A DEFINITION STUDY FOR A PROGRAM OF HIGHWAY SAFETY RESEARCH FOR THE AUTOMOBILE INSURANCE INDUSTRY

Prepared for the

Insurance Institute for Highway Safety

by the

Highway Safety Research Institute
The University of Michigan

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FOREWORD

This report is presented to the Insurance Institute for Highway Safety by the Highway Safety Research Institute, The University of Michigan, as the final result of their "Agreement for a Definition Study for a Program of Highway Safety Research for the Automobile Insurance Industry," dated April 2, 1968.

The study was performed over a period of four months, and was accorded priority attention at HSRI because of its potential importance to the national highway safety program. Seventeen members of the HSRI staff contributed to the study which was designed to take maximum advantage of expertise previously developed.

A large number of consultants also participated to lend a broad viewpoint to the report. Particular mention is given to Dr. Stanley Schuman of the Department of Epidemiology, The University of Michigan; Mr. Gordon Sheehe, Director of the Highway Traffic Safety Center, Michigan State University; Dr. George Briggs of the Department of Psychology, Ohio State University; Dr. Frazier Damron of the School of Education, The University of Wisconsin; and Dr. John Senders of the Department of Psychology, Brandeis University.

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SUMMARY

The purpose of the program definition study was to establish a plan for an IIHS-sponsored research program in highway safety based on goals established for the automobile insurance industry. It was expected that by carefully structured analysis and expert judgment, a program plan could be developed which would have the highest discernible potential for fulfillment of the goals. As a result of this study, HSRI believes that the expectation has been achieved.

The study was conducted in two phases. The first was a review of the existing situation in highway safety research, as presented in sections 2-4. The second phase dealt with the selection and synthesis of a recommended program plan, as reported in sections 5-8.

The major effort early in the study was a review of the status of highway safety research, as summarized in section 2 and Appendix 3. The review was divided into seven parts corresponding to the major components of the highway transportation system: driver, vehicle, roadway, pedestrian, physical environment, social environment, and highway services. The area of driver research is the one which has received most attention. Nevertheless, because of its complexity, research findings in this area have been less substantive than in other areas. Primary emphasis in driver research has been and should continue to be on sensory-perceptual processes and personality mechanisms.

Research findings dealing with vehicle and roadway factors in highway safety have kept pace with the evolutionary nature of the designs of vehicles and roads. Although many new design concepts have been studied, very few of them ever get to the implementation stage.

Research in the areas of pedestrians, the physical environment, the social environment and highway services has touched on a large number of miscellaneous subjects. It is unlikely that many of the findings will prove to be meaningful unless reconsidered in a system context. The areas with the greatest apparent potential are social environment and highway services.

Following directly from the research review was an analysis and compilation of the "research gaps", i.e., critical topics in highway safety research in which the findings are assessed to be insufficient for meaningful application, or lacking entirely. These research gaps are presented in section 3 in terms of the needs in highway safety research. The longest and most critical list of research gaps was derived in the area of research on the driver. Twenty such gaps were identified, covering virtually the whole driver problem, from social influences to alcohol effects, and from sensory processes to manual driving skills. In the vehicle research area, thirteen gaps were identified, dealing primarily with vehicle factors which have been improved over the years based on design innovations rather than fundamental research. Gaps

were fewer and less critical in the other areas--roadway (6), pedestrian (3), physical environment (4), social environment (7), and highway services (10). The latter two areas have been recognized as such only recently, and their gaps reflect very broad requirements. The composite list of research gaps provided the key link between the two phases of the study.

Another task performed during the first phase was a review of existing and potential methods of organization of highway safety research, as presented in section 4. Five types of organization were considered: universities, research firms, government agencies, industry, and foundations. Possible organizational forms within these basic types were also considered, e.g., multidisciplinary institutes, departments, individual consultants. The organizational role of IIHS in the research program was examined, and a few examples of overall organizational forms were derived.

At the end of the first phase of the study, the existing situation in highway safety research had been reviewed and analyzed sufficiently to set the stage for future projections of research that could be supported advantageously by IIHS.

The first step in these projections was an anlysis of the research program goals of IIHS, as presented in section 5. The goals were carefully examined in the light of HSRI experience, and were found to be complete, objective, and reasonable. Therefore, it was determined that the IIHS goals would serve ideally as a basis for evaluation criteria in assessing potential research programs. As a result of the goals analysis, a set of criteria was derived, as follows:

1. Amount of knowledge produced
2. Uniqueness of knowledge produced
3. Use of insurance industry data
4. Relative benefits to the younger population
5. Cost of research
6. Use of demonstration projects
7. Applicability of new knowledge to implementation programs
8. Potential for near-term implementation programs
9. Potential for early effectiveness of implementation programs
10. Relative cost for suggested implementation programs

11. Effect on the public image of the automobile insurance industry

12. Appropriateness of organizational form

13. Flexibility and adaptability

In section 6, twelve alternative program plans are presented for research in highway safety. The research themes listed below for these twelve alternatives were selected from the lists of research gaps derived earlier.

1. Improved Methods of Response to Highway Accident Injuries

2. Reduction in the Traffic Accident Involvement of Young Drivers

3. The Effectiveness of Legal Sanctions in Highway Safety

4. Methods of Evaluating Highway Safety Implementation Programs

5. Optimum Location and Design of Fixed Roadside Objects

6. Public Policy and Highway Safety

7. Reduction in the Role of Alcohol Misuse in Traffic Accidents

8. Risk Taking in Driving Behavior

9. Improved Methods of Driver Education

10. Basic Understanding of the Driving Process

11. Reduction in Losses Due to Vehicle Damage

12. Influence of the Social Environment and Public Information on Driver Behavior

As a basis for evaluating and comparing the twelve research alternatives, brief program plans were synthesized for each. Included were detailed objectives, descriptions of research areas and techniques, listings of subprojects, organizational recommendations, and estimates of required manpower, scheduling, and costs.

Section 7 presents the evaluations of the alternative program plans. In the first step, numerical ratings were derived for each of the twelve alternative plans on the basis of each criterion. From the consensus ratings of a team of five evaluators, a tentative order of preference of the alternatives was established. The list of research themes given above was arranged to indicate this order of preference.

Following objective evaluations, a final selection committee began the job of subjective evaluation. Alternatives were eliminated one by one until only the young-driver theme remained. The basic reasons for this choice were a positive effect on public image of the industry, good implementation potential, and strong relationships to several of the other alternatives, i.e., risk-taking, legal sanctions, and social environment effects. Thus, while it is recommended that the program theme focus on the young driver, it is felt that the added benefits of interrelationships with certain parts of other alternatives should also be included.

Details of the recommended program plan are presented in section 8. The title of the program is The Young Driver Research Program, and its objective is to reduce the traffic accident involvement of young drivers. In addition to investigations into the unique characteristics of young drivers and techniques for modifying them, the program would cover those aspects of risk taking, legal sanctions, the social environment, alcohol misuse, and driver education which have a particularly strong effect on the young driver.

The potential effectiveness of this recommended plan is great because of the poor record of young drivers (on the average) which exists at present, and their greater opportunity for improvement. The potential in man-years of life saved is obviously greater for young drivers. If the techniques developed from research are effective, their impact may be seen statistically before the end of the program. Meanwhile, the image of the insurance industry will be enhanced by sponsorship of this program at least as much as any other because of the high proportion of direct, beneficial influence of individual policy holders in the driving population.

The program plan is presented for a period of ten years, with an average annual cost of about 1.4 million dollars for the first three years. The recommended organizational form is a large multidisciplinary research organization in a university setting, with moderate use of subcontracts and establishment of several independent professorial chairs.

Conclusions of the program definition study are presented in section 9. The status of highway safety research is uncoordinated, inadequate, and minimally applicable. The area of driver behavior research is the most critical. Research gaps exist also throughout the other areas: vehicle, roadway, pedestrians, physical environment, social environment, and highway services. A system approach is needed for the whole field. Many different organizational forms are appropriate for highway safety research, but university institutes and research firms are best. Either of these two should perform the program management for the IIHS program, and several subcontractors should be employed. Technical recruiting would be a problem of a large program within IIHS. Technical liaison between IIHS and the contractor would be important. A ten year program at one million dollars a year is a minimum for desired results. Programs on injury treatment, young drivers, legal sanctions and implementation evaluations appear attractive. Research on the young driver provides great opportunity for improvement and man years of life saved. A Young Driver Research Program of 10 years at 14 million dollars would be best for IIHS sponsorship. The organization should be a multidisciplinary institute at a university. Professorial chairs should be established. Community laboratories and a data facility are essential to the Young Driver Research Program. Insurance data could be used for the research if improved in scope.

1. INTRODUCTION

This report presents the results of a program definition study in highway safety research, including recommendations of a specific program plan to the automobile insurance industry. The recommended program plan represents the final step in analyses aimed at selecting the research plan most deserving of industry support. The purpose of the report is to describe the recommended research plan and to justify its selection by summarizing the analyses.

1.1 OBJECTIVES OF THE PROGRAM

The concept of a large, comprehensive research program in highway safety was conceived by the automobile insurance industry in response to growing national concern over highway accident fatalities and other losses, and an awareness of the potential impact of highway safety on the industry. Thus, the industry goals for highway safety research, as developed by IIHS, reflect both the national concerns and industry concerns in highway safety. Ultimately, these concerns will be alleviated by action, i.e., the implementation of research findings in the highway transportation system. It is suggested that the ultimate desired outcome of industry-sponsored research is represented by the following action objectives:

1. To reduce the number of motor vehicle accidents, and resulting deaths, injuries, and damage.
2. To reduce the personal, public, and private economic losses resulting from motor vehicle accidents.
3. To establish a positive and respected role for the insurance industry in the national effort to improve highway safety.

1.2 SUBJECT MATTER OF HIGHWAY SAFETY RESEARCH

The subject matter of highway safety can be defined in terms of the elements and operations of the highway transportation system and related systems. The highway transportation system (HTS) is defined as the combination of physical components or elements which are essential to the actual movement of people and goods in the highway traffic process. The subsystems of the HTS are : (1) drivers, (2) vehicles, (3) roads (including all stationary auxiliary devices), and (4) pedestrians. The phases of HTS operations are: (1) conditioning (preparation for normal-mode functioning), (2) traffic (actual normal-mode functioning of HTS elements), (3) accident initiation, (4) collision, and (5) post-accident phases. Normal-mode functioning of the HTS occurs in phase 2, the traffic phase of operations.

The systems related to the HTS are defined as follows:

1. The Physical Environment. The composite of physical entities and phenomena which surround the HTS in its normal modes of operation.

2. The Social Environment. The aspects of the organizational system of society, as a whole, which influence the HTS.

3. The Highway Services System. The auxiliary services which facilitate use of the highways in emergencies and for purposes other than normal operations.

Detailed component listings of these seven subsystems and systems are given in Appendix 1.

The subsystems and systems may be related to the phases of operation by means of the subject matter framework or matrix shown in Table 1-1. All but four of the 35 cells in the matrix are marked, indicating that most of the potential interrelationships are pertinent subject matter in the field of highway safety. The entries in a given cell of the matrix are abbreviations for systems which affect the system/phase relationship corresponding to that cell. These entries constitute a third dimension to the matrix, which is useful in the study of interactions among elements of the various systems. The block diagram of Figure 1-1 also indicates the system interfaces.

1.3 STUDY APPROACH

The study was conducted in two phases. The first phase dealt with a review of the existing situation in highway safety research, including research areas studied, research techniques employed, organizational forms and resources. The second phase dealt with the synthesis and evaluation of alternative program plans, and the final selection of one preferred plan. The key link between the two phases of the study was the identification of research gaps which exist in the current state of the art and the use of these gaps as themes for the alternative plans.

The major effort during phase 1 depended upon literature searches and bibliographic material in the various special areas of highway safety research dealing with the driver, vehicle, roadway, and other elements of the system. Interfaces among these elements were recognized so that no important research areas would be missed. Finally, brief reviews of the status in each area were prepared, including the research gaps.

In phase 2, the approach was to translate the research gaps into basic themes for new programs, to expand the themes into alternative program plans, to evaluate and compare the alternatives by means of a rating methodology, to select one basic theme for final recommendation, and to synthesize the details of a program based on this selected theme.

Phases / Systems	1. Conditioning	2. Traffic	3. Accident Initiation	4. Collision	5. Post Accident
Drivers (D)	V,R,P PE,SE,HS	V,R,P SE,PE,HS	V,R,P SE,PE,HS	V,R PE,HS	V,R,P PE,SE,HS
Vehicles (V)	D PE,SE,HS	D,R PE,HS	D,R PE,HS	D,R PE,HS	R PE,SE,HS
Roads (R)	V PE,SE,HE	V PE,HS	V PE	V	PE,SE,HS
Pedestrians (P)	D,V,R PE,SE,HS	D,V,R SE,PE,HS	D,V,R SE,PE,HS	V,R PE,HS	V,R,D PE,SE,HS
Physical Environment (PE)	V,R SE,HS	V,R SE,HS	V,R HS	V	V, HS
Social Environment (SE)	D,V,R,P PE,HS	D,P			D,V,R,P HS
Highway Services (HS)	D,V,R,P PE,SE	D,V,R,P PE			D,V,R,P PE,SE

Note: Entries in cells of the matrix indicate other systems which affect the given system/phase relationship.

Table 1-1. Subject Matter Framework for Highway Safety Research

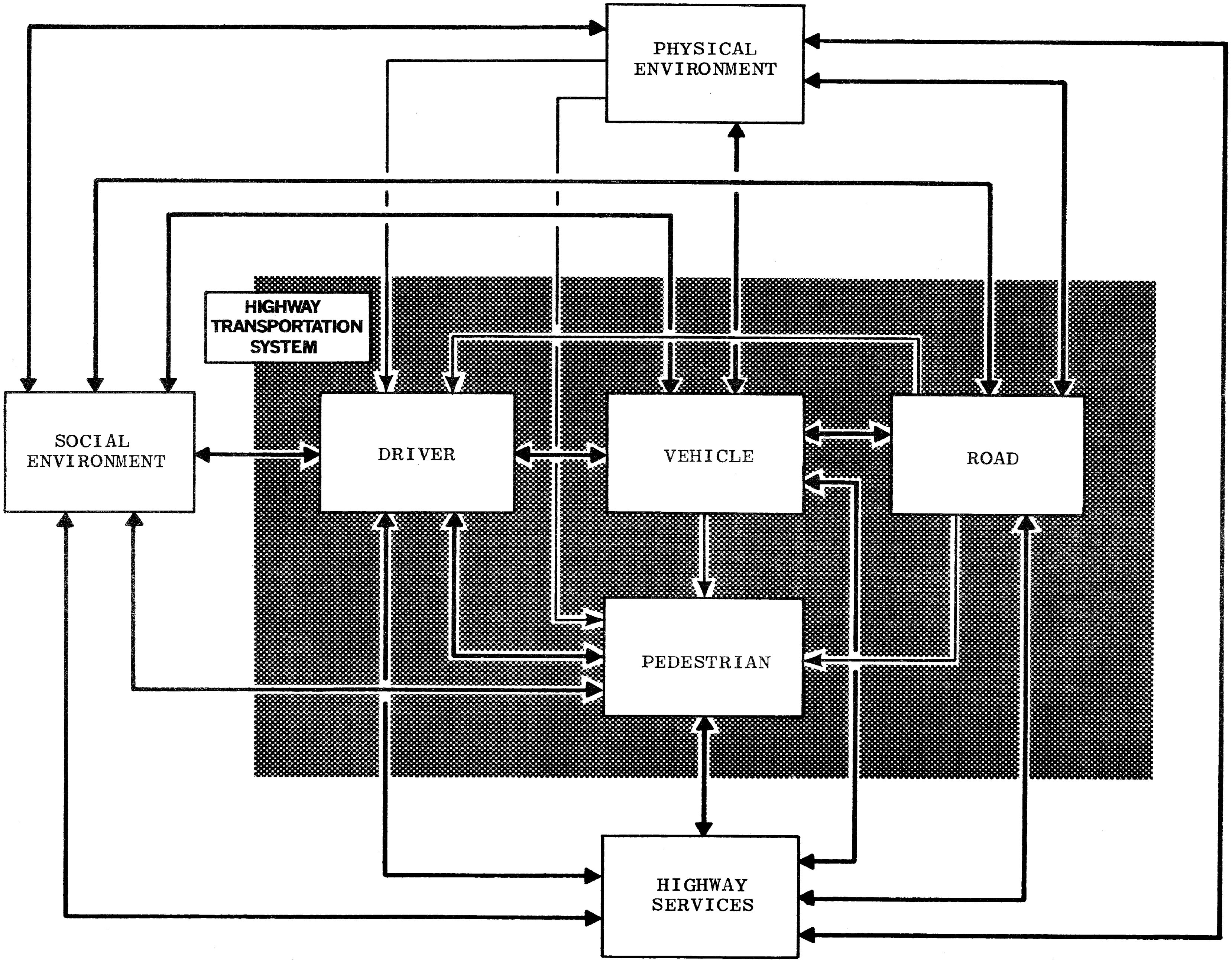


Figure 1-1. Block Diagram of the Highway Transportation System (HTS) and Related Systems

2. STATUS OF HIGHWAY SAFETY RESEARCH

The major task during the first phase of the program definition study was a review of the status of highway safety research. The review was conducted by a team of specialists assigned to the seven system areas mentioned in the Introduction, i.e., the driver, vehicle, roadway, pedestrian, physical environment, social environment, and highway services. This task was the longest one in the entire study, and it provided the essential basis for all of the succeeding tasks.

Because each of the seven areas interacts with all the others in terms of operations of the highway transportation system or adjunct operations, most research in highway safety deals with at least two of the areas, or systems. For example, research on traffic control signs deals with both driver vision and roadway location and design; and research on vehicle handling deals with both vehicle performance and driver skills. Therefore, many of the research projects to be reviewed could logically be categorized in two or more of the seven areas. In order to avoid duplication in the types of research reviewed in each area, the interfaces among the seven systems were defined and assigned to certain areas as described in Appendix 2.

The research status reviews were conducted in the manner of literature searches, covering information at the Highway Safety Research Institute Library and other public sources. The purpose of the reviews was to determine the general situation or status of highway safety research so that areas in which research is lacking could be clearly identified as "research gaps."

In order to determine the precise status of highway safety research, a state-of-the-art review would be required. However, the great magnitude of such a review precluded its feasibility in this study. Instead, specialists were relied upon for their continuing awareness of current research in their fields, and their informed ability to select a manageable number of research reports from the available material for review. Thus, though some minor aspects may have been omitted, it is felt that the general situation in each area has been well covered.

One approach considered was an attempt to update a previous state-of-the-art review, "The State of the Art in Traffic Safety, A Critical Review and Analysis of the Technical Information on Factors Affecting Traffic Safety" (Arthur D. Little, Inc., June 1966). It is certainly the best review of the field yet produced, and perhaps the only one which adequately defines parts of the state of the art. Nevertheless, in spite of its large magnitude, it fails to discuss several of the pertinent system/phase relationships defined earlier in Figure 1-1, and it fails to point out the need for further research in other areas. Therefore, it was not used as a basis for updating. On the other hand, many of its references were used and the complete set of over 1800 references is being obtained by HSRI.

Because of the very large mass and highly technical nature of the data compiled in the research review, it has been placed at the end of the report (Apendix 3). However, an overview of the status of highway safety research can be summarized briefly as follows:

1. The Driver -- This area has received more attention than any other throughout the history of highway safety research, but the research findings have been less substantive because of the complexity of the problem. Most of the research on driver behavior has been conducted at the universities, largely by independent researchers. Primary emphasis has been on sensory-perceptual processes and personality mechanisms influencing driving behavior.

2. The Vehicle -- This area has been covered very heavily by the automobile manufacturing industry, although the research findings are only partially released for publication. Government support for research in vehicle safety has grown in the last two years, and it is the primary interest of the National Highway Safety Bureau. Specific progress has been achieved in tire research, passenger restraints, interior injury mechanisms, door latches, and other minor factors relating to vehicle design.

3. The Roadway -- Research on roadway safety factors has been done in the past by various federal and state agencies. Often it has been an incidental aspect of research oriented toward new roadway design concepts which develop in an evolutionary way. However, results dealing with pavement surfaces and highway geometrics have been impressive. Results dealing with adjunct features such as signs and signals have been too constrained by conventional approaches.

4. The Pedestrian -- In this area, research has dealt with observed accident statistics rather than behavioral experimentation. The young, the aged, and the intoxicated have been identified as problem pedestrians, but little has been done to understand why.

5. The Physical Environment -- Weather factors have been identified fairly comprehensively with regard to their potential effects on traffic accidents. However, the solutions appear to be completely encompassed by vehicle and roadway factors.

6. The Social Environment -- The area has been recognized only recently as a major system related to highway transportation safety. Past research in the area has been uncoordinated, e.g., independent studies in driver education and traffic law enforcement, and results have been very inconclusive. Research on sociological factors, while sketchy, has shown its potential importance.

7. Highway Services -- This area, also, has been recognized only recently. Primary studies have been on treatment of injuries and ambulance services. The results have been instrumental in suggesting a systems approach.

A general assessment of the status of highway research is that past results have been uncoordinated and only partially applicable, that research in driver behavior has been the most prolific but the least substantive, that research on the physical factors has kept pace with designs, that research in social factors and highway services shows great potential, and in summary, that the overall research status is not adequate for the current needs in highway safety.

In the future, highway safety research will be guided primarily by the leadership of NHSB. Two points are especially critical: (1) leadership in the use of the systems approach for highway safety research, and (2) leadership in expanding and coordinating research on driver behavior.

The final result of the research status review -- a listing of current research gaps -- is presented in the next section.

3. THE NEEDS IN HIGHWAY SAFETY RESEARCH

In the preceding section, the current status of highway safety research was reviewed in order to define the foundation upon which future research can be based. In some areas the foundation is solid and meaningful, while in other areas it is vacuous. The purpose of this section is to define the areas of the research foundation which are lacking both in content and in quality.

Two aspects of the needs in highway safety research are presented. One -- the research gaps -- provides the key link between the two phases of the study. The other aspect is an indication of the research needs expressed by practitioners in highway safety implementation programs.

3.1 RESEARCH GAPS

The current research gaps in highway safety research have been compiled for each of the seven system areas previously defined. The composite list presented below is limited to those highway safety research areas which represent the most critical questions of the future, in the context of a nationally coordinated systems approach.

The Driver

1. Effects of alcohol consumption on drivers and driving performance
2. Reasons for overinvolvement of young drivers in traffic accidents
3. Improved methods of driver education
4. Effects of driver vision capabilities on driving performance
5. The role of nonvisual sensory cues in driving
6. Effects of social influences on driver attitudes, motivations, and personality
7. Effects of basic attitudes, motivations, and personality on driving behavior
8. Basic understanding of the driving operations, task requirements, sequences, and interrelationships.
9. Basic understanding of human driving skills, vehicle handling performance, and man-machine interfaces
10. Emergency driving operations
11. Reasons for risk-taking in driving and means for reducing risk-taking
12. Basic understanding and applications for the decision-making process in driving
13. Knowledge of the kinds of information needed by drivers in traffic
14. Knowledge of the means and content of public information most effective in improving citizens' driving behavior
15. Effects of various enforcement techniques on driving behavior.

16. Effects of various regulations and legal sanctions on drivers' attitudes
17. Improved methods of driver licensing and testing
18. Effects of drugs on driving behavior
19. Effects of fatigue on driving performance
20. Basic understanding of injury mechanisms in highway accidents and resulting trauma

The Vehicle

1. Basic understanding of vehicle control operations requirements, sequences, and interrelationships
2. Determination of explicit, objective measures of vehicle dynamic performance
3. Improved interior design of vehicles to minimize passenger injuries
4. Improved methods for passenger restraints
5. Knowledge of the dynamic effects of braking performance
6. Knowledge of tire deformation mechanics near friction limits
7. Effects of time, aging, deterioration, and operational wear (degradation) on vehicle components and performance
8. Knowledge of vehicle damage mechanisms
9. Knowledge of energy-absorption materials and structural designs to minimize transfer of impact energy to passengers
10. Knowledge of design techniques to minimize vehicle damage in a collision
11. Knowledge of techniques to minimize cost of vehicle damage repair
12. Effects of vehicle design on passenger comfort in terms of position, temperature, and vibration
13. Improvements in viewing limitations of vehicles

The Roadway

1. Improved friction characteristics of roadway surfaces for minimizing vehicle skidding
2. Improved illumination and delineation of roadway surfaces by passive and active means
3. Basic understanding of the effect of intersection design on traffic flow and accident causation
4. Determination of new methods for control of traffic volume flow and redistribution by automatic means
5. Basic understanding of the role of fixed roadside objects on traffic accidents, and means for alleviating the problem
6. Knowledge of correlation of highway accidents with types of roadway locations

The Pedestrian

Many of the research gaps in pedestrian safety are analogous to those for the driver, but are less critical. Three areas stand out.

1. Overinvolvement of aged pedestrians in traffic accidents
2. Overinvolvement of young children as pedestrians in traffic accidents
3. Overinvolvement of alcohol consumption as a factor in pedestrian accidents

The Physical Environment

1. Effects of reduced nighttime illumination of the roadway
2. Effects of slippery road surfaces due to rain, ice, and snow
3. Effects of glare on driver vision
4. Effects of fog on viewing of the roadway

The Social Environment

1. Effects of traffic laws on the driver
2. Effects of police enforcement on the driver
3. Effects of legal sanctions on the driver
4. Effects of driver education on the driver
5. Effects of driving regulations on the driver
6. Effects of public information on the driver
7. Impact of social structures and values on the driver

The Highway Services

1. Methods of reducing the severity of effects of highway accident injuries
2. Better methods of detecting the occurrence of accidents
3. Methods of extricating passengers from wrecked vehicles
4. Better methods of removing wrecked vehicles from accident scenes
5. Methods of semiautomatic law enforcement, e.g., of speed limits
6. Improved methods of traffic surveillance
7. Methods for communications for vehicles in traffic
8. Improved methods of repair of disabled vehicles
9. Improved vehicle inspection techniques
10. Improved methods of highway patrol

3.2 INFORMATION NEEDS OF HIGHWAY SAFETY PRACTITIONERS

Practitioners of highway safety are defined as those who create laws, regulations, and policy, prepare implementing programs, administer function, or perform specific actions, all of which relate to highway safety. The information needs of these personnel were analyzed primarily from informal discussions with members of the Michigan State Safety Commission and officials and administrators within the Michigan Departments of State, Highways, Police, and Education.

The general categories of practitioners and their major subcategories include:

Law Makers:

Federal Legislators
State Legislators
Local Boards and Councilmen

Policy Makers:

Secretary of Transportation
State Governors
Secretaries of State
Highway Commissioners
Transportation Commissioners
Safety Commissioners

Administrators:

Federal Highway Administrator
National Highway Safety Bureau
Bureau of Public Roads
Governor's Coordinators
Motor Vehicle Registrars
Driver Examiners and Licensors

Developers and Operators:

Highway Designers and Builders
Highway Operations Managers
Traffic Engineers
Automotive Engineers
Equipment Suppliers

Educators:

State Directors for Education
Educational Institutions
Traffic Safety Teachers
Driver Education Teachers
Professional Highway and Traffic Safety Associations
Traffic Safety Organizations and Councils

Enforcers:

State and Local Traffic Police
Transportation Regulators, Inspectors, Investigators
Traffic Court Judges

Medical Service Providers:

State and Local Health Departments
Hospitals
Doctors
Ambulance Operators

The most frequently enumerated categories of information required by highway safety practitioners were determined recently by HSRI in its Documentation Center Contract for NHSB, as follows:

Laws, Regulations, Standards
Technical Data
Administrative Procedures
Operating Techniques
Training Methods
Statistics on:
  Accidents
  Driver Exposure
  Vehicle Mileage
  Traffic Volumes
  Population
  Costs
  Resources
  Performance
Public Attitudes and Response
Program Analysis and Evaluation Techniques
Forecasts
Reporting Requirements and Techniques
Periodic Reviews, Summaries, State-of-the-Art Reports
Research in Progress
Current Activities of Others in the Field
Directories of Organizations and People
Speech and Brochure Material
Services and Aids Available

The normal and preferred formats for transmitting information requirements to highway safety practitioners include:

Newsletters
Bulletins

Lists
Guides
Synthesized Summaries
Survey Reports
Handbooks
Manuals
Reference Books
Document Lending Services
Audio-Visual Material

Naturally the many pracitioners have varying information requirements. However, much of the needed information depends on successful highway safety research. But to be useful the information generally has to be up-to-date, timely, and synthesized in a form that is understandable to intelligent laymen and readily applicable.

Surveys indicate, however, that practitioners seem to be inarticulate about describing their information needs or are vaguely aware of what needed information is available and where to find it. Therefore, user rates of existing information systems are low. Those who know what they want complain that the information available is not screened for essentials, is out-of-date, or arrives too late to be of use.

At times there is a wide gap between researchers and practitioners. It has been charged that many highway safety researchers work in a vacuum on isolated problems and fail to consider the whole problem, and that some practitioners feel that researchers often try to disprove implemented program results rather than evaluate them. Legislators in particular are continually overwhelmed by vast quantities of undigested or unsynthesized information, often have little dialogue with researchers, and don't always understand researchers and their programs.

An exception to the generally weak communications prevailing among highway safety researchers and practitioners is in the area of highway engineering and construction, primarily because of the close fraternity that exists among the professionals who constitute the membership of the American Association of State Highway Officials, the Highway Construction Industry, the Bureau of Public Roads, and the Highway Research Board. Even within this information system weaknesses are recognized, but serious attempts to eliminate them are being made by the Highway Research Board via a contract under the National Cooperative Highway Research Program to synthesize existing information on important highway problems.

The National Highway Safety Bureau, aware of the shortcomings in furnishing information requirements to highway safety practitioners, has funded studies to determine users and their information needs and to recommend solutions. The Highway Safety Bureau has instituted its own Information and

Documentation Center which so far exists primarily as an in-house service and does not fulfill all user needs.

The IIHS newsletter, Status Report, also serves an important function in fulfilling practitioners needs. This kind of service should be continued and expanded.

To fulfill the ever growing information requirements of all practitioners of highway safety, it is urgent that a National Traffic Safety Documentation Center be established. The principal functions of this Center should include:

Serving as a single point of access to all highway safety information

Formulating a Highway Safety Thesaurus of concepts, subjects, terms, nomenclatures

Issuing periodic newsletters

Providing definitive, authoritative, federally sponsored and approved state-of-the-art reports and critical reviews

Maintaining a universal personality-organization-facility file.

4. HIGHWAY SAFETY RESEARCH ORGANIZATION

Research in highway safety may be done in five organizational categories, as follows:

1. Colleges and universities
2. Research and consulting firms
3. Government agencies
4. Industrial organizations
5. Foundations, associations, and societies

This section indicates the extent to which these organizational categories have been used in the past for highway safety research, and indicates the organizational forms that might be used in the future.

4.1 EXISTING HIGHWAY SAFETY RESEARCH ORGANIZATIONS

A survey of highway safety research reports was conducted with a sample of documents in the HSRI Library in order to correlate research with organizational type. From a random sample of 135 documents, 47 of them (35%) were prepared at colleges or universities. This number was approximately twice as many documents as prepared by either government agencies or research firms. Foundations and industries produced only about one third as many documents as the colleges and universities. Results of the survey (see Appendix 4) identify the centers of excellence in highway safety research.

Although the sample number was only about 2.5% of the HSRI collection, it was enough to validate the results. Thus, colleges and universities appear to be the type of organization in which the largest amount of highway safety research is done.

4.1.1 COLLEGES AND UNIVERSITIES. Until about three years ago, there were only about three or four large research institutes for highway safety research at the universities. There were also a few small research projects related to highway safety within academic departments. However, most of the work was done by individual professors doing research in addition to teaching. Thus, there are two basic types of organizations for highway safety research at colleges and universities: the staff organization; and the diverse approach where work is spread around campus. The staff organization, whether in an institute or academic department, is the only feasible approach for a true program.

Within the past three years, several new research centers or institutes for highway safety research have sprung up in the universities. These groups are now doing the bulk of the highway safety research at the universities. In general, the centers and institutes are fairly large and they emphasize interdisciplinary programs. Their support comes from endowments, grants, and government contracts.

Colleges and universities, because of their teaching departments, research institutes, and laboratories, have traditionally been the pioneers in basic research. Even so, in some fields, such as engineering, their work is often directed toward the solution of particular problems. In performing this work they are dependent upon a wide variety of sponsors for financial support.

A unique feature of educational institutions is that they often are able to enlist the support of competing industries or companies in conducting research in a single area. Another strong point is their ability to draw upon a wide variety of disciplines represented on their staffs and facilities.

4.1.2 RESEARCH AND CONSULTING FIRMS. Research and consulting firms (profit, non-profit, private, quasi-public) are quite prolific in the field of highway safety. Although they have organizational structures much like industrial firms, they deal not in products, but rather in applying basic knowledge to practical problems. These firms may be large or quite small but they are usually specialists in one or more related fields. Their functions range from science and technology to management and business analysis. Like universities, they delve into basic knowledge, though in many their primary direction is in applications. Most of the highway safety research done by private firms is supported by government contracts, and therefore they are faced with a continuing competitive problem of obtaining new contracts.

4.1.3 GOVERNMENT AGENCIES. The role of government in highway safety research is fundamentally one of financial sponsorship. However, there is a great deal of self-sponsored research being conducted within the government agencies themselves.

Of most recent importance is the National Highway Safety Bureau and the funds that it has available to initiate research. Until the establishment of NHSB, the federal government's support of highway safety research was on a small contract or grant basis directed at solving a variety of rather diverse problems. Financial support from state governments has also been small and directed at solving specific problems raised by a highway department or public safety department. The NHSB has been formed with a legislative mandate to attack highway safety on a coordinated basis. Nevertheless, other government agencies will continue to be involved.

4.1.4 INDUSTRIAL ORGANIZATIONS. Although automobile industries are very active in highway safety research, much of their work is proprietary, and not published for open use. Therefore, the true magnitude of their research is probably not evidenced by the survey. Industries are product-oriented, and therefore their research is directed at a limited realm of highway safety. However, their research is often covered by overhead. Some of their research branches also compete for government contracts in highway safety.

4.1.5 FOUNDATIONS, ASSOCIATIONS, AND SOCIETIES. Foundations and similar organizations (e.g. ASF, AASHO, and SAE) are basically sponsors or promoters of highway safety research or implementation programs. Sponsorship may be manifested either by providing whole or partial funding to research organizations or by initiating programs through cooperative participation of the foundation's supporting members. Moreover, some of these organizations are prepared to conduct research themselves. The financial support offered by these organizations is usually not great and the research programs undertaken are usually small in scope. On the other hand, demonstration or implementation programs, supported by such organizations in cooperation with other agencies, are often nationwide in scope. Appropriate foundations and societies are often related to the automobile or highway construction industries and they sometimes derive their support directly from the industries. Membership dues also contribute to modest amounts of research in the technical societies.

4.2 POTENTIAL ORGANIZATIONAL FORMS

Each of the five types of organizations may be utilized to some extent in carrying out a large-scale highway safety research program. However, some are more versatile and flexible than others. To illustrate, the operational requirements of such a research program can be broken down into a hierarchy of functions, such as:

1. Undertaking the entire research program
2. Undertaking management and technical coordination of both in-house and subcontracted efforts
3. Undertaking technical coordination of subcontracted activities (no in-house research)
4. Undertaking subcontracted research projects only

The capabilities of various organizational types (and their major subelements) may be related to thie hierarchy, as shown graphically in the chart of Table 4-1.

By applying various constraints to the chart, it is possible to select the appropriate organizational form, or combination of forms, for a given need. For example, if IIHS prefers to have the entire program performed within one outside organization, the choice of a type of organization is quite broad (only foundations are eliminated). If, in addition, possible conflicting interests are to be avoided,

TABLE 4-1

Organizational Forms, Types, and Scopes

Form \ Type	University	Research Firm	Government	Industrial Firm	Foundations, Associations, etc.
Large, interdisciplinary research institute	1, 2, 3, 4		1, 3		
Medium, specialized research center	1, 2, 3, 4		1, 3		
Large Program or Department	1, 4	1,2,3,4		1, 2, 3	
Medium Program or Department	2, 4	2,3,4	4	2, 3, 4	3, 4
Small Project or Department	4	4	4	4	3, 4
Individual (Consultant or Professor)	4	4			4

Scope:
(1) Entire Research Program
(2) Overall management and some research
(3) Overall management only
(4) Subproject research only

then large industrial firms and government agencies would probably be eliminated. Thus, based on two restraints (whole program and nonconflicting interests) the choice is narrowed to universities and research firms. If another desire is to ensure that the program will command frequent attention from the top executive personnel, the choice is narrowed to a large, interdisciplinary research institute at a university versus a large program organization or staff department in a research firm.

Another possibility fulfilling all of the constraints in the preceding example is the establishment of an in-house research program at IIHS. Such a program could be organized within the present IIHS structure, or it could be established in a separately incorporated subsidiary of IIHS, either newly created or purchased.

A second example is the case where IIHS specifically prefers the program to be conducted by a large number of organizations. The first decision, then, is to select the organizational form for the overall management of the program. Some organizations would accept the management job only if they were also to perform a good sized share of the research and others might accept only the management job. Assuming either is acceptable, the choice of management form would depend on the feasibility of subcontracting to various other forms. Although the potential relationships among various organizational forms for subcontracting purposes are not shown on the chart, it should be assumed that there would be some obstacles to certain combinations. These would come about due to various competitive aspects and conflicts in goals. For these reasons, it again appears that universities and private research firms would be the best choices for an overall management organizational form.

A final example is the case where IIHS chooses to perform the overall management job itself. Possible conflicts with subcontractors is avoided, though there might be reluctance of contractors to cooperate if the various results of research were fully coordinated. It is desirable to have full coordination, and yet it would not be fair to disclose interim results among certain contractors with conflicting interests. The magnitude of the coordination job would be difficult for IIHS because of the large technical staff that would be needed. Recruitment of the staff would, of necessity, be gradual in the first few years, which would mean a more lengthy planning phase than necessary.

Simple organization charts for these three examples are given in Figures 4-1,4-2, and 4-3.

Regardless of the organizational form chosen, it is important that the functions of the organization do not become too formalized or cumbersome. Many new management

Figure 4-1. Organization by Single Contract

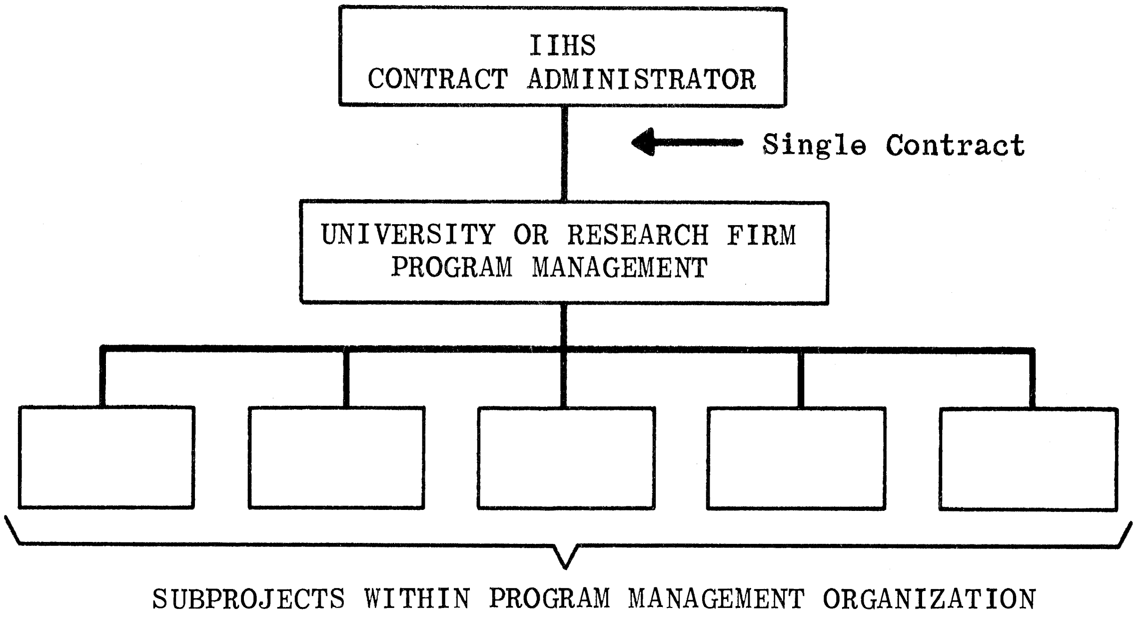


Figure 4-2. Organization by Subcontracts

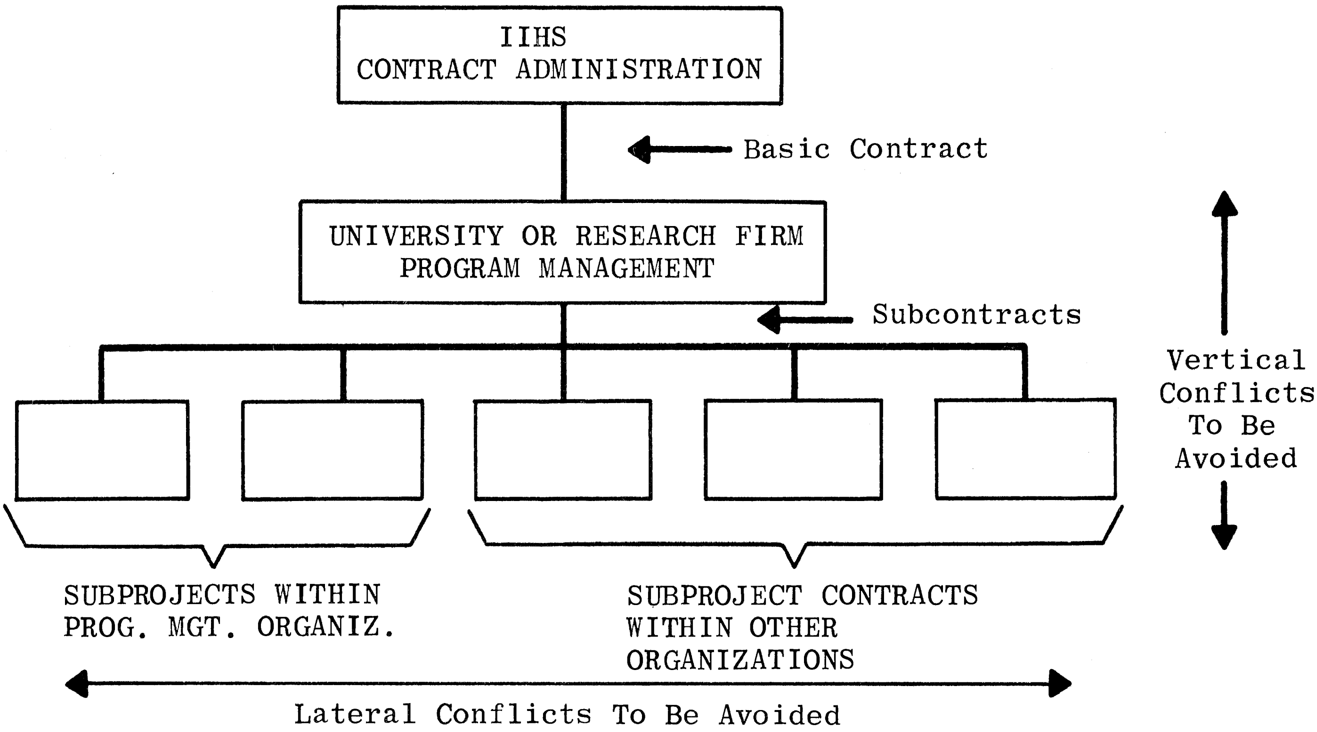
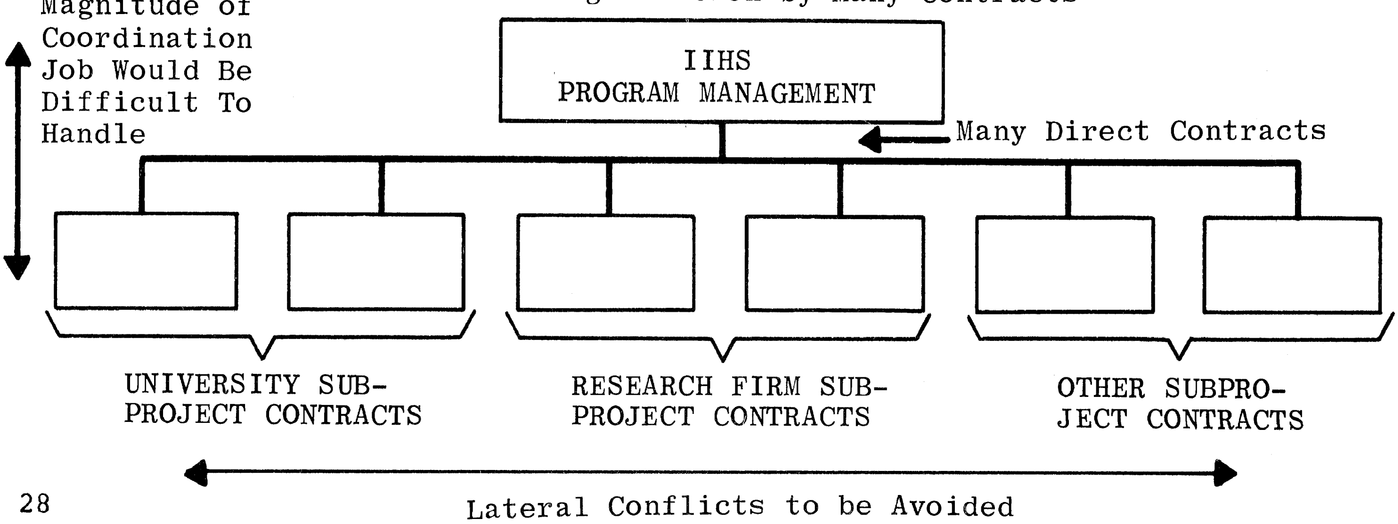


Figure 4-3. Organization by Many Contracts



techniques have been developed recently for planning and cost control of technical organizations, and many of them could be applied to this program. However, it is felt that the detailed administrative processes required of the top personnel in a viable highway safety research organization would be too restrictive if the new techniques were employed. The problem would be twofold: (1) the difficulty in finding a top researcher who would be willing to become director of an overly-structured program, and (2) the difficulty in finding good researchers to perform research in an environment hindered (in their eyes) by over-organization. The alternative of a conventional staff organization (without too many groups) and conventional planning, reporting, and budgeting channels, should be preferred.

4.3 THE IIHS ORGANIZATIONAL ROLE

The IIHS role in the organization of a large highway safety research program sponsored by the automobile insurance industry would have two major aspects: as a sponsor, and as a participant. As a sponsor, IIHS would supply all of the financial support, and as a participant, IIHS could perform any of the following functions:

1. Contract administration only

2. Contract administration plus technical liaison

3. Program management

4. Total research program

In the first two cases, another organization would be selected from among the large centers of excellence to perform the technical job of program management. In the second two cases, IIHS would perform the program management. The choice will be a very difficult one. The disadvantage of contracting out the program management function is the increased costs. The disadvantage of conducting the program mangement within IIHS is the severe difficulty in recruiting a competent staff because of the reluctance of the people most qualified for the work to leave the university or research firm environment.

In case IIHS does not perform the program management, there will probably be a need for an excellent technical liaison relationship between IIHS and the prime contractor. IIHS would need to have a technical staff of 4 or 5 professionals to monitor technical findings and to transmit the meaning and significance of the results to the IIHS board the IIHS public relations staff would probably be increased to handle a larger flow of information to the media.

Regardless of the role which IIHS chooses to adopt, it is clear that the magnitude of the research program, compared to previous IIHS implementation support, will change the balance of IIHS interests impressively. In fact, the research program could become a leading influence in changing the organizational structure of IIHS, and its role in our society.

5. THE GOALS FOR HIGHWAY SAFETY RESEARCH

In the Introduction the objectives of the automobile insurance industry were postulated in terms of the results of implementation programs which might follow from industry-sponsored highway safety research. In summary, these objectives are:

1. To reduce accidents, deaths, injuries, and damage
2. To reduce economic losses
3. To enhance the image of the industry

The research program goals produced by IIHS provide a more detailed outlook on these objectives. The IIHS goals pertain to the highway safety research which precedes implementation, but they all relate to the ultimate objectives in a basic, complementary fashion. From the original IIHS statement, the goals have been separated, paraphased and condensed as follows:

1. To contribute to knowledge of the highway accident process
2. To contribute to the national strategy in highway safety
3. To create and support a scholarly program in highway safety
4. To ensure a long-term, coherent program
5. To provide a basis for implementation of programs to correct highway safety problems
6. To encourage action in both the public and and private sectors
7. To estimate the effect of early action on the automobile insurance industry
8. To complement other highway safety activities
9. To conduct the program in the national interest
10. To produce the largest possible benefit to the public and the industry
11. To produce knowledge of value to the industry in considering its own problems
12. To suggest industry responses to future problems, in both the near future and the long term
13. To make use of industry sources of information applicable to highway safety
14. To focus on efforts which do not duplicate other programs, i.e., the driver
15. To produce interrelated results

These goals have been reviewed carefully, and the general assessment is that they are very complete, objective, and reasonable. As a basis for research in the private sector, they are highly responsible and responsive to the needs of a national effort in highway safety. They indicate a desire on the part of the industry to cooperate with all other programs in highway safety research, both current and future. Although there are some precedents for private sponsorship of specific research in this field, very little of it is so logically founded or freely intended for the public domain. Further, the previous private research has never occurred in the large magnitude proposed by IIHS. For this reason perhaps, the federal government has not prepared guidelines for private participation on a truly complementary basis. The IIHS goals take a large step toward the creation of such guidelines. They represent a most significant gesture on the part of the private sector, and they should have a striking influence on the national highway safety program. In particular, it is felt that the National Highway Safety Bureau will come to recognize the serious intent on the part of the industry, and they will surely accept the challenge to make use of the proffered resources in mutually beneficial ways.

The research goals serve two purposes. They serve as guidelines for the synthesis of industry-sponsored research programs plans, and they also provide a basis for criteria which can be used to evaluate the potential of suggested plans. Both purposes were served in this study.

While the use of goals as guidelines was informal and unstructured, the derivation and use of goals was quite analytical and objective in nature. The first step was to categorize each of the goals under each of the three basic objectives. Some goals related to more than one objective. The goals were translated into evaluation criteria and expanded into concise details. For instance, the criteria on effectiveness of a program in producing accident-process knowledge included amount, applicability, uniqueness, and validity criteria. The total list of possible criteria was then analyzed for duplications and overlaps. The final list of criteria for evaluation of alternative program plans is as follows:

1. Amount of knowledge produced

2. Uniqueness of knowledge produced

3. Use of insurance industry data

4. Relative benefits to the younger population
5. Cost of research
6. Use of demonstration projects
7. Applicability of new knowledge to implementation programs
8. Potential for near-term implementation programs
9. Potential for early effectiveness of implementation programs
10. Relative cost of suggested implementation programs
11. Effect on the public image of the auto insurance industry
12. Appropriateness of organizational form
13. Flexibility and adaptability

6. ALTERNATIVE PROGRAM PLANS

This section contains descriptions of the twelve alternative program plans which were synthesized for comparison in the evaluation process. The themes for the program plans were developed from the listing of research gaps presented in section 3. The twelve summaries contain brief statements of objectives, research areas and techniques, subprojects, schedule, manpower, and cost.

The choice of the twelve research themes was made by a special four-man working committee which had monitored the analysis of the research gaps and had become familiar with the needs and interrelationships of the gaps. Each member was already familiar with the general needs in all areas of highway safety. Consultation was provided by advisory specialists in several of the areas.

Because of time limitations for synthesizing and evaluating the plans, it was necessary to limit the number of alternative programs. By screening the list of research gaps and assessing the possible magnitude of related programs, a manageable list of potential program titles was derived. The intention was to synthesize the program plans simultaneously by means of several research teams working in parallel, concentrated efforts over a period of one to two weeks. It was felt that this approach was essential to project scheduling so that all plans could be evaluated together. During the early stages of the synthesis effort, a few programs were combined and others were added as certain gaps became more apparent. One program was added later, giving a final total of twelve alternatives, represented by the program plan summaries which follow.

Among the guidelines used to develop the program themes were the need for long-range study and the IIHS suggestions for program periods up to ten years and costs on the order of one million dollars a year. Further, it was felt that many of the themes, in order to be fully and adequately studied, deserved the total amount of support which could be made available. Therefore, it was decided to synthesize separate programs based on each of the selected themes. This was done with clear realization that the magnitude finally estimated for some of the programs might not require the full amount of available resources. Also, it was foreseen that some of the program themes might eventually be combined because of their interrelationships. Nevertheless, it was felt that initial development of separate program plans for the selected themes was the most straightforward approach at the mid-point of the program definition study, and that it afforded maximum flexibility for further use of the data.

In order to achieve consistency in the cost estimates for the twelve alternative programs, a common cost factor was used in all cases. This cost factor was $30,000, representing the equivalent of one man year of professional research effort and supporting functions. The cost factor is based on an average salary of $17,000, overhead of 50%, and an additional 25% for the average researcher's share of travel expenses, clerical support, and special equipment. All of these components are included in the salary items of the cost charts which follow, unless otherwise specified. It is assumed that programs would be housed in existing facilities owned by the contractors, and that existing laboratory equipment would be used for a large share of the experimental needs. Estimated costs for special facilities such as a driving test track or computer are added separately.

6.1 THE YOUNG DRIVER

The theme of the program is "Reduction in the Traffic Accident Involvement of Young Drivers." The problem of over-involvement among young drivers is well substantiated by accident statistics, and the general purpose is to alleviate this problem. The basic concepts of this program plan were developed by Dr. Stanley H. Schuman of the Department of Epidemiology, The University of Michigan.

1. OBJECTIVES

To describe the unique problems of young drivers in a detailed manner.

To identify and establish models of the risk factors, social influences, and other factors involved.

To determine and evaluate ways of modifying and controlling young driver behavior.

2. RESEARCH AREAS

Determine all possible factors relating to characteristics of young drivers that might influence their driving behavior.

Determine which factors are most important in driving behavior of the young driver.

Determine ways in which factors may combine to influence his driving behavior.

Determine whether these factors may be affected by new or changed external influences.

Determine whether changes in external influences can change a young driver's behavior.

Determine which changes in external influences have the most effect on a young driver's behavior.

Determine how changes in external influences may be brought about.

Evaluate effectiveness of actions to change external influences, and hence driving behavior.

3. RESEARCH TECHNIQUES

Data collection on young drivers, data storage, programming, data analysis.

Modeling of young driver risk problems.

Case studies, surveys, interview, school studies, family patterns, school seminars, etc., all in a community laboratory.

Experiments on advanced-driving test courses.

4. SUBPROJECTS

(1) Establishment and continued administration of a Community Laboratory.

(2) Establishment and continued administration of a Central Data Bank.

(3) Series of in-depth analytical studies of young drivers.

(4) Series of experimental group studies of young drivers.

(5) Follow-up studies of individual young drivers.

(6) Establish driving test courses.

(7) Driving-course experimental studies.

(8) Demonstration projects.

(9) Evaluation of demonstration projects.

5. ORGANIZATION

A special subsidiary research center to house and administer data project, community liaison project, driving range planners, interview and seminar rooms, experimental labs, and staff offices. The center could be created as a new non-profit corporation, or as an adjunct to an existing or university-related research organization.

University consultants and industry contracts to assist in establishing program.

University consultants and other contracts to conduct studies, including fellowships and professional chairs.

Contracts to contruct and operate driving test course.

Consultants and contracts to conduct demonstration evaluation projects.

6. MANPOWER

Over 300 man-months of professional research work, primarily by psychologists, sociologists, and data analysts.

7. SCHEDULING

The distribution of man-years of effort on subprojects over a ten-year period is given in the following chart.

	YEAR									
SUBPROJECTS	1	2	3	4	5	6	7	8	9	10
Community Lab.	10	10	3	3	3	3	3	3	3	2
Data Bank	8	8	8	8	8	8	8	6	4	4
In-depth Studies	3	8	10	10	10					
Group Studies		1	4	6	6	6	4			
Follow-up Studies					5	3	3	3	3	3
Driving Range			10	10						
Driving Studies					8	8	8	8	8	8
Demo. Projects				4	5	5	5	5	5	
Evaluation						3	3	3	3	3
Total Man Years	21	27	35	41	45	36	29	28	26	20

8. COSTS

The total cost over 10 years is $9,675,000 as given in the cost chart below:

COST ITEMS	YEAR 1	2	3	4	5	6	7	8	9	10
Salaries	630K	810	1,050	1,230	1,350	1,080	870	840	780	600
Driving Range			100	100						
Demo.				20	50	50	10	5		
Computer	50	50								
Total in thousands of dollars	680	860	1,150	1,350	1,400	1,130	880	845	780	600

6.2 RESPONSE TO INJURIES

The theme of this program is "Improved Methods of Response to Highway Accident Injuries." It is based on a fundamental assumption: If a highway accident victim is severely injured but not instantly killed, he often suffers various changes in his vital systems (respiratory, circulatory, nervous) and associated organs so that death may occur as an unnecessary secondary result of his injuries, to the extent that interaction of body defense mechanisms and the direct consequences of a given injury eventually lead to irreversible deterioration that could have been prevented by prompt and appropriate treatment.

Thus it is desirable to develop knowledge of procedures essential to discontinuing, reducing, temporarily halting, or reversing the chain of events created by injuries, and to disseminate this knowledge appropriately to medical, paramedical, and lay groups. A need exists to establish correlations between injuries, first aid, emergency room diagnosis, clinical findings, operating room reports, post-surgical complications, laboratory data, and autopsy findings.

According to an AMA brochure, "Suggestions for Community Action on Emergency Medical Services," January 1968, the organizational structure at the community level, which must coordinate all the components of the emergency medical services system, must assure citizens...

That they are being provided with the most up-to-date methods of first aid and emergency medical care which can be given by a laymen, an ambulance attendant, a policeman, or a physician.

That the vehicles transporting them will be the best staffed and best equipped attainable.

That emergency communications will assure them timely response when they are ill or injured, both in discovery and in treatment.

And, finally, that the personnel and equipment in their emergency facilities assure them the highest quality medical care.

Several research projects are presently being implemented in attempts to improve communication networks, to study the economic feasibility of helicopters, and to provide special physician teams on the scene of an accident.

Other critical questions already being investigated in other countries and in several American institutions concern survival periods and mortality rates for different kinds of injuries; mortality rate correlations with early or late therapy, misdiagnosis, and surgical versus conservative therapy; feasibility of telemetry, advanced communications, and TV applications during treatment; and delay-minimization techniques.

A number of other questions exist, to which trauma surgeons are frequently asked to give answers based only on observations and without the necessary statistical validaity. Some of these will develop into the main objectives of this program:

(a) What are the most frequent causes of death?

(b) How do injury patterns correlate with the ultimate cause of death?

(c) What are the probabilities of survival given the condition that injury was sustained in a given environment (site, time, therapy, etc.)?

(d) What are the clinical parameters whose measurements can be used as indicators for certain irreversible conditions?

(e) What are the real-time sequences of systemic changes in the human body, given the condition that injury was sustained?

(f) What are the best methods for diagnosis, prevention, and therapy of serious consequences of injury (such as fat embolism, shock, circulatory deficiencies in the brain, anoxia, etc.)?

1. OBJECTIVES

To develop criteria that allow for methodical evaluation of highway trauma and the whole sequence of events involving the injured patient from post-injury analysis to final recovery.

To reduce the number of accident victims who die as a result of their injuries, even though an early response by a properly equipped ambulance and properly trained attendants could have prevented death.

To reduce the number of cases that suffer death or permanent impairment as a result of actual mismanagement of the patient in the ambulance or in the hospital.

To produce a valid data bank that will permit the establishment of priorities to be employed in the emergency rooms of hospitals. To produce data that will be useful to suggest areas of research for improved diagnostic techniques in the trauma receiving hospital and for initial treatment.

2. RESEARCH AREAS

Autopsy records
Operating room records, medical records, laboratory data
Emergency room diagnosis and evaluation of ambulance service
Ambulance records (first aid and time elements)
The organization of injury records

3. RESEARCH TECHNIQUES

Knowledge of the morbidity process following highway injury will be gained by means of studies and data collection at accident scenes, in ambulances, and at hospitals. A very detailed reporting procedure must be devised in each of these areas to provide consistent data among various agencies.

A properly structured training program for improving paramedical attention at the scene of the accident and during transportation can develop after (1) autopsy data have statistically validated the claims that are presently made by many isolated trauma researchers, and (2) interactions among injury, body defense mechanisms, and systemic deterioration are established. Current beliefs about what is important in ambulance attendant training programs can be proved or disproved from the results of applying new paramedical techniques. The expectation is that there will be a change in the relationships between various observation vectors after these techniques are applied.

4. SUBPROJECTS

(1) To determine the elements of care at the scene of an accident and during transportation that will assure the victim an increased probability of survival, a reduction in morbidity of his injuries, or both.
To accomplish this it will be required to record the description of the injury, of the early care given by ambulance personnel, the delays involved in getting the patient to definitive medical care, the emergency room diagnosis and treatment, surgical procedures, and the causes of death.

(2) As a result of the frequency distribution of the data collected in subproject (1), it is possible to plan new ambulance services, emergency room facilities, and trauma centers in order to optimize therapy at each of the stages of the recovery and to minimize the respective time delays.

(3) A special research team, working in the emergency rooms of the trauma receiving hospitals, would take blood samples, conduct laboratory tests for blood gases and pH spirometer readings, measures of cardiac output by the dye dilution technique, serial electrocardiograms, and blood volumes measured through the isotope technique. This research unit would have several objectives:

a. To feed back useful information regarding the adequacy of the types of resuscitation that the rescue workers have provided.

b. To gather the biological data about the effects of injury on the physiology and metabolism of the injured patient.

c. To study specific injuries regarding their mechanism and physiologic and metabolic consequences with regard to gaining a better understanding of these problems in order that new and better methods of treatment might be instituted.

(4) A special demonstration project and implementation activity will make use, on a continuous basis, of the highly trained and experienced corpsmen when they return from their tour of duty in Vietnam. Measurement of the

effectiveness of these corpsmen as ambulance attendants will demonstrate some of the new lifesaving techniques currently being deployed in Vietnam.

(5) The findings of the preceding subprojects are then to be applied toward the development of curricula for training courses for ambulance attendants, and special trauma courses for physicians in the medical schools.

(6) A micro- and macroscopic autopsy procudure set up for the specific purposes of this investigation can lead to new autopsy techniques and to an expansion of autopsy research as an adjunct of medical research activities.

5. ORGANIZATION

All preliminary planning, design of experiments, and development of data collection procedures to be carried out at a research institution which is associated with a trauma receiving hospital and a medical school.

Data collection to be carried out in four to six environments that can offer combinations of all types of trauma, detection and communication, transportation of the injured and therapy. These sites to be selected such that a good trauma center and a research-oriented university be located nearby.

Data processing and analysis to be carried out in two phases:

Phase I. At the local level, in each one of the data collection centers, so that an immediate feedback allows for detection of errors, incomplete forms, inadequate approaches.

Phase II. In the data processing facility of the central research organization.

6. MANPOWER

Each of the subcontractors needs a fairly complete team made up of:

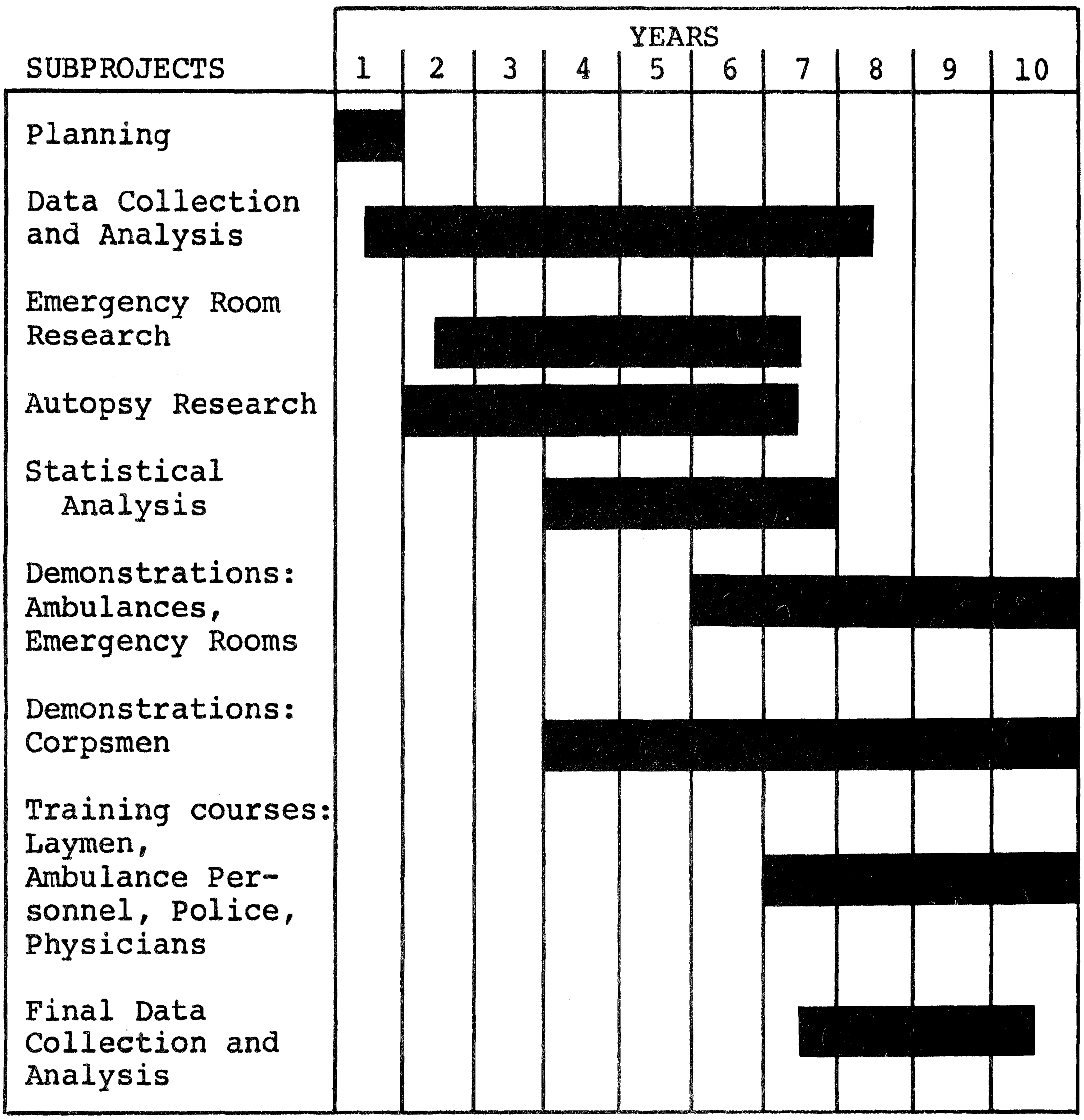
One trauma surgeon (1/4 time)
One pathologist (1/2 time)
One pathology laboratory technician (full time)
One emergency room intern (full time)
One emergency room and laboratory technician (full time)
Data-processing personnel (part time)

In addition, the central organization needs the following:

One chief investigator, preferably a trauma surgeon
(full time)
One pathologist (full time)
One systems analyst (full time)
One communications engineer (1/2 time)

7. SCHEDULING

The schedule over a ten-year period is given in the following chart.



8. COSTS

A. Cost per item:

(a)	Research Cost: uniformly spread over first seven years at about $500,000/yr.	$3,500,000
(b)	Demonstration Cost (subproject 2): ambulance services, communications equipment, $300,000 (year 6), $200,000 (Year 7)	500,000
(c)	Demonstration Cost (subproject 4): in payroll subsidies, equipment, medical supplies, years 4, 5, and 6 at $240,000 per year in 12 ambulances, about 2 in each geographical area.	720,000
(d)	Implementation: Reduced subsidy for corpsmen payroll. Economic analysis to be conducted with higher ambulance charges, better services, 4 years, 12 ambulances, total of $60,000/yr.	240,000
(e)	Training courses for ambulance attendants. Cost for training only at pilot project, $80,000/yr for 4 years. Payroll for new graduates subsidized minimally on basis comparable to corpsmen implementation program. About 10 graduates each year (year 8, $10,000; year 9, $20,000; year 10, $30,000)	60,000
(f)	Data processing and analysis (years 7-10) Final Report	300,000
	TOTAL	$5,640,000

B. Cost per year:

Year	$
1	500,000
2	500,000
3	500,000
4	740,000

Year	$
5	740,000
6	1,040,000
7	840,000
8	250,000
9	260,000
10	270,000
	$5,640,000

6.3 SOCIAL ENVIRONMENT

The theme of this program is "The Influence of the Social Environment and Public Information on Driver Behavior and Highway Safety." A basic hypothesis here is that human behavior in some way reflects human attitudes and that these attitudes may be amenable to modification by means of public information or other influences in the social context.

Another hypothesis to be considered is that driving behavior is strongly governed by the influences of our social and public institutions, and that one way of improving drivers is to restructure the institutions. In this context, many traditionally accepted institutional roles may have to be very seriously questioned. For instance, the role of current police practices in traffic law enforcement is now considered by many as completely ineffectual, and the next step may be to reconsider the desirability of traffic policing of any sort. Although the alternatives are not yet clear, some method of automatic traffic law enforcement now appears to be feasible. While the time may not be quite ripe for this king of change, it is important that some creative thinking along these lines be supported. In the future, research on the effects of the social environment may become a prime approach in the highway safety field.

1. OBJECTIVES

To gain insight into the influence of the social environment on the driver

To determine effects of an individual's social behavior on his driving behavior

To determine potential ways of modifying driving behavior through the social environment

To determine changes in the social environment which may help to improve driving behavior

To determine ways in which public information techniques can influence driving behavior

2. RESEARCH AREAS

Characteristics of social groups and influences which affect humans, directly or indirectly, in their roles as drivers.

Factors in social behavior which influence driving behavior

Changes in social behavior which might influence driving behavior

Changes in social groups and influences which might positively influence social behavior and driving behavior (via attitudes and motivations)

Ways of exploiting social groups and influences to modify social behavior and driving behavior

Aspects and techniques of public information which are most effective in governing behavior (social and driving)

3. RESEARCH TECHNIQUES

Surveys of group attitudes and motivations

In-depth interviews of attitudes and motivations

Experimental testing of social attitudes and motivations

Experimental testing of driving attitudes and motivations

Experimental testing of driving behavior

Correlational studies of social and driving behavior

Experimental studies of effects of changes in social groups upon social behavior and driving behavior

Test effectiveness of various kinds of public information media in terms of social behavior and driving behavior

Test effectiveness of various kinds of public information messages in terms of social and driving behavior

Conduct demonstration studies of promising group techniques and evaluate them

4. SUBPROJECTS

(1) Attitudes and Motivations

(2) Social vs Driving Behavior

(3) Group Interaction Effects

(4) Attitude-Behavior Correlations

(5) Social Changes and Effects

(6) Public Information and Effects

(7) Demonstration and Evaluation

5. ORGANIZATION

One large program organization would be appropriate, with liberal use of consultants and a few subcontracts. Either a university research institute or a non-profit research company would have to be the parent organization in order to attract the required professional staff.

6. MANPOWER

The total professional manpower requirement is 248 man years. The special research qualifications required are in psychology, sociology, system analysis, public information and media, data processing and statistics.

7.-8. SCHEDULE AND COST

Man-years of professional manpower are distrubed over a 10-year period as indicated. The subprojects are highly interrelated, and therefore are conducted simultaneously.

SUBPROJECTS	YEAR									
	1	2	3	4	5	6	7	8	9	10
Planning, Coordination	8	2	2	2	2	2	2	2	2	6
Attitudes, Motivation	5	5	3	2		4	2	2		
Social/Driving Behavior	5	5	3	2		4	2	2		
Group Effects		8	8	5	4	2	4	2		
Attitude/Behavior Correlations			6	6	4	2	4	2		
Social Changes		5	5	4	4		4	2	2	
Public Information		5	5	4	4		4	2	2	
Demonstration				5	10	12	6	12	12	6
Total Man Years	18	30	32	30	28	24	28	26	18	12
Cost in thousands of dollars	540	900	960	900	840	780	840	780	540	360

Total cost: $7,440,000.

6.4 THE DRIVING PROCESS

The theme of this program is "Basic Understanding of the Driving Process." This includes a taxonomy of all the driving tasks and their relationships, skill requirements, and interfaces between the driver and the vehicle.

1. OBJECTIVES

To derive detailed knowledge of all the requirements, mechanics, relationships, sequences, and outcomes of the complete set of possible driving tasks for all types of traffic situations.

To determine levels of performance of the driving population with respect to the systematized driving process.

To determine methods for modifying performance in the driving process.

2. RESEARCH AREAS

The main reaseach areas are: (1) investigation of driving requirements, (2) investigation of driving skills; (3) investigation of driver-vehicle interfaces; (4) investigation of sensory processes in driving, (5) investigation of driving task performance, (6) investigation of vehicle path characteristics, (7) investigation of vehicle controls improvements, (8) investigation of sensory aids and decision-making aids.

3. RESEARCH TECHNIQUES

Techniques include: predictive modelling, driving process observations, simulator studies, driver interviews.

4. SUBPROJECTS

The basic subprojects will correspond to the research areas above. In addition, studies will be added as needed under various subprojects, viz.

(1) Study of the alcohol-driver-environment relationship from the behavioral aspect.

(2) Research on sensory physiology and psychology.

(3) Research on motor-reflex behavior in driving.

(4) Operator-vehicle-road interrelationships systems analysis.

(5) Accident research with respect to component design, performance error in driving, external factors.

5. ORGANIZATION

A small, central research organization would coordinate the program at a university or research company. The central group would plan, coordinate, and administer a series of contracts of three different types.

The first type of contract would be small in magnitude, and would support individual research subprojects at universities or foundations over the first five years. These studies would investigate the fundamental concepts of driving skills, sensory processes, and interfaces. Five studies would be funded initially on an annual basis, subject to renewal.

The second type of contract would be the same magnitude as all individual subprojects combined. Contractors would be at other universities or research firms. Each contract would last for three years, and would be in a sequence of three such contracts over 9 years. These studies would correspond to the three phases of the total program: problem definition and analysis, experimentation, and evaluation

The third type of contract would be the same yearly magnitude as the second, but would cover the entire 9 year period, subject to periodic renewal. This study would draw on the work of the other two types, and would fill the voids in the program in order to maintain uniform progress. This study would be subcontracted, or performed by the central research organization if desired.

6. MANPOWER

The individual research projects of type 1 would each depend upon the direction of a single expert in driver psychology or system engineering. A typical team would be the project director (a research professor, half time), a full time research associate, and several graduate students doing thesis research.

Both the three-year and nine-year projects would have multidisciplinary research teams of approximately ten psychologists, system engineers, and data analysts.

7.-8. SCHEDULE AND COSTS

The chart indicates the distribution of programs cost according to subproject scheduling. The total cost over nine years would be $9,525,000.

	YEAR								
SUBPROJECTS	1	2	3	4	5	6	7	8	9
Planning Administration	100	100	100	100	100	100	100	100	100
Type 1	75	75	75	75	75				
	75	75	75	75	75				
	75	75	75	75	75				
	75	75	75	75	75				
	75	75	75	75	75				
Type 2	375	375	375	375	375	375	375	375	375
Type 3	375	375	375	375	375	375	375	375	375
Total in thousands of dollars	1225	1225	1225	1225	1225	850	850	850	850

6.5 RISK TAKING

The theme of this program is "Risk taking in Driving Behavior." An underlying assumption is that risk is involved in almost all driving decisions, and that there are ways to discourage risk-taking. The four objectives have one focus: to create measurable and applicable parameters of "dangerous driving." This qualitative classification of a driver can be useful only when it is measured with respect to known roadway and traffic hazards.

While it is possible that risk taking behavior of drivers may be modified, a contrasting theory--focussing on the overriding role of fate imposed by the traffic system--should also be considered. The notion here is that risks are imposed by the system, rather than being self-generated by the driver. Research should be directed at both concepts. However, in either case the approach of differentiating between high-risk and low-risk drivers can be used.

1. OBJECTIVES

Risk response index: To develop a risk response index which can be used to measure the driver's risk behavior in hazardous driving situations. If the hazard in a situation increases, the driver's risk response index should simultaneously increase.

Situational risk: To define situational risk to be used in constructing and presenting hazardous situations to samples of driver populations for the purpose of deriving a valid risk response index. The situational risk will then be used for the purpose of discriminating between different driver populations on the basis of how their risk response index varies with the risk value of the situation. The risk value will be a number assigned to a hazardous situation.

Risk diagnosis: To identify the high risk driver for rating purposes when he applies for insurance, for an operator's license, and in other circumstances when his fitness for driving must be evaluated. Diagnosis of his driving on a risk scale will pinpoint deficiencies that might be related to training or to more idiosyncratic driver variables.

Countermeasures for risky driving: This objective depends upon deriving appropriate risk response measures for the risk response index. These measures may be used for detection and analysis of those driving behaviors that must be modified to change the risk response index to acceptable levels in risk situations. Rational bases for remedial measures will be provided by a functional analysis of driving behavior that occurs in situations where the degree of hazard can be measured.

2.-3. RESEARCH AREAS AND TECHNIQUES

When a driver's risk response index varies directly with the situational risk the driver is a low-risk driver; otherwise he is a high-risk driver. The assumption here is that the low-risk driver will take into account high-risk situational cues whereas the high-risk driver either does not see risk cues or sees them and makes inappropriate decisions.

Some of the critical questions to be asked in this program are as follows:

Are low-claim drivers also low-risk drivers?

Are there measurable behaviors which differ for the low-claim driver population with respect to the high-claim driver population?

Can the driving behavior of the high-risk driver be modified such that his accident history changes toward that of the low-risk driver and his risk response index decreases accordingly?

Can the risk index be used for determining the potential claim rate of the driver who applies for insurance?

Can an individual driver's high-risk response index be useful for determining what must be modified through appropriate training?

What are the variables which will be used when selecting the driver test samples?

Using some of these questions as basis, techniques will include individual driving simulation studies, studies of insurance claims files, collecting of accident statistics for deriving situational risk, determining response patterns to risk, and remedial training procedures for high-risk drivers.

4. SUBPROJECTS

The subprojects, which correspond to the research objectives, are:

(1) Risk Response Index: This may be a function dependent upon physiological indicators (e.g. heart rate), perception scanning rate, and other response systems.

These systems must be explored as possible inputs for a reliable index. Current methodologies exist for measuring these response systems, therefore no new basic research in such techniques need be developed.

(2a) Construction of the Risk Situation: One possible approach to this task would depend on empirical determination of the traffic and roadway conditions which give high accident rates. An accident file data search might be useful in validating the simulated risk situations. Risk properties abstracted from high-accident-frequency situations would then be used to construct the simulated risk situations.

(2b) Risk Situations Simulation: This may be carried out through motion picture techniques, which may also include additional stereo, mechanical, and auditory cues.

(3) Risk Diagnosis: Once the risk response index has been obtained, longitudinal studies of, for example, newly licensed drivers, will further validate the index as a reliable predictor of future driving behavior.

(4) Countermeasures: Remedial training procedures which reduce the risk response index should also be tested against future driving performance, traffic violation records, and insurance claims of the re-trained drivers.

5. ORGANIZATION

Because of the continuity of the research, most of it should be done in the same research organization, either at a university institute, a psychology department, or a small research firm with access to a data processing facility. The remedial driver training demonstrations might be done by the insurance industry directly.

7.-8. SCHEDULE AND COST

The professional manpower would be distributed according to the following schedule. The total cost would be $5,940,000.

SUBPROJECT	YEAR 1	2	3	4	5	6	7	8	9	10
Planning Coordination	10	6	4	4	4	4	4	4	4	4
Risk Response Index	4	10	8	4						
Situational Risk			8	10	8	4				
Risk Diagnosis				6	10	10	2			
Countermeasures					4	10	14	14	10	10
Total Man Years	14	20	20	26	26	20	18	18	14	14
Cost in thousands of dollars	420	600	600	780	780	780	600	540	420	420

6.6 LEGAL SANCTIONS

The theme of this program is "The Role of Legal Sanctions in Highway Safety." In particular, the interest is directed at the effects of the awareness of sanctions on drivers' attitudes and behavior.

1. OBJECTIVES

To develop basic knowledge of legal sanctions and social controls for the purpose of regulating behavior related to highway safety.

To develop basic understanding of the institutions employing the sanctions and social controls.

To use this knowledge for benefits to society in terms of better regulation of driver behavior.

To present suggestions for change in institutions employing sanctions and controls.

To continually reassess the system of sanctions and social controls.

2. RESEARCH AREAS

To determine descriptions of basic sanctions and institutions employing the sanctions.

To determine attitudes of law enforcement officials and judicial and administrative officials toward the application of sanctions.

To determine knowledge and attitudes of the general public toward sanctions

To determine effectiveness of sanctions

To determine the effect of changes in parameters related to highway safety due to changes in social sanctions.

3. RESEARCH TECHNIQUES

Legal research

Surveys of enforcement attitudes and sanction attitudes

Testing and analysis of sanction effectiveness.

Demonstration projects, data collection, and evaluation.

4. SUBPROJECTS

The subprojects will correspond to the five research areas, as follows:

(1) Investigations of existing sanctions and institutions.

(2) Investigations of official attitudes:

   (a) Law enforcement

   (b) Judicial

   (c) Administrative

(3) Investigations of public attitudes and potential changes

   (a) Existing attitudes

   (b) Desired attitudes

   (c) Methods of changing attitudes

(4) Investigations of changes in sanctions

(5) Evaluations of sanction effectiveness

Subprojects 4 and 5 would encompass demonstration projects.

5. ORGANIZATION

The program would be directed from a central organization in a university law school. A prestigious advisory committee would be formed from a select group of law experts concerned with sanctions and highway safety on the national scene. While much of the work would be done at the central organization, another large share would be done at various universities centered around distinguished professorial chairs in law and sociology. Grants and subcontracts would also provide some of the subproject support.

6.-7. SCHEDULE AND PROFESSIONAL MANPOWER

This chart indicates the number of man years scheduled for each subproject over the total program period of 10 years.

	YEAR									
SUBPROJECTS	1	2	3	4	5	6	7	8	9	10
Central Administration	5	5	5	5	5	5	5	5	5	5
Existing Sanctions	12	12	12	5						
Official Attitudes		5	5	5	5					
Public Attitudes		5	5	5	5					
Changes in Sanctions				8	10	10	10	10	5	
Evaluations						5	5	5	10	10
Total man years	17	27	27	28	25	20	20	20	20	15

8. COSTS

Costs are given below in thousands of dollars for each of the 10 years. The total cost is $6,550,000.

ITEM	YEAR 1	2	3	4	5	6	7	8	9	10
Central Administration	150	150	150	150	150	150	150	150	150	150
Central Project	250	300	300	300	300	200	200	200	200	200
Chairs		100	100	150	200	200	200	200	100	100
Contracts		200	200	200	100	100	100	100	200	50
Total	400	750	750	800	750	650	650	650	650	500

6.7 IMPLEMENTATION EVALUATIONS

The theme of this program is "Methods of Evaluating Highway Safety Implementation Programs." In this context, implementation programs are the coordinated actions which are taken to apply highway safety research findings to real-world situations, primarily through government agencies. The need for methods of evaluating implementation programs has been a glaring weakness in highway safety for many years. Though national standards are now established, the need for precise evaluation methods still exists.

The intention in this program is to investigate the broad question of evaluation methods. However, it should be noted that the approach must be related to specific implementation areas.

1. OBJECTIVES

The general objective is to develop methods for evaluating highway safety implementation programs, and the specific objectives are as follows:

To develop criteria for evaluating implementation program effectiveness.

To determine interdependencies of programs in reducing highway losses.

To determine contributions of certain existing programs in reductions of losses.

To develop criteria for measuring state and local compliance with federal standards.

To develop criteria for comparing effectiveness of state and local programs.

To determine the relative safety environments of various states and localities.

To develop indices for measuring the national highway safety environment.

2. RESEARCH AREAS

What observable and measurable factors concerning safety program effects on accident rates have been overlooked?

What minimum data must accident reports contain and how can complete and accurate accident reporting be achieved?

What long range, continuing effects has driver education on the driving public?

How do rigid driver licensing standards affect driver attitudes and performance?

How do vehicle inspections affect the accident rate?

How do traffic court punishments and imposed driver improvement courses affect the accident rate?

What ratio of law enforcement agencies versus population and environment ensures full adherence to traffic laws?

What benefit-cost methodologies realistically measure highway safety programs?

How much and in what way is the driving public influenced by a given highway safety information program?

What percent in accident reductions should be expected of a given program or standard?

What is a reasonable accident and survival rate in a given traffic environment?

What are the components of a valid highway safety index?

3. RESEARCH TECHNIQUES

Select an environment which assures overall administrative, police, and legal cooperation (e.g., a county containing elements of all social, economic, and geographic factors), and develop a demonstration project as a field laboratory.

Conduct performance and attitude surveys.

Implement highway safety programs for observation and measurement, using investigating teams, traffic counters, photo and TV cameras, computers, etc.

With local enforcement agencies, investigate accidents.

Correlate findings with official accident reports and driver, police, traffic court, and insurance company records.

Make analyses, predictions, follow-ups, feedbacks.

Synthesize findings.

4. SUBPROJECTS

(1) Observe and measure the existing environment.

(2) Identify pertinent environmental variables such as road mileage, population, vehicle population, vehicle types and vintages; economic, social, and educational levels; and industrial development. Assess or weight such variables.

(3) Select highway safety variables such as driver education, status of vehicle maintenance, road conditions, traffic controls, law enforcement, sanctions, driver licensing and vehicle registration requirements, public information programs, and safety programs. Assess or weight such variables.

(4) Select programs for implementation and measurement.

(5) Analyze and test findings.

(6) Select control areas or communities for comparison of findings.

(7) Synthesize accumulated research results into hand books for implementation by practitioners.

5. ORGANIZATION

The span of disciplines involved, the cooperation and coordination required among researchers and governmental agencies, and the resources required in professional and technical personnel, documentation, library facilities, laboratory tools, computers, reproduction facilities, etc. automatically indicate the need for a broad, interdisciplinary approach. Therefore, a large interdisciplinary research institute, preferable one associated with a well-endowed university, is deemed the most appropriate organization for such an undertaking.

6. MANPOWER

(a) Program Director and eight Project Leaders in Motor Vehicle Administration, Driver Education, Engineering, Accident Records, Public Information, Medical Care and Alcohol, Laws and Courts, Police Traffic Supervision

(b) Up to 24 research engineers, scientists, and analysts.

(c) About 10 field investigators divided into teams

(d) An average of 10 outside consultants per year. Approximately 40 professional personnel, on the average, are required during the peak years of the program. During the first year and the last four years, the number would be about 30.

7. SCHEDULE

Organization and Planning (the first half year): Assemble key personnel; select laboratory site; coordinate arrangements; analyse and measure; site environment; select tentative test projects.

Operation Preparation (the second half year): Test and verify environmental findings; make hourly, daily, seasonal, situational comparison measurements of traffic volumes, speeds, peaks, origins-destinations, etc; check efficiency of procedures, e.g., accident reporting, police and field team response to traffic situations, etc.; design experimental safety indices; analyse and compare written standards.

Experimental Test Projects (the second year): Implement one or two simple projects; refine concepts, theories; verify reporting and data gathering techniques; develop effectiveness indices of highway safety projects; refine indices; evaluate selected safety standards.

Expansion of Tests and Evaluations (the third year): Implement an evaluation program; develop evaluation criteria; testing of trial indices, refinement; continue evaluation of safety standards.

General Evaluation Program (the fourth through tenth years): Evaluate all implemented highway safety programs; Evaluate proposed programs; continue evaluation of developed safety standards; continue development of safety program indices; develop community and regional highway safety indices; develop national highway safety index.

9. COSTS

During year 1, and years 7-10: $920,000 per year

During years 2-6: $1,120,000 per year

Total Cost: About $10,200,000.

6.8 DAMAGE LOSSES

The theme of this program is "Reduction in Losses due to Vehicle Damage." According to the NSC, the national repair bill for vehicle damage was 2.8 billion dollars in 1964. Insurance Facts (1967) states that the average vehicle property damage paid claim in 1966 was $221, while the typical repair bill was slightly higher ($235.) There are two basic ways to reduce vehicle damage losses: to find ways to minimize resulting damage and to reduce costs of repair once the damage occurs.

One very important tradeoff must be considered in attempts to minimize collision damage. On the one hand, it may be possible to develop vehicle components which have minimum susceptibility to collision damage. On the other hand, these very same components may not be compatible with other independent attempts to minimize occupant injuries by the use of crushable components for absorbing shock. Although the problem of occupant injury is very important, it is not encompassed within this program.

1. OBJECTIVES

To determine ways of minimizing the damage to motor vehicles involved in accidents.

To determine ways of improving repair practices.

To determine ways of minimizing the costs of repair.

To determine the possible effect of motor vehicle inspection on reducing losses due to vehicle damage.

2. RESEARCH AREAS

Study and comparison of damage mechanisms of body, structure, and other components under impact.

Study of damage reduction by new designs and materials.

Determination of a rating system for damage potential of various vehicles

Determination of ways of influencing changes in high-damage, patented designs.

Determine high-cost areas of repair.

Determine new, cheaper repair methods (automated, modular).

Determine if inspection leads to reduced damage in accidents.

3. RESEARCH TECHNIQUES

Study of wrecked vehicles.

Laboratory impact tests.

Manufacturer interviews.

Comparative loss models.

Repair industry interviews and visits to facilities.

Studies of repair methods and special designs.

Economic analysis.

Surveys and data analysis of inspection effects.

4. SUBPROJECTS

(1) Component Damage Analysis:

Study wrecked vehicles to determine resultant damage to body and structural components.

Conduct laboratory impact tests on components to categorize damage characteristics.

Evaluate resultant damage to comparative components.

Evaluate manner in which components might be redesigned to reduce damage.

(2) Damage Rating System:

Develop rating system of components based on results of damage study and data from insurance company files.

Develop and establish program by which component rating information is fed back to manufacturers to induce them to make design improvements.

(3) Repair Method Analysis:

Review garage repair methods and practices and recommend improved techniques based on new components design and economical procedures.
(Travelers Research Center has been involved in this approach).

(4) PMVI Effects

Determine what relationship exists between motor vehicle inspection and accidents.

Determine if vehicles subject to inspection have reduced damage repair costs.

Determine insurance benefits of requiring vehicle inspection prior to the issuance of insurance and immediately following any crash damage repairs.

Determine owner maintenance attitudes and methods the insurance industry might use to promote better maintenance.

5. ORGANIZATION

This program would be coordinated by a small staff in a consulting firm or research organization. The subprojects would be handled by separate contracts. The component testing work should be accomplished by research testing laboratories and engineering consulting firms. The rating system study should be handled by a consulting firm having considerable experience in design and manufacturing. Consulting firms well experienced in systems, processes and management should conduct the repair analysis and inspection subprojects. Professional manpower would be largely mechanical engineers, system engineers, and data analysts, with support from laboratory technicians and mechanics.

6.-8. MANPOWER, SCHEDULING, COST

The schedule is given in terms of professional manpower requirements for the subprojects over an 8-year period. The total cost is $5,200,000.

SUBPROJECT	YEAR 1	2	3	4	5	6	7	8
Coodination	5	5	5	5	5	5	4	4
Component Damage	3	5	4	3	3	3		
Damage Rating	2	6	6	4	3	3		
Repair Methods		2	6	6	6	4	4	
Inspection Effects			2	6	6	4	4	4
Total man years	10	18	23	24	23	19	12	8
Cost in thousands of dollars	400	800	1000	1000	800	600	350	250

6.9 ALCOHOL MISUSE

The theme of this program is the "Reduction of the Role of Alcohol Misuse in Traffic Accidents." Statistics show clearly that the consumption of alcoholic beverages by drivers has a very high correlation with accident involvement, especially in fatal accidents. However, in spite of much work, the precise role of alcohol in this correlation is still not known. If this role could be identified and alleviated, the payoff in saving lives, suffering and dollars would be exceptionally high.

1. OBJECTIVES

To determine the frequency of occurrence of alcohol misuse in highway accidents, especially in non-fatal accidents.

To determine the role of alcohol misuse in accident causation.

To determine ways in which the role of alcohol in traffic accidents could be diminished.

2.-3. RESEARCH AREAS AND TECHNIQUES

Develop and use methods for screening out problem drinking drivers.

Develop and use diagnostic methods for diagnosing alcoholism.

Develop and use treatements for rehabilitating problem drinkers.

Study the effectiveness of the treatments and of traditional controls such as legal sanctions.

Develop base-line data for measuring the significance of the problem locally; this will involve obtaining blood-alcohol concentration data on fatally injured and surviving drivers involved in atuomobile crashes.

Develop methods for measuring the public's knowledge of the problem.

Develop methods for disseminating appropriate information to all the driving population.

Develop legally and socially acceptable methods and procedures for conducting research in very sensitive areas involving the right to be personally free of harassment.

Research and demonstration projects will be concentrated in a single localized geographic area. The principal goal will be to demonstrate the effectiveness of full implementation of countermeasures so as to improve their acceptance nationwide while at the same time extending research into little understood areas such as the place of social drinking in automobile crashes. The National Highway Safety Bureau's proposed project on alcohol and highway safety will complement the effort.

4. SUBPROJECTS

The following four subprojects would be conducted simultaneously over about 8 years of the 10 year program.

(1) Problem people subproject:

(a) Screening: locating suspected problem drinking drivers

(b) Diagnoses: Examining the suspects to confirm or dismiss the results of screening

(c) Treatment and rehabilitation

(2) Crash investigation subproject

(a) Measure blood-alcohol concentrations in the fatally injured.

(b) Measure blood-alcohol concentrations in surviving drivers who come under implied consent compulsion.

(c) Measure blood-alcohol concentrations in surviving drivers who are not under legal compulsion but who volunteer upon request.

(3) Public information subproject

(4) Evaluation subproject

5. ORGANIZATION

The basic organization should be centralized at a university or research firm. In addition, self-contained research units should be established at the geographical locations of the subprojects, and they should have a demonstrated expertise in social or alcoholism research. The subproject efforts will entail major participation and cooperation with local law enforcement authorities; courts; social service institutions; medical institutions; and private treatment facilities.

6. MANPOWER

A total of 122 man years is required. Professional personnel should have research qualifications in medicine, physiology, psychology, psychiatry, and data analysis.

7. SCHEDULE

	YEAR									
PHASE	1	2	3	4	5	6	7	8	9	10
Planning	10	3								
Collecting Base-Line data		9	9							
Subproject initiation			5	10						
Experimentation and analysis				4	14	14	14	10		
Combined evaluation									10	4
Reporting										3
Re-assessment										3
Total man months	10	12	14	14	14	14	14	10	10	10

8. COSTS

The average cost per year will be about $400,000, and the total cost will be about $4,000,000.

6.10 ROADWAY OBJECTS

The theme of this program is "Optimum Location and Design of Fixed Roadside Objects." It is a problem which has not been studied in depth as yet, even though its critically is growing. On limited-access divided highways in Michigan where the conflicts in opposing streams of traffic have largely been removed, single-vehicle accidents are over 50% of the total. Of these, 66% result in collision with a guardrail, sign pole, utility pole, ditch, slopes, delineator, road curb, tree, fencing, bridge pier or other fixed object within the road cross-section.

1. OBJECTIVES

Achieve an understanding of reasons for vehicles going off the road in the vicinity of roadside objects, and the impact forces involved in collisions with these objects.

Determine methods for delineating roads and evolving warning systems so that drivers may be especially careful when roadside objects present hazards.

Determine strategies and rationale to justify removing nonyielding objects from the possible path of vehicles going off the road or into median areas, or buffering such objects with deflecting rails, etc.

Determine methods for reducing the extent of property damage in case the vehicle gets off the road and hits a fixed object.

Determine an optimum offset of fixed objects and minimum flat areas for vehicles going off the road to recover without collision.

Determine optimum slopes for roadside embankments and ditches to ensure the stability and safe recovery of vehicles going off the road.

To reorient the thinking of highway engineers toward limiting structural elements within the paved and unpaved roadway width to those which create minimum damage due to vehicle impact.

Even though a special AASHO committee in 1967 recommended an intensive program to remove roadside hazards and to improve roadsides of new roads, little has been done. Though there is an awakening to the problem, there is no coordinated activity at the federal level. Some research has been done at General Motors to suggest minimum distances from the pavement edges which must be kept clear, but it is only preliminary and quite narrow in scope. The studies proposed here aim to understand the problem of vehicles getting off the road or left of center, the hazards of objects or steep slopes on the roadside; to suggest remedies therof, to implement the recommendations in selected study areas across the country, and evaluate the results in accident involvement.

2. RESEARCH AREAS

Review past and current research in optimum offset of fixed objects from the road edge; design and location of guard rails; design of supporting structures for signs, lighting, and signals; uses of roadside curbs, delineators, and barricades; and delineation of driving lanes, shoulders, exits, entrances, forbidden areas, cross-walks, and stop lines.

Prepare an inventory of existing cross-sections of various types of roads, and actual locations of fixed objects thereon.

Evaluate impact forces on collision with nonyielding objects, and establish a rating scale as a measure of collapsing force with reference to the type of object and vehicle speeds.

Conduct applied research on yielding materials for the construction of support structures for signs, lights, billboards, or beautification material.

Study the trajectories of vehicles running off the road at various speeds under different light and weather environments. Evaluate the chances of a vehicle returning to its original path or stopping without overturning.

Determine driver requirements for steering and confining the vehicle within the boundaries of a defined lane.

Invent suitable materials and devices, either active or passive, so as to be of aid, in all light and weather conditions especially at night and in snowy weather.

Investigate the maximum steepness of slopes for ditches or embankments for roadway or median areas so that vehicles do not overturn.

Determine the minimum clearances of piers of overpass bridge structures or bridge-curb railings.

Evaluate potential implementation by means of demonstrations of the findings in the preceding areas. This will involve establishing a permanent accident data collection and data from selected study areas throughout the country.

3. RESEARCH TECHNIQUES

Simulations of vehicle trajectories while leaving the road at various speeds.

Testing of instrumented vehicles in collision with roadside hazards under simulated conditions on test roads, measuring of impact forces.

Modelling of collision concepts of vehicles and dynamics on very steep slopes or soft slippery ground.

Design of yielding type support structures in a material testing lab with different types of materials, alone or in combination.

Testing of yielding support structures in collision with vehicles on test roads.

Field testing of demonstration projects.

Computer analysis of accident data before and after making changes.

Comparison of costs of damages to vehicles before and after changes.

4. SUBPROJECTS

The subprojects correspond to the ten research areas above, and the brief titles in the schedule.

5. ORGANIZATION

Because of the sequential nature of many of the subprojects, it would be possible to handle the program by a series of contracts to different organizations. However, the demonstration projects in the last few years should have some continuity with their predecessor subprojects. To provide this, it is recommended that the program be based in a single coordinating organization for the 10-year period, but that many subcontracts be awarded and coordinated by the central organization. This organization could be at a university, a research firm, or a state highway department. Even though the work deals primarily with the roadway, there is a large amount of interdisciplinary work to be done. Thus, a multidisciplinary institute at a university would be most easily able to form the required staff team. On the other hand, several of the subcontracts should be awarded to non-profit research firms which have the appropriate experience in applied research areas.

6. MANPOWER

A total of 177 man years of professional manpower is required, with emphasis on highway engineering, vehicle engineering, system engineering, simulation, and data analysis.

7.-8. SCHEDULE AND COST

The professional manpower will be assigned to the various subprojects over a 10-year period according to the schedule below.

SUBPROJECT	YEAR 1	2	3	4	5	6	7	8	9	10
Planning Coordination	4	3	3	3	3	3	2	2	2	2
Review	6	3								
Inventory	4	3								
Impact Forces		5	5							
Yielding Material			2	6	4					
Vehicle Trajectories			4	4						
Driver Requirements				5	4	3				
Delineation Materials				2	5	4	1			
Slopes				2	4	3				
Clearances					3	5	1			
Demonstrations					2	10	15	14	10	10
Total Man Years	14	14	14	22	25	28	19	16	12	12
Cost in thousands of dollars	420	420	420	660	750	900	700	600	380	360

The total cost is $5,610,000.

6.11 IMPROVED METHODS OF DRIVER EDUCATION

This alternative program plan covers two new approaches to driver education: one involves driving skills instruction and practice for both school children and advanced drivers, and the other is a systems approach to driver education. The first approach was developed by Dr. George Briggs of Ohio State University and the second by Dr. Frazier Damron of the University of Wisconsin.

1. OBJECTIVES

To determine the influence of early skill training on driving performance

To determine the influence of early skill training and driving familiarity experience on driving attitudes.

To determine the influence of more advanced skill training prior to driver licensing.

To determine the advantages of more skill training over longer periods in conventional driver education programs.

To determine the influence of advanced skills training during periods following initial driver licensing.

To determine what things a person must learn by means of driver education.

To determine what elements of driver education instruction, curriculum, and learning are most effective.

To determine the required inter-relationship among the instruction, curriculum and learning.

2. RESEARCH AREAS

The research areas in the driver education program bear a direct correspondence to the objectives. In one part of the program the emphasis is almost entirely on driving skills, though some research would cover the transfer of skills training and basic familiarization into driving attitudes. The second part of the program would cover a wide variety of driver education factors in a very systematic way.

3. SUBPROJECTS

The first part of the program on driving skills would be divided into four subprojects, as follows:

(1) Grade School Driving Skills: This is concerned primarily with learning the rules of the road in a miniature road system with pedal-cars or perhaps slow battery-powered cars scaled down to children's size.

(2) Junior High Driving Maneuvers: This would also require a scaled-down replica of a street system. It would allow students to become further familiarized with driving skills and to start practicing difficult maneuvers.

(3) Senior High Driver Education: This would be a conventional driver education course except its classroom portion would be given over a longer time and more hours of actual road experience would be included.

(4) Advanced Skills Training: This would be conducted on a special driving course with facilities for high-speed maneuvers, skidding practice, obstacle avoidance, etc. Special safety provisions would be used.

The second part of the program on driver education system analysis would be divided as follows:

(5) Driver Learning Requirements

(6) Optimum Driver Education Curriculum, Instruction, and Learning Processes.

(7) Driver Education Curriculum, Instruction, and Learning Interrelationships.

4. RESEARCH TECHNIQUES

During the subprojects at the grade school and junior high levels, the driving courses would be established at selected locations, instruction techniques would be developed, and groups of children would be introduced to driving skills. Psychologists would observe the children's behavior in groups and as individuals and interviews would be conducted both before and after the training. Control groups of children not receiving the instruction would also be studied. Resulting data would be analyzed to determine immediate results. Longer range results would be determined in a few years when the first groups at the grade school level reached the junior high level. By the end of a ten-year program, results would also be determined for some groups which had gone all the way through driver education and licensing. Results of the advanced-skills training research (observations and interviews) could also be correlated with initial driver education research.

The techniques used during the driver education system analysis would be development of conceptual models of improved curricula, instruction and leaning processes and their interrelationships, testing of these models by experimental simulation and evaluation of the various alternatives to determine the optimum.

5. ORGANIZATION

The program would require the cooperation of a large public school system and the state motor vehicle administration. A university environment would be best for both parts of the program. An interdisciplinary research organization at a university would be best for the grade school through advanced skills subprojects, while a school of education project organization would be best for the system analysis. The two parts would interact to a small extent, but they would not need to be at the same university.

6. MANPOWER

Most of the researchers in the first part of the program would be psychologists, with a few sociologists, psychiatrists, traffic engineers, automotive engineers, and data analysts.

In the second part would be driver education specialists, psychologists, system analysis engineers, and data analysts.

7. SCHEDULE

	YEARS									
SUBPROJECTS	1	2	3	4	5	6	7	8	9	10
Course Planning	10	10	5	5						
Grade School Skills		8	5	5	5					
Junior High Maneuvers		8	5	5	5					
Senior High Course			8	5	5	5	5			
Advanced Course			8	5	5	10	10	10	10	10
Learning Requirements	10	4	2							
Optimum Driver Ed.		4	4	4	4					
Driver Ed. Interrel.		2	6	6	4					
Total Man Years	20	36	43	35	28	15	15	10	10	10

8. COST

Average $30,000 per year salaries, including overhead. Costs are given in thousands of dollars in the following chart.

ITEM	YEAR 1	2	3	4	5	6	7	8	9	10
Salaries	600	1080	1290	1050	840	450	450	300	300	300
Driving Courses	50	100	200	50	20	20	20	20	20	10
Total	650	1180	1490	1100	860	470	470	320	320	310

Total Cost: $7,170,000.

6.12 PUBLIC POLICY

The theme of this program plan is "Research on Public Policy in Highway Safety." The plan was submitted by the Michigan State University Highway Traffic Safety Center.

1. INTRODUCTION

Public policy decisions on a multitude of problems and issues at federal, state and local levels have to be made, have been made, and are going to be made. The problems resulting in the tremendous highway accident losses require that more be done and better highway safety practices be found and adopted.

Recently skepticism has been voiced repeatedly, and from various quarters, concerning the effectiveness of existing activities which have for many years been considered the means of preventing highway accidents. More frequently it is being said that there is little evidence that driver education, or enforcement, or driver licensing is effective in achieving the preparation or influencing of drivers to be safer vehicle operators.

Unfortunately, criteria and data are lacking, and little bona fide research has been done to evaluate the effectiveness of the existing highway safety activities which have been organized and developed for the most part on a basis of best judgement or logical deduction. There has been much controversy about the best means of achieving highway safety and whether the methods adopted have been good enough in terms of quality and quantity to make any appreciable impact upon the problems underlying highway accidents and casualties.

Many have believed, and repeatedly stated, that the concepts and approaches have been sound, but that far too few resources have been allocated to their implementation to expect large scale favorable results. Much that has been done is admittedly of the "stop," "hold the line" nature. Insufficient attention, resources, and effort have been devoted to refining and improving the traditional highway safety activities.

This situation is attributable to the fact that most highway safety activities involve large expenditures and affect most of the people as drivers and taxpayers. The individual citizen naturally resists highway safety measures which may limit his freedom or require him to do things he does not believe are essential to his own safety. Failing to maintain his vehicle in safe operating condition, failure to use safety belts, and driving after drinking too much are examples of the resistance encountered in getting compliance with long accepted and much publicized highway safety admonitions, and in most instances legal requirements.

The citizens' lack of understanding, unwillingness to comply, resistance to regulation and opposition to supporting the costs of larger scale and more rigorous methods affect the decisions of policy making and administrative officals responsible for laws, financing and the procedures to be followed.

Too often, in the absence of uncontrovertible evidence that a proposed action is essential, the decision has been made to do nothing, to do no more, or not to attempt to improve what is being done for fear the change which might be demonstrated as worthwhile would create problems of voter resistance or legal complications or become too costly.

Before policy makers responsible for laws, standards, procedures, and financing can be expected to act favorably, much better insight must be obtained and greater effort applied to determining what must be done to produce better results. Research of the problems and issues, the cost-benefit relationships, the advantages and disadvantages of alternative concepts and methods must be undertaken. Experiments and demonstrations of the improved or new approaches or methods to test and exhibit the benefits or lack of them, need to be conducted to implement the conclusions and recommendations of the research and gain needed support for measures which may be quite costly, possibly irksome and which may impose further restraints or hardships upon some vehicle owners and drivers. Only in this way can justifiable decisions be made which will achieve a greater degree of highway safety in the most economical manner.

Public policy research and development must address itself to three major questions:

(1) Are there improved or new concepts, policies or pro-

cedures which if adopted will produce significant favorable results in the reduction of accidents and casualties?

(2) What are the problems involved in instituting them and what are the costs? Does the expected reduction justify the expenditures, the restraints, the possible hardships?

(3) Are the changes politically and socially feasible, or can the needed acceptance climate be developed, and if so, how?

2. PUBLIC POLICY RESEARCH DEFINITION

From the foregoing, the following definition of public policy research can be arrived at:

> Public policy research relating to highway safety is the investigation of major issues, problems and questions in regard to the means of achieving the desired public goals of safe, rapid, efficient and economical movement of persons and goods by motor vehicles. It embraces the very wide and important field of organization, management, standards and operation of public and private agencies in the field of highway safety.

Techniques for operations research and management research have been worked out and are well known from industrial and military areas, and these should be applied to highway safety operations and management whenever possible.

Even more important, however, is research on the guiding principles or policies to be followed in achieving the desired goals of public organizations in the field of highway safety. Such research is especially important since there have been few opportunities for analysis, evaluation and reformulation of guiding principles in most public organizations.

The necessity in the past for immediate action in fields such as enforcement, legal approaches and the courts, driver licensing, traffic engineering and regulation, and others, resulted in action programs based for the most part on the best judgment of those involved and the conditions at the time. It is now, however, highly desirable that a new look and evaluation of these programs, their guiding principles and standards be undertaken, as well as the devising and evaluation of possible alternatives since highway safety problems are becoming more and more acute as the number of vehicles, the number of drivers, the miles of highway and the increased capability of vehicles grow.

It is thus of highest importance that exploratory research to point the way to attack such problems and devise possibly better alternative methods of resolving them should be started to substantiate the need and importance of such research and demonstrate the kind of results which can be achieved.

3. MAJOR AREAS OF PUBLIC POLICY RESEARCH IN HIGHWAY SAFETY

Some of the major areas related to highway safety which involve public policy questions, problems and decisions are the following:

(1) The legislative process including laws, codes and regulations

(2) The traffic law enforcement process

(3) The judicial and penalization process

(4) Less formal official persuasion

(5) Driver preparation including initial driver education and periodic subsequent training

(6) Driver licensing

(7) Highway improvements, facilities and services

(8) Traffic operation and control engineering

(9) Vehicle regulation, inspection and licensing

(10) Financing highway transportation--taxes, fees, earmarked funds, appropriate allocation of finance burden, etc.

(11) Vehicle insurance requirements and regulations

(12) Emergency medical services

In each of these subareas slightly different means of carrying out the function to differing levels of fulfillment have developed in different states and communities. There are important questions as to which organization, what kind of organization, and by what approaches the objectives can best be achieved. Further, under what guiding principles can this be done most effectively. Equally important is the assessment of the public's values, desires, and probable acceptance of changes which may involve constraints, regulations, more taxes, etc. as the price of safer motor vehicle travel.

4. TYPES OF PUBLIC POLICY RESEARCH IN HIGHWAY SAFETY

Research on the guiding principles and policies for best achievement of highway safety objectives by public organizations can be of two major types, i.e. theoretical and applied.

In the area of theoretical research, questions of basic philosophy should be considered without the constraint of meeting practical everyday considerations. Thus under theoretical research the whole basis of social relationships and philosophy underlying the need for social control of highways, vehicles, and drivers should be considered. This type of research might result in suggestions of completely new methods which could not be implemented under present conditions.

On the other hand, applied research on public policy and highway safety would consider, contrast, analyze and evaluate not only present procedures but other alternatives which might be developed within the general frame of reference of present conditions. This research would not, however, assume that present policies, standards and procedures must be followed. On the contrary, it would look for better methods of evaluating present activities, and develop and test more promising alternative approaches which would be practical to adopt within the next five or ten years.

The methods to be employed in the theoretical type of research would include theoretical discussion conferences, comparison of different philosophies, analysis of social principles involved, analysis of research findings in related fields, concentrated development of new proposals by theoretical experts, and the like.

Methods which might be used in the applied type of research would include development and use of check lists and questionnaires, interviewing of expert practitioners, development of new indices and methods of measurement, and the like.

Also, among the methods of great importance in the applied type of public policy research should be included experiments and demonstration projects in which are measured the benefits to be derived from improving to the greatest degree possible the quality and quantity of existing practices. Likewise, demonstration projects are needed to measure the effectiveness of new concepts or methods, determine the problems and costs involved and the feasibility of universal application.

In all of these methods a first consideration must be development of criteria, data acquisition, and analysis systems to enable measurement of results and for comparative processes.

Although reconsideration and revamping of the underlying basic principles should not be ignored, the more applied research in which existing principles and concepts are considered in relation to the present problems is recommended as yielding more immediate payoff.

5. TYPES OF RESEARCH PEOPLE

For such research, at least two general types of people should be involved. The first are the technical research people with background in social science and psychological measurement and statistics, and technical research people in areas specially related to each of the subareas. In addition, practitioners knowledgeable in the practical area of concern and its constraints should be involved. Without both types of people, the results of the applied research projects may miss the advantages of known technical developments in the social sciences and methods of measuring human behavior, or on the other hand, overlook certain practical and political constraints and methods of conforming to them or of changing procedures to avoid unfortunate results.

6. EXAMPLES TO ILLUSTRATE MAJOR PUBLIC POLICY RESEARCH AREAS IN HIGHWAY SAFETY

The important areas of public policy research in highway safety are so numerous that research of a continuing nature should be conducted to define them, determine priorities in undertaking them, and design research project proposals. This should be an essential continuing aspect of the plan for public policy research in highway safety.

A few examples are hereinafter provided for possible research of a manageable size to illustrate possible approaches, dimensions and costs of typical projects in the field of public policy research in highway safety. Until the more extensive research recommended in the preceding paragraph provides a better decision making base, it will be impossible to select the most critically needed projects deserving priority. The following examples are offered not as research proposals but as suggestions of types of projects in several of the major areas.

A total program combining several such examples could extend for a period of ten years at a level of about $800,000 per year.

THE ENFORCEMENT PROCESS

Definition of the Area: Police traffic supervision is the process concerned with regulating the safe and expeditious transportation of people and goods from one point to another. Police control of highways, automobiles, and people is intended to facilitate the safe and rapid movement of automobiles and pedestrians.

A Major Question: Should police be involved in enforcing the traffic laws and regluations, or should traffic enforcement be carried out by another agency? If so, of what type?

Study Objective: To ascertain and evaluate those public policies that have any influence over the police enforcement of the traffic laws and regulations and related to traffic safety.

General Methods: Would include research of the literature, personal interviews, demonstration projects on a sampling basis and a committee of outstanding authorities to evaluate findings and make recommendations.

Manpower Estimates: Two researchers, ten professional interviewers, two police personnel, two governmental personnel.

Estimated Costs: $350,000 per year.

Estimated Time: One year, in one state covering all levels of police jurisdiction. Research should be extended to other states on a sampling basis during two additional years.

Expected Results: Resulting data would indicate in what ways police functions and traffic enforcement functions enhance or interfere with each other and also advantages and problems of alternate methods of handling traffic enforcement. These findings would be valuable in allocating manpower and funds for this function.

TRAFFIC ENGINEERING

Definition of Area: Encompasses the use of traffic control devices and regulations to improve street traffic flow and increase safety; the features of street and highway design which relate to traffic operations thereon, and the development of street traffic systems.

A Major Question: Is traffic engineering considered an important function by local government and how is it provided in small communities?

Study Objective: To evaluate the local understanding and attitudes of traffic engineering and highway safety and determine how problems within the sphere of traffic engineering are now being handled. Determine the various means by which smaller communities can obtain better traffic engineering services.

General Methods: A combination of mailed questionnaries and personal interview. These would be used to obtain information on the state of traffic engineering in the small community throughout the country. Opinions of qualified traffic engineers would be obtained.

Manpower Estimates: For a minimum effort, it is estimated that two researchers and supporting staff would be needed.

Estimated Costs: It is estimated that the project would cost $100,000 per year.

Estimated Time: Two years.

Expected Results: From such a project, information would be obtained about what is being done to utilize traffic engineering approaches in smaller localities, what needs to be done, what organizations provide services needed and how local officials and groups may be interested in availing themselves of these services to a greater extent.

THE JUDICIAL PROCESS

Definition of the Area: The judicial process involves the filing of a complaint or an apprehension by an enforcement officer, submission of the issue to a court possessing appropriate jurisdiction, adjudication of the case, and, when there is a finding of guilty, application of the best principles of penalization.

A Major Question: Is adjudication of traffic law enforcement cases, as it is presently practiced, accomplishing the goal to the greatest degree possible?

Study Objective: To research the entire areas of legal sanctions to determine objective evaluations of the present system and possible alternatives.

General Methods: Surveys and studies commencing at the initial enforcement level and continuing through the courts and the records of motor vehicle administrators would allow comparative evaluations to be developed. In the research all conceivable innovations and alternatives to the criminal approach should be utilized, including experimental demonstrations.

A series of such studies should be carried out in several different states and localities selected to be representative. At least three projects should be planned.

Manpower Estimates: Substantial staff, including enforcement specialists, lawyers, psychologists, sociologists and clerical and logistical support. Research on a local basis would require three practitioners in the enforcement and judicial fields, and one social scientist, with appropriate supporting clerical and other staff.

Costs: Estimated costs for each project would range from $200,000 to $300,000 per year depending upon the size and scope.

Time: Each individual project is estimated to require one year to conduct necessary field work, nine months for evaluation with a total of six men over an 18-month period, for a total of nine man years.

For three projects, a total of four and one-half years would be required if they were conducted sequentially.

Expected Results: Methods of treating traffic offenders other than one a criminal basis would be suggested and evaluated, as well as conclusions and recommendations for modification of the present system.

DRIVER LICENSING

Definition of the Area: Driver licensing is the granting by the state of the privilege to operate a motor vehicle on public streets and highways to those deemed qualified. It includes maintaining a record of drivers' accidents and convictions and exercising the authority to suspend or revoke the privilege for cause.

Major Question: What information on persons, drivers and potential drivers should be considered in preparing driver examination, evaluating test performance, withholding or withdrawing a license and other decisions relating to licensing which ultimately serve the individual and public interest?

Study Objective: To explore methods of improving those aspects of the driver licensing system based on acquisition of skills and knowledge required and the developmental process in acquiring them.

General Methods: A three to five year comparative study of drivers in age groups most frequently licensed involving: (1) development of new tests designed to measure the increasing development of skills and adjustment to various driving conditions; (2) administration of new tests periodically to subject and control groups of drivers to compare levels of achievement; (3) evaluation of actual driving performance of drivers; and (4) a long-term study of these drivers to evaluate this developmental approach.

Manpower Estimates: One researcher, two professional staff, two field study personnel, two temporary personnel.

Estimated Costs: Estimated costs are from $200,000 to $300,000 per year.

Estimated Time: Minimum of three years at a level of 84 man months per year.

Expected Results: Establish the value of a new approach in licensing providing for gradual releasing of limitations or restrictions imposed on new drivers in response to the development of their abilities and performance as measured by tests of increasing difficulty.

7. EVALUATION OF ALTERNATIVE PROGRAM PLANS

Evaluation of the twelve alternative program plans was conducted in two steps. First, numerical ratings were derived for each plan with respect to each of the 13 criteria. And, second, subjective judgements were made of the plans with the highest ratings, and plans were eliminated from consideration successively until only one plan remained as the basic recommendation. During this process, potential relationships among the program plans were noted. At the end of the evaluation, a new research theme was derived, based on the basic recommendation plus several adjunct research areas. These adjunct areas were extracted from plans which had been previously eliminated, but which had significant relationships to the basic theme.

The evaluation criteria used for ratings were listed in Section 5. Each criterion was applied to the program plan under consideration, and a numerical rating from 1 to 5 was derived by each evaluator, as follows:

5 - Superior
4 - Better than average
3 - Average
2 - Fair
1 - Least desirable

Five evaluators from the project staff were assigned to each plan, and a consensus rating for each criterion was established from the average rating. The consensus ratings are given in Table 7-1, and the resulting order of preference is given in Table 7-2.

The second step of program evaluation was performed by a committee composed of the director of HSRI, the project director, a member of the HSRI executive committee, and two other members of the project staff. Initial discussions of the committee centered on the advantages and disadvantages of the top-rated programs as reflected in their ratings for certain criteria. Although there had been no weighting factors applied to any of the criteria earlier, it was generally felt that the uniqueness of knowledge produced, applicability to implementation, and effect on the public image of the automobile insurance industry were the most important. On this basis, three program themes were selected as a temporary focus for further consideration: the young driver theme, the response to injuries theme, and the legal sanctions theme.

In the elimination process which followed, programs were dropped successively on the basis of low ratings, nonrelationship to the three top themes, and other considerations. In each case, if a program had any significant relationship to the three top themes, this fact was noted for future use.

TABLE 7-1

CONSENSUS NUMBERICAL RATINGS OF ALTERNATIVES

EVALUATION CRITERIA \ ALTERNATIVE PROGRAM PLANS	Young driver	Response to injuries	Social environment	Driving process	Risk-taking	Legal sanctions	Implementation evaluations	Damage losses	Effects of alcohol	Roadway objects	Driver education	Public Policy
Amount of knowledge	4	5	2	4	2	4	3	1	3	4	1	3
Uniqueness of knowledge	2	5	3	5	5	4	3	1	2	2	1	4
Use of insurance data	4	2	3	2	5	2	3	3	2	2	1	1
Benefits to youth	5	3	3	2	4	3	3	1	4	2	5	2
Cost of research	1	5	1	4	5	2	2	4	3	3	3	2
Use of demonstration projects	3	4	2	1	2	2	5	3	3	4	4	4
Applicability to implementation	4	5	1	1	2	4	5	3	3	5	3	4
Near-term implementation potential	5	3	3	1	1	2	3	3	4	5	4	2
Early effectiveness of implementation	4	5	1	2	1	3	4	3	2	4	1	2
Relative cost of implementation	2	2	1	1	5	5	3	3	4	1	2	2
Effect on industry image	5	3	2	2	1	3	4	4	4	2	4	3
Appropriateness of organization	3	5	4	5	2	4	1	3	2	3	5	4
Flexibility and adaptability	4	3	2	5	1	5	3	3	2	3	1	5
TOTAL RATINGS	46	50	28	35	36	43	42	35	38	40	35	38
ORDER OF RATING	2	1	12	9	8	3	4	9	6	5	9	6

TABLE 7-2

Order of Preference from Numerical Ratings of Alternative Program Plans

1. Improved Methods of Response to Highway Accident Injuries
2. Reduction in the Traffic Accident Involvement of Young Drivers
3. The Effectiveness of Legal Sanctions in Highway Safety
4. Methods of Evaluating Highway Safety Implementation Programs
5. Optimum Location and Design of Fixed Roadside Objects
6. Public Policy and Highway Safety
7. Reduction of the Role of Alcohol Misuse in Traffic Accidents
8. Risk-Taking in Driving Behavior
9. Improved Methods of Driver Education
10. Basic Understanding of the Driving Process
11. Reduction in Losses Due to Vehicle Damage
12. Influence of the Social Environment and Public Information on Driver Behavior

The first two programs to be dropped were those dealing with vehicle damage losses and roadway objects. The former is a partial duplication of similar programs just recently initiated by Saab in Sweden and by the Travelers Research Center. Further, it is in the area of vehicle research which is being emphasized by NHSB. The roadway objects program is fairly unique in its comprehensive approach and yet it also is in an area which is being very well handled by other organizations, especially AASHO.

The third and fourth programs eliminated were the ones on evaluation of implementation programs and public policy. Their objectives are being covered partially already by the federal highway safety program standards. Although the federal plan is not yet clear as to the details of the evaluations which might be performed eventually, there is some likelihood that they will be fairly well systematized in another ten years. Though the evaluation program was dropped as an entity, it was noted that methods for evaluation of implementation program in specific areas might be appropriate for inclusion in several of the other alternative plans. The same would be true of parts of the public policy program.

Next, the alcohol misuse and driver education programs were eliminated, again because both areas are being given strong support in the federal program. Even though the proposed programs are unique, there are many possibilities for redundancy, and industry contributions might tend to become lost in the mass of other contributions.

At this point, four of the eliminated programs had nothing to do with driver behavior, and the other two had only an indirect bearing. Of the six remaining, five had a significant bearing on driver behavior. This result is consistent with earlier views of the most critical gaps in highway safety research. Nevertheless, the next program eliminated was the one on the driving process, which perhaps is the one with the most direct bearing on driver behavior. Its ratings were low because of weaknesses with respect to implementation and public image. Further, it did not relate well to any of the other programs.

The amount of deliberation necessary to eliminate seven programs provided sufficient bases for the committee to crystallize its comparative views regarding the remaining five program plans. Thus, it developed that the programs on response to injuries and the young driver were selected as the final contenders.

The final choice was made on the basis of increased benefits that could be achieved in the programs by adding related research elements from some of the other alternatives. It was felt that the last three programs eliminated (risk-taking, legal sanctions, and social environment effects) were most important in this regard. All three of them contained elements which were particularly appropriate to the young driver, and which would lead to a mutual enhancement when combined. On the other hand, the response to injury program did not have a relationship to any of the other alternatives. Therefore, the young driver program plan was selected, subject to improvements gained from elements of several of the other programs.

8. THE RECOMMENDED PROGRAM PLAN

This section presents a detailed discussion of the recommended program plan: The Young Driver Research Program. First, the important role of the selected theme within the entire field of highway safety research is discussed. Then, a lengthy description of the six basic subproject is presented, including both the early phases of basic experimental work, and the later phases of demonstration projects and evaluation. Next, the administrative aspects of the program are outlined, including organization, schedule, manpower and cost estimates. Finally, a few broad results of the program are forecases.

The objective of the Young Driver Research Program is to produce knowledge which, when applied, can reduce the overinvolvement of young drivers in traffic accidents. The research content of the program focuses on this objective. The program schedule is ten years in length, and the total cost is estimated as $14,000,000. The basic organizational form recommended for the program is a multidisciplinary research institute at a university.

8.1 THE YOUNG DRIVER AS A THEME FOR HIGHWAY SAFETY RESEARCH

Up until about two years ago one might have selected any one of a number of themes dedicated to highway safety research with the expectancy of making a genuine pioneering effort. Since then, national concern leading to massive infusions of support for highway safety research has affected almost every broad topic touching importantly on highway safety, and relatively few research topics of major importance remain untouched by this activity. For these reasons, the task of defining a unique research area in highway safety and structuring a research program that will justify substantial expenditures of resources on the part of its sponsor and the research community has presented a major challenge in our program definition study.

The Young Driver Research Program meets this challenge. In addition to being unique among the proliferating highway safety oriented research programs, the recommended theme of young driver research is especially attractive because the needs for improvements in young driver performance are so great, and because the potential payoffs are so high. Young drivers under 25 constitute nearly one-quarter of the driving population, and the proportion is increasing. They also have approximately one-third of all traffic accidents. If some method can be found to decrease the overinvolvement of young drivers in traffic accidents, the payoff will be the highest possible in terms of man-years of life saved.

The emphasis on help for the young driver is an appropriate one for IIHS in terms of public image and reduced claims. Further, the insurance industry has already established a good reputation for its support of driver education, and the young driver theme provides a very natural transition into a highly related, but broader research area.

Who is the young driver and why is he of particular concern in highway safety research? Basically, the young "problem driver" is drawn from the population of male drivers 25 years old and younger. Young female drivers are not excluded from concern, but their special driving problem (if there is one) is not visible to researchers yet. Differences in driving exposure may be the key to this distinction. Also, age 25 is not necessarily a firm cut-off. The problem is that young drivers kill and injure themselves and others in highway crashes at rates far exceeding those which would be predicted on the basis of their numbers alone. Moreover, automobile accidents constitute the principal cause of death for people in this age group, and the rates appear to be increasing in contrast to signs of decreasing highway death rates for the older age groups.

These statistics suggest two broad sets of objectives for a Young Driver Research Program. The first is people-oriented: to reduce the deaths suffered and caused by these young people; to reduce the pain, suffering, and crippling; and to reduce property destruction. In achieving these goals our national interests will also be served through the preservation of our most valuable resource, the future economic and creative potential of our youth.

The second objective is a longer-range one and perhaps ultimately even more significant: to permeate the total driving population with a new and safer pattern of automobile driving, a pattern producing far fewer crashes. The notion is very simple. If young drivers can be made safer drivers in their youthful, dangerous driving phase, then more of them will survive as safer drivers and will remain safer drivers throughout their driving years than they otherwise would have been. Thus, although the driving performance of the young drivers should improve first, in time the overall driving population will be saturated with the new breed and driving performance will be universally improved.

The glowing potential implied by these objective must be tempered by the prospective feasibility of achieving them. The process will be long-term and slow to mature, but given the support defined in this plan, its chances of success are high.

Several of the research ideas which follow delve rather deeply into personal aspects of the lives of research subjects. Although the in-depth participation of individuals will be largely voluntary, nevertheless, the need for protecting the rights of individual integrity, dignity, and freedom are recognized and endorsed. Counterbalanced against these concerns is our perception of a continuing trend for society to form tighter and more densely compacted groups in which the unchecked aberrant behavior of any individual is more likely to harm others. Reconciling these two concerns is a dilemma with which our culture will wrestle for some time. Accordingly, throughout this project, the researchers should be especially sensitive to socio-legal problems and may be expected to experiment with, develop, and report on acceptable solutions.

8.2 SUBPROJECTS IN A YOUNG DRIVER RESEARCH PROGRAM

Achieving the objectives stated above is a monumental task and cannot be fully attained quickly nor by concentrating on any one field of study--indeed there is no single "young driver" discipline. Instead, a systematic effort, drawing upon many and varied disciplines, is required to

(1) Build a composite description of youthful driving behavior,
(2) Acquire a reasonable understanding of it, and
(3) Develop experimentally a means for influencing young driver performance toward safety.

Consequently, although a well defined program can be laid out initially, it must also be flexible enough to fully accommodate changes in direction and emphasis as initial findings clarify areas with the greatest potential. Moreover, the researchers chosen to carry out the program must be given considerable latitude in shaping it and using the latest and best research methodology. The subprojects developed in later sections are proposed in that spirit. Briefly, they are:

Subproject A: Studying the Young Driver To Describe His Driving Performance and Attitudes.

A1. Measuring the young driver's driving and accident record: clearly describe its significance; establish a performance baseline; and lay the ground for measuring improvement.

A2. Learning how the young problem driver is different: measure and describe the young accident-involved and violation-involved driver; measure and describe his no-accident, no-violation counterpart; search for significant differences.

A3. Explore the range of critical behavior: measure and describe the significance of risk taking and alcohol misuse in youthful driving.

<u>Subproject B</u>: Studying the Young Driver To Learn How He Shapes His Personal and Driving Attitudes and How He May Be Encouraged To Improve His Performance.

B1. Measuring and describing the pressures of the personal and social environment and learning how they may better operate to improve youthful driving performance.

B2. Measuring and describing the pressures of the legal environment and learning how they may better operate to improve youthful driving performance.

B3. Experimenting with the learning environment to develop programs for improving the youthful driving performance.

<u>Subproject C</u>: Demonstrating and Evaluating Productive Countermeasures for Improving Young Driver Performance.

<u>Subproject D</u>: Program Assessment and Formulation of Future Goals for Young Driver Research and Implementation.

Although these are conceived as separate subprojects, they are by no means independent, and the findings of some may represent postulates for others. However, even where one project is in a sense a prerequisite of another, portions of the latter project may begin on the basis of judiciously posed hypotheses.

Many of the proposed tasks will necessarily generate large amounts of data. Some of the data will be relevant to more than one project and all of the programs will need data processing and analysis services. Moreover, much of the data gathered in this program may be valuable to independent researchers and organizations and, just as likely, their data may prove valuable to this project. Accordingly, it is recommended that a Driving Behavior Data Center be supported, staffed, and maintained as a part of the program and that it serve as a data services research facility for the Young Driver Research Program and the larger scientific research community as well.

The thrust of the recommended program entails studying human behavior and learning to modify it, as it is exhibited within the social and dynamic driving environment. Relatively little of the research is conducive to laboratory methods of experimentation. On the contrary, as in most studies of human populations, subjects must be studied and countermeasures must be tried within the living environment. Consequently, for the purposes of the Young Driver Research Program, it would be useful to select one or more Community Laboratories on the basis of parameters such as geographic areas, climate, population density, and population character. These Community Laboratories would serve as research and demonstration sites for the various subprojects, or might prove desirable to conduct the entire program in a single demonstration community. A fine example of a potential Community Laboratory is Oakland County, Michigan, just north of Detroit. A citizen-organized group there, the Traffic Improvement Association (TIA), has already established a basis for a Community Laboratory by means of a cooperative accident data project among its thrity-eight police departments. In addition, Oakland County has an extremely wide range of geographic and population characteristics, providing nearly all of the environments appropriate for study in young driver research. These range from highly urbanized areas near Detroit to widespread farming and rural settings in outlying areas. The population of 850,000 is highly diverse, and there are 4,375 miles of public roads, from expressways to winding rural roads. Further, the TIA is one of the first communities to receive a grant from NHSB to serve as a national demonstration model under the Highway Safety Act of 1966.

Figure 8-1 shows the logical subproject relationships in the Young Driver Research Program. Each subproject will be conducted within the context of one or more community laboratories. Each subproject also depends on the central data facility. One of the important influences not shown in the diagram is that of system constraints imposed on the research approach by the community laboratories. Certainly, constraints such as poor roads or socio-economic extremes in the population would make the research more difficult.

8.3 STUDYING THE YOUNG DRIVER TO DESCRIBE HIS DRIVING PERFORMANCE AND ATTITUDES (Subproject A)

The young driver problem is extremely complex, and is identified thus far only in terms of a few very broad sociological hypotheses. No serious researcher yet pretends to understand just what the problem is and how it operates. Indeed, one opinion on the subject is that young drivers really have no worse driving performance than others and that their apparent bad record is attributable to using an

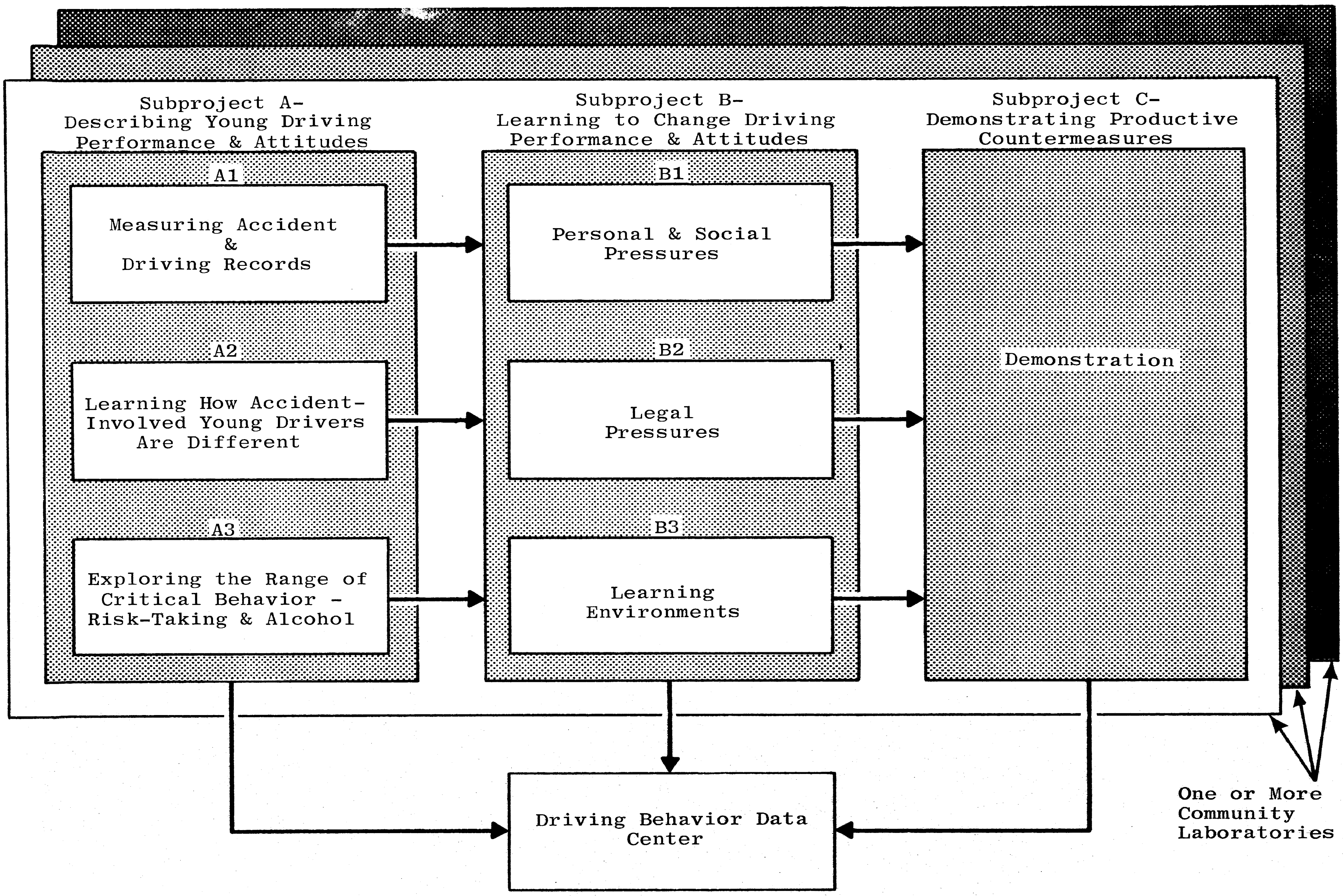


Figure 8-1. Diagram of the Young Driver Research Program

improper exposure or risk index. Therefore, a key research goal is to carefully describe the problem as defined by the young drivers' driving and attitudes. The following tasks are directed to that end.

8.3.1. MEASURING THE YOUNG DRIVER DRIVING AND ACCIDENT RECORDS (Subproject A1). Measuring the driving and accident record being compiled by young drivers has three purposes in the context of the total program: the first is to clearly describe the significance of the young driving problem; the second is to establish a performance measurement baseline; and the third is to prepare the way for measuring improvement.

Since the true extent of the youthful driving problem is not well known, an initial task will be to remedy that deficiency by collecting sufficient accident, violation, exposure, and driving performance data for adequate description. It is recommended that this task be approached in the following steps.

The initial step, which is extremely important in that it establishes the scope of the potential findings, is to define the parameters which will be measured. One group will be such accident parameters as driver age and accident severity. A second major group will be driving performance parameters describing the exposure to hazard of the driving population according to age. Measuring exposure is crucial to quantifying the young driver performance record, and has proved an intractable problem to date. However, its consideration has been limited mainly to abstract discussion. Thus, measuring exposure may prove more feasible when placed in the context of a comprehensive experiment such as this. Developing data requirements and sources will be a prerequisite to the success of this task.

The second step is to determine the amount of data necessary to produce statistically reliable conclusions and to estimate the population size and geographic extent of a locality sufficient to produce the needed data. This step will be repeated for each different setting to be studied: e.g., rural, small town, metropolitan, cold climate, warm climate, mountainous, plains, etc.

The third step is to select a geographic locality or localities to serve as the community laboratory. The sites chosen must be suitable both for conducting this task and for conducting the tasks under subproject B so as to facilitiate measuring the effects of corrective activities.

The fourth step is to determine the time intervals over which measurements are to be made. At least three measurement periods are envisioned: the baseline period; an intermediate monitoring period; and a post-project evaluating period.

Finally, all preparations will have been made to implement the measurement program. This requires planning for numerous logistic requirements and poses a substantial task of obtaining the cooperation of local traffic and law enforcement authorities.

The result of this task will be the generation of accident rates based on some control parameter or parameters that will allow valid comparisons among different groups of drivers. It will probably be desirable to produce separate accident rates for different kinds of accidents (e.g., fatal, severe, personal injury, and minor). In order to have a valid basis of comparison to show how bad (or good) youthful driving performance is, similar data describing one or more control groups drawn from the older driving population should be generated as a part of the experiment.

The results will be useful in several ways:

(a) The youthful driving performance data will establish a baseline for comparison with later data, gathered after corrective action has been taken. Comparing the two will provide a measure of program evaluation.

(b) Comparing the youthful driving performance data to the data generated by the control groups of older drivers will provide a meaningful measure of the young drivers' performance and indicate its good and bad features.

(c) Fully evaluated youthful driving baseline data, measured in selected community laboratories, might provide a standard against which to measure performance data generated in other localities for the purpose of determining whether that locality needs corrective action.

8.3.2. LEARNING HOW THE YOUNG ACCIDENT-INVOLVED DRIVER IS DIFFERENT (Subproject A2). Assuming that young drivers as a subpopulation constitute a peculiar and measurable driving hazard, there are at least two explanations for it. Either something about the young as a class gives them unusual susceptibility to accidents and the actual victims are produced more or less randomly, or within the class of young drivers there are one or more subclasses which present unusual risk and thus contaminate the statistical image of the entire group. In either event, learning how the accident-producing youthful driving population differs from populations producing fewer accidents is a critical goal. If a measurable set of parameters appears to distinguish the groups, then they will form points upon which to concentrate studies for learning how the phenomena being measured may be influenced.

The program will proceed generally as follows. A first step will be to develop the list of parameters to be measured or tested. These might include: all circumstances surrounding the accident, personal history, family background, etc. The need for exploring the behavior of young drivers by examining areas outside of the driving realm has been described as follows:

> The automobile is a symbol of economic and social worth; it provides a vicarious sense of power; it represents freedom and escape from parental authority; in many areas it is an essential feature in dating and courtship. For many young people it provides an outlet for hostility, discourtesy, emotional conflict and revolt. All of these factors may combine to make the automobile for some a weapon rather than a convenience, and unsafe, rather than safe, driving habits the more satisfying way to operate a car.*

Along with developing the parameters to be measured, the set of descriptive parameters to be held constant between accident and nonaccident groups must also be chosen (e.g., selected age brackets, socioeconomic status, etc.). Together these represent a significant task since, if there are causative differences between accident and nonaccident groups and if they are to be detected, then the measuring tool must be adequate for the job.

Next, the numbers of individuals in each group needed for producing statistically reliable conclusions must be determined and community laboratories of appropriate dimensions and characteristics must be selected. It might be desirable, but is not necessary, that this project be conducted in the same sites as chosen for A1. After the necessary local liaison and support is obtained, experimental programs will begin. When the data have been gathered, they will be analyzed for the presence of identifiable parameters distinguishing the young driver groups.

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* McFarland and Moore, "Youth and the Automobile," Golden Anniversary White House Conference on Children and Youth, 1960.

A complementary task will determine whether young accident drivers are different (apart from age) from older drivers. A carefully selected group of older accident-involved drivers and a control group of non-accident drivers will be studied. Comparisons between the young-driver and older-driver studies should disclose the important differences.

At this point, the experimenters must be prepared for sobering findings. Many behavioral scientists would probably predict that bad driving performance is merely a superficial manifestation of deeper problems; therefore, studying problem driving behavior may uncover a stratum of underlying troubles needing attention. Such a finding may substantially increase the scope of the corrective programs. On the other hand, it would simultaneously open up the possibility of producing greater benefits throughout the social realm.

In addition to the rather sweeping program discussed above, more specific projects will evolve during its course. For example, Dr. Schuman at The University of Michigan has suggested a project dealing with young veterans, 18-25, returning from military service to civilian life and civilian driving conditions. The purpose of the study would be to determine the effect of military discipline and duty, in-service training, new roles and responsibilities, and military driving experiences on the returning veteran, and, from an actuarial viewpoint, whether the returning veteran is in substantially the same risk-category as his non-veteran peers. Differences between veterans' civilian driving records and their in-service records (rank, type of duty, conduct, accident record, in-service driver training courses, etc.) would be studied. Numerous excellent studies on accident prevention have been conducted in the relatively "closed" environment of military bases; the applicability of these studies to the "freer" environment of civilian life is subject to speculation. However, a study of the multiple and changing factors influencing accident behavior and experience in the young male in transition from military to civilian life presents an intriguing target group for study and for possible insight into the role of life-situations and motivations influencing a young man's potential for survival on the highway.

Another possible demonstration project might be conducted in cooperation with one or more insurance companies. This would involve the screening of applications for automobile liability insurance, within a younger age group, by the use of military service categories, in a manner analogous to that proposed for use of high school grades. Follow-up of a driver's experience and accidents over time would provide one kind of comparison study. The confidentiality of the information obtained would be a basic consideration in each phase of this study.

In summary, the young male adult population returning to civilian life and to civilian driving suggests to the epidemiologist a target group for contemporary study of the effects of young men in transition on a scale not previously available. Such a segment or sample of the population could provide valuable insights in our understanding of some aspects of sociological factors in the accident process.

8.3.3. EXPLORING THE RANGE OF CRITICAL BEHAVIOR OF THE YOUNG DRIVER (Subproject A3). Some theories of accident causation hold that certain kinds of behavior are more likely to produce accidents than others. Risk taking and alcohol misuse are believed to be two such predominant factors. Accordingly, in investigating the range of critical behavior, special attention will be given them. If others appear during the program, they, too, will be given special emphasis.

8.3.3.1. The Significance of Risk Taking To the Young Driver. It would be fortuitous if the risk-taking behavior of a driver could be modeled, or expressed in some mathematical form analogous to a gambling situation. There are a number of reasons why this is not directly feasible.

(a) Awareness of a risk: It is quite obvious that tremendous differences divide drivers with respect to their ability to perceive certain cues which indicate hazardous situations, and moreover, that for one and the same driver this ability to detect danger signals changes with time and experience.

(b) Driving skill: If, on the one hand, increased experience can bring about earlier detection of a hazardous situation, then on the other hand this same experience may lead the driver to a new level of technical skill such that the former "danger" situation no longer exists, since the driver may have acquired the required technical and behavioral knowledge and skills to counteract a given situation properly.

(c) Multiple factors interacting to create a risk situation: Usually a number of events occur simultaneously, involving many variables as well as several driving and perception tasks, which interact to produce a succession of borderline vehicle dynamics behaviors (with variable risks) that can be controlled to a certain extent by a keen, skillful, and alert driver.

(d) Randomness of occurrence of the risk situation: The driver can seldom predict all elements that intervene in a driving situation.

The researchers' task, therefore, becomes that of isolating as many risk factors as possible, of conducting controlled experiments, and of developing a methodology that, by eliminating extraneous influences, allows him to measure or to evaluate the conscious willingness of a driver to face a certain risk.

Among the important driver-situation variables to be studied (some independent of driving skills) are:

1. Length of time available to make a given risk situation decision. Is it a fraction of a second requiring reactions almost at the reflex level, or is there time to think and reason?

2. Is the driver alone in the car? Are there other young drivers, male or female, in the same car?

3. Is the driver alone on the road, or are other cars belonging to friends ahead of him or behind him?

4. Is the driver under the effect of any stimulant, depressant, or alcohol?

5. What is the state of consciousness, alertness, or exhaustion of the driver?

6. Can the effect upon risk taking of these and other parameters be measured, either quantitatively or qualitatively?

These will be important factors in determining the value of any research finding about risk taking. By contrast, it should be stated that the amount of value to be derived from simulated studies of risk taking in young drivers will be a function of how well the simulated condition duplicates frequently occurring situations in their daily lives.

8.3.3.2. The Significance of Alcohol Misuse to the Young Driver. Alcohol misuse is the single most culpable factor known to be at work in autombile accident causation, particularly in fatal accidents. However, a full description of alcohol involvement is lacking. Even though alcoholics have been shown to be represented disproportionately in accidents, the place of social drinking in accident causation is not known, nor have patterns of alcohol involvement by age of driver been developed. Moreover, although alcoholism is popularly believed to be an "older" person's problem, some recent studies have shown that its symptoms may be displayed at early ages. However, even if the alcoholism problem is laid aside so far as young drivers go, it is true that young people start to drink about the same time they start to drive and it seems intuitively sound to assume that the mixture may be in part responsible for the bad youthful driving performance. This, then, sets the stage for exploring alcohol misuse in youthful driving.

Despite the criticality of this task, a comprehensive proposal cannot be developed yet because of the federal government's activities in the field. One of the initial highway safety program standards developed by NHSB concerns alcohol misuse in highway accidents. Parts of the program will generate large amounts of data to supplement present knowledge and other parts will encourage state and local governments to apply specified action programs (e.g., Highway Safety Program Manual, Vol. 8, "Alcohol in Relation to Highway Safety"). However, the current plans do not place special emphasis on youthful drivers.

Therefore, because the area is not specifically covered by the federal program, and becuase of the slow pace at which that program is likely to move, there will be conspicuous gaps in regard to young drivers which should be filled as a part of this project. Moreover, some studies of alcohol misuse in youthful driving may be begun as a part of subproject A2 (and perhaps A1 as well), regardless of what the final shape of the federal program is to be.

To the extent that this is practicable, the data collected in A1 should include a description of alcohol involvement in the crashes. Nevertheless, because present accident reporting may not be adequate for producing meaningful data for this purpose, this task may not be useful unless it is expanded to such an extent that it duplicates the federal plan. In that case, it should be dropped as a part of A1. However, since A2 anticipates an in-depth study of smaller samples of young drivers, a number of questions relating to alcohol use may be inserted into the experimental design. Comparing the information obtained from the crash groups with that obtained from the control groups will provide a measure of alcohol over involvement in the crashes. It will be particularly useful to learn if excessive drinking is more prevalent in serious crashes than in the less serious.

Moreover, the contacts with young people and the older control groups will provide an opportunity to learn more about the youthful use of alcohol than can be learned from studying the situations preceding accidents alone. Among critical questions that may be explored are:

(a) What kinds of activities are usually associated with youthful drinking? Is driving a necessary adjunct to them?

(b) What sort of parental approval for drinking do young drivers have? Do the parental attitudes influence the combination of driving and drinking?

(c) What do the young drivers know about the effects of alcohol on the human body and brain? What do they know about the effects on driving performance? How do they obtain their information?

(d) What are the peer-group pressures that might cause young people to drive while drinking, even against their better judgment?

Carefully developing a sound set of hypotheses and questions for testing them, such as those above, will be done early in conjunction with task A2 and the investigations will proceed concurrently with that task. If this subproject proves successful, much valuable new information describing youthful drinking and driving practices will be available. That information would provide needed background for the work in subproject B, which will be devoted to learning how the social, legal, and learning environments may be employed in influencing more healthful practices.

8.4 STUDYING THE YOUNG DRIVER TO LEARN HOW HE SHAPES HIS DRIVING ATTITUDES AND HOW HE MAY BE ENCOURAGED TO IMPROVE HIS PERFORMANCE. (Subproject B)

Subprojects A1, A2, and A3 are intended to investigate youthful driving performance and attitudes for the purpose of learning what they are really like. The three subprojects in this section--B1, B2, and B3--are intended to explore why they are as they are, and from that to attempt to learn what may be done to influence them toward safety. Conceptually, the findings of the former subprojects should precede the latter subprojects. However, it is expeditious to begin the latter projects before the former are completed, based on carefully developed hypotheses. As findings from subproject A become available, the hypotheses should be modified and the tasks redirected.

It should also be pointed out that the various tasks in subproject B are themselves closely related. Indeed, the three environments being considered--social, legal, and learning--are all parts of the total milieu in which young drivers find themselves, and the separation into subordinate elements is largely artificial. However, this division is necessary in order to break the overall problem context into segments manageable by available analytical tools. The division made here seems desirable from the point of view of research disciplines.

8.4.1. MEASURING AND DESCRIBING THE PRESSURES OF THE PERSONAL AND SOCIAL ENVIRONMENT AND LEARNING HOW THEY MAY BETTER OPERATE TO IMPROVE YOUTHFUL DRIVING BEHAVIOR (Subproject B1). The young driver is an ideal focus for studying the influence of the social environment upon driving behavior.

First of all, he represents a special problem: about 1/3 the highway deaths, injuries and property damage are of his doing.

Second, he has a great many person-years at stake with all that implies in terms of native resources. This contrasts with the potential pay-off from concentrating upon the elderly, who have relatively few years and potential resources at stake.

Third, the young drivers are crossing a portal-of-entry into the driving population. The driving attitudes of each new class has a profound effect upon the nation's future driving performance.

Fourth, the young have flexibility. Not yet hardened in their attitudes and thinking, they may be more amenable to change then are older drivers.

Fifth, psychosocial factors seem to be of great significance in the driving behavior of the young. For example, only occasionally do the young have solo fatal accidents. Frequently, they take three or four peers along, a pattern not so prevalent in older drivers. However, the psychosocial component has one handicap from a research point of view in that studying it requires resorting to the tools of the social sciences which are not so precise as those available in the hard sciences.

Sixth, studying the young driver has potential for extraordinary public impact since the youth driving record is a matter of national concern (as polio once was), and might even be said to be a disgrace.

Enough study has been made of young drivers to convince some researchers of the soundness of certain fundamental hypotheses. One of them is that a young person's driving behavior is an end product of an amalgamation of life situation pressures, personality and character pressures, and immediate concerns. These integrate to form demands of one sort or the other and the young person reacts to the demands by the way he drives, among other things. A second hypothesis is that the young begin their driving during that period in which they enter adulthood. This is the experimental stage of life: the young person tries smoking, drinking, sex, and a great number of other things. Almost invariably he tests himself in the automobile under all sorts of circumstances. A third hypothesis (and one to be tested by earlier elements of the program) is that the dangerous young driver (the one who has accidents) is drawn more or less at random from the population of young drivers. One might characterize the young driver population by the distribution curve in Figure 8-2. One sixth will almost never have a driving problem, or any real behavioral problem of any kind because they are fortunately endowed and well adjusted; one sixth will continually be in trouble, driving and otherwise, because they are poorly endowed and maladjusted; and about two thirds will be "average." The hypothesis is that the majority supplies most of the accident victims, as a matter of chance, depending upon which young person had an unusual reinforcement of pressures against him at some crucial time. Justifying this hypothesis is vital since shaping countermeasures for effective control depends upon adequately diagnosing the problem. The fourth hypothesis is that the young driver is in transition. The pressures prevailing against him change almost continuously, as do his reactions to them and his attitudes. The young male seems to be beset with newer and stronger pressures during this period, answering questions like, what will I do?; shall I go college? Will the army get me? Shall I get married? How to get ahead? Job? debts? etc. Figure 8-3 shows a hypothetical curve of these pressures from authoritarian sources as they build up against young males (the declining curve for females is shown for contrast). Moreover, the young driver's driving skills and confidence levels are changing during this period. Figure 8-4 shows a hypothetical curve depicting skill (or experience) and confidence. The gap between the two, where confidence exceeds skill, represents a dangerous period. With aging and the experience of driving the two cross over into a more mature and safer pattern for the majority of the population. Finally, and very important, the peer influences over the young drivers

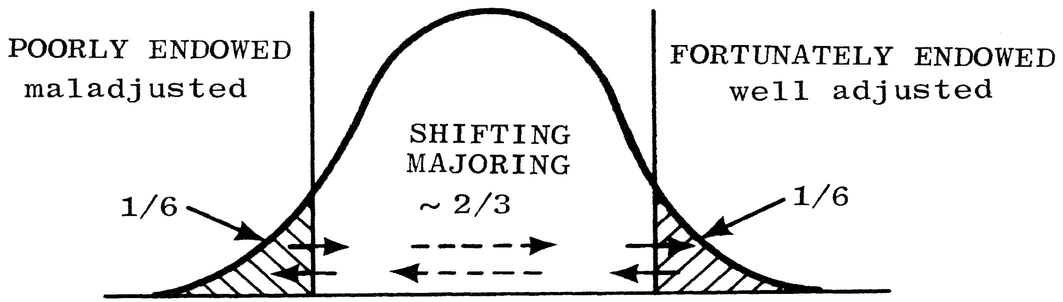


Figure 8-2. Hypothetical Young Driver Distribution
(Arrows Suggest Shifting Directions)

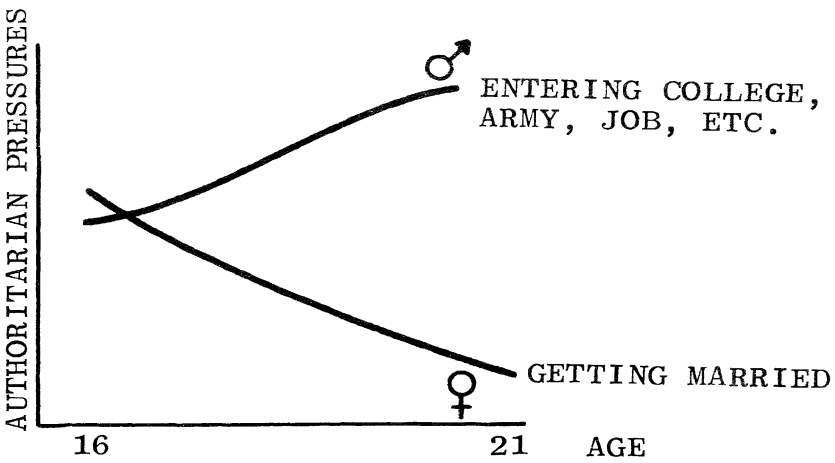


Figure 8-3. Changing Authoritarian Pressure on Young Adults

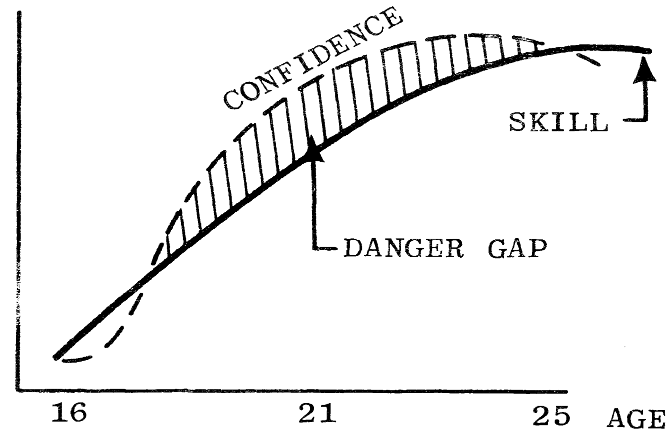


Figure 8-4. The Danger Gap: Driver Confidence Minus Skill

change significantly during this experimenting period, decreasing as the young people develop individual personalities less dependent upon peer influences. This suggests the desirability of starting some programs early enough to optimize the peer-group goal-setting and reinforcing constructive behavioral patterns.

Having laid this foundation, one may now gain some insights about how to study the social pressures affecting the driving behavior of the young. First, the young driver must be considered as an entity. Understanding his driving assumes understanding his living, because driving is such a direct, available, and attractive outlet for reacting to the problems of living during the metamorphosis from childhoold to adulthood. Second, doing something about the young driver's attitudes requires careful timing to be sure of reaching him where it counts while it counts.

The purpose of this program element will be to attempt to find out what counts, when it counts and how it may be made to count. The results from studies described in subproject A will influence these efforts to be sure, but in the meantime, these efforts will go forward.

Understanding young driving behavior (and the factors that influence it) is extremely difficult to achieve. The most widely used techniques of study now available are case studies, surveys, in-depth interviews, group sessions, school studies, family pattern studies, experimental trials, etc. All of these are conducive to the community laboratory approach described earlier and some of those earlier studies will have more than usual significance for this work. Moreover, a total community approach is inherently economical in that it provides support for a number of related studies. For example, a single group of young drivers may be unusually relevant to studying (1) why a preference for high powered sports cars?, (2) control reactions to good vehicle performance characteristics of a new engineering development, (3) effect of new legal sanctions aimed at risky driving, (4) the influence of offering incentives such as insurance rebates as rewards for safe driving, or (5) differences in types of driving exposure of sports car drivers from owners of sedans.

In addition to the related tasks described in A2, this program element will include several group oriented projects to set the stage for studying social pressures, particularly from the peer group. The projects include seminars, in which the researcher observes the reactions to various topics raised by the leader or by members of the group itself, and peer group action programs in which a core of young people is presented with a problem and is given the mission of developing a plan for dealing with it. As sensitive factors are identified, more precise tasks will be formulated for learning how they may be influenced one way or the other by changes in the pressures imposed by the environment.

These findings may be used in such group programs as driver education, advanced driver courses, department of state remedial driving programs, mass media campaigns, driver intern programs, and others. A number of the studies will be conducted in a pilot or experimental basis in one or a few schools or other social settings. As more concrete program plans emerge and as confidence in their effectiveness builds, selected projects of more than ordinary prospects both of success and of acceptability will be conducted on a large-scale demonstration basis.

8.4.2. MEASURING AND DESCRIBING THE PRESSURES OF THE LEGAL ENVIRONMENT AND LEARNING HOW THEY MAY BETTER OPERATE TO IMPROVE YOUTHFUL DRIVING PERFORMANCE (Subproject B2). Our legal structure is founded in part upon loosely laid hypotheses that certain kinds of human behavior need regulating and that punishments for infractions of the regulations will deter undesirable behavior. This description is particularly applicable to law enforcement as it operates in regulating driving behavior. Traffic laws generally focus upon one or the other of two goals: efficiently managing traffic flow, or preventing dangerous driving practices. Definitions of dangerous driving behavior seem to have developed along with the growth of automobile use by a process of loosely correlating accidents with the activities engaged in by the drivers just before their accidents. Penalties doubtless grew in a similar way but generally have been directed toward deprivation, e.g., fines, jail sentences, loss of driving privileges. Even though the total system grew quickly, it has been tested and refined throughout this century. Nevertheless, some critics say that modern law enforcement really doesn't control dangerous driving behavior as well as it should, and that it has been largely free of critical and comprehensive professional examination. Factors requiring consideration are:

The relationship between dangers being guarded against and the behaviors being controlled

The reasons drivers engage in undesirable behavior

The relevance of the usual penalties in changing behavior patterns (particularly with respect to different categories of drivers)

The effectiveness of new penalties or other sanctions in controlling driving behavior.

The purpose of this task is to undertake a study of the legal environment as it regulates driving behavior with emphasis on youthful driving behavior. As with all the rest of the programs, highlighting young drivers promises benefits extending far beyond the young themselves. Not only are the findings likely to apply broadly to drivers of all ages, but also the better regulated young drivers as they grow older will permeate the driving population with better regulated older drivers. However, in directing the attention of law enforcement studies to a particular class of individuals caution must be applied, since any new legal controls recommended must be based upon behavior and not status. Therefore, some aspects of this program may be focused upon more general legal institutions, regulations, and practices than upon the young drivers themselves.

The broad objectives of the task will be:

(a) To develop a basic knowledge and a comprehensive description of our society's legal controls, having the purpose of regulating behavior related to highway safety (with particular attention to youthful behavior), and to develop a basic understanding of the institutions which employ them.

(b) To develop a basic understanding of what behaviors really need controlling; why individuals engage in those behaviors; and what kinds of actions need to be taken to eliminate them.

(c) To present suggestions for change, where study reveals the desirability of change, in those institutions in command of the relevant processes; to encourage the adoption of pilot or experimental programs; and to provide assistance in implementing and evaluating them.

(d) Finally, to continually reassess the legal environment, the significance of changes made to it, the need for continued study and change, and the continued place of this sponsored activity in encouraging the production of knowledge, catalyzing change and disseminating information.

These objectives are much too ambitious to anticipate attaining them fully within the course of any single study. However, a beginning would be made by answering some critical questions posed below to form hypotheses for research projects:

(a) What do we control? What harmful youthful driving behavior should be suppressed? What beneficial youthful driving behavior should be encouraged?

(b) How do we control behavior? What controls are available for suppressing undesirable or inducing favorable activities? What institutions administer them and how do they work?

(c) How effective are existing controls in regulating driving behavior? How effective is each relevant sanction in controlling youthful driving behavior? Is a given sanction effective against some individuals but not against others or on some occasions but not on others?

(d) What are the attitudes of law enforcement, judicial and administrative officials toward detention and apprehension of youthful drivers and toward the relevance and application of sanctions? Do they differ from those applying to older drivers? How do they effect young drivers' attitudes and performance?

(e) What do young drivers know about and what are their attitudes toward existing controls and their enforcement?

(f) What are the processes which disseminate knowledge about legal controls to the young drivers? Are there any specific subpopulations which fail to "get the word"? Where are the communication blocks?

This subproject has important implications for legal and social institutions in our culture. It must be undertaken with deliberation and restraint since neither the requirement for immediate change as a paramount traffic safety function nor the prospect that study will result in significant changes are sure. It is anticipated that a large proportion of these studies will originate from individual scholars or researchers in the academic community.

8.4.3. EXPERIMENTING WITH THE LEARNING ENVIRONMENT TO DEVELOP PROGRAMS FOR IMPROVING YOUTHFUL DRIVING PERFORMANCE (Subproject B3). In particular, this subproject will isolate for individual study those facts and processes relating to learning about driving per se, as opposed to those which indirectly influence the way young people drive. Obviously, the two are closely related and the findings of each should reinforce the efforts of the other.

A statement keynoting the need for this particular study was cogently expressed in HEW's Report of the Secretary's Advisory Committee on Traffic Safety, as follows:

> The Highway Safety Act of 1966 requires that States shall provide comprehensive highway safety programs, including driver education. Unfortunately, the present state of knowledge as to the effectiveness of driver education provides no certainty, and much doubt, that the return on this enormous prospective effort will be commensurate with the investment. A broad and systematic enquiry is needed into the general question of how driving behavior is acquired, and how drivers can be taught not only to operate automobiles, but also to understand the major problems of highway safety, including its crash and post-crash aspects.

The report goes on to point out that despite the expenditure of considerable sums of money over several decades, including generous investment by the insurance industry, the product of today's driver-education programs may be no better prepared for his task than the youngster taught to drive on back roads by his father.

The National Highway Safety Bureau plans to give strong attention to present driver education programs, particularly those operated by the public schools (See Highway Safety Program Standard 4.4.4.). For that reason and, more fundamentally, because contemporary driver education is ill-suited for supporting the kinds of research really needed, the program recommended here will investigate more basic aspects of learning about driving.

An early task will be to attempt to learn whether there are some sorts of things that can be taught in "driver education" and appear also to be involved in accident causation. Some conclusive studies have been attempted to show differences between the accident involvement rates of those with and without driver education. The absence of measurable differences suggests that neither group is learning more to help avoid accidents. The approach suggested here is to learn what sorts of factors operate to influence accidents during the moments just preceding their occurrence. An attempt should be made to classify the factors according to a relevant set of characteristics including: those involving manual skill; those involving judgment; those involving ignorance of performance characteristics; and probably others.

A catalog of critical pre-crash factors may appear. If they do, they will provide a beginning inventory of facts and processes to be learned in driver education. A careful inquiry should also be made into those same factors as they appear in the driving practices of nonaccident young drivers.

Another major part of this subproject deals with the effectiveness of driver education curricula throughout the school years. Learning-about-driving should extend throughout a child's developing years and could be emphasized in at least four different stages of that development: (1) early grade school, (2) junior high school, (3) senior high school, and (4) post-high school.

It is anticipated that the knowledge to be obtained in the program outlined in the preceding discussion will eventually shape the pace, form and content of this task. In the meantime, the work should go ahead on the strength of several hypotheses:

(1) Good driving performance demands cooperative management of traffic flow. The need for cooperative driving practices and how to make use of them should be learned early.

(2) Far too little formal training in acquiring driving skill is available to learning drivers.

(3) Formal training in maneuvers requiring skill and control (such as high-speed maneuvering) can satisfy the young drivers' need to know about the limits of their skills and about the limits of the vehicle-road-driver system.

Based on these hypotheses, a suggested program can be outlined in four stages.

<u>Stage 1.</u> Stage 1 would introduce early grade school children to driving. The primary concerns would be with teaching them the "rules of the road." The youngsters would apply the rules in small pedal-operated or self-propelled mini-cars, within a small-scale replica of the real traffic environment. Emphasis would be placed upon demonstrating why controls are necessary, how to operate under them, and what could happen when they are violated.

<u>Stage 2.</u> Stage 2 would use a simulated driving environment during junior high years. In many respects, the stage 1 experience would be repeated, using larger vehicles in larger replicas of the traffic environment. The students would be introduced to the skills needed in complicated maneuvers and the limits of the vehicle-road-driver system.

Stage 3. This would be a conventional high school driver training course with expanded content over a longer time period.

Stage 4. After an appropriate amount of driving experience (about 5000 miles) the students would return for the last stages of their training. This would entail operation of automobiles in demanding maneuvers on specially designed driving ranges. The experience should produce skill in maneuvering out of dangerous situations; show the young drivers the performance limits of the vehicle-driver-road combination; and satisfy some of the urges for testing those limits.

All four stages would be initiated simultaneously for the entire sequence, a large enough sample of younsters should be processed through the course during the span of the project to produce statistically reliable conclusions. Also, of course, an appropriate control group of youngsters who are not to receive the training, should be selected so as to evaluate the change in performance produced in the test group. Not only should the two groups be compared by testing (either as to knowledge or performance or both) throughout the course, but they should be followed for a time after they graduate so as to make comparisons of their later driving records.

8.5 DEMONSTRATING AND EVALUATING PRODUCTIVE COUNTERMEASURES (Subproject C).

To be successful the Young Driver Research Program must produce knowledge which, when utilized, will reduce the accident rates of young drivers. Whether or not this occurs can be tested in one or more community laboratories chosen as sites for demonstration projects. The larger question, whether the entire driving population is in time being imbued with a safer sense of driving, will take longer to answer than a 10-year program. Nevertheless, the demonstration projects will be important parts of this program, particularly in its later years. They will be the means for showing the validity of giving young drivers the national attention they deserve and for convincing state and local authorities to adopt appropriate programs locally.

In a sense many of the research tasks outlined in subprojects A and B are demonstration projects in that they will demonstrate how the community laboratory concept may be used for researching very difficult problems. Moreover, many of the research projects themselves (particularly in subproject B) constitute small demonstrations of tentative countermeasures under test on a pilot basis. In short, then, the community laboratories could be called demonstration communities. Demonstration projects will produce from all phases of the program and might include: demonstrating the effectiveness of a new law enforcement program in controlling a particularly hazardous driving behavior; demonstrating the four-stage driver education program or some parts of it; demonstrating young-driver intern programs in which young drivers earn full licensing privileges by degrees as they accumulate safe driving points; demonstrating the influence of young drivers' safety councils in the schools; and many more.

A small-scale demonstration project, which may be illustrative of the types that could be employed, is presently being tested in several Michigan high schools, and plans are already being made for expanding it. The program may be briefly described as a pilot demonstration project for high school seniors in a sample of Michigan schools for the 1968-1969 school year. It is based on the HSRI Longitudinal Study of Young Drivers, and is aimed at small groups of young experienced drivers who are encouraged to participate in self-examination and sharing of 1-2 years of on-the-road driving experiences. The program consists of eight one-hour seminar sessions under a trained instructor who is well versed in group-discussion techniques. Useful seminar time is also devoted to advanced driving problems concerning perceptional skills, diagnosis of accident causation, and accident prevention topics.

8.6 PROGRAM ASSESSMENT AND FORMULATION OF FUTURE GOALS (Subproject D).

The total program and each of its subprojects should be evaluated periodically. Achievements should be weighed to provide information on the value of the program.

The evaluation should cover such questions as:

(1) Does massive attention to young drivers have measurable effect in reducing their crash rates?

(2) Do newly imbued safe driving practices carry over into adulthood?

(3) What are the costs and what are the benefits?

(4) What were the successful subprojects and why?

(5) What were the major problems and their solutions?

(6) What were the gaps in the program, and means of filling them?

The ultimate evaluation will be seasoned with subjective judgment. Nevertheless, many objective measures will be available and have been built into the experimental plan. For example, part of the plan deals with obtaining baseline data describing the existing young driving record in terms of crash and exposure rates. Contrasting post-demonstration rates will provide an objective evaluation.

Of course, in a situation so complex and fluid as the traffic system, it is extremely difficult to produce numerical data which describe the effects of a single program when so many other factors are involved. Careful statistical procedures will be necessary and the facilities of a Data Bank should provide them. As an illustration, one researcher has suggested a regional traffic accident surveillance system. The proposed system would provide current and on-going surveillance of all fatal and serious injury crashes occurring to young drivers in a state (or other geographic area). Pertinent detailed information from the police traffic accident files, driver record files, and the death records would be collated monthly for the age group 15-24, by driver involvement, single year of age, kind of accident, number killed and injured, evidence of alcohol, etc. Over about a three-year period these data should provide an ongoing index of the effectiveness of major safety efforts in a populous region of a state for an important age-segment of the driving population in which driver behavior seems to play a critical role. The dimensions of the problem in terms of lives to be saved, disability prevented, and unmet needs in driver education, driver re-education, and prevention would be more clearly and currently documented as a basis for promoting state-wide action programs.

Throughout the life of the program, its goals should be continually reassessed in the light of developing knowledge, the incursions of the activities of other projects and the revelation of new areas of concern.

The program director should be able to stay fully abreast of the field so that he may keep goals in the right perspective. At the end of the program, future goals should be defined so that the preceding support will serve as a springboard for further work in the future.

8.7 PROGRAM ORGANIZATION

The organization form chosen for conducting the Young Driver Research Program is fundamentally important to achieving the goals of IIHS sponsorship. The organization must be capable of carrying out a large, high-quality research program which is well-suited to the scientific aims just described. Further, the organization must be responsive to the sponsor with respect to public relations needs of the automobile insurance industry.

Of the five types of organizations suggested in section 4, it is felt that only universities and research firms need to be considered seriously. The others--government agencies, industrial firms, and foundations--would present problems to IIHS in terms of conflicts in goals. Government agencies would be concerned only with the public interest, industrial firms would be concerned with relationships between the research and their products, and foundations would be concerned with narrow special interests.

The organizational forms within universities or research firms would probably tend to be quite similar for this program. Both would be completely acceptable for conducting the whole program, for managing the program and coordinating subcontracts, or for performing subcontracts only. Despite the similarities, it is clear that a university environment should be selected as the primary organizational form. The major reason is its superior ability to attract the most prestigious and productive researchers, and this is especially true in the field of human behavior. Another factor is the lower salary and overhead rates at the universities.

For a comprehensive plan such as the Young Driver Research Program, it will be necessary to have a strong technical coordination function in the selected university organization. In addition to the coordination function, the selected organization will certainly be involved in a large percentage of the subproject research work. However, another large percentage should be performed by subcontract to other universities or research firms.

The organizational form within the selected university could be any of the following:

1. A specially established research institute involved solely in the Young Driver Research Program.

2. A program directorate within an existing multi-disciplinary research institute.

3. A program directorate within an existing institute in psychosocial research.

4. A specially established program organization within an academic department.

Each of these should be considered by IIHS in selecting the basic contractor. If the whole effort is to be done by one organization, then a program within an academic department should be avoided because of the large size. If the whole effort is not to be done by one organization, the creation of a new institute would not be justified. Therefore, the strongest possibilities are existing research institutes, which have the flexibility to vary the size of their major programs and their subcontracting level.

It is recommended that research management be separated completely from sponsorship for two reasons. One, it would be very difficult for IIHS to secure the large, expert staff required to perform the research management function. Two, research managed outside the usual structures of research management would not recieve full professional acceptance by the academic research community. Even without the research management function, IIHS would play a major role in administration of the research contracts, liaison, and monitoring of progress.

In addition to the basic organizational form for the Young Driver Research Program, it is recommended that IIHS provide several sponsored professorial chairs for the duration of the program. These chairs would provide full research support and educational development support for perhaps three or four distinguished scientists and scholars at universities other than the one with the basic program. Appropriate fields for these chairs involve behavioral, social, legal, and human engineering disciplines. The chairs would be awarded directly by IIHS on recommendation of the program director with the expectation that their research would focus on some aspect of the young driver. The chair awards would also include fellowship grants for graduate students to work with the chair recipients. In addition to their campus work, the recipients would also be available to consult with the program staff and among themsélves occasionally.

An organization chart of the Young Driver Research Program is shown in Figure 8-5. The IIHS function is keyed to a research program administration director who would draw on members of the IIHS staff, as needed. The IIHS director would have direct contact with the program director at the selected university in terms of funding, general liaison, and receipt of progress reports. The link between the two directors is an important key to the success of the program. Informal working links could also exist between the IIHS and program staffs at the discretion of the directors. Another set of liaison links would operate infrequently between the subproject directors and public relations personnel on the IIHS staff. By this means, IIHS would identify

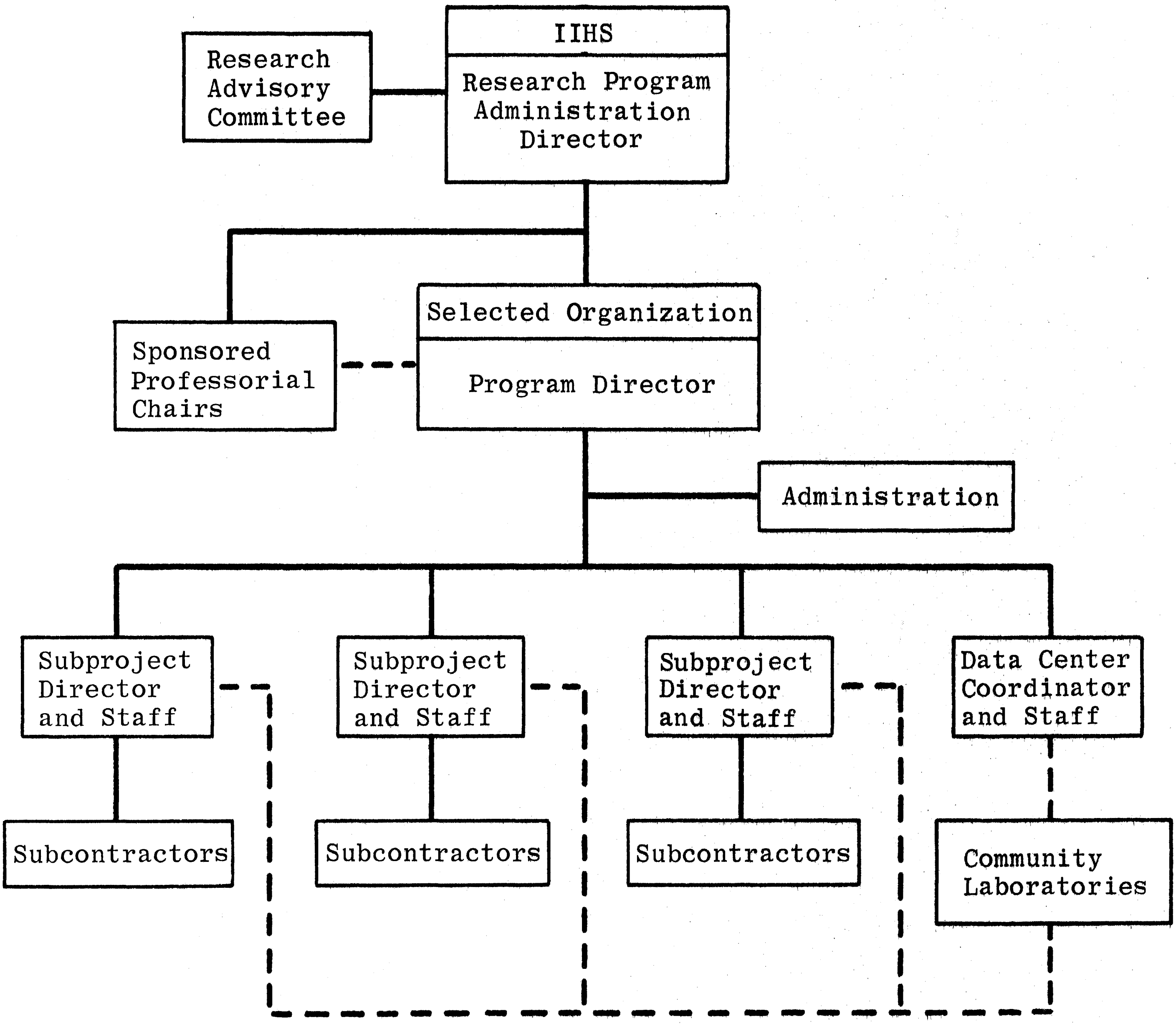


Figure 8-5. Recommended Organization Chart

findings appropriate to industry needs, so as to better communicate the research progress periodically to the supporting insurance companies.

Three or more subproject directors would be in charge of the basic sequences of research effort shown earlier in Figure 8-1. Initially, three groups would be established to correspond to subprojects A1, A2, and A3. A special coordinator would be assigned to the Driving Behavior Data Center, and his staff, in addition to computer duties, would assist in establishing data policies in the community laboratories. In addition, they would continually work toward the possibility of expanding present insurance industry data collection practices with regard to driver characteristics and claims, so that the data could be used in later parts of the subprojects.

The IIHS Research Advisory Committee, or a similar body, would also serve an important function in the overall program. The committee would provide technical advice to the IIHS director, and would meet periodically with the program director to discuss the research approaches which would be continually reshaped in response to new findings. This procedure will help to retain flexibility in the program, especially during the middle phases as new findings begin to evolve rapidly. However, in order to provide full opportunity for testing of initial plans and hypotheses, it is recommended that the basic plan of action not be changed during the first three years.

A program charter should be supplied by IIHS, setting out the general objectives and delegating the mission of the recommended program to the selected institution. The Young Driver Research Program will be charged with providing an overall framework for the program and insuring reasonable progress throughout its life; conducting the subprojects either within the parent organization or by contracts and grants; identifying new critical research areas; soliciting, accepting, and awarding contracts and grants; placing new knowledge into context within the scope of the program; reporting to the sponsor; and performing all other administrative functions.

One very important point to be worked out is the priority of publication of research results. The researchers, of course, will want to (and should be encouraged to) publish their individual work in technical journals. Such journal publication should be coordinated with any plans for independent release of the findings by IIHS. Delays in IIHS release can be minimized by expediting the submission of manuscripts to the journals as soon as research is completed.

Then, simultaneous with journal publication, the findings would be released by IIHS. Lead time for journal publication would also provide IIHS liaison personnel time to summarize the findings in suitable form for public relations release.

The technical manpower within the selected organization will be primarily psychologists, sociologists, engineers, and data analysts. The program director and his subproject directors should be carefully selected on the basis of their reputations as recognized researchers in appropriate disciplines, plus experience in research program management.

During the course of the program, the selected organization will overwhelmingly dominate the area of young driver research in highway safety. Also, because of its many interrelationships among other areas, the Young Driver Research Program will become strongly involved in informal cooperative activities throughout the highway safety research community. The growing trend toward such cooperative activity already indicates that a national professional society in the broad area of highway safety research is an imminent need. The impetus for establishing this kind of organization will probably come from among the existing university research centers. Assuming that this occurs, it will be very natural for the Young Driver Research Program to play a major role in the new society, e.g., by contributing its research findings in the form of journal articles or presentations at technical meetings.

8.8. PROGRAM SCHEDULE

As emphasized throughout, the Young Driver Research Program is long term and elements of it will easily span ten years or longer. Because of the designed pace and because of the nature of the institutions which will be participating, it is important that the program be carefully planned very early in order to be fruitful within a reasonable period of time.

The schedule is presented in four overlapping phases of development:

Phase I: Planning and Development Phase, covering the first two years;

Phase II: Initial Research, covering the second through fifth years;

Phase III: Continuing Research, Demonstration, and Evaluation Phase, covering the sixth through tenth years;

Phase IV: Maturity, years following the tenth. Discussion of each follows.

Phase I: Planning and Development Phase. The initial task will be the establishment of a Young Driver Research Program at an appropriate institution, and the appointment of a program director within the selected institution.

The director will face two primary tasks immediately. The first will be to develop an overall framework for the program within the constraints of the charter given him by the sponsor, including the basic objectives and research plans. Second, he must begin to assemble a staff, and start the process of bringing the program to the attention of appropriate scholars and researchers and selecting colleges and universities suitable for and willing to establish professorial chairs.

The director should be allowed discretion in his order of approach, but it should be expected that these activities be substantially completed at the end of the first year. During the first year, the growing program staff will begin to perform some of the in-house research and to initiate contracts for subproject work in other organizations. During the second year, more detailed planning of subprojects and their interrelationships will be completed.

Phase II: Initial Research Phase. In this phase, all of the research subprojects will be initiated and some will be completed. Most of the significant contracts and grants will be made during this period and the professorial chairs will be awarded. Interim results from subproject A will be evaluated and used in initiating subproject B. Although the results of several subprojects should be expected in later years, the fundamental significance and status of the program should be assured and widely recognized by the end of the fifth year.

Phase III: Continuing Research, Demonstration, and Evaluation Phase. During this phase, the results of the research subprojects will be accumulating and benefits of the professorial chairs will begin to appear. Although the evaluations of the demonstration projects will not be available until the latter years of this phase, the existence of the demonstration projects should have a strong continuing influence on the national highway safety effort, and they will dramatize public awareness of the program. Not only will individual research and scholarly products be evaluated throughout, but the significance and value of the entire Young Driver Research Program will be assessed during the tenth year. The goals of future activities in young driver research also should be determined during that year.

Phase IV: Maturity. Some Phase II and III subprojects might profitably be continued after the tenth year in order to fulfill the original objectives. The need for such continuation will probably occur because of various assessments and redirected efforts as new approaches are required.

Also as the evaluation results of demonstration projects are considered by various governmental agencies, some of them will surely be adopted as implementation programs. Concurrent with the development of these implementation programs, there will be a need for refined research and evaluations to clarify and optimize details.

A schedule for the first three phases, over a period of ten years, is shown in Figure 8-6. A more detailed schedule for the first three years is shown in Figure 8-7, wherein task schedules are indicated by distributions of professional manpower levels of effort.

8.9 PROGRAM COSTS

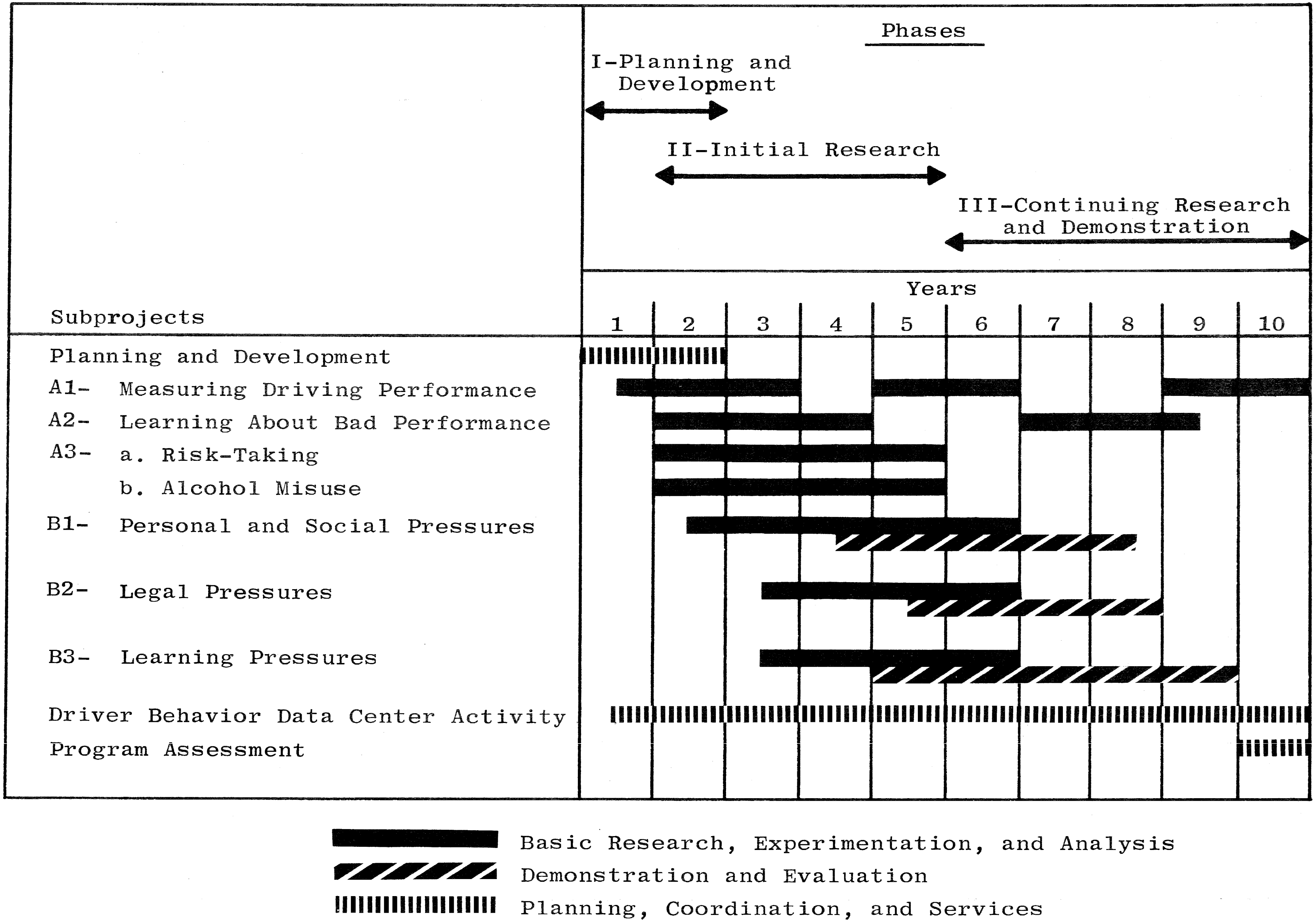
The major costs of the Young Driver Research Program will be salaries and overhead charges. Costs for the data center will also be significant throughout the program, and costs for the special driving ranges will be significant near the midpoint of the program.

Detailed cost estimates have been prepared for the first three years of the program, based primarily on the professional manpower distribution shown in Figure 8-7. If the professorial chairs are excluded, the numbers in Figure 8-7 cover only the subproject directors and researchers. The program director and two administrators must be added to give the total professional manpower estimate, as indicated in the chart that follows. Support manpower is estimated on the basis of a gradually increasing ratio as more technicians become involved in experimental work and as documentation is produced more frequently.

MANPOWER CHART: YOUNG DRIVER RESEARCH PROGRAM

Manpower	Year 1	2	3	4	5	6	7	8	9	10
Professional man years	15.5	37.5	43	48	50	45	35	25	18	16
Support man-years	5	13	16	20	21	20	16	12	11	7
Professorial chairs		1 to 2	3 to 4	4	4	4	4	4	4	4
Totals	20.5	52	62.5	72	75	69	55	41	33	27
	Detailed estimates			Rough projections						

Figure 8-6. Recommended Program Schedule



Subprojects and Tasks	Months 1-6	7-12	13-18	19-24	25-30	31-36
Planning and Development	4	10	5	3		
A1- Measuring Performance						
Define Parameters		6	2			
Determine Data Needed		2	2			
Select Community Lab.		3	2			
Collect Data			4	5	4	2
Analyze Data				2	4	4
A2- Assessing Bad Performance						
Define Parameters			4	4		
Determine Data Needed			2	2		
Organize Data Collection			1			
Collect Data				4	5	4
Collect Control Data					2	1
Compare Data Sets					1	1
Analyze Data					2	4
Data on Veterans					1	2
A3a- Assessing Critical Performance						
Define Risk Situations			3	3	3	1
Design Field Experiments				1	2	1
Conduct Experiments					1	2
Analyze Data						
Simulator Tests					1	1
Verify Data						
A3b- Alcohol Misuse/Performance			3	4	4	4
B1- Personal and Social Pressures						
Hypothesis Development				1	2	2
Select Community Lab.					1	1
Group Interaction Studies						1
Pilot Projects						
B2- Legal Pressures-Planning						2
B3- Learning Pressures-Planning						2
Data Center		2	6	6	6	6
Professorial Chairs			1	2	3	4

Note: Entries Indicate Average Levels of Effort of Professional Manpower Over 6-Month Periods

Figure 8-7. Detailed Three-Year Schedule

The peak year is the fifth year, when as many as 75 people could be involved during the transition toward more demonstration project activity.

The basic salary costs are estimated on the average as follows:

Program Director:	$30,000 per year
Subproject Directors:	22,000 per year
Researchers:	17,000 per year
Administrators:	13,000 per year
Technicians:	10,000 per year
Services Personnel:	10,000 per year
Research Assistants:	7,000 per year
Secretaries:	7,000 per year

The average salary cost for the professional personnel in the first four categories is estimated at $18,000 per man-year. The average salary cost for the support personnel in the lower categories is estimated at $8,500 per man-year.

Based on the manpower and salary estimates, the cost breakdown for the first three years of the Young Driver Research Program is given in the following chart:

COST CHART: YOUNG DRIVER RESEARCH PROGRAM

Cost Elements	Year 1	Year 2	Year 3
Professional Salaries	$279,000	$675,000	$774,000
Support Salaries	42,500	110,500	136,000
Overhead (60%)	192,600	471,300	546,000
Staff Benefits (12%)	38,520	94,260	109,200
Travel	18,000	42,000	45,000
Data Facility (lease-purchase)	50,000	80,000	80,000
Materials and Services	3,000	7,000	8,000
Program Totals	$623,620	$1,480,060	$1,698,200
Professorial chairs	-	52,500	122,500

The program cost for the first three years is estimated at $3,800,000, and the average is nearly $1.3 million per year.

By extrapolating the costs for the first three years, estimates for the total program on a yearly basis have been derived, as follows:

Year	Total cost to IIHS
1	$ 624,000
2	1,480,000
3	1,698,000
4	2,050,000
5	2,100,000
6	1,900,000
7	1,500,000
8	1,100,000
9	920,000
10	770,000
	$14,142,000

The total estimated cost to IIHS for a ten-year Young Driver Research Program is thus estimated to be approximately $14 million. The average cost per year is about $1,400,000.

Of the contracted work, it could be expected that about 75% would be spent directly by the prime contractor and 25% would be spent on subcontracts. The latter amount ($3,500,000) could be subcontracted by the prime contractor or could be contracted directly by IIHS (with the understanding that the prime contractor would maintain complete technical direction of the subcontracts).

In the initial synthesis of the young driver program plan as one of the twelve alternatives, the magnitude of the research was based partially on a guideline of approximately one million dollars per year cost. The initial cost estimates were very close to this level. A subsequent assessment of the program plan led to a feeling that the one million dollar level was appropriate and adequate for a straight-forward research program on the young driver theme as then conceived. Thus, the one million dollar level was established as a "critical" level for the intended scope of the program, i.e., the level below which the program could not fall, by any significant amount, if it were to provide the comprehensive coverage desired.

When the Young Driver Research Program was selected for recommendation, its scope was extended to cover related subjects such as legal sanctions and risk taking. While it was realized that the extended scope would lead to higher costs, it was expected that the costs could be kept within a reasonable range of the guideline. Actually, the final estimates for contracted work were about 40% higher. However, because the subprojects are flexible enough to be spread out further in time, the manpower estimates per year can be reduced, and costs during the early years can be brought closer to one million dollars per year.

The increasing trend of contracted costs during the first three years reflect an optimistic estimate of the required staff buildup by the prime contractor. However, since the rate of buildup is reasonable and desirable from the technical and management standpoint, it was retained to illustrate the optimum program. Further, even if the required buildup is not possible within the organization of the prime contractor, it can be compensated for by a higher rate of subcontracting than would ordinarily be planned during the early years. However, as pointed out in the preceding paragraph, it would also be possible to spread out the subprojects and reduce costs during the first few years.

8.10 FORECASTS

At the end of ten years it should be expected that the Young Driver Research Program will have produced large amounts of significant knowledge pertaining to the traffic accident process of young drivers, and will have provided a strong impetus for the adoption of implementation programs and countermeasures to help reduce the rate of young driver accidents. It is likely that some of the suggested implementation programs may be adopted by the seventh or eighth year of the program. Therefore, by the end of the program it would already have had some direct highway-safety influence on our social, legal, and educational systems. Among the possibilities are new legal controls atuned to the young driver, better but less authoritarian traffic-law enforcement techniques, judicial methods with greater built-in incentives for the young violator, new licensing and learning methods for young drivers, and the beginnings of new social attitudes about driving in the younger generation.

This program will be more comprehensive than any other in the history of highway safety research. In fact, there are no precedents in the field. However, precedents in the aerospace field at several universities have been successful, and would seem to portend success in the Young Driver Research Program. Nevertheless, the value of success in the research can be lost if the research results are not translated into action. The best assurance that the research results will be properly applied is the wide dissemination of research results in the traditional way so that as many researchers as possible are in a position to advocate the research recommendations and to augment them with their own work. If the program results are widely published, as recommended, it is predictable that the Young Driver Research Program will achieve a position of eminence in the highway safety field.

It would be unwise to forecast the changes in accident patterns and fatalities that might result from implementation of the young driver research findings. However, it is felt with some confidence that the independent contribution will tend to reduce accidents to a measurable extent, assuming all unrelated factors are constant.

It can be expected that some of the progress in the early years will be slow. Therefore, the sponsor should not expect too much in terms of early results in achieving the fundamental goals. The research will be hard; research into human behavior is less exact (thus perhaps harder), and is more difficult to evaluate, than research in other areas. Furthermore, much of the preliminary work, such as formulating specific work statements, creating needed facilities, and establishing subcontracts, will be very time-consuming. Finally, obtaining the services of competent, respected researchers is perhaps the most important and most difficult preliminary step. The supply of such people is short, and the demand is high; consequently obtaining desirable individuals will to some extent require meeting their standards. In sum, this means that most aspects of the actual research planning and activities will proceed at an academic pace. If allowed to do so, the rewards should be commensurate--high-quality research accomplishments that will be received with respect by the research community; and that will afford the basis for positive constructive action in highway safety.

9. CONCLUSIONS

1. The field of highway safety research is best summarized in seven system areas: driver, vehicle, roadway, pedestrians, physical environment, social environment, and highway services.

2. The area of driver behavior research is the one which has been given most attention in the past, the one in which results have been least substantive because of its complexity, and the one in which the future needs are most critical.

3. Within the area of driver research, the topics of sensory-perceptual processes and personality mechanisms have been and should continue to be the most important.

4. Research dealing with the physical factors in highway safety has kept pace with the evolution of vehicle and roadway designs.

5. Research on vehicle factors is being emphasized by the National Highway Safety Bureau.

6. Research in the other areas of highway safety has touched on miscellaneous topics, most of which will have to be reconsidered in a system context to be of value.

7. In general, highway safety research has been uncoordinated, inadequate, and only minimally applicable to the current needs.

8. Programs to implement highway safety research findings are essential if the research is to be of any value.

9. A great need exists for application of the system approach to the overall problem of highway safety.

10. Two important system areas related to highway safety--the social environment and highway services--while only recently recognized as such, can be seen to have especially great potential for solutions.

11. Critical research gaps exist in all seven system areas, and all must be accorded appropriate support to maintain uniform progress.

12. Five types of organizations are appropriate for highway safety research: universities, research firms, government, industry and foundations.

14. More research has been done in the universities (both in staff organizations and individual or team approaches) than in other types of organization.

15. Appropriate organizational forms within the basic organizations range from individual consultants, through small projects and departments, to large, multidisciplinary research centers or institutes.

16. Within the various organizational forms, the work done on a large, coordinated research program may be the whole job, the management job plus some research, the management only, or subprojects only.

17. Universities and research firms are the best types of organizations for performance of the type of large, coordinated highway safety research program proposed by IIHS.

18. The program to be sponsored by IIHS could be performed within IIHS itself.

19. The program management of the IIHS-sponsored program is a technical job which can be done adequately only within a technically oriented organization.

20. The program director should have direct authority over all research work on the program, and should be not only a capable manager but also a highly-respected researcher in the highway safety field.

21. A severe disadvantage of having the technical management (and the majority of the research work on the program) in any organization other than a university or research firm is the extreme difficulty of recruiting and attracting a staff away from their positions in universities and research firms.

22. The IIHS program should be conducted by several different organizations, either on the basis of subcontracts from the prime contractor or many direct contracts from IIHS.

23. Technical liaison between IIHS and the research organization is very important.

24. The research program goals established by IIHS on behalf of the automobile insurance industry are complete, objective, and reasonable.

25. The IIHS goals are valuable as guidelines for selecting potential program themes and as bases for evaluation criteria.

26. On the basis of the twelve alternative research program plans considered, a ten-year program at an approximate support level of one million dollars a year is adequate and necessary for the achievement of major syntheses in highway safety.

27. For a ten-year program at one million dollars a year sponsored by IIHS, the themes of responses to accident injuries, young drivers, legal sanctions, and implementation evaluations are superior alternatives when considered independently.

28. Certain combinations of various aspects of alternative research themes have greater potential, even at equal cost levels, than any of the alternatives taken independently.

29. There is a greater opportunity for improvement among young drivers than among any other group of drivers.

30. There is a greater potential for man-lives saved among improved young drivers than among any other group of drivers.

31. The image of the automobile insurance industry would be enhanced by sponsorship of a Young Driver Research Program at least as much as by any other program.

32. A Young Driver Research Program, lasting ten years and costing 14 million dollars is the best choice for IIHS sponsorship.

33. The best organizational form for a Young Driver Research Program is a large, multidisciplinary research institute at a university, performing the program management function and part of the actual research.

34. Professorial chairs should also be established by IIHS to augment the Young Driver Research Program.

35. An important feature of the Young Driver Research Program is its basis within one or more community laboratories which provide diverse driving populations and environments for study.

36. Use of a data center within the community laboratory is essential to the Young Driver Research Program.

37. Data from automobile insurance industry files would not be useful, in its present form, for use in the Young Driver Research Program.

38. Data from selected insurance companies could be useful in the Young Driver Research Program if the extent of data collected from insurees were significantly increased according to requirements established by the research.

Appendix 1

ELEMENTS OF THE HIGHWAY TRANSPORTATION SYSTEM AND RELATED SYSTEMS

1. <u>Drivers</u>

- 1.1 Physical Characteristics
  - 1.1.1 Anthropometric Characteristics
  - 1.1.2 Sense Organs
    - 1.1.2.1 Eyes
    - 1.1.2.2 Ears
    - 1.1.2.3 Proprioceptors (kinesthetic sense)
    - 1.1.2.4 Vestibular organs (balance and motion)
    - 1.1.2.5 Other
  - 1.1.3 Brain
  - 1.1.4 Nervous System
  - 1.1.5 Motor Organs
    - 1.1.5.1 Arms, Hands
    - 1.1.5.2 Legs, Feet
    - 1.1.5.3 Neck
    - 1.1.5.4 Torso
- 1.2 Mental Functions
  - 1.2.1 Sensory Perception
  - 1.2.2 Information Processing
  - 1.2.3 Memory
  - 1.2.4 Decision Making
- 1.3 Performance Capabilities
  - 1.3.1 Vision
    - 1.3.1.1 Focus
    - 1.3.1.2 Image Resolution
    - 1.3.1.3 Sub-image Discrimination
    - 1.3.1.4 Intensity Detection
    - 1.3.1.5 Distortion
    - 1.3.1.6 Color Detection
    - 1.3.1.7 Fixation
    - 1.3.1.8 Scanning
    - 1.3.1.9 Peripheral Vision
  - 1.3.2 Hearing
    - 1.3.2.1 Volume Detection
    - 1.3.2.2 Frequency Detection
    - 1.3.2.3 Source Discrimination
  - 1.3.3 Proprioceptive Sensing Capability
  - 1.3.4 Vestibular Sensing Capability
  - 1.3.5 Other Sensory Capabilities
  - 1.3.6 Information Input Acceptance Rate
  - 1.3.7 Information Processing Response Rate
  - 1.3.8 Memory Capacity and Recall Rate
  - 1.3.9 Decision Making Capability
  - 1.3.10 Motor Skills
    - 1.3.10.1 Steering Action
    - 1.3.10.2 Braking Action
    - 1.3.10.3 Acceleration Action
    - 1.3.10.4 Clutching Action
    - 1.3.10.5 Shifting Action
    - 1.3.10.6 Auxiliary Action

1.4 General Status
- 1.4.1 Age
- 1.4.2 Sex
- 1.4.3 Marital Status
- 1.4.4 Employment
- 1.4.5 Socioeconomic Level
- 1.4.6 Educational Status
- 1.4.7 Race
- 1.4.8 Family
- 1.4.9 Driving Experience
- 1.4.10 Driver Licensing Status
- 1.4.11 Car Ownership
- 1.4.12 Driving Record
- 1.4.13 Court Record

1.5 Behavioral Attributes and Influences
- 1.5.1 General Condition
  - 1.5.1.1 Physical Condition
  - 1.5.1.2 Physiological Health
  - 1.5.1.3 Mental Health
- 1.5.2 Immediate Condition
  - 1.5.2.1 State of Arousal
  - 1.5.2.2 Fatigue
  - 1.5.2.3 Emotional State
  - 1.5.2.4 Influence of Alcohol or Drugs
  - 1.5.2.5 Comfort
- 1.5.3 Intelligence
- 1.5.4 Personality and Character
- 1.5.5 Attitudes and Motivations (cooperativeness, responsibility, habit, aggressiveness, hostility, confidence, instincts, expectations, aspira-ations, patience, anxiety, idealogy, incentives, prejudices, impulsiveness, courtesy)

2. <u>Vehicles</u>

2.1 Physical Characteristics
- 2.1.1 Static Mechanical Characteristics
  - 2.1.1.1 Size, Shape, Dimensions
  - 2.1.1.2 Weight
  - 2.1.1.3 Center of Gravity
  - 2.1.1.4 Moments of Inertia
- 2.1.2 Gross Physical Features
  - 2.1.2.1 Chassis Structure
  - 2.1.2.2 Body Structure
  - 2.1.2.3 Engine Structure
- 2.1.3 Functional Systems
  - 2.1.3.1 Steering System
  - 2.1.3.2 Braking System
  - 2.1.3.3 Propulsion System
  - 2.1.3.4 Transmission
  - 2.1.3.5 Suspension
  - 2.1.3.6 Wheels
  - 2.1.3.7 Tires
- 2.1.4 Auxiliary Exterior Features
  - 2.1.4.1 Bumpers

- 2.1.4.2 Trim
- 2.1.4.3 Ornamentation
- 2.1.4.4 Handles
- 2.1.4.5 Racks
- 2.1.4.6 Hub Caps
- 2.1.4.7 Exterior Mirrors
- 2.1.4.8 Windshield Wipers and Washers
- 2.1.4.9 Antennas

2.1.5 Lighting
- 2.1.5.1 Exterior Lighting
- 2.1.5.2 Interior Lighting
- 2.1.5.3 Signal Lights
- 2.1.5.4 Color of Lights

2.1.6 Major Controls
- 2.1.6.1 Steering Wheel
- 2.1.6.2 Brake Pedal
- 2.1.6.3 Accelerator
- 2.1.6.4 Shift
- 2 1.6.5 Clutch

2.1.7 Passenger Compartment
- 2.1.7.1 Size and Shape
- 2.1.7.2 Seat Characteristics
- 2.1.7.3 Door Characteristics
- 2.1.7.4 Window Sizes and Locations
- 2.1.7.5 Pillar Sizes and Locations
- 2.1.7.6 Floor
- 2.1.7.7 Ceiling
- 2.1.7.8 Glass Characteristics
- 2.1.7.9 Interior Mirrors
- 2.1.7.10 Dashboard Design
- 2.1.7.11 Padding
- 2.1.7.12 Steering Assembly Characteristics
- 2.1.7.13 Pedals
- 2.1.7.14 Other Controls
- 2.1.7.15 Handles and Knobs
- 2.1.7.16 Head Rest
- 2.1.7.17 Seat Belts
- 2.1.7.18 Shoulder Harnesses
- 2.1.7.19 Other Restraints
- 2.1.7.20

2.1.8 Miscellaneous
- 2.1.8.1 General Condition
- 2.1.8.2 Cargo Area Characteristics
- 2.1.8.3 Gasoline Tank
- 2.1.8.4 Radio
- 2.1.8.5 Heater
- 2.1.8.6 Air Conditioning
- 2.1.8.7 Door Lock Characteristics
- 2.1.8.8 Electrical System
- 2.1.8.9 Horn
- 2.1.8.10 Exhaust System
- 2.1.8.11 Color of Vehicle
- 2.1.8.12 Exterior Load
- 2.1.8.13 Trailer

- 2.2 Performance Capabilities
  - 2.2.1 Handling Properties
    - 2.2.1.1 Steering (turning)
    - 2.2.1.2 Braking (deceleration and stopping)
    - 2.2.1.3 Acceleration
    - 2.2.1.4 Speed
    - 2.2.1.5 Suspension Dynamics
    - 2.2.1.6 Skidding
    - 2.2.1.7 Vehicle Dynamics
  - 2.2.2 Vibration and Ride Dynamics
  - 2.2.3 Lighting System Effectiveness
  - 2.2.4 Viewing System Effectiveness
  - 2.2.5 Communications System Effectiveness
  - 2.2.6 Noise
  - 2.2.7 Exhaust Content
  - 2.2.8 Reflections and Glare
- 2.3 General Aspects
  - 2.3.1 Vehicle Manufacturer
  - 2.3.2 Year of Manufacture
  - 2.3.3 Model
  - 2.3.4 Cost

3. <u>Roads</u>

- 3.1 Physical Characteristics
  - 3.1.1 The Roadway
    - 3.1.1 Roadway Surface Material
    - 3.1.2 Roadway Surface Condition
    - 3.1.3 Roadway Cross-Section Design
    - 3.1.4 Slope
    - 3.1.5 Number of Traffic Lanes
    - 3.1.6 Widths of Lanes
    - 3.1.7 Lane Markings
    - 3.1.8 Cross Walks
  - 3.1.2 Geometrics
    - 3.1.2.1 Curves
    - 3.1.2.2 Intersection Characteristics
    - 3.1.2.3 Merging Lanes
    - 3.1.2.4 Parking Lanes
    - 3.1.2.5 Driveways
  - 3.1.3 Adjunct Roadside Features
    - 3.1.3.1 Medians
    - 3.1.3.2 Shoulders
    - 3.1.3.3 Gutters
    - 3.1.3.4 Curbs
    - 3.1.3.5 Traffic Islands
    - 3.1.3.6 Sidewalks
    - 3.1.3.7 Guard Rails
    - 3.1.3.8 Drainage Ditches
  - 3.1.4 Special Structures
    - 3.1.4.1 Bridges
    - 3.1.4.2 Tunnels
    - 3.1.4.3 Toll Booths
    - 3.1.4.4 Railroad Crossings

3.1.5 Auxiliary Equipment
 3.1.5.1 Signs
 3.1.5.2 Signals
 3.1.5.3 Lighting
3.1.6 Other Objects
 3.1.6.1 Sign Poles
 3.1.6.2 Utility Poles
 3.1.6.3 Parking Meters
 3.1.6.4 Fences
 3.1.6.5 Trees and Shrubs

4. <u>Pedestrians</u>

Same as Drivers, except:
4.3.10
 4.3.10.1 Walking
 4.3.10.2 Crossing
 4.3.10.3 Stopping
 4.3.10.4 Standing
 4.3.10.5 Running
 4.3.10.6 Bicycling
 4.3.10.7 Pushing (carriage, etc).
 4.3.10.8 Playing
 4.3.10.9 Working

5. <u>Physical Environment</u>

5.1 The Scene
 5.1.1 Urban
  5.1.1 Building Density
  5.1.2 Building Height
  5.1.3 General Complexity
  5.1.4 Level of Activity
 5.1.2 Rural
  5.1.2.1 Fields
  5.1.2.2 Woods
  5.1.2.3 Farms
5.2 The Topography
 5.2.1 Level Areas
 5.2.2 Hills
 5.2.3 Mountains
 5.2.4 Rolling Land
 5.2.5 Adjacent Waterways
 5.2.6 Cliffs and other Formations
5.3 The Atmosphere and Weather
 5.3.1 Atmosphere
  5.3.1.1 Temperature
  5.3.1.2 Clouds
  5.3.1.3 Fog
  5.3.1.4 Smog
  5.3.1.5 Smoke
  5.3.1.6 Wind
 5.3.2 Precipitation
  5.3.2.1 Rain
  5.3.2.2 Snow

6. The Social Environment

- 6.1 Social Customs
- 6.2 Social Institutions
- 6.3 Cultural Influences
- 6.4 The Economic System
- 6.5 The Political System
- 6.6 The Governmental System
- 6.7 Laws and the Legal System
- 6.8 The Enforcement System
- 6.9 The Educational System
- 6.10 The Highway Administration System
- 6.11 The Driver Administration System
- 6.12 The Vehicle Regulation System
- 6.13 The Public Information System
- 6.14 The Vehicle Manufacturing and Sales Industry
- 6.15 The Automobile and Driver Insurance Industry
- 6.16 The Private Highway Safety Action and Information Organizations
- 6.17 The Highway Safety Research Organizations
- 6.18 The Highway Design, Construction and Maintenance System
- 6.19 The Systems of Personal, Commercial, and Public Highway Use
- 6.20 The Parking System
- 6.21 The Systems of Non-highway Transportation

7. The Highway Services System

- 7.1 Highway Patrol
- 7.2 Surveillance, Detection, Communications
- 7.3 Emergency Aid
- 7.4 On-Scene Medical Services
- 7.5 Ambulance Services
- 7.6 Hospital Services
- 7.7 Debris Cleanup
- 7.8 On-Scene Vehicle Servicing
- 7.9 Vehicle Towing
- 7.10 Vehicle Repair
- 7.11 Highway Repair and Maintenance
- 7.12 Route Direction Services
- 7.13 Adjunct Food, Comfort, and Vehicle Services Facilities

Appendix 2

INTERFACES WITHIN THE HIGHWAY TRANSPORTATION SYSTEM (HTS)

The interfaces with the HTS may be identified in Diagram A. Each element of this interface matrix represents the interface between a pair of subsystems. The subsystems of the HTS are driver (D), vehicle (V), roadway (R), pedestrian (P), physical environment (PE), social environment (SE), and highway services (HS). The subsystems along the left side are inputs to the interfaces and those along the top are outputs. The designations of the interfaces consist of two letters separated by a slash mark. The first letter is the input and the second is the output. Thus, the driver-vehicle interface (wherein the driver affects the vehicle) is designated by D/V, and the converse is V/D.

There are opportunities for 42 such interfaces, but 5 do not exist, thus leaving 37 valid interfaces. The 5 that do not exist would have been D/R, D/PE, P/V, P/R, and P/PE. Most of the interfaces are paired (i.e., D/V and V/D). Of the 21 possible pairs, 16 include two interfaces and 5 are single interfaces. The 16 pairs can be viewed as action-reaction operations.

In addition to these 21 basic sets, there are 7 other interfaces along the diagonal which are actually interactions within subsystems: D/D, V/V, R/R, P/P, PE/PE, SE/SE, and HS/HS. These will be viewed as interfaces because they can represent interactions among separate entities, e.g., D/D can represent a driver's hand signal to another driver.

Most of the 28 sets come into play during more than one of the five phases of operation. The phases are conditioning (1), traffic (2), accident initiation (3), collision (4), and post-accident (5). In Diagram B the appropriate phases are entered in each element of the interface matrix. All five phases are involved in 14 of the interfaces. The total number of entries is 164.

Descriptions of the system interfaces are listed below. The composite of the descriptions should cover, in general, all occurrences, operations, events, situations, policies, feelings, and characteristics which influence highway safety. Also, the interface descriptions may be combined into various kinds of groupings which define different approaches to highway safety research.

DIAGRAM A. INTERFACE DESIGNATIONS

IN \ OUT	D	V	R	P	PE	SE	HS
D	D/D	D/V	-	D/P	-	D/SE	D/HS
V	V/D	V/V	V/R	V/P	V/PE	V/SE	V/HS
R	R/D	R/V	R/R	R/P	R/PE	R/SE	R/HS
P	P/D	-	-	P/P	-	P/SE	P/HS
PE	PE/D	PE/V	PE/R	PE/P	PE/PE	PE/SE	PE/HS
SE	SE/D	SE/V	SE/R	SE/P	SE/PE	SE/SE	SE/HS
HS	HS/D	HS/V	HS/R	HS/P	HS/PE	HS/SE	HS/HS

DIAGRAM B. PHASE APPLICABILITY OF INTERFACES

IN \ OUT	D	V	R	P	PE	SE	HS
D	1,2,3, 4,5	1,2,3, 4	-	1,2,3, 5	-	1,2,5	1,2,5
V	1,2,3, 4,5	2,3,4	1,2,3, 4	1,2,3, 4,5	1,2,3, 4,5	1,5	1,2,5
R	1,2,3, 4,5	2,3,4, 5	1,4,5	1,2,3, 4,5	1,2,3	1,5	1,2,5
P	1,2,3, 5	-	-	1,2,3, 4,5	-	1,2,5	1,2,5
PE	1,2,3, 4,5	1,2,3, 4,5	1,2,3, 5	1,2,3, 4,5	1,2,3, 5	1	1,2,5
SE	1,2,3, 5	1,5	1,5	1,2,3, 5	1,2,3	1,2,5	1,5
HS	1,2,3, 4,5	1,2,3, 4,5	1,2,5	1,2,3, 4,5	1,2,3, 5	1,5	1,2,3, 4,5

A2.1. Driver-Initiated System Interfaces

D/D:	D1D	Driver prepares himself for driving
	D2D	Driver perceives the inputs from traffic situations and makes decisions; one driver signals or yells to another.
	D3D	Driver makes and perceives a judgment error and reacts (near miss or collision)
	D4D	Driver braces, experiences collision
	D5D	Driver observes and participates in aftermath
D/V:	D1V	Driver obtains and maintains vehicle, indirectly influences vehicle design
	D2V	Driver performs mechanical driving tasks
	D3V	Driver makes initiating or reacting mechanical driving error (improper, inadequate, inefficient)
	D4V	Driver impacts vehicle
D/P:	D1P	Driver makes impression on pedestrian in non-traffic context
	D2P	Driver communicates with pedestrian (signals, yells from car!)
	D3P	Driver action impells pedestrian into unsafe action
	D5P	Driver helps injured pedestrian in aftermath
D/SE:	D1SE	Driver social attitudes, reactions, business demands, opinions, etc. influence planning of SE components
	D2SE	Observed driving actions influence planning of SE components
	D5SE	Observed aftermath participation of drivers influence planning of SE components
D/HS:	D1HS	Driver demands highway services
	D2HS	Driver in traffic communicates with highway services subsystem (yells, warns).
	D5HS	Driver presents problem to HS or augments HS

A2.2. Vehicle-Initiated System Interfaces

V/D:	V1D	Vehicle capability, condition, and value affect driver attitudes
	V2D	Vehicle supports driver, permits visibility, provides information and feedback, and is visible in varying numbers and speeds to other drivers, governs driver accommodation to it.
	V3D	Vehicle performance responses limitations or failures require emergency actions of the driver and other drivers or may stimulate unsafe actions of other drivers.

	V4D	Vehicle restrains and/or injures driver
	V5D	Vehicle traps or impedes driver after collision
V/V:	V2V	Vehicle parts interact in normal driving
	V3V	Vehicle performance aspects interact in unsafe ways.
	V4V	Vehicle parts interact in collision damage; one vehicle damages another.
V/R:	V1R	Vehicle wears down pavement
	V2R	Vehicle occupies road; wears down pavement
	V3R	Vehicle blocks roadway, hides signs or signals
	V4R	Vehicle damages roadway components
V/P:	V1P	Potential vehicle threat affects potential pedestrian attitudes
	V2P	Vehicle is visible to pedestrian in traffic
	V3P	Vehicle action may require emergency response of pedestrian or stimulate unsafe action of a pedestrian.
	V4P	Vehicle injures pedestrian
	V5P	Vehicle impedes pedestrian after collision.
V/PE:	V1PE	Vehicles emit pollutants, disperse water from pavement, wear down snow.
	V2PE	Vehicles emit pollutants, disperse water from pavement, wear down snow.
	V3PE	Vehicle sprays water on other vehicle windshield
	V4PE	Vehicle damages roadside objects
	V5PE	Vehicle fire makes smoke
V/SE:	V1SE	Existence of vehicle requires government services, laws, manufacturing, research and insurance. Vehicles influence families, social life.
	V5SE	Condition of vehicle after an accident spurs society to provide better systems.
V/HS:	V1HS	Existence of vehicles requires highway services
	V5HS	Vehicle needs after an accident require highway services.

A2.3. Roadway-Initiated System Interfaces

R/D:	R1D	General highway effectiveness affects driver attitudes; specific highway affects plans
	R2D	Vision of road affects driver; signs and signals affect driver.
	R3D	Road failures or weaknesses present problems to driver; signals could confuse driver.

	R4D	Road components may injure driver
	R5D	Road components may impede driver
R/V:	R2V	Road wears tires, causes bumping, road supports vehicle.
	R3V	Bumps and edges cause dangerous motions of vehicle.
	R4V	Road damages vehicle
	R5V	Road components may impede vehicle towing or repair.
R/R:	R1R	Existing road affects design of adjacent one
	R4R	Road components interact in collision
	R5R	Road components block one another
R/P:	R1P	Road characteristics affect pedestrian attitudes and plans
	R2P	Vision of road, signs and signals affect pedestrian
	R3P	Road may be unsafe for pedestrian crossing; signals confuse pedestrian.
	R4P	Road components injure pedestrians
	R5P	Road may impede pedestrian
R/PE:	R1PE	Road design may affect topography and scene; accumulate and melt snow, accumulate and channel rain
	R2PE	Accumulate ice and melt snow, accumulate and channel rain
	R3PE	Road accumulates and accentuates precipitation accumulations.
R/SE:	R1SE	Existence of roads affects society's attitudes
	R5SE	Damage to roads affects society's understanding of needs
R/HS:	R1HS	Road needs are apparent to highway services
	R2HS	Road needs are observed during traffic by services.
	R5HS	Road needs are observed after a collision

A2.4. <u>Pedestrian Initiated System Interfaces</u>

P/D:	P1D	Potential pedestrian makes impression on potential driver in non-traffic context
	P2D	Pedestrian communicates with driver (yells, waves)
	P3D	Pedestrian action impells driver into unsafe actions or emergency response
	P5D	Pedestrian helps driver after collision

P/P:	P1P	Pedestrian becomes accustomed to pedestrian role
	P2P	Pedestrian acts in traffic situation, communicates with or assists another pedestrian
	P3P	Pedestrian makes and perceives an error, and reacts
	P4P	Driver foresees collision, braces, and experiences it
	P5P	Pedestrian observes and participates in aftermath
P/SE:	P1SE	Pedestrian's social actions affect social environment planning.
	P2SE	Pedestrian's observed actions in traffic influence social environment planning.
	P5SE	Pedestrian's observed actions in aftermath influences social environment planning.
P/HS:	P1HS	Pedestrians demand highway services
	P2HS	Pedestrian actions attract highway services
	P5HS	Pedestrian needs attract highway services

A2.5. Physical Environment-Initiated System Interfaces

PE/D:	PE1D	Known dangers of physical environment affect driver attitudes in long and short range
	PE2D	Physical environment influences driving procedures; presents situation and information to driver.
	PE3D	Physical environment obstructs vital information to driver; irritates
	PE4D	Driver could be hit by an object or drown in water
	PE5D	Irritant and deterrent to recovery of driver
PE/V:	PE1V	Sun can heat up car, rain can leak in and affect ignition
	PE2V	Rain or snow cover part of windshield, heat affects engine, tires, ice or snow affect tires, wind blows.
	PE3V	Windshield covered, engine or tires fail, tires lose friction, vehicle yaws
	PE4V	Object could damage vehicle, water could ruin it
	PE5V	Darkness hides vehicle for service; snow could cover vehicle or water flood it; snow banks block vehicle
PE/R:	PE1R	Precipitation accumulates and blocks road, heat expands roadway elements; topography affects road geometry designs
	PE2R	Precipitation accumulates and blocks road, heat expands roadway elements; topography affects road geometry designs

	PE3R	Snow covers signs, signals, or lane marking. Accumulation presents hazard, blowout from heat.
	PE5R	Precipitation blocks road for highway service; darkness hides road for service.
PE/P:	PE1P	Known dangers of physical environment affect pedestrian attitudes
	PE2P	Physical environment presents situation and information to pedestrian and influences his actions
	PE3P	Precipitation hides signs, signals, lanes; accumulation forces unsafe detours.
	PE4P	Pedestrian could be hit by object, and drown in water
	PE5P	Irritant and deterrent to recovery of pedestrian
PE/PE:	PE1PE	Wind affects snow drifting, slope affects water flow
	PE2PE	Wind drives snow or rain; shadows; temperature/ice
	PE3PE	Wind drives snow or rain; shadows; temperature/ice
	PE5PE	Snow-drifting and water flow effects after collision
PE/SE:	PE1SE	Effects of physical environment accounted for in social environment planning
PE/HS:	PE1HS	Effects of physical environment accounted for in highway services planning; need for plowing; weather extremes hinder highway services preparedness
	PE2HS	Diminished accessibility of roadside services; need for snow plowing
	PE5HS	Hindrance to post accident services

A2.6 Social Environment Initiated System Interfaces

SE/D:	SE1D	Social environment governs development of drivers attitudes and preparation
	SE2D	Social environment influences driver behavior in traffic; more in daytime; more drinkers at night
	SE3D	Social environment affects driver errors
	SE5D	Social environment influences driver participation after the accident
SE/V:	SE1V	Social environment governs design, manufacture, maintenance and repair of vehicle
	SE5V	Social environment influences repair of vehicle after accident

SE/PE:	SE1PE	Highway needs govern location (scene, topography); smog
	SE2PE	More traffic needs in daytime; social demand influences artificial lighting
	SE3PE	Smoke
SE/SE:	SE1SE	Social system interactions relative to highway transportation
	SE2SE	Enforcement affects custom
	SE5SE	Social systems interact after accidents (e.g., insurance and enforcement and laws, etc.)
SE/HS:	SE1HS	Social systems demand and provide highway services
	SE5HS	Social systems evaluate highway services

A2.7. Highway Services-Initiated System Interfaces

HS/D:	HS1D	Existence of services governs driver attitudes
	HS2D	Presence of services governs driver attitudes and actions
	HS3D	Actions or proximity of services governs driver attention and actions
	HS4D	Components of services injure driver
	HS5D	Services help driver after accident
HS/V:	HS1V	Services prepare vehicle for travel
	HS2V	Road clearing ineffectiveness could allow vehicle bumping, etc.
	HS3V	Road clearance ineffectiveness could allow dangerous vehicle bumping
	HS4V	Service vehicles cause damage to other vehicles in collision
	HS5V	Services affect vehicles after collision
HS/R:	HS1R	Services prepare roadway
	HS2R	Roadway services during traffic
	HS5R	Roadway services after an accident
HS/P:	HS1P	Existence of services governs pedestrian attitudes
	HS2P	Presence of services governs pedestrian attitudes and evaluations
	HS3P	Actions or proximity of services governs pedestrian attention evaluations
	HS4P	Components of services injure pedestrian
	HS5P	Services help pedestrian after accident
HS/PE:	HS1PE	Services alleviate environment effects in advance
	HS2PE	Services alleviate environment effects in traffic

HS3P	Services accentuate environment effects unintentionally
HS5PE	Services alleviate environment effects after accident
HS/SE:HS1SE	Highway services image governs social awareness
HS5SE	Highway services effectiveness governs social demand
HS/HS:HS1HS	Services interact in continued improvements and planning
HS2HS	Services interact in traffic
HS3HS	Services interact in accident initiation
HS4HS	Services interact in collision
HS5HS	Services interact in post accident phase

Appendix 3

REVIEWS OF HIGHWAY SAFETY RESEARCH

3.1 THE DRIVER

The review of driving behavior research attempted to cover as wide a range of pertinent literature as possible in the time available. Previous bibliographies in the area were screened in order to pick out reports and papers of greatest importance, and other literature review techniques were used to limit the number of documents. A list of 180 references was selected, and is presented at the end of this section.

There is no single report which serves as a classic in the whole field of driving behavior. However, one excellent document deserves mention because of its forward-looking intent, viz. "Behavioral Approaches to Accident Research," published by the Association for the Aid of Crippled Children in 1961. Many of the concepts and methodologies presented there were considered in this review, and they should be adopted in future driver behavioral research.

Although summaries of findings from previous reviews were considered in the initial literature search on driving behavior, the primary approach in this study did not attempt to compile findings from other summaries. Rather, it encompassed a broad sweep of the whole driving behavior area in order to avoid constraints of previous categorizations. Thus, the categories selected here reflect the current status in terms of the distribution of significant research topics, rather than preconceived notions of needed research. The selected categories include general considerations, theoretical considerations, sensory-perceptual processes, psychomotor processes, personality mechanisms, driver education, drugs and alcohol, and medical aspects. A final subsection compiles the research gaps derived from each of those categories.

The large number of references reviewed in this section reflect a feeling developed gradually throughout the course of the study that the areas of the driver and driving behavior are especially appropriate for private support in highway safety research, in comparison to other elements of the highway transportation system. As a result, the driving behavior review continued after other phases of program planning had begun. However, the large number of references in this section does not reflect the relative status of driver research. On the contrary, it has been concluded that the needs in driver research are particularly critical, because of the complexity of the subject, the relatively long time periods required for meaningful results, and the relative difficulty in deriving models of driving behavior in contrast to other related systems.

Of the driving behavior research categories covered here, two stand out in terms of the large amount of research done and their apparent criticality as potential bases for ultimate improvements in the driver's performance. These categories are sensory-perceptual processes and personality mechanisms. Though much has been done in these areas, there has been no serious attempt to define their research objectives and to promote establishment of comprehensive, cooperative research activity which attacks their inclusive problems on a long-term basis. Until this is done, the research on driver behavior in these two critical areas, or any other area, will probably continue to be as diverse and loosely related as it is now.

3.1.1 GENERAL CONSIDERATIONS. The material reviewed in this section covers several broad subjects which give a general view of the problems of driver behavior. Most do not fit into the remaining specific categories. Several deal with the driver in a system context, though none are self-identified as such.

McFarland (1966)* has discussed the measurement of human factors in accident research, and concluded that most accidents have a multiple causation with a nonspecific etiology. One very important factor not taken into account is an assessment of driver exposure, i.e., some measure of the amount, intensity, and danger of various driving experiences.

McFarland (1966) has also presented information on the older driver and accidents. It has been found, for example, that the ratio of "blameworthy to nonblameworthy accidents" was higher for inaccurate turning into or crossing of junctions for those over 65 years of age. It was concluded that those over 65 are involved in accidents because of failure to give the right of way, improper turning, ignoring of stop signs, and improper starting.

Pelz and Schuman (1968) have found that young drivers with repeated accidents and violations were more involved in cars, drove more miles during the year, were more aware of social pressures and tensions, more likely to use driving as an outlet for such tensions, more likely to come from a working-class home, and less successful in school.

While the youngest drivers had the most accidents, it was not until the "dangerous years" from 19 to 22 that their accidents became severe and traffic tickets increased. Social pressures and involvement with cars were highest at 19-20 years. These results suggest that tensions surrounding the onset of adulthood spill over into driving behavior, and that feelings of resentment against adult authority are high.

*References for 3.1 are included in section 3.1.10 and are listed alphabetically by author.

Versace (1967) surveyed the literature in the area of driving and safety and indicated the many complexities of this topic. Experiments have been conducted to relate to driver's speed to his accident rate. Munden (1967) recorded the speed and license numbers of more than 31,000 cars at ten different sites on rural main roads. He obtained a "speed ratio", which was the observed speed divided by the mean speed of neighboring cars in the traffic stream. Accident data for more than 13,000 cars was collected. Munden concluded that there was a U-shaped variation between the accident rate and relative speed, with the average speed driver having the lowest rate and high accident rates for the slow and fast drivers.

Rockwell and Snider (1965) explored variability in driving performance on the highway. In a three-year study using different longitudinal control tasks for both professional and non-professional drivers in an instrumented passenger car, a "threshold control" model was devised. Parameters used in the model include vehicle velocity, vehicle velocity change, vehicle acceleration, vehicle jerk, relative headway, relative headway change, and relative velocity. The results showed that the subjects tend to damp out the effects of the leading vehicle velocity variability through a corresponding headway increase. These results supported their model.

Tindall (1966) devised methods for measuring variables along a highway. Two vehicles were instrumented for data collection from the highway. The objective was to assess the rate at which data is presented to a driver and the rate with which it is absorbed; the distribution of discrete and continous variables that are related to accidents; the ability to rapidly automatically collect data for a highway inventory; and photographic technique for recording data. One conclusion was that time lapse photography accomplishes a floating car survey, a classification count, an inventory of traffic events, and an inventory of many highway variables. It may have an important role in human factors studies.

"Ergonomics" has been defined by Singleton (1966) as systems design with the characteristics of the human operator as a frame of reference. Among the techniques used in this area are studies of cues of assumed importance (e.g. visibility), critical incident studies (e.g. the occurrence of errors), internal environment measures (e.g. vibration effects), performance measures (e.g. mental arithmetic), controlled environment studies (e.g. simulators), conceptual models (e.g. decision theory models).

A model has been developed for specifying a vehicle's trajectory in an emergency maneuver. Sheridan and Roland (1967) specify a mathematical model, embodied in a digital computer, to be used in conjunction with both a closed-circuit TV laboratory simulator and actual road tests.

Vehicle speed changes have been studied at road curves by Hoffmann (1967). The variables included angle of deviation, speed of entry, and longitudinal acceleration effect. The results showed that the longitudinal acceleration of vehicles is accompanied by an increase in the lateral acceleration at a given entry speed, and that the optimum vehicle response time was 0.20 seconds for a driver's maximum performance. Driver characteristics at interesections were measured by Betz and Bauman (1967) in Phoenix, Arizona. They showed that out-of-state vehicles have significantly longer headways than do in-state vehicles. Brown (1965) explored the effect of a car radio on driving in light versus heavy traffic. The three varaibles used were music, speech, and silence. The results showed that the effects are opposite. In light traffic, speech and music reduces the time and number of control movements, whereas in heavy traffic, both increase.

In his doctoral dissertation at Purdue, Dunlap (1955) investigated human factors involved in the design of vehicle cab areas. Using a mock-up truck cab and a mock-up road, the subject adjusted the seat, the steering wheel position, and the angle of the toe pan. From the criteria of subject comfort, time off the road, and frequency off the road, Dunlap found significant differences for vertical seat height, horizontal seat position, length of seat bottom, height of post pivot, and length of the steering post. He concluded that people of different height perfer different settings for each of the five criteria, and that a good design, in terms of spatial relationships within the cab, decreases accidents.

Bacon, Breuning & Sim (1965) analyzed the passing habits of Michigan drivers. McCarroll & Haddon studied automobile accident fatalities in New York City. Watson (1960) explored the insurance aspects of traffic accidents in his doctoral dissertation at Ohio State University. Wierwille, Gagne, & Knight (1967) presented a model and closed-loop analysis methods for high-speed driving. Todosiev & Fenton (1966) studied velocity thresholds in following cars under night-time conditions. Taylor, Foody, Blackwell, Treiterer, & Branden (1967) related accident occurrences to traffic control devices. Snider & Ernst (1965) explored driver variability in car following and in open road driving. Severy (1967) related rear-end collisions to motorist injuries. Schuster (1966) attempted the prediction of accident records for youthful drivers. Schlegel (1965) discussed preventive aspects of accidents. Rolls & Joubert (1967) experimented with driver free turns on a horizontal surface. Reilly & Woods (1967) related the driver to traffic control devices. Rashevsky (1965) analyzed the man-machine interaction in car driving. Peck, Coppin, & Marsh (1967) presented statistical information on driver records by age, sex and marital status. Mohler (1966) discussed the causes and therapy for crashes. Mittenecker (1966) studied the so-called "accident tendency" on the highway. And Miller (1967) obtained results for accidents occurring on a highway under fog conditions. Lohr (1966) discussed psychological analysis of car driving, and Litman and Tabachnick (1967) analyzed fatal one-car accidents. Klebelsberg (1954) discussed traffic signs, and Hulbert & Beers (1966) analyzed wrong-way driving. Fenton (1966) presented an improved man-machine interface for the driver-vehicle system. Donigan & Fisher (1966) presented reckless driving cases. Dille & Morris (1966) summarized human factors in general aviation accidents. Cosgriff, English, & Roeca (1966) presented an automatic system for the longitudinal control of individual vehicles. Coppin & Samuels (1961) reviewed the characteristics of negligent drivers in the state of California. Coppin & Van Oldenbeek (1966) presented information concerning the negligent driver six years in duration. And Coppin and Van Oldenbeek (1962) also discussed the driving performance of negligent drivers. Collins (1967) analyzed the freeway pileup.

3.1.2 THEORETICAL CONSIDERATIONS. The papers reviewed in this section deal with various methods of theoretical modeling of driver behavior. Such techniques may have a strong role in future research in other categories.

New conceptions of the driving situation, as theoretically analyzed through the use of mathematical models and of simulators, were recently introduced at a conference held at Massachusetts Institute of Technology (1967). A wide range of papers discusses this topic from a variety of viewpoints.

Algea (1964) has formulated a preliminary theoretical framework in what he calls a driver-vehicle feedback control model. This model consists of a reference input variable (the desired velocity), an error-measuring device, the driver, the vehicle, a controlled output variable (the actual velocity), and feedback. This model is different from the usual type in that it focuses on the individual driver, as apart from large-scale models.

Herbert (1963) used Air Force and Army volunteers on an initial test battery of 12 driving tests (with a truck) at the Yuma Desert Test Station in Arizona. The test battery was readministered after various numbers of hours of desert fatigue driving. Factor analysis of the driving performance under these conditions produced five significant factors: multilimb coordination, spatial orientation, proprioception, response orientation, and reaction time.

Ehrlich (1966) used tracking performance in an attempt to establish a taxonomy of automobile driving.

2.1.3 SENSORY-PERCEPTUAL PROCESSES. The human process of vision provides the primary informational input to the driver of an automotive vehicle. The visual perception process which translates the actual highway image to a perceived image is probably the most critical of all driving behaviors, since it provides an estimated 90% of the information used by the driver in his decision making process. Other sensory processes, such as hearing and proprioceptive cues (i.e., "feel"), are also important in completing the picture. In spite of the large amount of work in this area, real progress has only recently begun with experiments on informational input needs and input rate capabilities of the driver.

Duration, distance, and speed of travel were judged in an experiment by Cohen, Ono, & Skelly (1966). 75 subjects drove over an experimental route, during which these three factors were estimated. The results showed that speed is more accurately judged than the other two factors, that speed is overestimated at high speed and underestimated at low speed, that distance is overestimated in general, that speed is underestimated in general, that duration is underestimated in general, and that the so-called kappa and tau effects were confirmed.

Gordon (1966) experimentally isolated the driver's visual input through the use of an aperture device which restricted vision and recorded the visual fixation positions. Results showed that the essential or critical input was the road edges and center line. Gordon (1966) also related vehicular guidance to the visual environment in terms of position and movement. On the basis of his extremely intricate analysis, in mathematical terms, he presented the following summary. (1) Interpretive scaling of visual angle is a key factor; (2) simple and obvious features of the visual environment are aids for vehicular guidance; (3) the driver may see his vehicle or some part of the environment as a reference for motion; (4) roadway boundaries and lane markings are used in aligning the vehicle with the road; (5) angular acceleration increases as the square of vehicle speed; (6) the pattern of the angular acceleration field does not resemble any familiar pattern of visual experience; (7) the motion parallax cue to distance fails when the observer follows a curved path; (8) when vehicle is aligned with straight or regular curved highway, the road assumes a steady state appearance; (9) if the moving vehicle is misaligned laterally with the road, the entire field moves as a unit; (19) the extent of lateral misalignment is indicated by the rate and extent of sideslipping of the road borders and lane markers; (11) anticipation requirements are considered important in the design of road features; (12) estimates of time to reach an object may be based on estimates of perceived distance; (13) visual stimulation to car following a curvilinear path needs empirical validation; and (14) the features of a velocity field shift with the vehicle's curved path of motion.

Olson (1963), employing a dial monitoring task, studied the variables influencing information processing. The criterion measures were the time to note a deviant dial, and the time off the track (in a tracking task). Reaction time (initial criterion) significantly varied for: arrangement of the dials, rate for dial deviation, load or number of dials, and location of dials. The tracking task significantly differed for the first three factors mentioned.

Judgment of vehicle velocity, under time limitation and viewing restrictions, was investigated by Salvatore (1967) using two camera iris diaphragms and two slats running parallel to the optical axis. Under different rates of vehicle speed, the subjects made verbal estimates of that speed.

Vision test scores were evaluated with respect to driving record in the state of California by Burg (1967). Among other findings was the conclusion that driving performance was predicted best by a dynamic visual acuity test, by a static acuity test, by a glare recovery test, and by a test of the visual field.

A theoretical derivation of the driving stiuation has produced an uncertainty model that is based on "steady-state driving with intermittently occluded vision" (Senders, Kristofferson, et al., 1967). They used two kinds of experiments. One employed a constant period of occlusion and a constance observation time. The other used a constant speed. The results showed that the less frequent the observations, the slower will be the speed the subject maintains. These findings are apparently in agreement with their model.

Kao & Nagamachi at The University of Michigan investigated feedback requirements in three kinds of driving: backing, parallel parking, and forward driving. Two conditions, obstructed (taped window) and normal, showed that feedback is significantly affected by the obstructed state, with all three driving behaviors significantly worse.

Schlesinger & Safre (1965) tested a perceptual model by the use of an experimental car making inside and outside turns at different speeds. The results were in the proper direction.

Car drivers were tested for their ability to remember road signs by Johansson & Rumar (1966). In stopping 1,000 drivers past five signs, they found 47% could remember the sign just passed.

Visibility from the position of the driver's seat was explored by Moore & Smith (1966), who found that 95% of all drivers have their eye position in a zone seven inches by four inches. They also discussed the factors indicating the presence of a vehicle, and the process of signalling intention.

The visual task evaluator (VTE) was employed by Blackwell et al. (1965) to show that there are many different degrees of difficulty in performing visual tasks. Luminance and task contrast influence the degree of difficulty, but contrast apparently is more important in defining visual tasks.

Intensity requirements for a red traffic signal were explored by Cole (1966). It was recommeded, on the basis of minimum driver reaction time, that a light of 200 candles at a distance of 100 meters be used when observed against a bright sky.

Allen et al. (1967) made an interesting study of the visibility of different colored traffic lights. This was achieved by projecting a movie onto the back of a translucent screen and, as the subject counted the cars approaching (in the movie), additionally presented a colored test spot of light, whose color and brightness was varied. The concluded that relative brightness is the dominant influence on detectability (and not color per se).

The state of California (1965) has presented information on reduced visibility under fog conditions. Richards (1967) described vision at different levels of night-time illumination. He also discussed the needs for visual control of the car at nighttime in another article. Rumar (1965) tested visibility conditions under nighttime driving conditions with misaligned, meeting, dipped headlights. Stabell & Stabell (1967) explored night vision as chromatic vision. Bugelski (1967) investigated the relationship between traffic signals and depth perception. osberry & Mills (1959-60) summarized the measurement of driver visibility. Gordon also presented an article on visual input, experimentally isolated. Hoffmann analyzed driver detection of vehicle velocity changes. Keese & Cleveland (1966) reported on intersection and sign illumination. Klipple (1967) explored the variables affecting the perception of angular change. Migliorino (1965) summarized visual perception in relation to speeding vehicles. Mortimer & Olson (1966) investigated front-turn signals, and the variables affecting their power of attraction. Mullin (1966) summarized the role of visibility in the design of roads. Reading (1966) tested the relationship between age and yellow and white headlamp glare. Richards (1966) presented information on the relationship between age and acuity changes and contrast sensitivity, at levels of nighttime illumination. Taburri & Theobald (1967) presented data on reduced visibility under fog conditions, under the auspices of the state of California. The amount of perceptual latency in drivers during car following was explored by Torf & Duckstein (1966). Ungar & Barnett (1966) discussed vision and the driver. Wilson (1965) presents additional information on the topic of reduced visibility under fog conditions in the state of California. Wolf studied the diminution of the visual field with age. Burg & Coppin (1966) dicussed visual acuity and driving record. Case & Hulbert (1966) also comment on reduced visibility in an article for the state of California. The effect of glare from street lights on the vision of drivers at different ages was discussed by Christie & Fisher (1966). Cole & Brown (1965) describe the intensity of traffic lights. Connolly (1966) discussed the safety aspects of visual limitations. Schmidt & Connolly (1966) summarize the topic of vision for highway use. And Schober (1965) has reviewed the influence of glare on visibility in fatigued versus normal subjects.

3.1.4 PSYCHOMOTOR PROCESSES. The pyschomotor process research reviewed in this section deals with the least understood area of driving behavior. Especially in topics such as decision-making, techniques are limited to empirical methods. Although much is known of the mechanical aspects of driving skills, little is known of the motor initiatory processes.

Human motor control of vehicles was surveyed and analyzed by Biggs (1966). Cumming (1967) likewise analyzed the critical habits involved in driving performance. Burns, et al. (1966) made a study of electrocardiographic changes occurring during prolonged driving. They found that the electrical activity of the heart responds to the duration of driving and to critical road situations. For example, there are periods where the T-wave is flattened or inverted. Therefore, the conclusion is obvious that the myocardium is involved in the stress of driving.

The reduction in driving performance occurring during a continuous twenty-four hour driving period was studied by Safford & Rockwell (1967). An instrumented automobile recorded vehicle velocity, gas pedal position, steering wheel position, and brake pedal position. Although seven subjects drove for a twenty-four hour period, there were rest breaks at refueling stops. The results showed that (1) change in any one of the four variables (whether increase or decrease) was not systematically related to fatigue, (2) the more demanding the task, the more will deteriorated performance be related to the passage of time, (3) within a one-way trip period (two and a half hours), most of the variables showed greater variability, (4) the physiological measures did not significantly change, and (5) a drug used (dextroamphetamine sulphate) more than doubled the steering wheel reversal rate.

An eight-hour driving period was used by Brown (1963) to study fatigue in eight British policemen. Their performance was evaluated a the beginning and end of the experimental period by means of two auditory tests. A test of attention was employed by presenting numbers and requiring the detection of an odd-even-odd sequence. A test of memory was employed by presenting letters and requiring the detection of a twice-occurring letter out of a sequence of ten. The results showed that both tests were significantly worse while the subjects were driving, that the test of attention was significantly worse at the beginning of the period but that the test of memory was significantly worse at the end of the period, and that, amazingly, both tests were significantly better at the <u>end</u> of the driving period. Brown (1967) performed additional work in this area by noting habit deterioration after seven hours of driving, in another study.

Fatigue effects on vigilance have also been measured. Mast & Heimstra (1964) reported their work, and Mast, Jones and Heimstra (1966) also reported the effects of fatigue on performance in a driving device. Herbert & Jaynes (1963) studied performance decrease during driving, and Greenshields (1966) also investigated the changes in performance with time in driving.

3.1.5 PERSONALITY MECHANISMS. As previously mentioned, this area has great potential for future highway safey research. Although personality mechanisms such as attitudes and motivations are not fully understood, many of the psycho-social factors involved are at least identified.

The development of a method for predicting high-accident and high-violation drivers has been the concern of Greenshields & Platt (1967). Using a Drivometer in an instrumented car allows them to record three categories of events: driver control actions, vehicle motions, and traffic events. Four groups were employed, a control group (consisting of driver education teachers and low-accident drivers), a high-accident group, a high-violation group, and a beginning drivers group. Using an uncommon statistical technique called "discriminatory analysis," they found that five variables (measures) significantly differentiated between any two of the groups. The measures were: traffic density, running time, accelerator reversals, gross steering reversals, and fine steering reversals. They concluded that the inexperienced or poor driver tends to make more reversals of the controls, and is therefore operating closer to his limits.

Another approach to predicting driver accidents was that developed by Schuster (1967), who investigated the validity of the "Driver Attitude Survey." This instrument is supposed to predict accidents and violations. Tested on Iowa driver license renewals, he found that the attitude scale best predicted accidents, when compared with the use of the previous record of violations and accidents and/or annual mileage. The percentage of correct prediction, however, was only 30%.

In McFarland's (1966) summary of the relationship between psychological adjustment and accident rate, he stated that the most significant biographical predictor was a history of previous accidents. He also stated that the personality structure of the accident repeater was "eccentric, impulsive, and mildly psychopathic."

Shaw (1965), and Shaw & Sichel (1961) have been concerned with developing more effective accident control in a South African transportation company. They originally discovered that in charting the accident experience of their bus drivers the most significant factor associated with individual records was the time interval between accidents. That is, they discovered that they could improve their initial assessment of accident probability by including two specially designed projective test of the TAT type. Follow-up studies show highly significant differences between the use or non-use of these techniques.

Selling (1940) made a neuropsychiatric study of traffic offenders in the city of Detroit. He found a considerable distribution of neurological findings among a random sampling of serious violators. Crancer (1967) presented differences in the state of Washington between problem drivers versus typical drivers. Hackley (1963) found no significant differences on two behavioral tests between those receiving a "risk technique" driver improvement course versus those receiving the normal course. David (1966) explored the reasons behind the passing of railroad signals by British railroad engineers. The conclusions fell into a variety of categories. Scott (1966) observed that "feedback" in the form of a test plus the observations by supervisors of airmen reduced the accident rate by 46.5% over a control group. Adams (1968) measured hazard judgment by a so-called "stimulus accretion technique". Stimulus accretion occurs by the uncovering of a hazard picture. A caution-impetuousness dimension apparently is involved.

Smart & Schmidt (1962) reviewed psychosomatic disorders and traffic accidents. Schuster & Guilford (1964) presented a psychometric approach to the prediction of problem drivers. Kaestner (1963) analyzed driver immaturity in fatal accidents. Quenault (1967) discussed safe and unsafe drivers. Kole (1964) investigated the reactions to traffic cartoons as a means of distinguishing between problem and nonproblem drivers. Adams & Weinstein (1965) presented the stimulus accretion technique in an earlier article.

Denton (1966) attempted to scale the sensation of speed into arbitrary units against real or actual speed in miles per hour; in an attempt to find a law relating the two. A ratio-setting technique was used, in which the subjects halved or doubled the speed at which they were previously driving. The results showed that in halving or doubling the speed, underestimation becomes larger at higher speeds. This finding indicates that the sensation of speed is not a simple power function of the objective stimulus for speed, but that the response has become distorted due to positive time error, adaptation, or visual after-effects.

Farber & Silver (1967) conducted three experiments relating the knowledge of a car's oncoming speed to a driver's passing behavior. On the basis of their results, they concluded that drivers can estimate distances to oncoming cars moderately well, and that drivers can use verbal knowledge of oncoming car speed in making passing judgements.

Kole & Henderson (1966) created a 40-item cartoon reaction instrument whose function is specifically directed toward driving behavior. The reliability and validity are considerably significant, for the groups so far tested.

Michaels (1965) measured driver attitudes by an attitude scale on the Maine Turnpike. The traffic characteristics of two routes were measured, and the tension generated on each route was determined. These routes were an expressway toll road and a parallel rural primary. A summated rating attitude scale was administered to 3,259 drivers. The results showed that reliable attitudes distinguished between the two routes. Michaels concluded that the total stress incurred in driving was a more important determinant of route choice than either operating costs or travel-time costs. He further concluded that drivers evaluate the use of alternative highways in rational although subjective ways independent of financial plans.

Levonian (1965) studied the effectiveness of traffic safety films in relation to the emotional involvement of Los Angeles high school students. Emotional involvement was determined by measuring the skin resistance. A 30-item questionnaire was administered immediately after the film, and repeated one week later. The results showed that there was a small arousal increase for forgetting, a medium arousal increase for retention, and a large arousal increase for reminiscence. Levonian concluded that an effective film for traffic safety is one which presents information during the arousal-increasing sections.

A discriminative reaction test of a multiple performance type was developed by Nagatsuka (1967). Michaels (1966) considered the problem of route choice by drivers. Klebelsberg (1963) discussed the "psychological right-of-way" at intersections. Jones & Heimstra (1966) analyzed the ability of drivers to make critical passing judgments. Gibbs (1968) investigated the effect of psychological stress on the ability to make decisions in a tracking task. Quenault (1967) discussed the driving behavior of professional drivers.

3.1.6 DRIVER EDUCATION. This is one of the traditional areas for driver research and many of the results have a strong relationship to highway safety. Some researchers claim that driver education has a beneficial effect in this regard. Though the research basis for driver education techniques is not yet well developed, it is obvious that driver education is one of the most direct types of countermeasures for highway safety.

Conger, Miller & Rainey (1966) investigated the effect of motivation, intelligence, social class, and exposure on the results due to driver education. Three groups of male Denver high school students were selected: those electing driver education, those wanting to take driver education but unable to do so, and those who did not wish to take driver education. Intelligence was determined by the Otis test; socioeconomic status by percent dilapidation of neighborhood. The results showed that the first group were significantly lower in "points" and violations. Then, matching the three groups for all variables, a smaller subsample of 40 subjects was derived from the larger groups. This matching produced results which showed that groups two and three were significantly different from the first group in legally responsible accidents. The previous significant result was eliminated. On the basis of these results, the authors concluded that driver education plays a significant role with regard to accidents but not with regard to points and violations.

In their book on driver education, Aaron & Strasser (1966) pay special attention to classroom instruction, laboratory instruction, and extended driver education.

Dunn (1963) in a doctoral dissertation at Michigan State University developed a test of the knowledge of traffic safety concepts. A cross-validation procedure showed 29 items in the test significantly distinguished between traffic violators and nonviolators. Results showed that nonviolators have significantly more knowledge of traffic laws and safe driving practices.

Schlesinger (1967) discussed objectives, methods, and criterion tests in driver training. Among other statements was one which specified that there are no systematic routines for the purpose of identifying the significant cues in the environment and the vehicle.

Glassman (1965) found no significant differences between a teaching machine program and traditional instruction in the learning of correct responses to hazardous driving situations, in a doctoral dissertation at New York University.

Coppin et al. (1967) studied the effects of short, 30-40 minute individual driver improvement sessions. Using a control and an experimental group, they found that the experimental group received significantly fewer citations in the first year following the sessions but were not significantly different the second year.

The high school driver education program in the state of Illinois has been evaluated in a five-year study published by the University of Illinois (1963). Hayes (1964-65) investigated immediate reinforcement of driver training with motion pictures in a publication by the Harrisburg City School District. Clark (1967) found that a driver improvement course reduced the number of traffic infractions and the accident fatalities. Schuster (1966) studied operant behavioral methods in the training of problem drivers under stress at Iowa State University.

Cornell University has developed an on-the-road driving simulator, whereby a separate front cab houses the student driver and the controls are modulated by an electronic computer. The safety driver sits in a cab behind and above the student. Learner (1960) describes a minimum analog driving simulator composed of three subsystems: a pulse-width modulation recording and reproducing unit that provides road geometry, a vehicle dynamics computer to solve the automobile motion equations, and a cathode-ray tube display that provides a representation of visual information required by the driver. Denton (1966) describes a "moving road simulator". This device produces apparent movement of a road surface in a three dimensional display on a viewing screen. Hand control and foot control allow study of motion after-effects. McKnight & Hunter (1966) found no significant differences in knowledge between simulator and control groups in evaluating a driver simulator for safety training at George Washington University. Von Buseck (1965) in his doctoral dissertation at The University of Michigan explored the effect of augmented feedback in a driving simulator. Bishop (1967) discussed simulator instruction in driving education. And McGlade (1960) in a doctoral dissertation at New York University evaluated the road test phase of various states' driver licensing examinations.

3.1.7 ALCOHOL AND DRUGS. The effects of alcohol and drugs on driving behavior is a subject of very strong interest in highway safety. There is a great deal of statistical evidence to support the view that alcohol, especially, may be a direct causative factor in traffic accidents. However, much more needs to be done to separate these factors from the related sociological factors.

Carpenter (1962) reviewed the effects of alcohol on the major psychological processes. His conclusions show that reaction time is increased from up to 200%, that motor skills are either unaffected or may be moderately affected (with large individual variation), that positional nystagmus is observed at an early stage in all subjects, that nearly all sensory processes are impaired, that there is considerable impairment of intellectual functions, and that automobile driving is moderately to considerably impaired.

Miller (1962) used an AAA auto trainer to evaluate the effects of drugs on driving behavior. Miltown, Equanil, Dexedrine, Meprobamate, and alcohol were the drugs investigated in twice normal dosage. Miller concluded that drugs should be evaluated for their behavioral toxicity, that drugs can be validly tested in their relationship to driving, and that most of the tranquilizers do not have serious behavioral toxicity.

McFarland (1966) summarized the present knowledge concerning alcohol and highway accidents. He stated that driving deterioration begins at blood alcohol levels of 0.03 to 0.04% that there are significant effects in all drivers if 0.10% is reached, that the risk of accident involvement is one and half times greater with blood alcohol concentration between 0.05-0.10% than if it is below 0.05%, and that the evidence indicates that alcohol is causally related to about 50% of fatal accidents in the United States.

Goen found that the enforcement system is not adequate to influence behavior involving alcohol and traffic accidents. Wadsworth (1966) discussed the etiological approach to evaluating the effects of alcohol on behavior, and stated that alcohol is widely part of the social and economic structure of

Canada. The state of California (1967) published a report on alcohol, drugs, and organic factors in fatal single-vehicle traffic accidents. Gibbs (1966) studied the effect of minor alcohol stress on decision processes in a step-tracking task. Carpenter & Varley (1963) summarized the action of tranquillizers and alcohol on driving behavior. Selzer, et al. (1967) analyzed the possibility that automobile accidents are an expression of psychopathology for alcoholics. Waller & Turkel (1966) discussed alcoholism and traffic deaths.

3.1.8 MEDICAL ASPECTS. The literature on medical aspects in highway safety of drivers is not extensive, but it is complete enough to identify all the potential factors which might have a causative effect on accidents. Heart attacks appear to be the greatest single medical problem in accidents.

Simonson, et al. (1968) studied cardiovascular stress produced by automobile driving. They found that the heart rate responds to critical situations, and that there may be a lowering or flattening of the T-wave decreased to one-half its original size. At other times, there may be transient flattening or inversion of the T-wave. Imachi (1968) continuously recorded blood pressure in automobile driving. Quevauviller (1966) dicussed medical aspects of driving, and Zanaldi (1967) discussed the preventive measures due to such medical considerations.

Imagawa et al. (1963) studied reaction time in relation to traffic medicine. The Vienna symposium on epilepsy and driving licenses (1965) stated that three out of 10,000 traffic accidents (on the basis of the Herner study in Sweden in 1965) are caused by epilepsy, and that a knowledge of the prognosis for epilepsy was important for evaluating the fitness to drive. Falconer & Taylor (1967) evaluated driving behavior after temporal lobectomy for epilepsy. Of 15 subjects who obtained driving licenses, three had accidents in a three to ten year period. Ross (1964) was the chairman of the symposium on epilepsy in relation to medicine and law, which also discussed insurance problems. Espir (1967) in reviewing the topic of epilepsy and driving found that the granting of driving licenses was based on clinical judgments of the different types and forms of epilepsy, and discussed how this process should be handled.

3.1.9 RESEARCH GAPS IN DRIVER RESEARCH. From the preceding reviews of driving behavior research in several categories, a list of research gaps has been derived. Although the reviews were limited in terms of the number of specific documents, many other general impressions of the status of driver research were utilized to derive the research gaps. Discussions were held with several consultants in this regard, and the combined expertise of the HSRI staff was employed to the fullest in subjective assessment of the problem. In the final list, only one--understanding of injury mechanisms in traffic accidents--was not covered in the detailed review.

1. Effects of Alcohol Consumption on Drivers and Driving Performance
2. Reasons for Overinvolvement of Young Drivers in Traffic Accidents
3. Improved Methods of Driver Education
4. Effects of Driver Vision Capabilities on Driving Performance
5. The Role of Nonvisual Sensory Cues in Driving
6. Effects of Social Influences on Driver Attitudes, Motivation, and Personality
7. Effects of Basic Attitudes, Motivations, and Personality on Driving Behavior
8. Basic Understanding of the Driving Operations, Task Requirements, Sequences, and Interrelationships
9. Basic Understanding of Human Driving Skills, Vehicle Handling Performance, and Man-Machine Interfaces
10. Emergency Driving Operations
11. Reasons for Risk-Taking in Driving and Means for Reducing Risk-Taking.
12. Basic Understanding and Applications of the Decision-Making Process in Driving
13. Knowledge of the Kinds of Information Needed by Drivers in Traffic
14. Knowledge of the Means and Content of Public Information Most Effective in Improving Citizens' Driving Behavior
15. Effects of Various Enforcement Techniques on Driving Behavior
16. Effects of Various Regulations and Legal Sanctions on Drivers Attitudes
17. Improved Methods of Driver Licensing and Testing
18. Effects of Drugs on Driving Behavior
19. Effects of Fatigue on Driving Performance
20. Basic Understanding of Injury Mechanisms in Highway Accidents and Resulting Trauma

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3.2 VEHICLE

The review of vehicle research in relation to highway safety was limited to factors which were prejudged to be research gaps. The results of the review emphasize the several areas in which additional or continuing knowledge is required. Some of these areas either have been previously recommended or have studies being initiated by the National Highway Safety Bureau. This discussion will indicate the broad areas where work has been done or is being done, and will note the areas which require further investigation.

Vehicle factors were reviewed from the standpoint of each of the five phases of operation occurring in the highway transportation system. The first phase, conditioning, involves the preparation of the vehicle prior to entering the normal mode of the system. This includes design, manufacture, and maintenance prior to and between periods of usage. Traffic is the second phase and it is the functional normal-mode of the highway transportation system. Basically, this phase deals with the performance of the vehicle. The third phase, crash initiation, is the transient period during which the normal-mode function breaks down and a collision is imminent. Phase four, collision, covers the time, often less than one second, during which the vehicle strikes an object and comes to rest. The last phase, post-accident, is concerned with everything that takes place after collision, i.e., emergency services such as vehicle towing. For the vehicle, this phase lasts until repair work is begun, at which time the vehicle again enters the conditioning phase.

The references for this section represent only a small sample of the literature covered in this review.

3.2.1 CONDITIONING PHASE. This phase begins with the design of the vehicle where human factors aspects influence the physical design of the vehicle. This area of influence is concerned with three classes of vehicle requirements dictated by operator needs: visibility, control accessibility, and control operation.

The human factors affecting vehicle design have been covered many times over by researchers (4, 5, 6, 7)* based on the needs of a "standard" operator from a physical viewpoint. The standard concept breaks down when one considers that an ordinary passenger automobile may be driven by people ranging from little old ladies to huge professional athletes. To be safe, the vehicle must meet the physical requirements of this wide range of people. Meeting vehicle design requirements for a wide variety of operators is recommended throughout the literature.

For example, visibility from within the vehicle is concerned with the ability of the operator to see the road ahead,

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*Numbers in parentheses refer to references in section 3.2.6.

the surrounding area, the road behind, and the instruments and controls within the vehicle. To accomplish this, design standards have been drawn up and human physical capabilities described. Standards (10) prescribe the minimum area that should be used for proper windshield visibility, but there are no standards showing the influence of vision obstruction by hood, fenders, and rear deck. There are standards concerning the wiping area of windshield wipers and the recommended eye height for proper forward vision. Studies have been conducted which indicate requirements for rear-view mirrors (11) and the loss of visibility of transmitted light through clear and tinted windshield (4, 12, 13). Standards (8, 10) have been established for the type of glazing to be used and the recommended window sizes.

In addition to visibility, the same approach has been made in the field of control accessibility. Much data has been gathered on the placement of controls for the standard human, but again, not all human operators are standard.

An area not so adequately covered by research is that of control operation. Here again much knowledge exists about how controls should operate, but minimum force requirements are not so well known.

The National Highway Safety Bureau has had or currently has under investigation most of the areas discussed in general above. At this time these programs have not been completed, and therefore the results are not known. Also, although there is not much information in the recent literature, it can be assumed that the automobile manufacturers are working on proprietary projects in these areas themselves. However, several researchers (e.g., McFarland, 2) have indicated that the greatest need is not necessarily more research but that factual information on existing design deficiencies are not fed back to the manufacturers to correct any existing problems. It appears that the Highway Safety Act of 1966 will provide more impetus to action in this area.

The engineering design of the mechanical components of the vehicle involves not only basic engineering knowledge but also performance testing of the designs prior to starting production. For this discussion, only the components that directly affect vehicle safety are considered; these include the brake system, steering, suspension, tires and wheels, structures and lighting.

Over the years much research and design work has been done on these systems by automobile manufacturers and components suppliers in their efforts to improve designs. However, because so much of this work is of a proprietary nature, important findings are not published in the open literature. The recent pressure from the federal government is resulting in the release of some of this information. In addition, the NHSB has launched many studies on these various systems. Part of the reason for this is that the work done by the manufacturers in the past has not gone deeply enough into the basics of the various systems.

In order to assure that certain safety features are included in vehicle design, the NHSB has issued the Federal Motor Vehicle Safety Standards(9). In addition to those already issued, others are being reviewed for incorporation at a later date. These standards not only describe the items to be included but also specify the manner in which they must be tested. Further, the manufacturers must certify that they have complied with these standards. Means of assuring the federal government that the manufacturers have complied with the standards have been under study, and reports (1, 14) have been issued.

Once the vehicle has been manufactured and sold, the problem becomes one of maintaining some level of roadworthiness during its privately owned and operated phase. Although preventive maintenance programs are recommended by the manufacturers it is not known to what level of maintenance owners actually keep their vehicles. The NHSB has studies underway dealing with the subject of maintenance. It has long been felt that periodic motor vehicle inspection is a way of requiring owners to maintain their vehicles at certain minimum performance levels. It has been shown (17) that vehicles are in better overall mechanical condition where inspection is required than where it is not. Also, NHSB has been conducting a study on what defects are found in the operating vehicle population with a view to issuing federal standards based on the results of these investigations.

3.2.2 TRAFFIC PHASE. This phase covers the normal-mode functioning of the vehicle--in other words, vehicle performance. It deals with moving the driver in his vehicle safely from one location to another. The manner in which the vehicle does this is of prime importance. Many studies (3, 5) have been done on the way in which the driver performs his task and what his attitudes are. However, one area in which there is not much knowledge is the effect of the vehicle's interior environment on driver behavior. One researcher (4, 6) points out that while much is known about the influence of temperature and humidity in industrial safety, this knowledge has not been applied to highway safety; work in this area is recommended.

Other aspects in this phase are concerned with vehicle performance on the road. Although automobile manufacturers have been working in this field for years, many of their goals have not necessarily been safety-oriented. The NHSB is currently sponsoring studies on vehicle handling, braking systems, tires, and lighting systems.

Another area where definitive knowledge is lacking concerns the effects of time-aging deterioration and operational wear degradation of components on vehicle performance. In this regard it would be beneficial to know what performance systems are affected and how they react in this condition. In addition, this wear information would be useful in recommending preventive maintenance procedures that would assist in keeping vehicle performance at as high a level as possible.

3.2.3 CRASH INITIATION PHASE. The point at which the normal-mode function of the highway transportation system breaks down is the beginning of this phase. Knowledge of the system breakdowns would be valuable in preventing them or in averting the resulting collision if breakdown does occur.

Of the many contributing factors, one of the most critical is skidding. Skidding can be initiated by a number of causes such as brake locking, tire blow-out, slippery pavement, excess speed, or even loss of steering control. With regard to brake locking, several anti-skid devices have been proposed, but few have performed satisfactorily. However, a recent development, pulsating brake systems, may have promise. Tire damage from either road hazards or excessive wear may contribute to a large number of skidding incidents. On slippery pavement or at excessive speeds for the road surface, skids are directly related to the loss of friction between the tires and road surfaces. Better knowledge of the physical characteristics of the friction phenomenon would assist in designing better tires. Also, more tire mechanics data at levels of tire deformation at or near the friction limit are needed.

The extent to which loss of control may be caused by mechanical defects has not been sufficiently substantiated. A team of accident investigators have thoroughly examined (2) wrecked vehicles and have discovered broken and worn parts along with willful sabotage in some cases. Defects of this type are not usually detected because police officers investigating accidents do not have the time, nor, in most cases, the training to discover these defects. More complete accident investigations need to be carried out in order to establish what causative effects vehicle defects provide. If sufficient knowledge could be made available to manufacturers this would pave the way for component improvement. Such knowledge would also help to pinpoint poor maintenance practices on the part of the owners. In addition, such thorough investigations would provide factual data on the influence of periodic inspection on accidents.

3.2.4 COLLISION PHASE. This phase covers that period of time, usually less than one second, during which the vehicle collides with some object. In this phase, rapid deceleration occurs, the vehicle is deformed, occupant restraint devices (if worn) are utilized, and occupants may collide (second collision) with interior surfaces.

Studies sponsored by the NHSB are being conducted in these areas as well as independent research programs. It appears that a considerable amount of knowledge will be created for use in designing better occupant protection systems. One area in which work has been done and more needs to be known is that of energy absorption by specially developed materials and structural systems which have a controlled deformation capability.

Research sponsored by NHSB, manufacturers, and other private interests is being conducted on occupant restraint systems. It has long been known that the use of lap belts would greatly reduce injuries and fatalities, but the public has been very slow to adopt their usage. With this in mind, perhaps more effort should be directed toward developing systems which are automatically activated by impact or high forces to protect passengers from injury.

The second collision has been much discussed and considerable work has gone into redesigning vehicle interior handles, knobs, devices and surfaces. Reports on the laminated windshield (15) and energy-absorption steering column (16) have shown a great reduction in fatalities and injuries. Results of work currently in progress in this area should be available in the near future.

3.2.5 POST-CRASH PHASE. The final phase is concerned with what happens following impact and the loss-limiting factors that can be applied. This covers the emergency services employed, including vehicle towing and repair.

Accident investigation begins at the time the first police officer arrives at the scene of the traffic accident. Aside from obtaining aid for injured people, the officer's first concern is to the clear the scene to avoid presenting a further traffic hazard. However, in performing this function, he destroys much vital information concerning vehicle position, trajectory, and speed. This is the point at which a comprehensive investigation should begin to reconstruct the accident to obtain valuable information for use in determining the real causes.

However, once the vehicle has been towed away to the garage, the damage must be assessed and a decision made as to its repairability. In cases of severe damage it is usually more economical to scrap the vehicle. Vehicle repair costs are usually high because of both components and labor. It would appear that improved repair methods and practices could reduce these costs, and NHSB is sponsoring a study of garage repair practices. In Sweden the Saab Company has opened a specialized plant to dismantle wrecked cars and rebuild them for subsequent sale. This reduces the losses involved in scrapping a damaged vehicle, and returns to the road a vehicle which is in better condition than the average used car.

This discussion has reviewed the status of the vehicle in general terms with respect to highway safety rather than component-by-component. There have been some improvements since the A. D. Little state-of-the-art report of 1966, but more important, research activity has burgeoned since that time, and many research programs have been or soon will be initiated. However, it is too early to realize many significant results from the new programs.

3.2.6 RESEARCH GAPS IN VEHICLE RESEARCH.

1. Basic understanding of vehicle control operations requirements, sequences, and interrelationships
2. Determination of explicit, objective measures of vehicle dynamic performance
3. Improved interior design of vehicles to minimize passenger injuries
4. Improved methods for passenger restraints
5. Knowledge of the dynamic effects of braking performance
6. Knowledge of tire deformation mechanics near friction limits
7. Effects of time, aging, deterioration, and operational wear (degradation) on vehicle components and performance
8. Knowledge of vehicle damage mechanisms
9. Knowledge of energy-absorption materials and structural designs to minimize transfer of impact energy to passengers
10. Knowledge of design techniques to minimize vehicle damage in a collision
11. Knowledge of techniques to minimize cost of vehicle damage repair
12. Effects of vehicle design on passenger comfort in terms of position, temperature, and vibration
13. Improvements in viewing limitations of vehicles

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3.3 THE ROADWAY

There is an abundance of roadway research dealing with highway safety, most of which is covered in the A. D. Little report. Another excellent source is "Traffic Control and Roadway Elements, Their Relationship to Highway Safety," prepared by the Automotive Safety Foundation in 1963. A revision of this document is now underway at The University of Michigan under the direction of Professor Donald Cleveland. The review of roadway research conducted for the program definition study has covered many of the works mentioned in the two reports above. However, only a few are referenced to indicate typical results.

Most of the research deals with factors which are pertinent in the accident initiation phase of system operation, and a few in the collision phases.

3.3.1 RESEARCH ON ROADWAY DESIGN FACTORS. Roadway design factors include all the aspects of road geometrics, pavements, characters of adjacent features, and the adjunct signs and signals. Most of the attention is given here to geometrics and adjacent features.

Interrelations between accident frequency and road geometrics have been developed by regression techniques, relating number of accidents to gradient rate, degrees of curvature, number of driveways opening on the road, signalized or non-signalized intersections, median width, level of service, number of lanes, lane width, and shoulder width (11, 12, 5, 17, 18, 32).* Raff (1) conducted an extensive study of one-year accident data on 5,000 miles of highway in fifteen states. He determined the accident rate per million vehicles for different types of roads with varying road geometrics, gradient, curve, shoulder width, paved/unpaved shoulder, median width, lateral clearance for overpass structures, etc. The accident rates are statistically evaluated (42, 43, 44, 45) to determine hazardous spots (6, 26). The high-accident locations are programmed for improvements (21, 22, 7) and then these improvements are evaluated (25, 20, 24). Byington (14) found that the accident rates on the interstate highway system are about half as great as those on nearby highways, and injury and fatality rates are about one-third as great. The interstate system produced the greatest reductions in fatalities in rural areas, and the greatest accident-rate reductions in the more densely populated areas with heavier volume.

A. Ramps and Interchanges. Ramp and interchange designs have been the subject of several detailed studies with

*Numbers in parentheses refer to the references in section 3.3.4.

conclusions typified by the following: the accident rate for off-ramps is double that for on-ramps, the increase being mainly due to collision of single vehicles with fixed objects (13). Smoother vehicle paths and speeds are attainable on circular ramps than on an elongated ramp (19). Adequate length of acceleration and deceleration lanes together with careful treatment of terminals and control of access can practically eliminate accidents at interchanges (9). Left-hand entrances and exits have poor accident records. It is desirable to have increased width and lenth of entrance ramps (16). The gore areas at the exit on a freeway should be kept clear of heavy structures and unyielding sign supports (24).

Proper spacing should be provided between interchange ramp terminals and cross-route access points dependent on traffic volumes and route speed values (31). On-ramps on upgrades and off-ramps on downgrades should be provided with full visibility as one of the important requisites at all points on the ramps (27). Accident rates are considerably higher (60%) for left-hand ramps than for right-hand entrance ramps (40%).

B. Shoulders. There are conflicting results from shoulder-width studies. Though it may generally be argued that the wider the shoulder the lower the accident rate, it has not been conclusively proved (2, 3, 4). Raff concluded that the accident rate on a curved alignment goes down with each additional foot of shoulder but that on two-lane straight sections the shoulder width has no constant ratio to accident rate.

Property-damage-accident frequency shows a significant tendency to increase as paved shoulder-width increases (4). Researchers agree on the difficulty of showing whether increasing the width of paved shoulders is really helpful in reducing the accident frequency. However, shoulders should be flush with the adjoining through lane and width should be carried across all structures (23). Color controls are recommended to discourage use of shoulders by through traffic.

C. Medians and Guard Rails. It is an accepted fact that separating the opposing traffic streams with a median strip considerably reduces the accident rate. However, there are conflicting opinions on the optimum width. The design of guard rails has been improved in the recent years. Median widths of 60-80 feet are recommended (23) and median barriers should be provided for widths less than 30 feet. Openings in medians should be avoided. A precise optimum spacing of median openings for maximum safety and level of service has not been determined (12). The geometric design of a highway seems to influence the number of collisions with median-barrier guard rails, e.g., interchange areas and curves have more rail collisions (30). The optimum median width may be narrow, medium, or wide, depending on the traffic volume using the road. A traversable divider seems to be the best solution for surface streets.

D. Number and Width of Lanes. The number of lanes required depends directly on the average and peak hour traffic, and level of service desired. The subject of design capacity for carrying level of service has been investigated at great length (37). Lundy (36) maintains that the total number of freeway accidents can be significantly reduced by increasing the number of traffic lanes even though such an increase may not be required by traffic volumes.

Wide pavements encourage safety on two-lane curves but there is no constant relation for straight alignments (1). Typical lane widths were formerly 10 feet, but the current trend is to a standard 12-foot width for each lane. Lane drops must be avoided as far as feasible, and advance notice should be given (23). Separate truck climbing lanes should be provided where warranted by commercial vehicle usage.

There are conflicting reports on numbers of lanes necessary for adequate safety on low volume rural roads. Some have found three lanes safer than two lanes, and others have obtained different results. The divided highway minimum is four lanes.

C. Alignment and Gradient. The alignment and gradient should be the best obtainable from the prevailing topography and future development. Zig-zag alignment and sharp curves should be avoided. Adequate sight distance commensurate with the type of roadway must be provided so as to permit the driver to adjust to the merging or approaching traffic. Evidence indicates that sight distance is the limiting factor in many accidents. Often the driver does not see the vehicle or pedestrian coming out of a driveway or crossroad.

Curves are the scenes of many accidents. Many researchers have correlated the degree of curvature with accident frequency. Raff found that accident rate increased by about 15% for two-lane roads and by about 40% for four-lane divided roads for each additional degree of curvature. The effect of frequencies of curves is uncertain.

On straight sections there does not appear to be any relation between grade and accident rates. At high volumes above 5,000 vehicles per day, the accident rates are higher on roads with steep grades.

The grades affect highway capacity and safety (29, 40). The truck speeds are reduced even on 2% grades and the slowdown of trucks on two-lane highways affect capacity adversely when volume reaches an optimum value. Grades over 5% in combination with curves over 5% degrees are associated with higher accident rates. Bitzel (28) found that accident rate increased rapidly with an increase in grade to the highest gradient (over 4%).

Major changes in vertical alignment (crests and sags) generally created a concentration of accidents at these spots (41).

D. Accidents Related to Fixed Objects on Roadway. Fixed objects such as sign poles, utility poles, trees, roadside curbs, delineators, embankments, and ditch slopes are involved in a majority of injury accidents. State highway officials (23) recommended an intensive program to remove roadside hazards and to provide embankment and cut slopes not steeper than 6:1 or even flatter. A clear recovery area of 30 feet from the edge of travelled way is recommended in rural areas.

Increased lateral clearances at overpasses and bridges reduce accident rates and property damage costs (Cirillo, 10). Stonex of General Motors concludes that a 33-ft obstacle-cleared roadway will provide safety for at least 80% of drivers leaving the road, and 50 ft for at least 90%. If a clear roadway cannot be provided, guard rail may be installed in such a way that a vehicle leaving the roadway returns after impact.

Center piers and abutments should be surrounded by guard rails of the plate type. Posts should be designed so that they will break off successively if struck on the end.

The top of the concrete foundations of poles or towers for supporting signs, signals, or lights should be below the roadway level.

A general conclusion is that there is no uniformity in road geometrics or signing among the states. The variation is especially apparent in the design of acceleration and deceleration lanes.

3.3.2 RESEARCH ON ACCIDENT RATES FOR VARIOUS ROAD TYPES. Many researchers have found that traffic volume has a strong effect on accident rates. The general consensus is that the accident rate increases with increasing volumes, and that volume is related to road type.

According to Raff, the common pattern is for accident rates to increase as volume increases, except at very high volumes, where the accident rate drops somewhat due to congestion.

McDonald (35) claims that accident rates at intersections are much more sensitive to changes in crossroad (minor road) volume than to changes in divided highway (major road) volume.

Kihlberg and Tharp (15) observed after conducting statistical analysis of accident data from Ohio, California, and Lousiana that the accident rate on a highway segment is dependent on type of highway, average daily traffic, and segment length. They also concluded from the accident data that (a) four-lane highways had higher accident rates than two-lane highways when there was no median, and no access control; (b) access control was the most powerful accident-reducing measure; (c) medians tended to reduce number of accidents; and (d) there was no evidence that geometric elements affected severity rates.

At intersections, the percentage of total traffic on the minor road is extremely important and 15% cross traffic can make an intersection more than twice as hazardous as 10% cross traffic.

There have been very few traffic controls to prevent the development of congestion on roads. Ramp metering has been tried of late with minor success. Signals actuated by traffic-counters need to be investigated further for remedying such situations.

Findings to date do not indicate optimum speeds for combinations of various types of drivers, vehicles, highways, traffic and environmental conditions. A low speed may be unsafe on a divided limited access highway but safe for city streets. Speed must be related to given conditions, type of road, traffic, sight distance, visbility, and pavement condition, and the same is true of the spread in speeds from highest to lowest.

The effect of road geometrics, vehicle, traffic, and environment on traveling speed has been studied in detail by Rowans and Keese (33) and Oppenlander (34), and they concluded that horizontal and vertical curves, sight distance, changes in cross-section, type of roadside development (commercial or residential area), rural or urban area, speed zoning, and highway patrol had tremendous influence on the variation in traveling speeds. Light conditions and the density of traffic also affect vehicular speeds. The traffic responds to changes made in roadway, roadside development, and environmental conditions so as to keep within safe limits.

Inadequate illumination of the pavement at night is a significant factor in higher accident rates at night. Much research has been done to determine the extent of minimum lighting necessary, but no firm results have been reached.

Driving performance under nightime conditions does not degrade considerably and one is capable of driving at a constant speed and constant lane position (Matanzo and Rockwell, 38). Minimum street lighting standards which should ensure potential reduction in accidents have been suggested (Fisher, 39). Current U.S. standards for illumination of roadways have been prepared by the Illuminating Engineers Society, revision adopted in 1963.

Night driving conditions can also be improved by the use of surface treatments, reflector signs, markings, delineators, restricted lighting of exits and potentially hazardous objects. All before and after studies following installation of street lighting widely support the assumption of improvement in accident experience following the installation of improved street lighting. However, continuous lighting of rural freeways is not recommended (AASHO, 28) in view of scanty accident data. They recommend higher mounting heights for lighting installations, reducing the number of lighting standards, and lateral placement further from the roadway to minimize glare.

Further work is warranted in the following areas to achieve a reduction in accidents and their severity:

(1) Determine maximum traffic volume for each type of road geometrics for free flow conditions and automatic diversion of additional traffic to the alternate adjacent streets.

(2) Determine minimum offset from the road edge of fixed objects, and maximum steepness of ditch/embankment slopes for safe recovery of the vehicle.

(3) Improve skid-resistance of the pavement surfaces.

(4) Design intersection and traffic signals accurately based on the actual and projected traffic volume.

(5) Determine minimum lateral clearance of the bridge piers of overpass structures for maximum safety.

(6) Determine necessity to provide separate lanes for commerical traffic and buses.

(7) Determine break point between the cost of making improvements in road geometrics, delineation, or traffic controls and the increased benefits in the reduction of accidents.

(8) Determine minimum level of illumination of pavement or roadside hazards and exits/entrances for maximum safety.

(9) Determine speed limits on scientific basis considering road geometrics, traffic volume, weather, light conditions, vehicle characteristics,etc.

3.3.3 RESEARCH GAPS IN ROADWAY RESEARCH.

1. Improved friction characteristics of roadway surfaces for minimizing vehicle skidding
2. Improved illumination and delineation of roadway surfaces by passive and active means
3. Basic understanding of the effect of intersection design on traffic flow and accident causation
4. Determination of new methods for control of traffic volume flow and redistribution by automatic means
5. Basic understanding of the role of fixed roadside objects on traffic accidents, and means for alleviating the problem
6. Knowledge of correlation of highway accidents with types of roadway locations

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3.4 THE PEDESTRIAN

Haddon et al. (1961)* studied the characteristics of pedestrians killed in motor vehicle accidents in New York City (Manhattan). Using an epidemiological approach, a case series of 50 pedestrians was obtained, while a control group of 200 pedestrians was matched in terms of accident site, sex, day of week, time of day, and age. The control group received a breath test and an interview. The period studied covered May-November, 1959. The results showed that 73% of the fatalities occurred in the 12-hour period starting at 3:00 p.m. The accidents, statistically speaking, tended to occur outside of the major business and shopping areas, and weather condition was not a significant factor. The pedestrians killed were more often foreign-born, less often married, more often of a lower socioeconomic status, and the presence of ethyl alcohol in the blood was highly associated with accident involvement. 51% of the accidents occurred in the six hours preceding midnight. The smallest number of accidents occurred in the 6-9:00 a.m. period. The mean age of those killed was 58.8 years.

Yaksich (1960) studied pedestrian fatalities in Washington, D.C. during the years 1948 to 1957. He found that nearly 50% of all fatalities occurred in the 4-8:00 p.m. period, that more pedestrians were killed on Saturday, and that 71% of the adult pedestrians killed on weekends were under the influence of alcohol. Yaksich found that a large number of pedestrians were killed in the central business district. Nearly 20% were killed during inclement weather. The pedestrian was at fault in nearly 75% of the accidents. Alcohol was involved in at least 25% of the fatalities.

Garwood & Moor (1962) described pedestrian accidents in Great Britain. They found that pedestrian casualties are not increasing as rapidly as is the quantity of traffic, and that pedestrian accidents are not increasing as rapidly as are other kind of accidents. It was found the pedestrians will use a bridge or subway if the time involved is at least 25% less than using the street. The overall effect of pedestrian traffic crossings (light-controlled or uncontrolled) is to increase safety.

Severy & Brink (1966) employed a series of 38 anthropometric dummies in simulating automobile-pedestrian collisions. Independent variables consisted of impact speed, size of the car, and pedestrian size. Dependent variables consisted of position at impact, brakes, car structure, car bumper, where pedestrian was struck, and pedestrian posture.

McLean & Ryan (1965) surveyed traffic accidents in Adelaide, Australia. They obtained information at the scene of

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*References for this section are included in section 3.1.10 and are listed alphabetically by author.

accidents during a six-month period of 1962. They found that Saturday had the highest frequency of accidents, and that the 4-9:00 p.m. period likewise had the highest frequency.

Accident Facts (1967) indicates that pedestrians most frequently cross the street between intersections. Johnson (1965) evaluates freeway pedestrian accidents in terms of youth, disregard for law, and carelessness. Marks (1957) emphasizes the need for child pedestrian safety education. Hazlett & Allen discuss night-time visibility of pedestrians in relationship to clothing, reflectorization, and driver intoxication.

Research findings in pedestrian safety have still not uncovered basic causative factors in pedestrian accidents. However, overinvolvement of the aged, children, and alcohol consumption in pedestrian accidents continue to stand out as the broad problem areas.

3.5 THE PHYSICAL ENVIRONMENT

The physical environment surrounding the highway transportation system includes the weather, the local scene (urban or rural), the topography, the time of day and season, the lighting, and such extraneous factors as debris. Most of these factors have been studied fairly well in the context of their influence on the driver, vehicle, or road during traffic and the onset of accidents.

Weather factors have been heavily studied, and there is no doubt that poor weather leads to an upswing in accident rates. However, no single report appears clearly authoritative on this topic. Slippery roads caused by snow or ice are the most frequently studied problem. Although a general tendency to skidding and longer stopping distances on slippery roads are noted, little has been done to understand these processes in full detail. However, considerations of center of gravity and coefficient of friction have contributed to substantial improvements in braking systems and tire design.

Nighttime driving factors, especially night vision, are also very important in the accident process. The problems of glare and limited illumination are paramount at night, and glare is especially bad on rainy nights. Improved road illumination and delineation methods are currently under study and will probably provide a basis fairly soon for diminishing the danger of nighttime driving.

Visibility in fog is another serious environment problem being studied in terms of headlight design and fog sweepers.

Other factors covered in the literature include effects of tinted windshields at night, effects of hills on traffic flow, effects of roadside structures on driving patterns, monotony on freeways, sun shadow patterns on signs, and problems of water thrown up by vehicles.

The research gaps include the following: effects of wind, effects of distractions such as flashing lights and urban activity, effects of smoke and smog, effects of partial flooding of roadways, effects of direct sunlight at various angles, effects of debris on the road way, and effects of extreme heat on drivers. These factors are not critical. However, among the areas studied, it is felt that critical problems still exist with respect to night vision, slippery road surfaces, glare, and fog.

3.6 THE SOCIAL ENVIRONMENT

The social environment in this context includes the interpersonal relationships and institutional influences which have an effect upon drivers, vehicles, or roads in the highway transportation system. Included are family and group experiences, schooling, employment, housing, socioeconomic status, driver education, licensing, enforcement, auto manufacturing and insurance businesses, and many other factors.

In 1964 it was claimed by Haddon, Suchman, and Klein in Accident Research that, "There is an almost complete lack of significant studies which bring to bear on accident phenomena the full force of social theory and method." This is still true today. Many potentially valuable theories have been suggested, e.g., in Behavioral Approaches to Accident Research published by the Association for the Aid of Crippled Children in 1961, but few have been pursued in depth. Likewise, preliminary studies were conducted at the Harvard Medical School in 1961-1963. One noteworthy study, The Accident-Prone Driver --A Study of the Psychiatric and Social Background was done by Tillman and Hobbs in 1949. Its conclusion, in essence, is that a man drives as he lives. From a given driving population it was found that the high accident group exhibited aggressiveness and intolerance to authority, which derived from family instabilities during early childhood and generally antisocial behavior during youth. There have been no comprehensive efforts to build upon these early findings.

It should be noted that the social environment has its greatest effect on the driver during the conditioning phase, e.g., during times when the individual is not acting specifically in the role of driver. Early life and day-to-day social interactions are the primary sources of influence. However, some social interactions occurring during traffic operations can influence driving, and in fact, lead to some accidents (e.g., family arguments in the car). No work has been found in the latter area, or in areas wherein the social environment might affect the vehicle or road.

Among the most applicable social environment factors studied in terms of their effectiveness are traffic laws, police enforcement, and driver education. Most studies in these areas have been brief, narrow in outlook, and unrelated to other research. The inevitable conclusions are generalizations that we need stricter laws, more policemen, and better driver education. Such conclusions are of little value because they do not reveal new information regarding the basic impact of the social environment on driver behavior.

Two problem areas clearly identified by several researchers are the role of alcohol consumption in highway safety and the role of the young driver. However, little has been done to discover the basic reasons for these social problems.

Even in those areas where some work has been done, there is a great need for more work. Therefore, the research gaps in the social environment area in highway safety cover the whole gamut, as follows:

Effect of traffic laws on the driver
Effect of police enforcement on the driver
Effect of the legal sanctions on the driver
Effect of driver education on the driver
Effect of driving regulations on the driver
Effect of public information on the driver
Impact of social structures and values on the driver (e.g., custom, culture, socioeconomic status, employment, family, etc.)

3.7 HIGHWAY SERVICES

The highway services system includes all those auxiliary functions which facilitate use of the highways in emergencies and for other purposes not directly related to the normal transportation. These functions include highway patrol, emergency aid, on-the-scene medical services, ambulances, debris cleanup, towing, and service stations.

The research areas which have been treated are as follows:

Accident Sensing and Surveillance, Emergency Medical Care, Safety of Pedestrian Crossings, Parking as an Element of Urban Transportation Planning, Motorists' Needs on Interstate Highways, Emergency Call Systems, Disabled Vehicle Handling, Vehicle Detection, Road Splashing, Icy Road Warnings, Police Traffic Service, Snow Removal and Ice Control in Urban Areas, Snow Plow Blade Materials, Surveillance Methods and Means to Communicate with Drivers, Audio Signs.

In general, the findings in these areas deal with needs for improvements in various equipment, operations, or services, all along conventional lines. Further, the reliance of each element in the system on many of the others is often noted. Although the coordination of these functions has not been reported in the research literature, the need for a systems approach is quite obvious.

Among the current research projects in highway services, the following would seem to be outstanding:

1. "Motorists Needs and Services on Interstate Highways," Airborne Instruments Laboratory

2. "Motorway Service Areas," University College, London

3. "Factors Affecting the Siting of Service Stations, Royal Institute of Technology, Sweden

4. "Evaluation of Emergency Communication Systems," Bureau of Public Roads

5. "Statistical Analyses of Accident Data as a Basis for Planning Selective Enforcement," UCLA

An assessment of the research gaps related to highway services has produced the following:

1. Methods of reducing the severity of effects of highway accident injuries
2. Better methods of detection the occurrence of accidents
3. Methods of extricating passengers from wrecked vehicles
4. Better methods of removing wrecked vehicles for accident scenes
5. Methods of semi-automatic law enforcement, e.g., of speed limits
6. Improved methods of traffic surveillance
7. Methods for communications for vehicles in traffic
8. Improved methods of repair of disabled vehicles
9. Improved vehicle inspection techniques
10. Improved methods of highway patrol

Appendix 4

HIGHWAY SAFETY RESEARCH IN VARIOUS ORGANIZATION CATEGORIES

These listings summarize the results of a survey made to correlate highway safety research with various organizational categories, as reported in Section 4. Because the survey was based on a random sample of highway safety research documentation, not all of the centers of excellence are included. Further listings (approximately 700 organizations) may be found in Safety-Oriented Organizations, published by the Automotive Safety Information (SASI), General Motors Research Laboratories, September, 1967. Another comprehensive reference is the International Road Safety Research Directory, second edition, Organization for Economic Co-Operation and Development, Paris, 1966.

4.1 COLLEGES and UNIVERSITIES

Antioch College -1
- anthropometric manikins

Arizona, University of -1
- computer software

California, University of -30
- impact survival
- passenger ejection
- computer software

College of Engineering
- traffic flow
- street planning
- controls design

Operations Research Center
- traffic flow models
- traffic controls

Institute of Transportation and Traffic Engineering
- highway capacity
- traffic flow
- crash studies
- problem drivers
- driving skills
- impact studies
- computer simulation
- traffic control
- occupant ejection
- accident and investigation
- accident reporting
- safety education
- vehicle lighting
- highway surfaces
- highway planning

California at Los Angeles, University of -9
- information retention
- mathematics

Department of Engineering
- graphical analysis
- vision and accidents
- collision analysis

Department of Surgery
- trauma

Carnegie Institute of Technology -1
Graduate School of Business Adninistration
- cost effectiveness analysis

Chicago, University of -10
Committee on Mathematical Biology
- biophysics of driving

Cincinnati, University of -1
College of Medicine
- injuries and licensing

Columbia University -2	
Teachers College	driver behavior driver education
Cornell University -15	
Medical College	accident studies pedestrian accidents traffic deaths crash injuries psychiatric testing safety design
Denver, University of -2	demographic models
Franklin Institute -1	human operator dynamics
George Washington University -19	
Driver Behavior Research Project	driver attitude driving simulation driver improvement operator variables driver education
Georgia Institute of Technology -1	tire hydroplaning
Harvard University -36	urban transportation
School of Public Health	human factors vehicle design accident prevention accidental trauma accident investigation human factors engineering
Medical School	highway deaths emergency care injury mechanisms
Illinois, University of -20	road geometrics visual discrimination steering configurations behavioral factors
Department of Civil Engineering	sign design speed controls
Engineering Experiment Station	speed limits bridge design roadway delineation

Highway Traffic Center
registration and titles
College of Medicine
alcohol and driving
Research and Educational Hospitals
emergency service

Indiana, University of -12
Division of Optometry
night driving ability
night vision
color recognition
glare reduction
vehicle lighting
windshield optics

Kansas State College -1
Applied Mechânics Department
friction phenomena

Kentucky, University of -1
Department of Civil Engineering
roadway delineation

Maryland, University of -2
School of Medicine
perceptual information
shock/trauma

Massachusetts Institute of Technology -19
gear design
vehicle handling models
high speed traffic
automobile aerodynamics
Department of Civil Engineering
highway planning
urban transportation
traffic flow
Department of Mechanical Engineering
friction and wear
automated transportation
vibration isolation

McGill University, Montreal Canada -1
Department of Neurology and Neurosurgery
injury/trauma

Michigan State University -25
accident record analysis
traffic engineering
driver performance
highway planning
Graduate School of Business Administration
systems analysis
decision models

Department of Communication
- opinion surveys

Highway Traffic Safety Center
- driver skid control
- road surface friction
- driver improvement
- driver education
- driver performance
- visual acuity

Department of Psychology
- visual acuity

Department of Social Science
- socio-economic aspects

Michigan, University of -63

College of Engineering
- transportation systems
- computer education
- tire characteristics
- paving materials
- automatic highway system

Highway Safety Research Institute
- biomechanics
- collision simulation
- legal sanctions
- driver regulation
- driver studies
- motor vehicle inspection
- vehicle handling properties
- documentation
- systems analysis
- human factors

Institute for Social Research
- survey research

Institute of Industrial Health
- crash injuries

Medical School
- anthropometric spaces
- alcoholism
- anatomical properties
- trauma management
- fatal injuries
- injury mechanics
- restraint effects
- impact injury

Minnesota, University of -11

School of Engineering
- automotive construction
- human crash studies
- suspension geometry

School of Medicine	physiological performance fatigue traffic fatalities injury rehabilitation abdominal injuries shock
Mississippi, University of -1 Medical Center	arterial injuries
Newark College of Engineering -1	traffic simulation
New York City College -1	psychological modeling
New York University -22 College of Engineering	friction characteristics prosthetic devices biomechanics
Law School	legal studies driver licensing
School of Medicine	respiratory systems
Center for Safety Education	driver education young driver accidents
Northwestern University -33 Traffic Institute	law enforcement alcohol/accidents accident investigation enforcement and training accident reduction traffic control driver testing
Transportation Center	urban transportation system models
Ohio State University -26 College of Engineering	driver-vehicle modelling automatic steering traffic flow automobile simulation accident prevention electronic traffic devices nighttime driving roadside development

College of Medicine
- trauma
- thoracic injuries
- acceleration/acceleration effects

Oklahoma, University of -1
School of Medicine
- restraint systems
- impact injury

Oregon, University of -1
Medical School
- nervous systems
- shock

Purdue University -28
- night vision performance
- tire force measurements
- human factors

School of Civil Engineering
- friction phenomena
- highway systems modeling
- traffic flow

Joint Highway Research Project
- paving materials
- highway design
- accident analysis
- traffic flow
- traffic control

Rensselaer Polytechnic Institute -1
- soil-vehicle systems
- handling mechanics

Rhode Island School of Design -1
- environment and man

Southern California, University of -10
School of Medicine
- human factor/accident
- shock/narcotics
- cardiovascular system
- computer patient monitoring
- injury/trauma

Stanford University -1
School of Medicine
- carbon monoxide effects

Tennessee, University of -5
Department of Civil Engineering
- pavement skid testing
- towed vehicle testing
- highway materials testing

Texam A & M University -19	
Texas Transportation Institute	
	transportation planning
	sign support structures
	interchange design
	traffic capacity
	computer analysis
	ramp control
	traffic surveillance
Tufts University -1	
Institute for Psychological Research	
	human engineering
Virginia Medical College -1	
Department of Ophthalmology	
	visual injury
Virginia, University of -1	
School of Medicine	
	crash injuries
Wayne State University -8	
	human acceleration response
	modeling, systems analysis
	impact testing evaluation
College of Medicine	
	penetrating heart injuries
	bone/stress-strain
	injury/trauma
	penetration injuries
Western Ontario, University of (Canada) -2	
Medical School	
	problem drivers
	group therapy
West Virginia, University of -1	
	biomechanics
Wisconsin, University of -1	
Department of Mechanical Engineering	
	friction phenomena
Wyoming, University of -1	
College Commerce and Industry	
	traffic accident costs
	highway economics
Yale University -13	
Center of Alcohol Studies	
	alcoholism
	behavioral skills

Bureau of Highway Traffic	parking, planning highway administration traffic engineering urban transportation
School of Medicine	ambulatory medical case hospital emergency services
Department of Psychology	driving skills degrading influence

4.2 RESEARCH AND CONSULTING FIRMS

American Institutes for Research -1	human factors in accidents
Applied Psychology Corporation -1	mid-air visual collision avoidance research
Autonetics -1	two vehicle situations/studies
BioTechnology, Inc. -1	visual information translation vehicular control actions
Bolt, Beranek and Newman, Inc. -2	human response/sudden change
Booz, Allen and Hamilton, Inc. -1	research center creation Detroit area
Control Specialists, Inc. -1	human operator response
Cornell Aeronautical Laboratory -56	automobile lateral stability automobile control dynamics of steering system traffic surveillance communication with drivers automobile crash injuries vehicle vibration dynamics crash safety research automobile lateral motions simulation steering control/automobile response automobile stability barrier systems/impact conditions highway barrier design
Automotive Crash Injury Research	automobile doors/crash conditions side window glass/glass damage ejection/automobile fatalities safety belts/report data accumulation door lock effectiveness leading causes of automobile injury traffic accidents/gaurdrails fire in automobile accidents
Industrial Division	automobile crash safety research
Transportation Research Department	design elements of rural highways vehicle accident rates

De Leuw, Cather and Company, Engineers -1
control devices on traffic operations

Dunlap and Associates, Inc. -2
accident causation/personal factors
human behavior/mathematical models

Human Factors Research -1
vigilance/psychology

Institute for Research in Human Relations -1
ground safety
psychology

Roy Jorgenson and Associates -4
snow and ice control
non-chemical methods
managing highway maintenance

Louis T. Klauder and Associates -1
auto-on-train project/equipment

Mayo Clinic -1
Section on Medicine
clinico-physiologic aspects
passenger flight

University of Michigan Transportation Institute -1
driving behavior/driving accidents

Miller-Warder Associates -1
construction control procedures

Planning Research Corporation -1
traffic signals
individual intersections

Rand Corporation -10
marginal cost function
highway construction and operations
research and development costs
urban transportation
decreasing freeway travel time
computational linguistics
land transportation vehicles

St. Joseph's Hospital -2
Dept. of Psychiatry
persons in frequent auto accidents
group therapy

Wilbur Smith Associates -3
motor vehicle accidents
Washington, D. C. accident study
future highways
urban growth

Stanford Research Institute -1	intercity traffic movement
Systems Technology, Inc. -2	quasi-linear pilot models handling qualities, a theory
United Research, Inc.	future transportation needs

4.3 GOVERNMENT AGENCIES

Air Force Systems Command -7
    Aeromedical Research Laboratory
        impact injury/pregnant female
        lap belt restraint
    Aerospace Medical Research Laboratories
        human body model
        computer software
        controls and handles
        rim surfaces
        manikin fabrication and development
        human engineering

Air Research and Development Command -2
    Air Force Missile Development Center
        hydraulic bumper
        roll-over structure
        multiphase acceleration profiles

Army Medical Research and Development Command -5
    Driver Control Branch
        static muscle endurance measurement
        body position
        strength/endurance/manual pull
        body stabilization
        relative muscle/loading and endurance

Army Office of Surgeon General -1
        accident facts
        accident prevention

Army Tank-Automotive Center -1
    Land Location Laboratory
        educational aspects/land locomotion

Bureau of Public Roads -22
        bridge lighting
        composite networks
        sign supports
        expressway medians/evergreen trees
        continuous highway bridges
        highway research
        development studies
        highway statistics
        traffic flow on trunkline system
        motor vehicle registration
        model traffic ordinances
        highway construction/regulations
        highway accidents/prevention
        roadside control
        highway finance bibliography
        parking guide
        accident records
        speed today

California Highway Patrol -2
- single car accidents
- safety belts

California Highway Transportation Agency -14
- reduced visibility/fog

Dept. of Public Works, Div. of Highways
- skid resistance test
- freeway fatal accidents
- comparative freeway study
- truck classification counter
- median barrier effectiveness

Traffic Department
- freeway pedestrian accidents
- freeway accident rates
- traffic volume
- number of lanes
- freeway illumination
- wrong-way driving
- ramp type/accidents
- geometry/accidents

California State Department of Public Health -2

Division of Accident Prevention
- traffic deaths

Family Research Center
- accidental injury
- children

Department of Commerce -7
- highway safety program standards
- high speed ground transportation

Business and Defense Services Administration

Automotive and Transportation Equipment Div.
- motor vehicle production
- motor vehicle registration, 1959-60

Transportation Equipment Div.
- motor vehicle production
- motor vehicle registration, 1960-63

Connecticut State Department of Motor Vehicles -1
- motor vehicle accident prevention

Federal Aviation Agency -20
- federal aviation regulations
- airworthiness standards

Aircraft Development Service
- carbon monxide indicators/evaluation

Office of Aviation Medicine
- light adaptation
- vision considerations
- human factors

Civil Aeromedical Research Institute
- deceleration/human body
- extreme vertical impact
- human tolerances/extreme impacts
- tranquilizing analeptic effects
- vasadilation drugs effects
- acceleration, impact, weightlessness
- emergency escape
- restraint systems
- vibration
- human face tolerances
- human tolerance/water impact
- padding materials/crash protection
- pregnant female/impact injury
- lap belt restraint

Department of Health, Education and Welfare -9
- alcohol/accidental injury

Office of Assistant Secretary for Program Coordinator
- injury prevention program

Secretary's Advisory Committee on Traffic Safety Research
- insurance industry
- traffic safety

Social Security Administration, Office of Research and Statistics
- economic value of human life

Traffic Safety Branch
- emergency medical care

Highway Research Board -10
- poor drivers
- highway safety bibliography
- roadway delineation system
- highway research information service

Department of Traffic and Operations, Committee on Highway Safety
- research needs report
- research problem

National Cooperative Highway Research Program
- disabled vehicles location
- running cost of motor vehicles

Michigan State Highway Department -14
- freeway traffic/incidents
- skid resistance/pavement surfaces
- survey and design manual
- lane changes/urban freeway
- state road accidents
- road standard plans

Traffic Division
- traffic flow on trunkline system '65
- traffic flow on trunkline system '58
- freeway ramp closure
- traffic flow on trunkline system '60
- traffic flow on trunkline system '62
- traffic flow on trunkline system '64

National Aeronautics and Space Administration -8
- impact acceleration stress

Langley Research Center
- crushable structures
- acceleration protection
- impact characteristics/materials
- pneumatic tire hydroplaning

National Bureau of Standards -7
- infrared/visibility improvement
- colors of signal lights/standards
- information systems

National Highway Safety Bureau -9
- highway dangers
- safety program standards
- highway safety

Division of Emergency Treatment and Transfer of the Injured
- medical evacuations/helicopters
- accident lanes

National Institutes of Health -1
- alcohol and traffic safety

New York Port Authority -1
- theory of traffic flow

New York State Department of Health -4

Driver Research Center
- alcohol
- single vehicle fatal accident

Epidemiology Residency Program
- fatal automobile accidents in N.Y.C.
- adult pedestrians/fatally injured

New York State Department of Motor Vehicles -11
- alcohol
- single vehicle fatal accidents
- accidents involving excessive speed
- farm vehicle accidents

Division of Research and Development
- motorcycle safety problems
- compact vehicles

New York State Department of Public Works -6

Bureau of Physical Research
- new highway barriers
- railing type bridge lighting
- traffic paints/glass beads

Division of Construction
- design standards/interstate highways

Subdivision of Transportation Planning and Programming
- composits networks

Office of Naval Research -2
- information systems
- mechanics of human posture

Post Office -1
- post office vehicle crash study

President, Office of -17

Committee for Traffic Safety
- health of injured
- medical care of injured
- transportation of injured
- adult driver improvement project
- traffic courts
- traffic accidents records
- police traffic supervision
- motor vehicle administration
- engineering

Public Health Service -10
- driver licensing
- medical advisory boards
- injury-producing accidents
- automobile crash injuries
- medical aspects

Division of Accident Prevention
- accident research
- automotive accidents/epidemiology
- human variables/traffic accidents
- automotive safety belts

Texas Highway Department -3
- impact behavior/sign supports
- peak period freeway volume
- map use/photogrammetric methods

Virginia Department of Highways -9

- state tire procurement
- traffic accidents/interstate
- accident analysis
- superelevation of curve

Location and Design

- road designs
- roads standards

Traffic and Planning Division

- accident data summary
- traffic study

4.4 INDUSTRIAL FIRMS

B. F. Goodrich Company -2
- tire design
- tire testing

Boeing Company -1
Military Airplane Company
- human body vibration

Bunker-Ramo Corporation -2
- design engineering
- human factors

Chrysler Corporation -17
- handling requirements
- truck performance
- fire disturbances
- injury reduction
- ride dynamics

Automotive Safety Engineering Office
- vehicle safety engineering
- restraint systems

Defense Engineering Department
- vibration tolerance of humans

Dodge Division
- technical service bulletin

Cutler-Hammer, Inc. -1
Airborne Instruments Laboratory
- visibility through fog

Douglas Aircraft Company -1
- vehicular controls

Fairchild Hiller Corporation -1
Republic Aviation Division
- N. Y. safety car programs

Firestone Tire and Rubber Company -3
- tire skid resistance
- tire performance requirements

Ford Motor Company -18
- vehicle cornering
- traction, braking
- steering, handling
- vehicle stability analysis
- highway safety
- shop manuals
- vehicle trends
- car acceleration
- automotive trends
- windshield penetration resistance
- data accumulation

Frost Engineering Development Corporation -1
- restraint and support systems

General Motors Corporation -68
- safety in automotive design
- single car accidents
- traffic flow
- visual considerations
- automobile-travel trailer control
- crash research
- rapid transit
- caliper disc brake
- traffic trauma

Cadillac Motor Car Division
- independent wheel suspension
- shop manual

Chevrolet Motor Division
- ride requirements
- chassis overhaul manual

Proving Ground Section
- elements of skidding
- car control factors
- car control factor measurement
- gaurdrail installation
- vehicle simulation
- vehicle crash study
- automobile restraint system
- tire-road friction measurement
- safety test instrumentation
- vehicle aspects of safety problem

Research Laboratories Division
- automobile directional control
- intervehicle spacing
- motoring safety
- traffic pacer systems
- rolling tire characteristics
- signalized intersections
- response to speed signs
- tire uniformity measurements
- highway communications
- steering systems
- lateral stability
- tire lateral forces
- automobile control and stability
- vehicular safety
- automatic car controls
- driver aid development
- relative controllability
- body impact tests

Training Center
- safety seminar

Truck and Coach Division
- commercial brake systems

Goodyear Tire and Rubber Company -3	
	tire skid resistance tire inflation tire traction
International Business Machine, Inc. -1	
	traffic flow
Lockheed-Georgia Company -1	
	body vibration
Minneapolis-Honeywell Regulator Company -1 Aeronautical Division	
	human engineering manual control
New York Telephone Company -1	
	traffic flow
System Development Corporation -1	
	computer soft ware
United States Rubber Company -2	
	tire skid resistance passenger tire enveloping forces

4.5 FOUNDATIONS, ASSOCIATIONS AND SOCIETIES

American Association of Motor Vehicle Administrators -7
- vehicle inspection statistics
- driver performance, govn't role
- vehicle and traffic law
- vehicle inspection reference guide
- medical advisory boards
- driver licensing

American Association of State Highway Officials -1
- highways and urban development

American Association of Teachers Colleges -1
- safety education
- college instruction

American Automobile Association -17
- motor vehicle inspection
- motor vehicle research
- pedestrian safety

Traffic Engineering and Safety Dept.
- parking manual
- reaction time, age
- seat belts
- skidding, skid-accidents
- human element in skidding
- aging and driving
- traffic safety
- pedestrian fatalities
- elderly pedestrians
- pedestrian, legislation, enforcement

American Medical Association -3
- medical advisory boards
- driver licensing
- medical terminology
- seat belts

American Society for Testing and Materials -12
- spectral characteristics test
- color of objects test
- materials test
- concentrated engine antifreezes
- specific gravity test
- luminous reflectance test
- transmittance test
- specular gloss test
- Munsell system color specification
- alkalinity test/engine antifreeze
- ash content test/engine antifreeze
- pH test in concentrated antifreezes
- hydrometer-thermometer-
- field tester specifications
- aqueous solutions/engine antifreeze
- directional reflectance/opaque

Automobile Manufacturers Association -5
- automobile inspection handbook
- dual headlighting system
- highway safety
- urban transportation
- highway emergency locating plan

Automotive Safety Foundation -10
- driver education
- highway act, 1958
- highway program scheduling
- highway safety program
- Maine highway classification
- Penn. highway policies and practices
- community organization
- urban transportation crisis
- future highway use
- freeway operations/highway service

Institute of Traffic Engineers -1
- audio-visual aids
- traffic engineers

Insurance Institute for Highway Safety -7
- mileposting on state highways
- guidelines for public policy
- driver improvement courses
- safety glazing materials
- glazing motor vehicles
- public education/safety standards

National Education Association
- traffic/driver safety education
- college safety education/guide
- driving simulators
- driver education evaluation
- bicycle safety
- school bus drivers
- school bus standards
- regulation of driver
- motivation of driver

National Commission on Safety Education -14
- safety education research
- school bus standards

National Research Council -2
- research centers directory
- transportation research

National Safety Council -18
- road aircraft patrol
- accident facts
- safety activities effectiveness
- highway safety
- traffic accident prevention

small car information
studded tire performance/evaluation
safety literature guide

Committee on Uniform Traffic Accident Statistics
ran-off-roadway accidents
vehicle accident classification

Committee on Winter Driving Hazards
specialized tire performance
packed snow surfaces

Society of Automotive Engineers -19
seat belt assembly installations
tire operation/constant slip angle
rear vision/design aspect
truck tire economics
passenger door hinge systems
variable-stability automobile
steering wheel assembly/test
determining reflectivity

Body Engineering Committee
vehicle steering accommodations
side door latch systems

United States of America Standards Association -4
motor vehicle fleet accident
standard inspection requirements
glazing materials
glazing motor vehicles

Virginia Council of Highway Investigaiton and Research -1
road surface slipperiness

Virginia Highway Research Council -2
tire procurement
highway safety