical Properties of the Human Neck in Relation to Lateral Hyperflexion Injuries/40
- Biomechanics of Cervical Spine Injuries/41
- Crashworthiness and Occupant Protection in General Aviation Aircraft Accidents/42
- Human Impact Tolerances in Free Falls/43
- Development of a High-Speed X-Ray Cinematographic System/44
- Human Tolerances to Dynamic Loads/46
- Modular Program Development for Vehicle Crash Simulation/47
- Prediction of Head and Neck Responses to Impact Accelerations/49
- Quantification of Thoracic Impacts and Injuries/50
- Training and Other Services Related to the MVMA 2-D and 3-D Computer Simulation Models/51
- Validation of Mathematical Simulations of Occupant Dynamics During Crashes/52
- Validation of a Model of Head-Impact Injuries/53
- Viscoelasticity of Soft Tissues and Related Injuries/54
- Whole-Body Kinematic Responses to Crashes/55

Roadway Design and Traffic Engineering/57-60

- Luminous Requirements of Retroreflective Highway Signing/59
- Motorcycle Headlighting Characteristics/60

Public Policies and Driver Improvement/61-72

- Alcohol, Drugs, and Highway Safety: State of Knowledge and Information Needs/63
- Citizen Participation to Improve Highway Safety/64
- Colloquium on Research Directors for Improving Driver Performance/65
- Methodologies for Improving Unexceptional Drivers/66
- Michigan Checklane Evaluation/67
- Michigan Driving Characteristics File/68
- Revision of Michigan Original Operator Written Licensing Test/69
- Public Communication on Alcohol and Highway Safety/71
- Roadside Breathtesting Surveys/72

HSRI Professional Staff and Participating Faculty Members/73-78

HSRI Research Facilities/79-98

- The HSRI Building/81
- Research Information and Publications Center/83
- Computer Facilities/83
- Impact Sled Laboratory/84
- Biomedical Laboratories/86
- Impact Barrier Test Facilities/87
- Materials Testing Laboratory/88
- Statistical Research System/89
- Mobile Truck Tire-Brake Tester/91
- Mobile Tire Tester/91
- Flat-Bed Tire Tester/93
- Variable Braking Vehicle/94
- Vehicle Lighting Research Instruments/94
- Driver Performance Research Instruments/96
- Mathematical Models of Crash Victim Motion/98
- Vehicle Dynamics Simulation Programs/98



Robert L. Hess, Director

Introduction

1976 marks the tenth anniversary of the Institute and its mission: to apply the resources of the University to the task of improving transportation and safety. The current projects described in this booklet illustrate the various ways in which HSRI is engaged in creating and disseminating knowledge essential to the solution of a broad range of transportation problems.

The Institute has grown appreciably since it was established in 1966. A decade ago its handful of staff members, located in scattered facilities, were conducting research involving total annual expenditures of \$68,700. This year HSRI staff and affiliated members of the University faculty, supported by specially designed research facilities, are conducting more than 40 research programs involving total annual expenditures of more than \$3.2 million.

In the ten years since the Institute was established, its full-time researchers and affiliated U-M faculty members have conducted 344 research programs involving total expenditures of more than \$28.2 million. The research findings have been disseminated in more than 950 journal articles and reports, in Institute publications, Institute-sponsored conferences and symposia, and through staff participation in hundreds of other technical conferences.

The Institute has also been contributing to the education of U/M students. In the past ten years, 27 doctoral students have conducted the research for their dissertations within the Institute, and more than 240 graduate students and 235 undergraduate students have gained invaluable working/learning experience through their employment on Institute research projects. The students have represented a broad range of disciplines and cross-disciplinary programs in such fields as law, medicine, engineering, public health, business, and the social sciences.

The role the Institute has played in defining transportation problems and conducting research can be best understood by considering two basic concepts—the breadth and connectedness of various transportation problems, and the responsibilities the University has to itself and to American society. First, even cursory scrutiny of a “transportation” problem reveals it to be a complex mixture of social, economic, political, medical, engineering, and public health problems. Thus no transportation problem or its solution lies solely within the province of any single academic discipline. This is why the Institute approaches research problems by considering just what disciplinary specialties must be represented if a program team or task force is to define the problem adequately and design a program that can produce significant, useful results.

The second point that must be kept in mind is that the Institute, as an arm of the University, functions as an independent role player in a national transportation scene often characterized by spirited dialog between such other role players as federal and state agencies, the motor vehicle industry, industrial and commercial associations, the general public, and the news media. The Institute has no special interest to defend in pursuing questions of what changes might be made in driver licensing and revocation policies, vehicles, roadways, aircraft, FAA regulations, insurance laws, and so forth. Institute programs in transportation safety research are designed to establish *what* elements of our transportation systems are most dangerous; how much safer those systems would be if this or that change were to be made; and, finally, *what* social, economic, or political costs would be incurred (and by whom) if a change were put into effect. That is a service the Institute provides for all other participants in the transportation scene.

What contributions has the Institute made to the reduction of transportation safety problems over the past decade? The Institute is noted as one of the leaders among all research organizations for developing basic tools and techniques essential for coping with some very difficult problems in

transportation safety research. Most of these contributions have been quite technical, but the following brief overview offers readers a general view of the types of contributions the Institute has made.

Accident Data. The Institute has pioneered in applying modern computer technology to the collection, storage, and analysis of motor vehicle accident data. In the 1960s, information obtained from accident investigations was being stored on punched cards and analyzed by slow and relatively simple keysorting operations. HSRI systems specialists developed techniques and computer programs for storing accident data on magnetic tape and conducting sophisticated multivariate analyses of accident- and injury-causation mechanisms. The Systems Division has also developed a set of more than 160 data banks containing millions of accident cases investigated by police or multi-disciplinary teams throughout the U.S., designed computer-analysis programs easily usable by researchers at other organizations, and, through computer links, has made the HSRI data banks available to other universities, the U.S. Department of Transportation, and the major motor vehicle manufacturers.

In contributing to improvements in the quality of accident data, HSRI researchers have assessed the strengths and weaknesses of currently available data and have designed and recommended a national data collection system that would ensure collection of precisely representative data highly valuable for assessing the effects of safety-related changes in driver behavior, vehicle designs, restraint system performance, law enforcement policies, and other aspects of traffic safety.

In work on the problem of alcohol and highway safety, HSRI researchers have made important contributions in determining just how much drunk drivers contribute to accident frequencies, in identifying problem drinking drivers, and in developing action programs designed to reduce

alcohol-related accidents. They have also developed and applied techniques for evaluating federal and state counter-measure programs, including the Alcohol Safety Action Projects (ASAPs). HSRI researchers designed and conducted the first nationwide roadside breathtesting survey, and have established a national computer archive of data from nearly 100 roadside breathtesting surveys conducted in 27 local ASAP areas throughout the country.

Vehicle Handling and Tire Performance. HSRI researchers in the Physical Factors Division have made several major contributions to the art of testing the emergency maneuvering performance of passenger cars, the dynamic behavior of trucks and tractor-trailers during braking and steering maneuvers, and the measurement of tire traction by use of HSRI-developed over-the-road dynamometers. Through development and use of computer simulations along with new test techniques, the group has earned international recognition for its contributions to assessment of the dynamic behavior of all forms of commercial vehicles.

In research on roadway problems, the group recently conducted computer analyses of accident data from the Ohio and Pennsylvania Turnpikes, and established that inadequate levels of superelevation on long-radius curves were causing poor drainage, excessive water depths on the expressway surfaces, and loss-of-control accidents. The study findings are a notable instance of the power of computerized data analyses to pinpoint roadway design problems. The curve and grade combinations at the problem sites were relatively mild and thus not obviously dangerous.

Protection of Vehicle Occupants. In this area, too, specialists in the Biosciences Division of HSRI have applied the computer to some complex analytic problems involving questions of just what forces act on vehicle occupants during crashes of various types and severities. The group has developed two- and three-dimensional computer simulations

of occupant motions, and, in parallel biomechanical experiments, has generated new information concerning the behavior of the human body when it is subjected to impact forces. The researchers have used the simulation and impacted data in developing a crash-test dummy that behaves much more realistically than did the dummies available to researchers in the 1960s and early 1970s. Dummies possessing lifelike properties of mass distribution, skeletal linkage, and mechanical response to load are essential for obtaining crash test data that are valid and reliable, because researchers concerned with improving occupant restraint systems and occupant compartments must depend on that information. The models developed at HSRI are now being used by many other research organizations in the country.

HSRI bioscientists—anthropologists, anatomists, bioengineers—have also been conducting extensive studies in aircraft crashworthiness and occupant protection, in “whiplash” injuries and the biomechanics of the human neck, in the strength of U.S. children, and in comprehensive anthropometric measurements of U.S. infants, children, and adults. An example of work in that last-mentioned area is a three-year study jointly conducted with the Pediatrics Department of the U-M Medical School. This national program obtained measurements on 41 dimensions of more than 4,000 infants and children ranging in age from two weeks to 13 years. This precise information on a representative sample, obtained with specially designed instruments linked to a portable mini-computer, is needed by standards writers and designers concerned with improving the safety of consumer products used by infants and children—toys, furniture, bicycles, automotive child-restraint seats, and many other products.

Vehicle Lighting. Specialists in the Human Factors Division of HSRI have made important contributions to the design of improved headlighting and rearlighting systems by conducting laboratory and field experiments that established the effectiveness of current lighting and signalling systems

and dozens of experimental systems. One program developed a computer simulation that assesses the visibility and glare performance of any current U.S. or European headlighting system as well as any new combination of beams likely to be adopted in the future. By use of this system, researchers can forego making costly and time-consuming field experiments, because the computer simulation can predict the performance of a system once its parameters are supplied as inputs.

These brief discussions of a few Institute activities illustrate how HSRI contributions have tended to be on the basic, developmental end of the applied research spectrum. HSRI programs have often attacked problems that have had to be solved before other problems could be successfully addressed. The descriptions of current HSRI programs in the next section illustrate how the Institute is continuing that effort. As for the future, HSRI is developing programs that represent expansion of its activities in public policy studies and new activities in the broad area of transportation systems planning. Those efforts will be employing a multidisciplinary approach to some complex transportation problems that call for inputs from specialists in systems engineering, economics, impact analysis, technology assessment, land use, energy tradeoffs, and environmental concerns. The programs in transportation systems research are expected to involve several components of HSRI, other components of the University, other academic institutions, industrial organizations, and federal, state, and local government agencies.



Work in Progress

Accident Investigations and Data Analysis

Clinical Case Studies of Selected Collisions

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

Sponsor: Motor Vehicle Manufacturers Association

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

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

Methods: Approximately 130 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.).

Design of a National Accident Sampling System

Investigators: P. Cooley, R. J. Kaplan, J. O'Day

Sponsor: National Highway Traffic Safety Administration

Objectives: To develop a system for obtaining valid nationwide statistics on traffic accident and injury rates and trends, as well as rapid answers to questions concerning special traffic safety problems.

Significance: Current federal, state, and local accident-data collection programs and methods produce data inadequate for the most effective statistical analyses of cause-and-effect factors, including the effectiveness of various changes in roadway designs, vehicle designs, and driver licensing policies.

Methods: The system recommended calls for investigation and reporting of 15,000 to 20,000 accidents annually by some 35 teams located throughout the U.S. in accordance with a sampling plan. The plan also controls the quantities of types of accidents each team would be responsible for investigating, to assure that the data would be a valid, representative sample of accident phenomena nationally.

Results: A report that describes the system and recommends that it be tested by means of a pilot program has been submitted to the sponsor.

Effects of the Energy Crisis on the Safety of U.S. Toll Roads

Investigator: R. E. Scott

Sponsor: National Highway Traffic Safety Administration

Objective: To evaluate the effects of the energy crisis on toll road traffic, with emphasis on examining changes in accident rates and changes in exposure.

Significance: Toll road records of the major turnpikes offer superior possibilities for comparing accident rates with exposure rates, since the toll tickets provide the needed exposure data. Because the turnpikes are similar to the interstate highways in design and use, the findings are generalizable to the interstate system.

Methods: Digitized accident and traffic data for 1973 and 1974 have been collected from several toll roads, along with speed data for periods before and after the onset of the energy crisis.

Results: The data are being analyzed to determine the frequencies and rates of accidents by classifications of accident severity and types of vehicles.

Exploratory Data Analyses

Investigator: J. O'Day

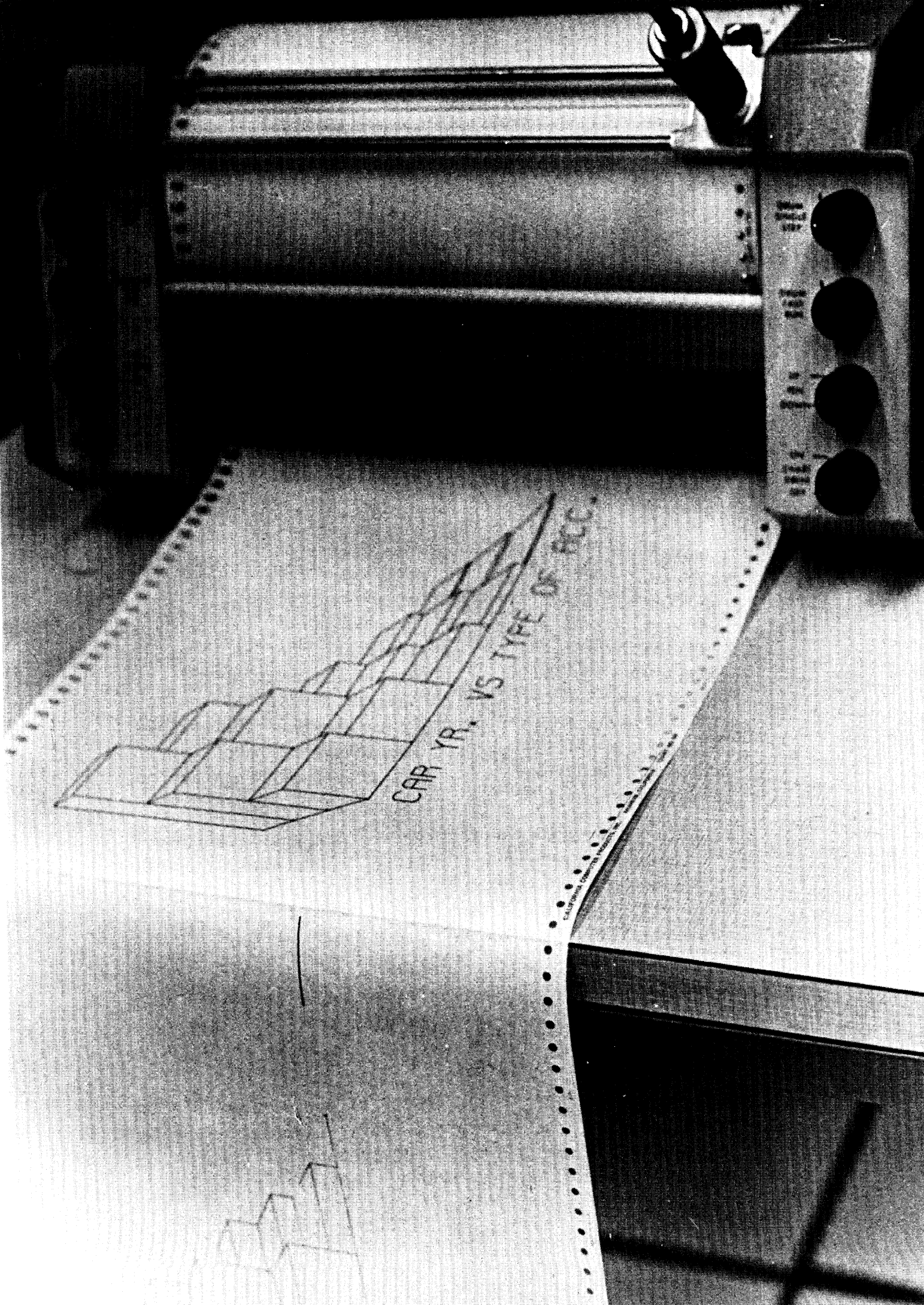
Sponsor: National Highway Traffic Safety Administration

Objective: To conduct specific accident-data analyses during fiscal 1976 on topics jointly agreed upon by the sponsor and HSRI.

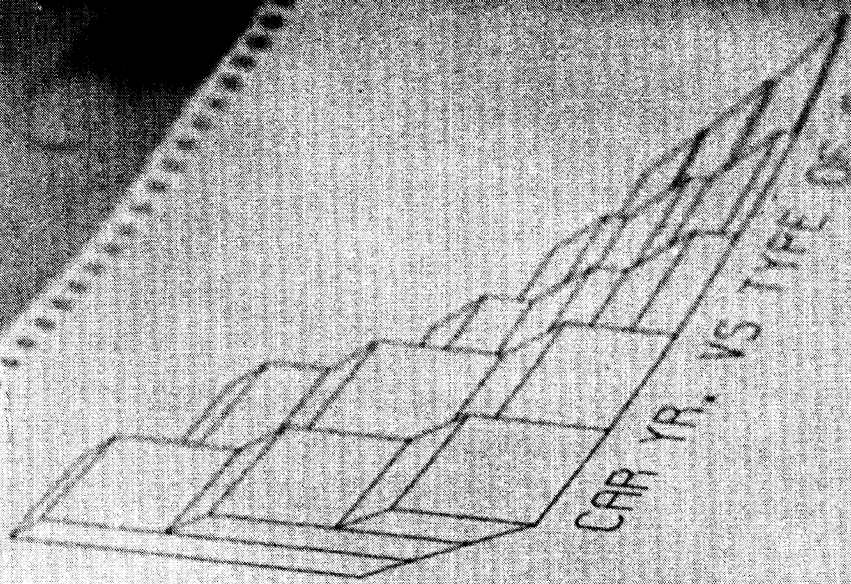
Significance: This project permits short, specific analytical studies to be initiated quickly and thereby provide rapid responses to questions of current import.

Methods: The basic data files of the Institute serve as the source of material for these analyses. Upon agreement with the sponsor, an analyst is assigned to a defined topic, necessary computer runs are made, and a report is provided.

Results: The results of each quick-response study are used by the NHTSA to evaluate its current programs and plan new ones.



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Highway Incident Textures Laboratory (HIT-Lab)

Investigator: J. O'Day

Sponsor: Motor Vehicle Manufacturers Association

Objectives: The objectives of this continuing program 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.

Results: This program, initiated in 1970, provides quick computerized access to more than 160 general or specialized collections of accident data now regularly used by U-M analysts and 12 other research organizations throughout the U.S.

Improved Methods of Collecting and Analyzing Bicycle Accident and Injury Data

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

Sponsor: Bicycle Manufacturers Association

Objectives: To review and evaluate the representativeness of accident data gathered by the National Electronic Injury Surveillance System, conduct an independent analysis of bicycle accidents, and improve the current methodology of bicycle-accident analyses.

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.

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. Three calendar years of NEISS data have been analyzed to assess the sensitivity of measures of hazard currently used by the Consumer Product Safety Commission for ranking products, and a computer program has been developed for use in obtaining a rapid and economical standard summary analysis for any given product.

Results: The study identified several problems with the current sample design and its application. Several recommendations were 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.

Multidisciplinary Accident Investigation Files

Investigators: J. C. Marsh, J. O'Day

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 more than thirty-five 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 7,800 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 tape accessings per month.



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 on injuries and restraint system 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 300 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 establish 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.

Special Collision Data Analysis Topics

Investigator: J. O'Day

Sponsor: Motor Vehicle Manufacturers Association

Objectives: To conduct statistical analyses of data relating to selected topics, and to provide tabular and interpretive reports on the findings.

Significance: The output of this project is intended to bear on important questions regarding accident causation, the effectiveness of injury-preventive measures, and the definition of likely countermeasures for reducing accidents and injuries.

Methods: The studies entail defining the topics and questions of interest, selecting HSRI data banks containing information applicable to those topics, conducting the computerized analyses, and interpreting and reporting the findings. Specific planned topics include a study of restraint systems effectiveness and the relationship of vehicle handling and braking to particular types of accidents.

Results: The data collection on the first of the topics planned has recently been completed and is in the process of final entry into digital data files. The results of the first analyses made on these files have been reported to the sponsor. The vehicle handling and braking study has been designed and has recently entered the data collection phase.

Washtenaw County Accident Investigations

Investigator: L. D. Filkins

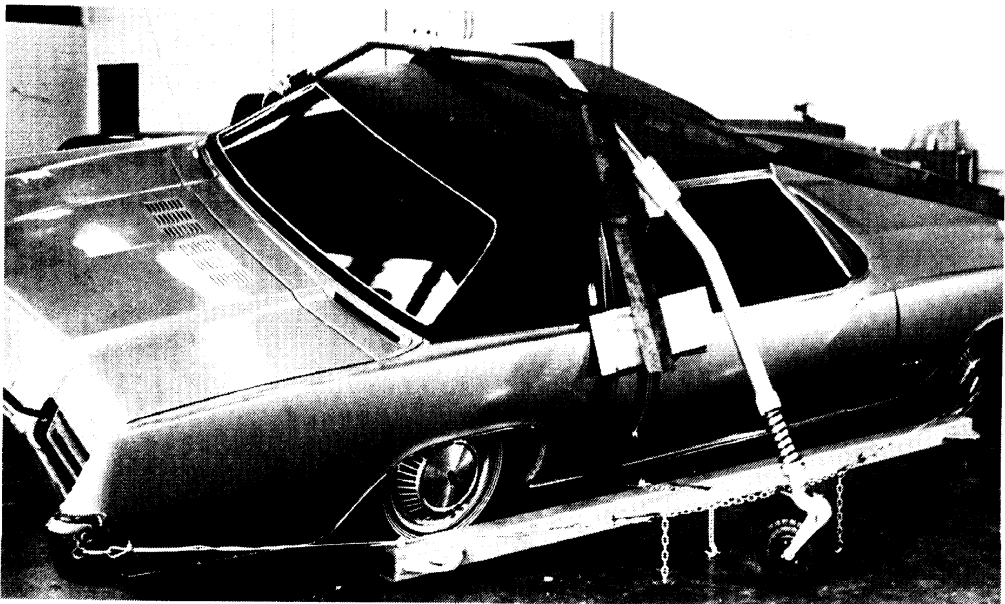
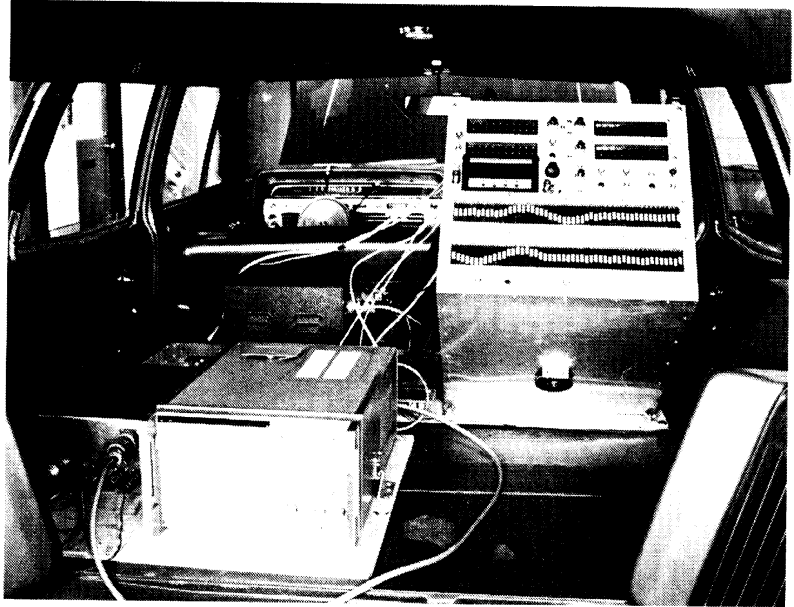
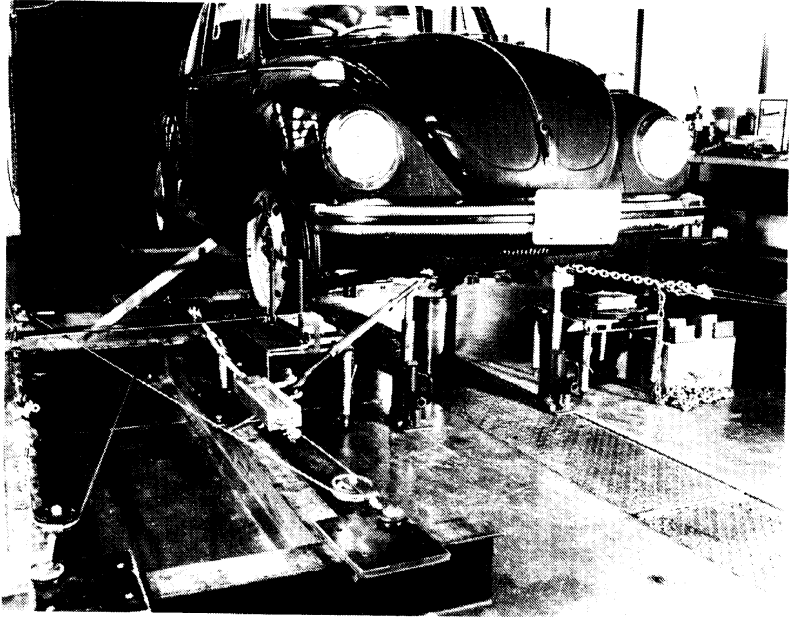
Sponsor: Motor Vehicle Manufacturers Association

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

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.



Driver-Vehicle Interactions and Performance of Vehicle Components

Effects of Tire Properties on Truck and Bus Handling

Investigators: R. D. Ervin, C. B. Winkler, J. E. Bernard

Sponsor: National Highway Traffic Safety Administration

Objectives: To determine the value of kinematic, compliant, inertial, and dimensional parameters needed for analyzing the dynamic behavior of four trucks and buses; to determine the relevant mechanical performance characteristics of tires such as those on the selected vehicles; to develop a mathematical model for predicting force and moment responses of the tires; to refine and validate the model through laboratory and road tests using stationary and mobile dynamometer equipment; and to determine the sensitivities of truck and bus performance to tire characteristics as determined by an extensive computerized parameter sensitivity study.

Significance: The dynamic behavior of trucks and buses is significantly affected by the dynamic properties and performance of their tires. But safety-related improvements in tires depend upon generation of new knowledge of their on-the-road performance and the effects of that performance on vehicle stability.

Methods: The study entails a combination of tire traction experiments, mathematical modeling, tire-vehicle systems simulations, and full-scale vehicle tests.

Results: The study will generate new knowledge of relationships between tire performance and vehicle dynamics, including information on whether the range of parameters represented by "optional" tire selections introduces a large range of vehicle performance characteristics.

Methodology for Determining the Role of Vehicle Handling in Accident Causation

Investigators: L. Segel, D. F. Dunlap, P. Cooley, R. D. Ervin

Sponsor: National Highway Traffic Safety Administration

Objectives: To develop and assess a methodology for determining the role of vehicle handling responses as a factor in accident causation.

Significance: The role of vehicle handling in accident production is largely unknown. Work has been done on fringe areas but never directly on this problem.

Methods: The eight tasks in this project consist of developing a plan of work, reviewing the literature and generating an annotated bibliography, identifying accidents involving vehicle handling in HSRI's data files, formulating hypotheses that link vehicle properties to pre-crash accident descriptors and a set of vehicle handling parameters, developing a methodology for defining the relationship between vehicle handling response parameters and accident production, using accident investigation forms to test the accident data collection methodology, and refining the methodology.

Results: The study is expected to produce new information on the role of vehicle handling in accident causation, as well as a new methodology for collection and analyses of data that can identify specific problems in this area.

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.

Trailer Braking Performance

Investigator: J. E. Bernard

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 will 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.

Tire Involvement in Highway Traffic Crashes

Investigators: R. E. Wild, J. O'Day

Sponsor: Rubber Manufacturers Association

Objectives: To collect and index data regarding tire involvement in highway accidents.

Significance: Heretofore no data file useful for assessing the role of tires in accidents has existed. The file to be created in this study is expected to permit assessment of how tire characteristics, uses, and abuses relate to highway accidents.

Methods: Project tasks include collecting data from multidisciplinary case reports and HSRI library documents, indexing the data by subject, cataloging the printed materials, and maintaining an information log.

Results: Preliminary inspection of multidisciplinary accident investigation reports in which a tire was identified as a major contributive factor has shown that in many cases the vehicle operator was misusing the tires (e.g., the tires were bald, or underinflated, or mismatched).

Truck Braking and Handling

Investigators: P. S. Fancher, R. D. Ervin, J. E. Bernard, C. B. Winkler, C. C. McAdam

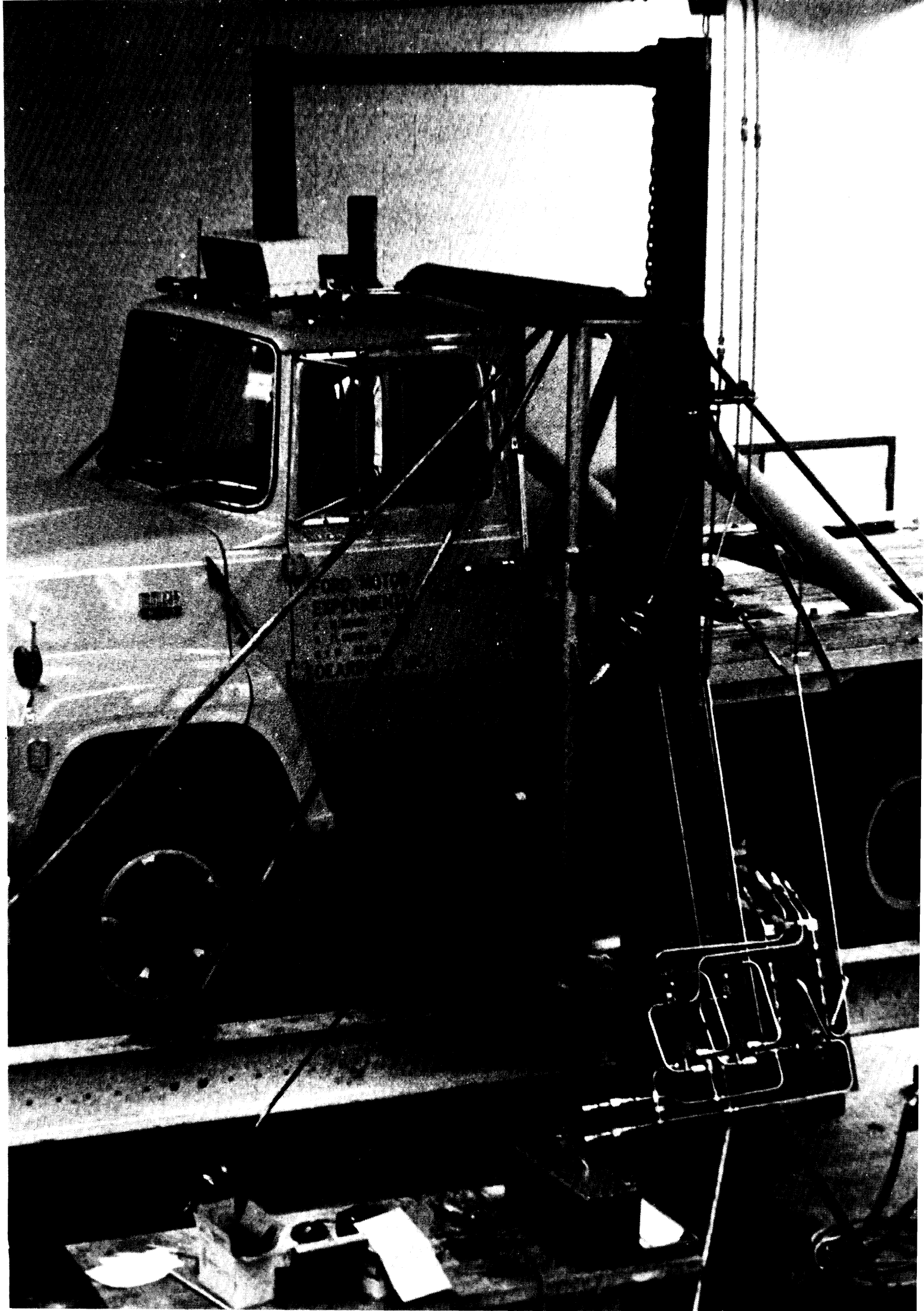
Sponsor: Motor Vehicle Manufacturers Association

Objectives: To verify simulations of straight-line braking performance of vehicles equipped with anti-lock brakes, to develop a computer program for evaluating the performance of actual anti-lock system hardware in simulated straight-line stops; to develop a functional description of commercial vehicle brakes, and to determine the longitudinal shear force characteristics of various types of heavy truck tires.

Significance: A functional description or model of commercial vehicles is needed to aid in planning commercial vehicle braking tests and to assist in interpreting the measured data.

Methods: The four projects involve employing combinations of laboratory tests, mathematical modeling, computerized simulations, over-the-road mobile dynamometer tests of tire and brake system performance, and full-scale vehicle braking tests.

Results: The studies are expected to produce information essential for determining the quality of parametric data for predicting braking performance of trucks.



Truck Tire Noise and Traction

Investigator: R. D. Ervin

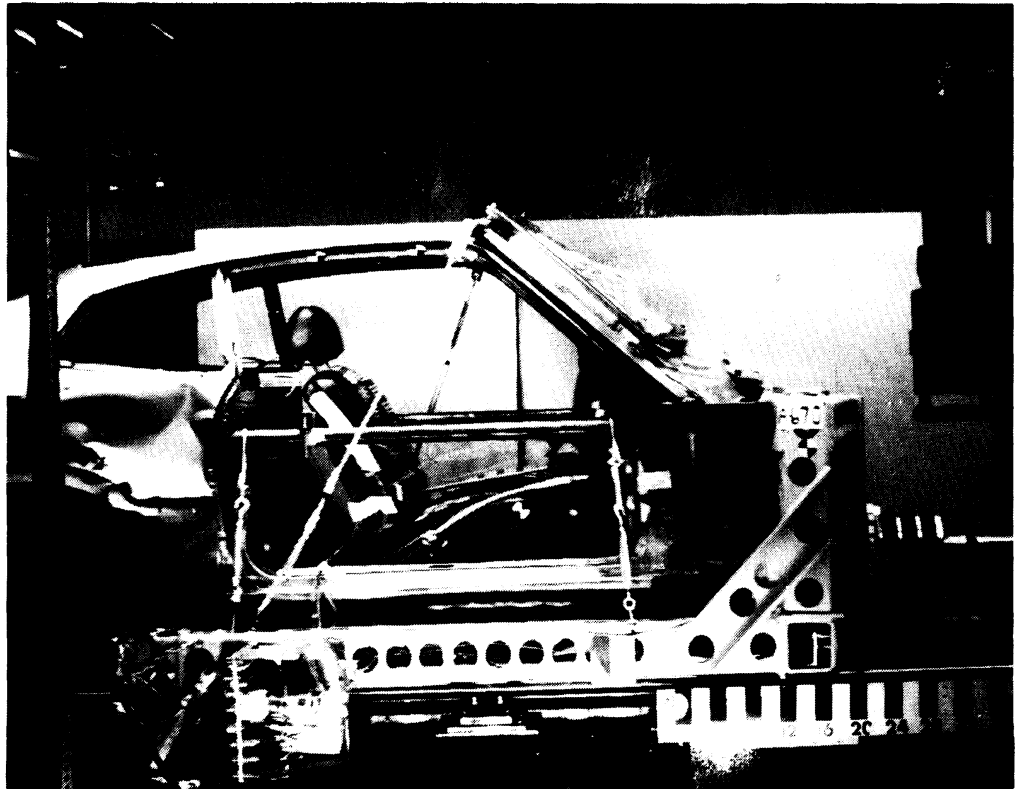
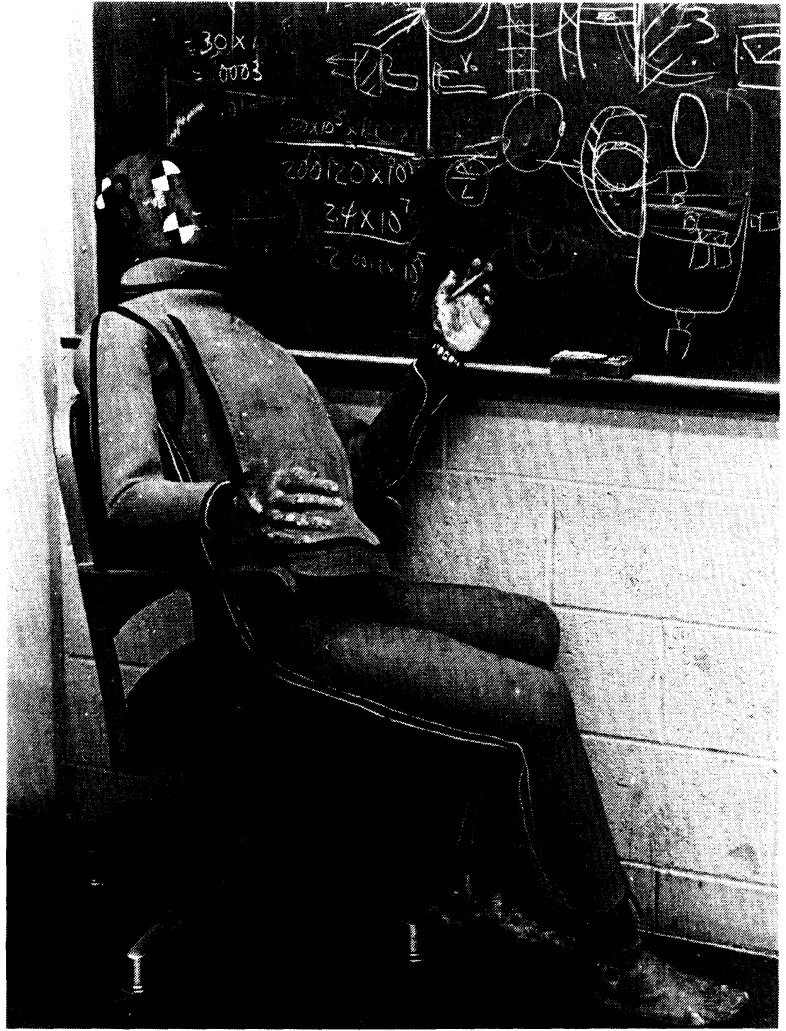
Sponsor: Motor Vehicle Manufacturers Association

Objective: To investigate the relationships between tread patterns, tire noise, and longitudinal and lateral traction properties of truck tires.

Significance: In view of recent research findings which show that the so-called "traction" tire (a cross-bar rib design) provides no more longitudinal or braking traction on paved surfaces than that produced by the circumferential-rib "highway" tire, it is useful to determine whether this finding holds as well for lateral traction. In general, tradeoffs between noise, traction, tread wear, and carcass life need to be carefully assessed.

Methods: Experiments with a sample of variously treaded truck tires are being conducted to establish their noise generation and traction properties on various surfaces.

Results: The study results are expected to facilitate more discerning judgments concerning conflicting requirements on the design and use of truck tires.



Occupant Protection and Human Tolerance to Impacts



Anthropometry of U.S. Children to Age 18 for Improving Safety of Consumer Product Designs

Investigators: R. G. Snyder, C. L. Owings, L. W. Schneider, and 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: The study has included development and use of special techniques involving pressure transducers and automated measuring devices for anthropometry and centers of gravity. Two teams are measuring children and youths at various U.S. locations to provide a sample representative of the U.S. population.

Results: A handbook of currently available data and bibliographic references has been compiled to serve as an interim guide until the data now being collected can be made available.

Basic Biomechanical Properties of the Human Neck in Relation to Lateral Hyperflexion Injuries

Investigators: R. G. Snyder, D. B. Chaffin, L. W. Schneider

Sponsor: Insurance Institute for Highway Safety

Objective: To develop new information on human head-neck injuries incurred by lateral or rear-quarter forces, or when a vehicle occupant's head is turned to one side at the time of impact.

Significance: Basic data on head-neck injuries associated with lateral flexion and rotation are important for the design of anthropomorphic dummies and occupant restraint systems.

Methods: Measurements obtained from a representative sample of the U.S. population aged 18 through 75 are being related to measurements of muscle strength and response time and to radiographic, photogrammetric, and anthropometric measures, and an attempt is being made to measure the range of voluntary motion in combined lateral flexion and rotation.

Results: The study is expected to provide information valuable for designing improved anthropomorphic dummies and safer occupant seats, restraint systems, and passenger compartments.

Biomechanics of Cervical Spine Injuries

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

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

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

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

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

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

Crashworthiness and Occupant Protection in General Aviation Aircraft Accidents

Investigator: R. G. Snyder

Sponsor: Highway Safety Research Institute

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

Significance: These investigations, conducted since 1970, are being pursued in cooperation with the National Transportation Safety Board, the Federal Aviation Administration, and the Michigan State police. The on-scene investigations provide the kind of biomedical data essential for safer designs of 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.

Human Impact Tolerances in Free Falls

Investigator: R. G. Snyder

Sponsor: Insurance Institute for Highway Safety

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

Significance: This investigation is designed to reduce the serious lack of precise data concerning human tolerances to impact trauma through study of free-fall impacts involving various heights, surfaces, contact positions, sequences, and resulting injuries.

Methods: The study entails investigation of selected reported falls within a 600-mile radius of Ann Arbor through on-site visits, interviews with survivors, witnesses, and medical personnel, and study of biophysical environmental evidence relative to trauma received.

Results: The study will provide new data on the capacity of the human body (particularly of children and females) to tolerate impacts to various body regions, given particular impact configurations and forces.

Development of a High-Speed X-Ray Cinematographic System

Investigator: M. Bender

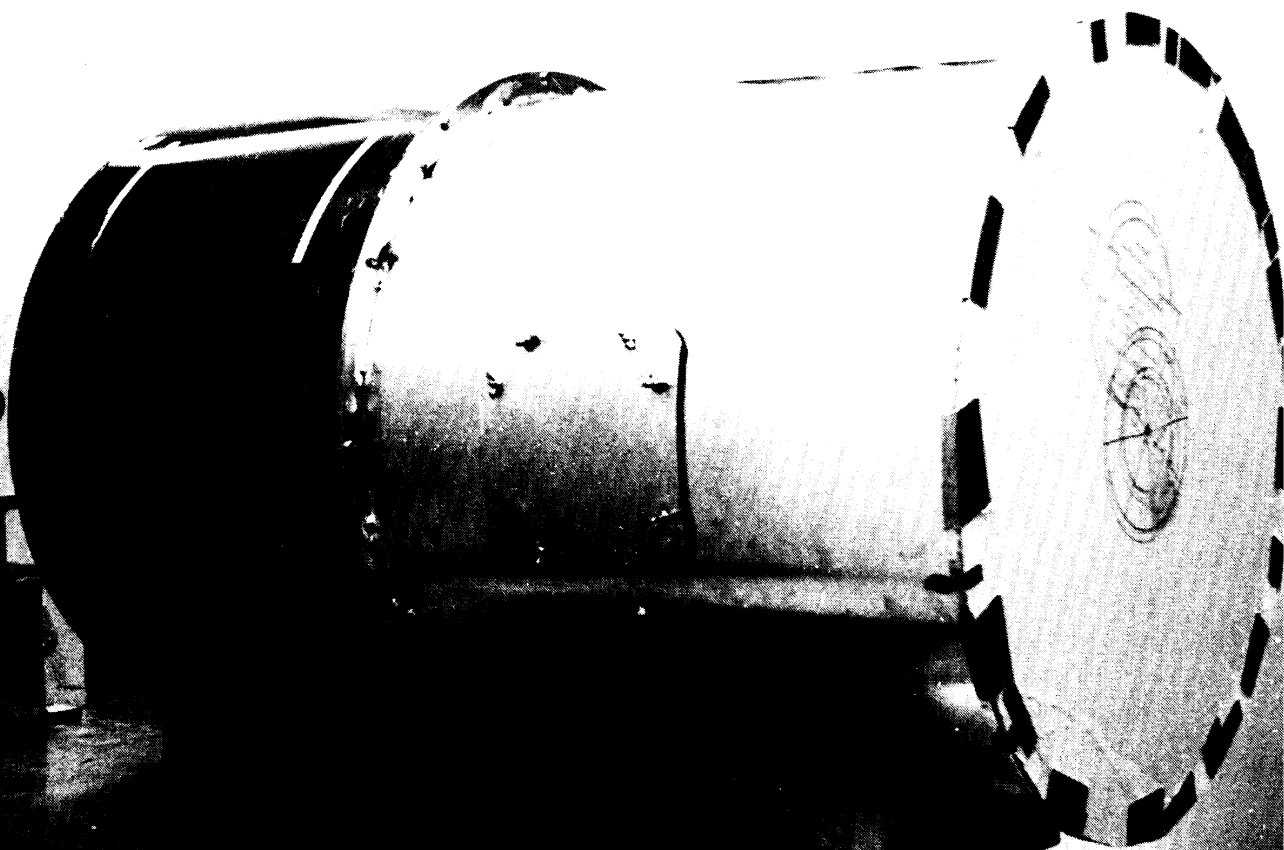
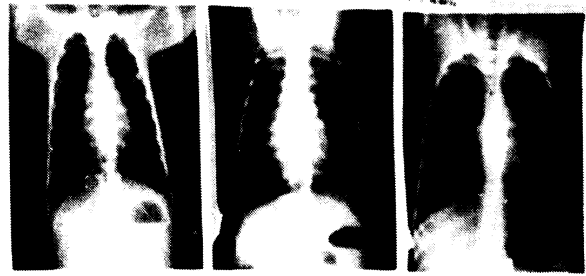
Sponsor: Motor Vehicle Manufacturers Association and the National Science Foundation

Objectives: To develop a high-speed X-ray cinematographic 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 will 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 principal components have been constructed and assembled, and the system is being used in current biomechanical studies underway at HSRI.



Human Tolerance to Dynamic Loads

Investigators: R. L. Stalnaker, J. W. Melvin, N. M. Alem

Sponsor: Motor Vehicle Manufacturers Association

Objective: To obtain basic data regarding the response of the human body to dynamic loads, with emphasis on the head and legs.

Significance: One of the most serious deficiencies in assessing the protective potential of safety systems is the lack of definitive biomechanical information relating mechanical impact parameters to resulting injuries.

Methods: Unembalmed human cadavers are being used in instrumented impact experiments.

Results: The study results indicate that the dynamic load-carrying ability of the upper leg skeletal system is much greater than previously thought. Methods for accurately assessing the injury potential in such loading situations are being developed. The head impact studies are producing data that will allow a general characterization of the mechanics of head impact, thereby expanding the ability to assess injury potential in the wider variety of head impacts associated with real-world accidents.

Modular Program Development for Vehicle Crash Simulation

Investigators: I. K. McIvor, D. H. Robbins

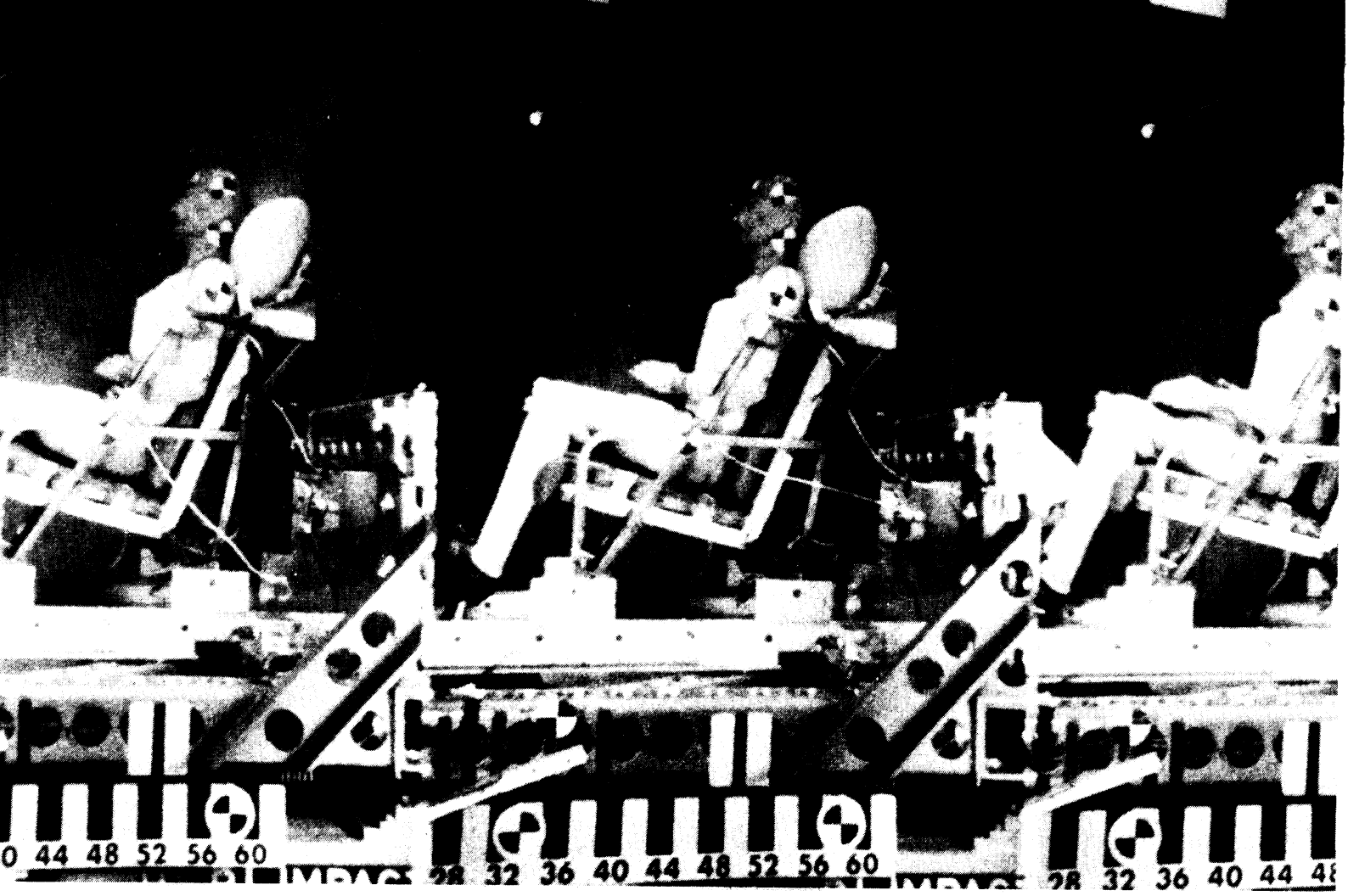
Sponsor: National Highway Traffic Safety Administration

Objective: To develop a capability of computer simulation of vehicles during impact under arbitrary crash configurations.

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. A large plastic deformation structural theory was developed to model the modular components. A computer executive system assembles the equations for each specified module and effects the solution through numerical integration.

Results: The computer simulation is in the final development stage. It has been exercised on a number of test problems. Dynamic validation tests have been conducted on models with features characteristic of crashworthiness applications. Comparison of predicted and experimental results show good agreement.



Prediction of Head and Neck Responses to Impact Accelerations

Investigator: L. W. Schneider

Sponsor: U. S. Naval Aerospace Medical Research Lab

Objectives: To determine specific head and neck characteristics of Navy test subjects and compare those measurements with HSRI data obtained from the general U.S. population. Measurements obtained from Navy subjects will be used in the MVMA two-dimensional crash simulation model to simulate NAMRL sled test runs.

Significance: By comparing simulated and actual test data for the Navy test subjects, the simulation model can be validated and used for (1) projecting Navy test results to segments of the general U.S. population, and (2) predicting more accurately, by computer simulation, the responses and injury susceptibility of vehicle occupants in various automotive crash situations.

Methods: Properties of the human neck, including anthropometry, neck muscle strength, range of motion, and neck muscle reflex times, are being measured in a laboratory equipped with special instrumentation and measuring equipment. Range-of-motion measurements are being obtained in three dimensions, using orthogonal photogrammetry. Mathematical modeling is being conducted with the MVMA-2D Crash Victim Simulation, Version 3.

Results: A subgroup of Navy test subjects whose physical characteristics match well has been established, and sled test data and results for those subjects are being compiled by the NAMRL for use in computer simulations and validation of the models.

Quantification of Thoracic Impacts and Injuries

Investigator: D. H. Robbins

Sponsor: National Highway Traffic Safety Administration

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

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

Methods: Basic data are being obtained through instrumented impact tests on human cadavers and primates. 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.

Training and Other Services Related to the MVMA 2-D and 3-D Mathematical Models

Investigator: D. H. Robbins

Sponsor: Volkswagenwerk AG, Wolfsburg

Objectives: To train VW employees in use of the two mathematical models, assist in installing the two programs on VW's computers, provide computer tapes of source programs and demonstration examples, develop selected data sets for use with the models, and provide consulting services to VW after the training period.

Significance: To use the two- and three-dimensional models effectively in computer simulations of crash tests, engineers employed by auto manufacturing companies need to understand how the programs work, and they need to have source and crash-dummy data essential for conducting valid simulations.

Methods: These include training and observational sessions for VW employees at HSRI.

Results: The project is expected to provide VW with an independent capability for making full use of the MVMA 2-D and 3-D mathematical models for simulating occupant motions during crashes.

Validation of Mathematical Simulations of Occupant Dynamics during Crashes

Investigator: D. H. Robbins

Sponsor: Motor Vehicle Manufacturers Association

Objective: To develop validation and verification procedures suitable for use with the MVMA two-dimensional and the Calspan three-dimensional mathematical crash victim simulators.

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. But before a computer simulation can be effectively used, it must be validated (demonstrated to be accurate) through a process of comparing its results with those obtained from actual impact tests and refining the simulation so that the results are in agreement.

Methods: These include developing procedures for identifying types of impacts, selecting indicators of dynamic responses (severity index, HIC, femur loads, etc.), displaying the validation level adequately and simply, and determining the parameters of input data to be used in the validation tests. The procedures will be demonstrated for the MVMA two-dimensional crash victim simulator.

Results: These will be presented in two reports. One will include the technical details of the validation procedures, the computer exercises, and the sled tests; the other will compare the modeling and experimental procedures.

Validation of a Model of Head-Impact Injuries

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

Sponsor: National Highway Traffic Safety Administration

Objectives: To perform experiments involving head impacts in animals and fresh cadavers with sufficient precision and reliability to validate an analytic model of the impacts, and to determine the brain-injury mechanisms from the pathologic and engineering data obtained in the experiments.

Significance: To properly design devices for minimizing head injuries in automotive crashes, engineers require a means of predicting potential injuries. This is called a head-injury model. The model can be used in reconstructions of real accidents, in car-crash and sled-test experiments, and in mathematical simulations.

Methods: The work involves conducting specially instrumented impact tests that include systematic control of impulse directions, forces, and times.

Results: The study results are expected to be integrated in a comprehensive NHTSA finite-element representation of the entire head and neck—a model capable of simulating the role of skull deformation, skull geometry, gross head motions, and compression waves in the skull and brain. The data will also provide information on the correlation between mechanical impacts, inputs, and resulting injuries.

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

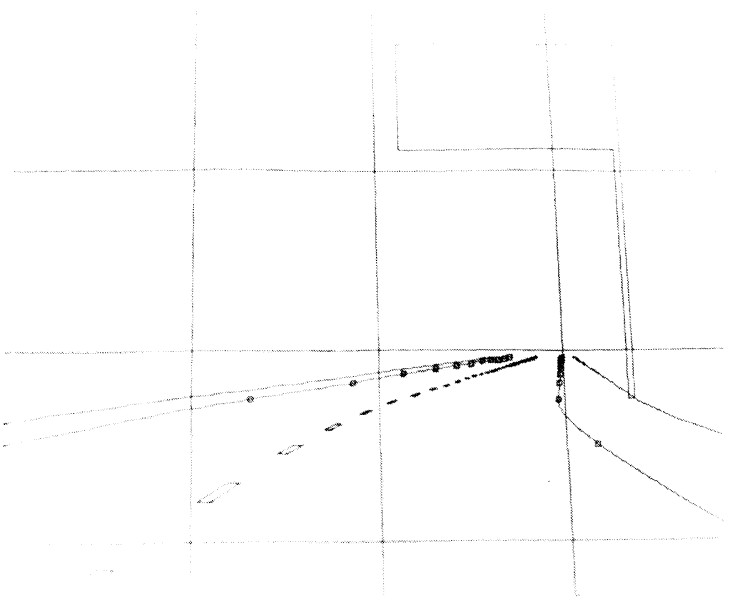
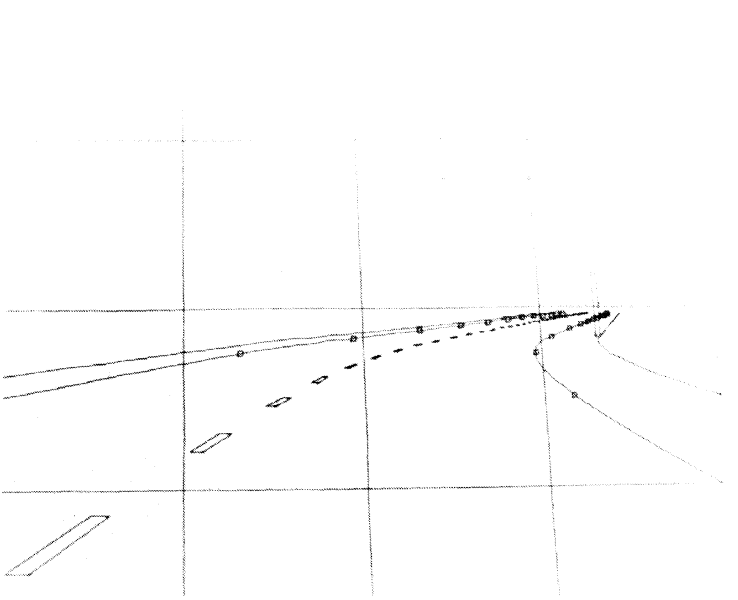
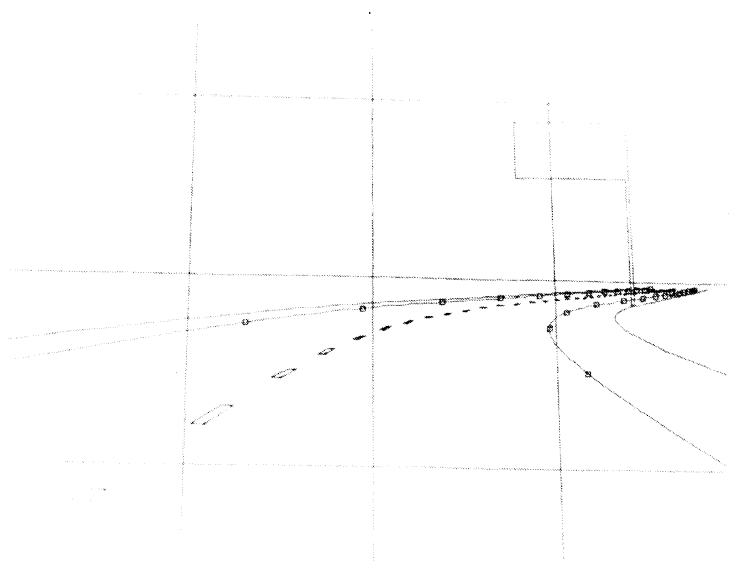
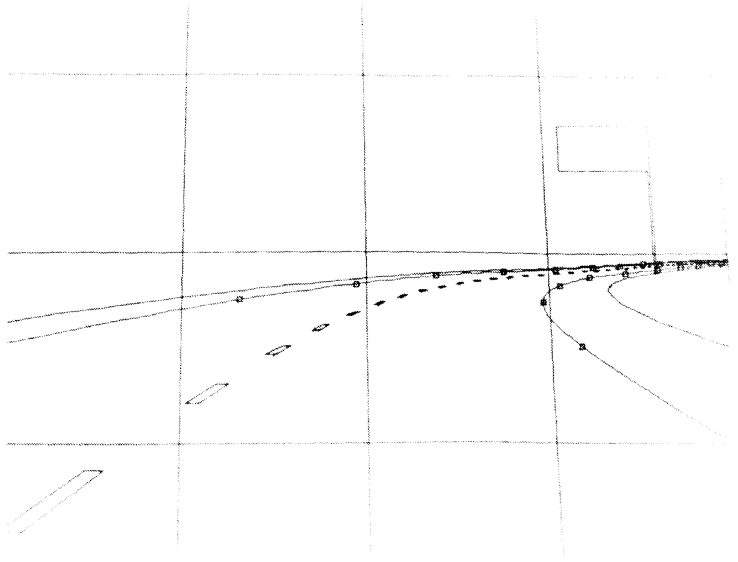
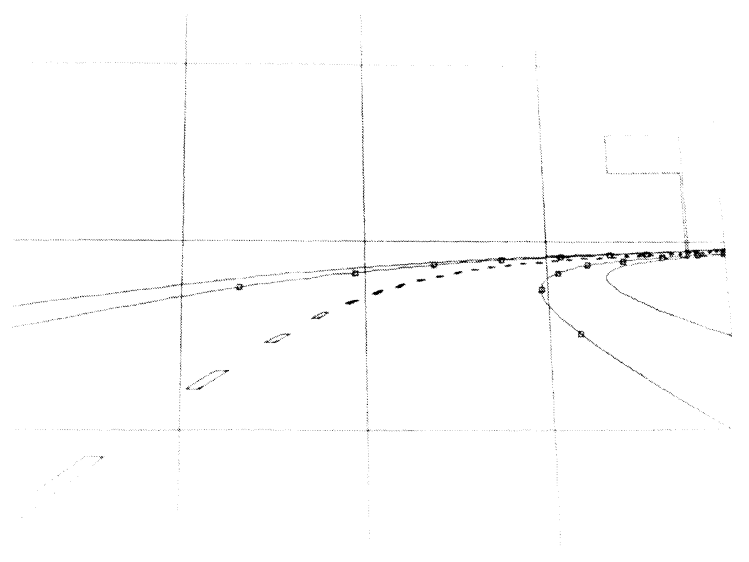
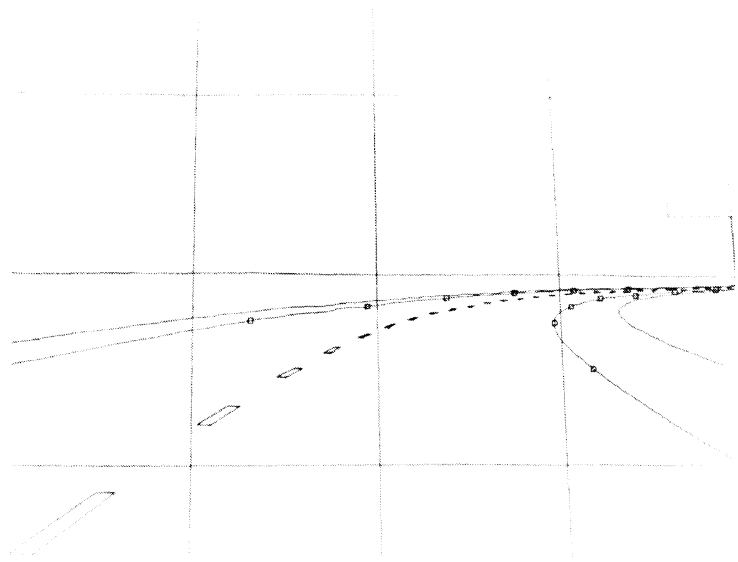
Objective: To obtain detailed measurements of whole-body kinematic responses in a crash environment.

Significance: The 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 data will be used in development of scaling laws and performance requirements for different sizes of anthropomorphic test dummies.

Roadway Design and Traffic Engineering



Luminous Requirements of Retroreflective Highway Signing

Investigator: P. L. Olson

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: The results of the study will provide traffic engineers, for the first time, with performance-based guidelines for selecting retroreflective signing materials.

Motorcycle Headlighting Characteristics

Investigators: S. P. Sturgis, P. L. Olson

Sponsor: National Highway Traffic Safety Administration

Objective: To provide recommendations for characteristics of motorcycle headlamp beams for three classes of motorcycles.

Significance: Unlike automobiles, two-wheeled motorized vehicles vary greatly in the maximum speeds they can attain. Thus different categories of the machines need different headlighting standards to ensure adequate illumination for night driving.

Methods: Samples of currently used headlamps and mopeds and motorcycles have been obtained, photometrically described, and a subset of them subjectively evaluated for their adequacy in providing illumination in night driving. Analytical evaluations of the effectiveness of these lamps have been made and used to structure potentially satisfying beam patterns. A subset of these beams has been evaluated in field studies of the controllability of the machine and the visibility provided the rider.

Results: Recommendations based on the study findings have been made for the characteristics of headlamp beams needed for three major classes of motorcycles, including mopeds.

Public Policies and Driver Improvement

Alcohol, Drugs, and Highway Safety: State of Knowledge and Information Needs

Investigator: K. B. Joscelyn

Sponsor: National Highway Traffic Safety Administration

Objectives: To review, evaluate, and summarize existing knowledge concerning the problems of alcohol and highway safety and drugs and highway safety.

Significance: The development of effective new research programs in these areas depends upon a critical review and careful evaluation of what is now known about those problems.

Methods: The review and evaluation of existing knowledge relating to alcohol and highway safety includes examination of findings in the areas of alcohol in crashes and violations, physiological effects of alcohol, laboratory and field research on alcohol and driving behavior, and the effectiveness of countermeasure programs. A similar evaluation in the area of drugs and their influences on highway safety entails indentifying general and specific research questions relating to drug measurement, accident analysis, effects of specific drugs on driving behavior, and the most promising countermeasure concepts.

Results: The study results will be presented in written reports as well as in technical and nontechnical slide presentations.

Citizen Participation to Improve Highway Safety

Investigator: P. L. Olson

Sponsor: National Highway Traffic Safety Administration

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

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

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

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

Colloquium on Research Directions for Improving Driver Performance

Investigator: W. T. Pollock

Sponsor: Motor Vehicle Manufacturers Association

Objective: To identify research needed to develop techniques for inducing all drivers to perform more in accord with their safe driving potential, and to disseminate the colloquium conclusions and recommendations to those individuals and agencies responsible for planning and conducting research on driver behavior control and modification.

Significance: Evidence confirms that the vast majority of traffic crashes involve "average" drivers during lapses in applying their repertoire of skills and knowledge for safe, efficient driving behavior. Focus of the colloquium is on reward and punishment techniques for encouraging consistent display of accident-avoidance driving behavior within the capability of these "average" drivers.

Methods: A two-day meeting of invited participants was convened in June, 1975. A balanced mix of senior highway safety researchers and of noted sociologists, educators, economists, and legal scholars was formed into four working groups of 10-12 participants, with each group charged with exploring Education, Legal System, Social, or Economic Approaches to inducing better driver performance.

Results: Based on tape recordings of each working group's deliberations and on four area review papers prepared prior to the Colloquium, a report is being prepared to summarize the conclusions and recommendations on approaches to driver performance improvement. The proceedings report will be widely distributed to highway safety research and operational activities as an aid to their formulation of programs aimed at driver performance improvement.

Methodologies for Improving Unexceptional Drivers

Investigator: M. E. Lee

Sponsor: Ford Motor Company Fund

Objectives: To provide guidance to those responsible for developing driver-improvement programs for “non-negligent” drivers—programs such as might be offered to policyholders of insurance companies, employees of corporations, or participants in the driver license renewal process.

Significance: Most driver-improvement efforts have concentrated on the punishment, restriction, or rehabilitation of drivers with exceptionally poor conviction and accident records. There is considerable need to apply research findings to the improvement, through individual contact, of large portions of the unexceptional driver population.

Methods: An extensive analysis of recent literature on research and program efforts related to driver improvement in North America and Europe has revealed the general state of knowledge applicable to unexceptional drivers. More detailed aspects of the content and organization of improved programs are being addressed through site visits and analysis of data from a small number of experimentally controlled adult road-user programs, including the one developed by HSRI in its evaluation of the Ford Employee Skilled Driving Program.

Results: A series of publications will eventually comprise a comprehensive research package for those developing these programs. The first, published in the autumn of 1975, is an extensively annotated and classified bibliography of more than 400 research reports and program documents relevant to the problems of content selection, program evaluation, and the assignment of drivers. Subsequent volumes will cover those topics individually. All are subject to review by the user community before publication.

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 study results 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.

Michigan Driving Characteristics File

Investigator: M. E. Lee

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 will be carried out by State personnel over a twelve-month period beginning in late 1975. 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 capability 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.

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 serve as an incremental improvement in the educational and testing characteristics of the Michigan Original Operator Test.

Methods: Subject matter for emphasis in the tests will be selected from various accident and violation data files to reflect significant, persistent driving problems in Michigan. Emphases on recent traffic legislation and on new highway signing practices will be developed. Test items covering these knowledge emphases will be developed/selected, and prototype tests put through a test-revision-retest operation with license applicants and driver education students. Several test forms with equivalent content and difficulty will be developed.

Results: Multiple forms of a new written test of safe, efficient, legal driving knowledge will be provided for sponsor use in educating and testing original license applicants.

How many people will somebody's cocktail party kill tonight?

It often depends on how many drinks those people have.

And that's up to you.

A good hostess keeps the glasses full, but not the guests.

Remember—they have to drive home with your booze in them.

The few who manage to drink more than you planned to serve?

Put 'em in a cab or

on the couch. But don't let them drive. Even if they give you a hard time.

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Public Communication on Alcohol and Highway Safety

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

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

Objective: 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 and private 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 drinking and driving are held semiannually.

Results: The program has collected more than 2,700 campaign items and survey and research reports from over 300 organizations, has loaned more than 2,300 items in response to requests, has conducted several peer review seminars, and published their proceedings. Within the University, the public communication graphics collection has served as a basic resource for graduate training in the Schools of Public Health, Education, and Social Work. Additionally, graduate students have used the collection as a data base for research projects on alcohol countermeasures and project evaluation methodologies.

Roadside Breathtesting Surveys

Investigator: A. C. Wolfe

Sponsor: National Highway Traffic Safety Administration

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

Significance: Information about the distribution and characteristics of alcohol-impaired drivers can assist in formulating effective countermeasures for reducing the numbers of alcohol-related crashes. Data from a series of roadside surveys 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 1970-1976 are being collected and placed in a single computer file with common format for future comparative analyses.

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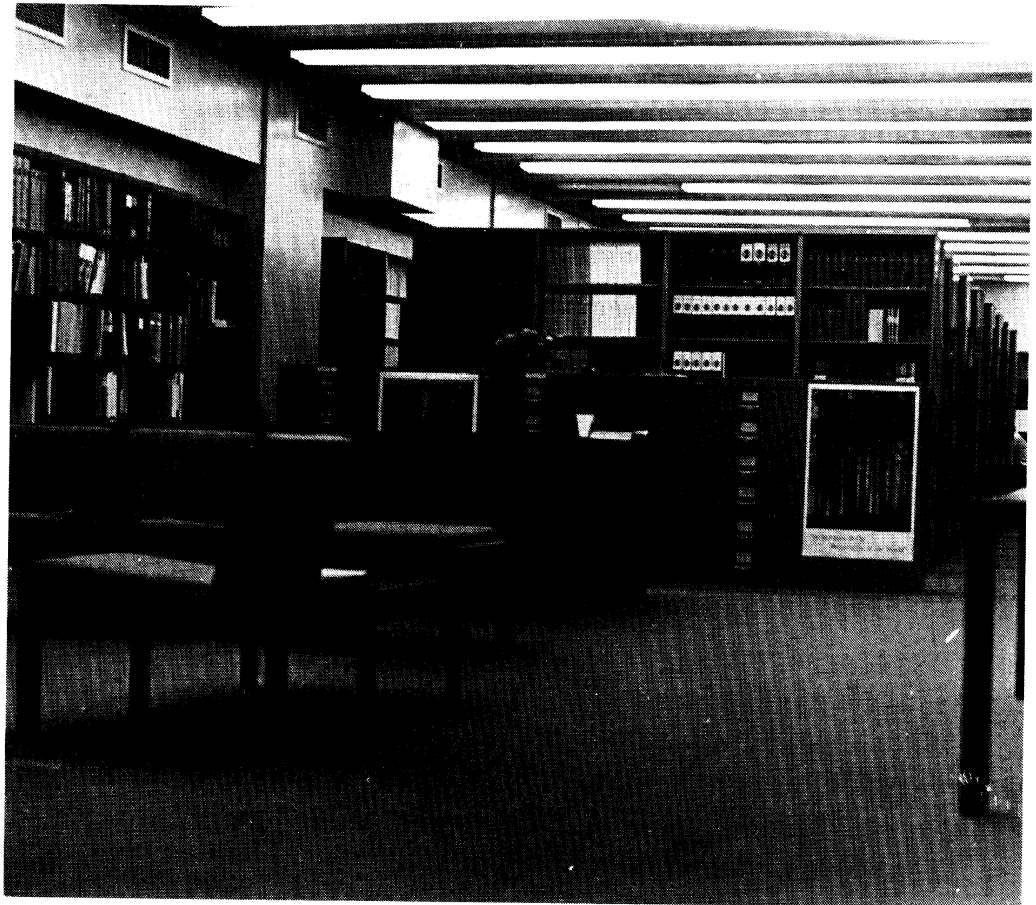
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HSRI Research Facilities

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 HSRI staff and U-M faculty members engaged in the multidisciplinary research programs.





Research Information and Publications Center

This facility provides a specialized information service for the Institute staff and other members of the transportation research community. Its collection includes more than 35,000 cataloged documents and more than 230 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, 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

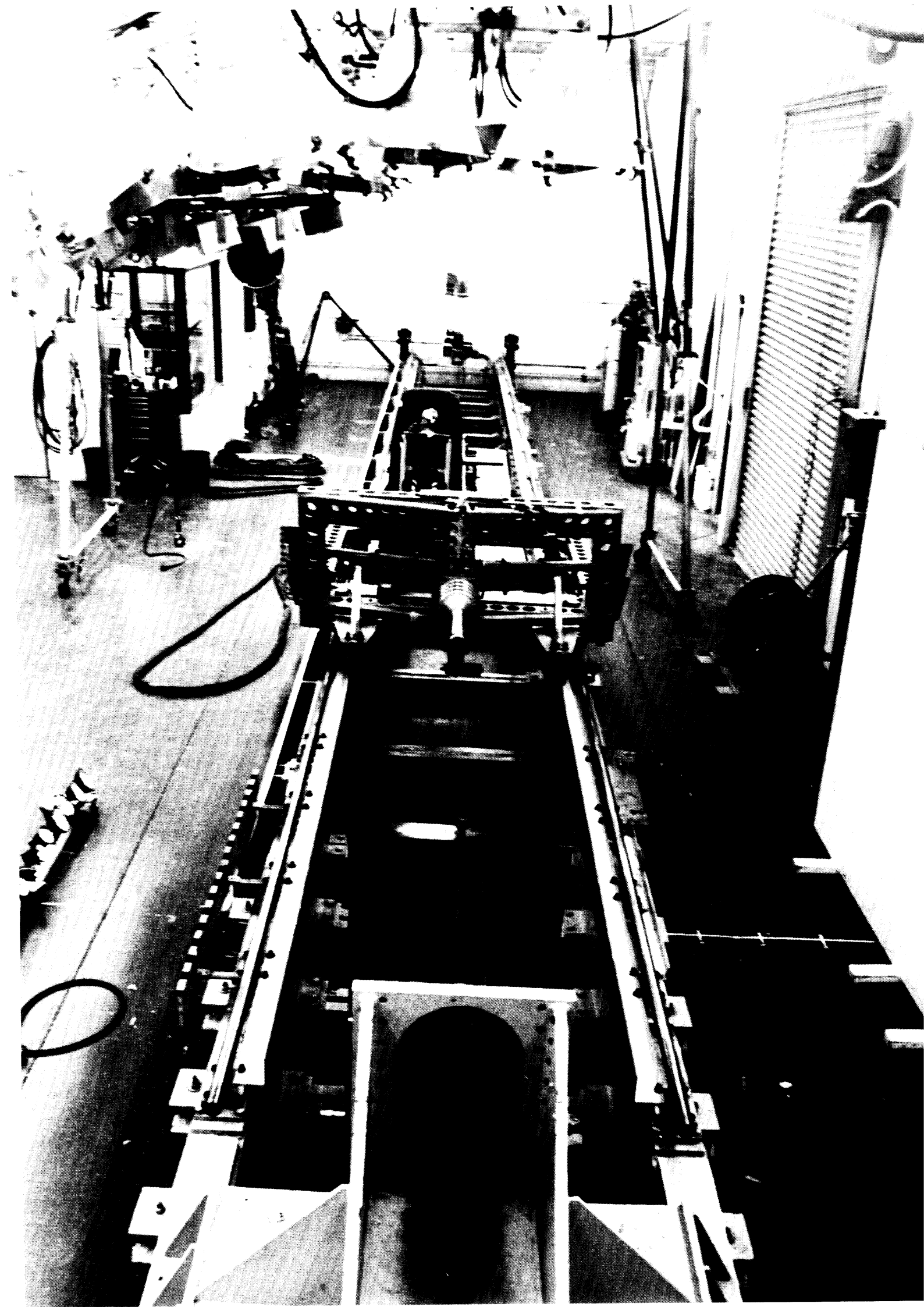
The HSRI Computer Laboratory has a Digital Equipment Corporation PDP 11/45 digital computer and an Applied Dynamics AD4 analog computer, and is linked to the University's AMDAHL 470V/6 computer by four on-line consoles and a remote job-entry terminal.

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.

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.

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 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.



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 simulating the crash kinematics of vehicle occupants. The machine uses 6-lb. or 20-lb. 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. An oscilloscope and high-speed cameras record force times, displacement times, and acceleration times. The radiographic laboratory includes an examination room, a dark room, and a hospital-type Picker Radiographic 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.

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.

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.

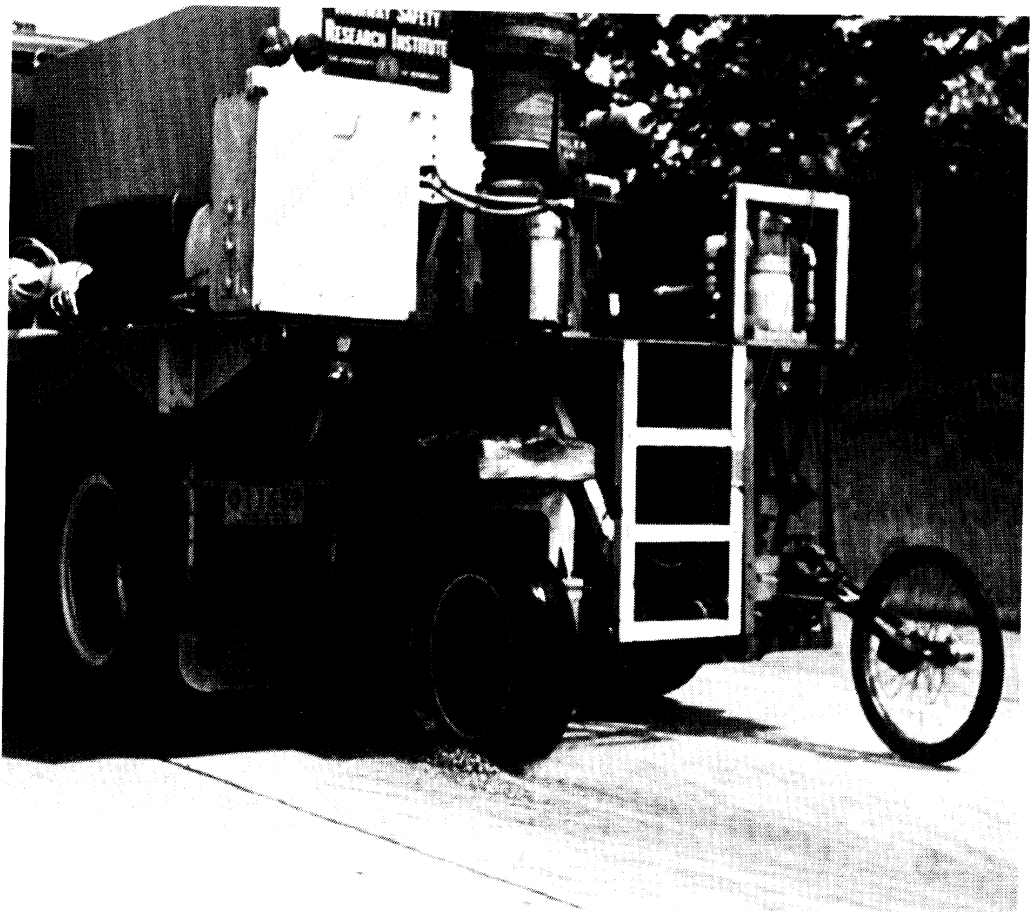
The Instron machine can supply loads of up to 10,000 lbs. at speeds ranging from .02 to 20 inches per minute. It has a moving crosshead operated by two vertical drive screws, and a positional servomechanism for precise control of the crosshead movement.

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.

Statistical Research System (SRS)

The Statistical Research System (SRS) maintained by HSRI is a package of data handling and processing programs for analyses of accident, driver, and vehicle data. The SRS is a version of the OSIRIS package widely used in the analysis of social and scientific data. SRS is resident on the University's AMDAHL 470V/6 computer and may be operated in either batch or conversational mode via teletype terminal. The system is a group of application programs and a subroutine library. Twenty-eight programs are accessed by a unique reference number. The system permits analyses of large data sets by processing magnetic tapes or direct-access files. Control operations for handling magnetic tape are performed by the programs and are transparent to the user. Subsidiary data-management programs developed by HSRI permit inexperienced users to apply the SRS to accident data files maintained at the Institute.



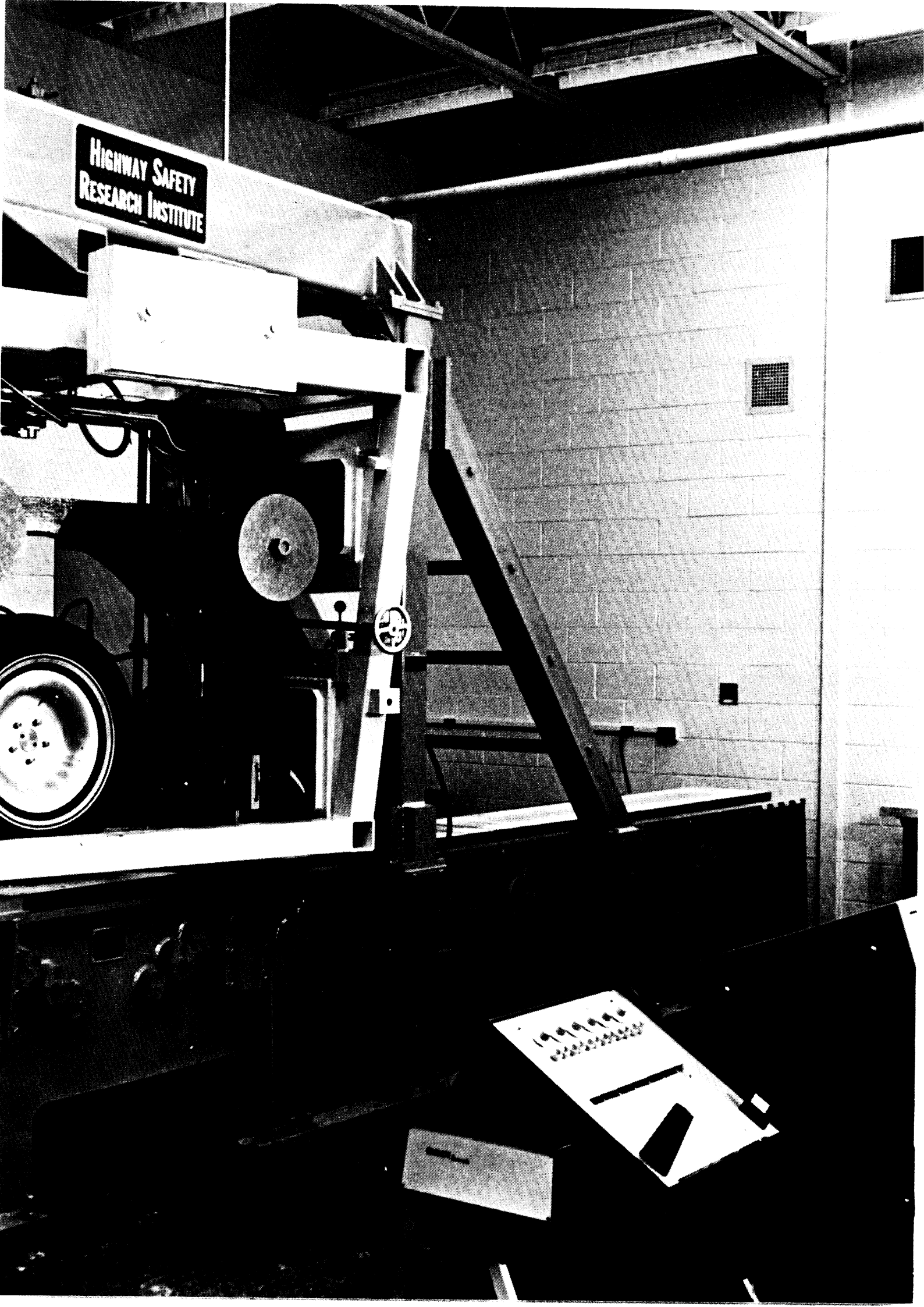
Mobile Truck Tire-Brake Tester

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 shear-force properties of truck tires ranging in size from 6.50-20 to 18-22.5 inches. The test tire is mounted centrally on the trailer and can be vertically loaded through an adjustable air spring to a maximum of 20,000 lbs. The test wheel is supported by a parallel-arm suspension that maintains a zero camber angle as the tire follows undulations in the pavement surface. A large disc brake provides braking torque to the test wheel in response to servo commands through a brake-pressure control system. Brake torque and the longitudinal and vertical components of tire force are transduced through a strain-gauge load cell. Wheel angular velocity is measured with a directly driven tachometer. These data signals, together with a fifth-wheel output of road speed, are conditioned in the tractor's instrumentation system and recorded on both magnetic tape and a light-beam oscillograph. An on-board watering system is used for wet-surface testing. This apparatus is being employed to examine the mechanics of tire brake-force generation as influenced by vertical load, road speed, pavement texture, surface wetness, tire tread design and rubber compound, and dynamic factors in the lockup process.

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.

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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.

Variable Braking Vehicle

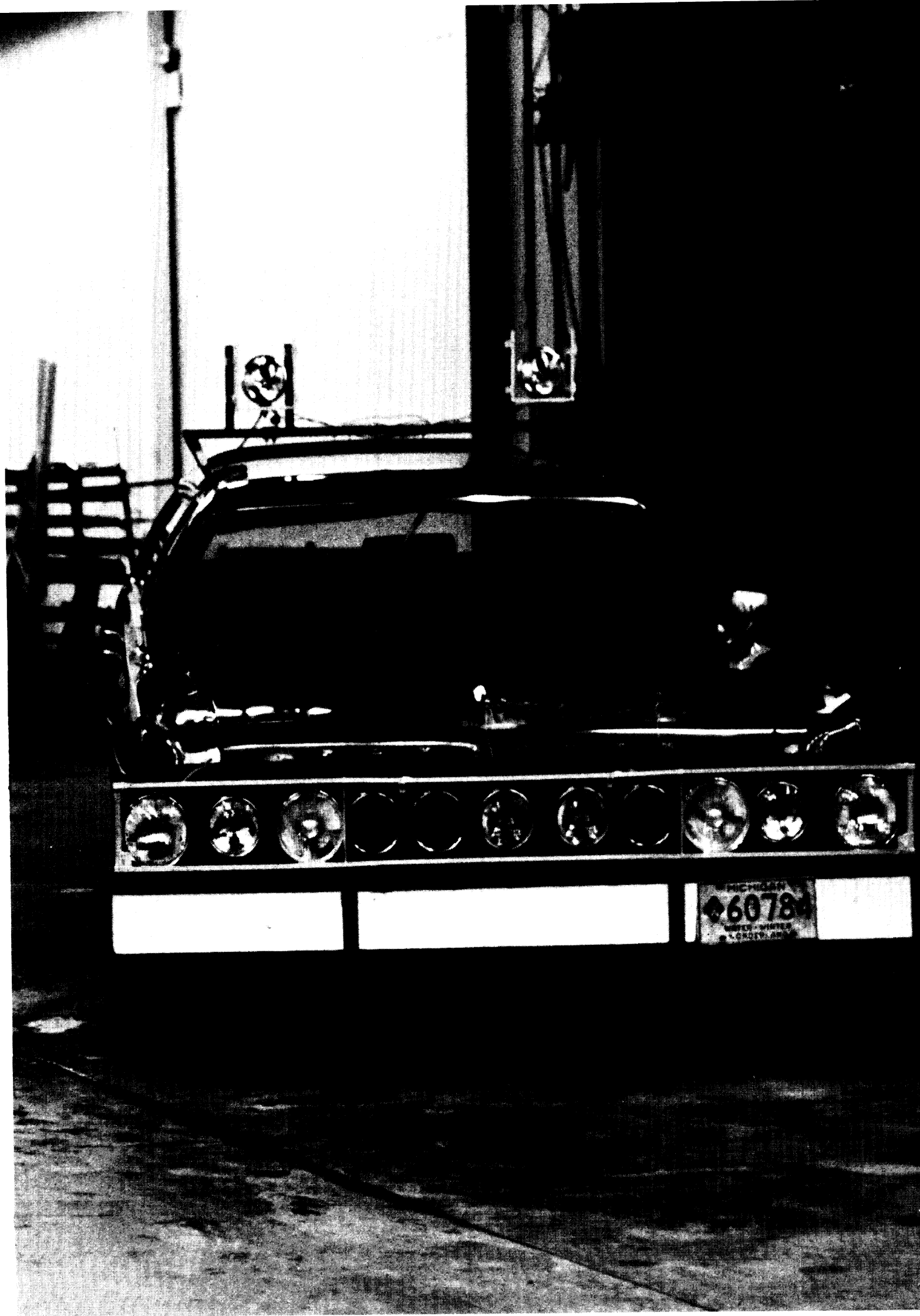
This research tool was designed and constructed at HSRI to study human factors in man-machine interactions during braking, to conduct engineering evaluations of innovative brake system configurations, and to determine the ability of diagnostic devices to detect degradations in vehicle braking performance. 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 electrohydraulic control systems that independently actuate the left and right rear brakes of the vehicle.

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 rear-lighting 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.



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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.



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, 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.

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.