Proceedings of ROADS AND TRAFFIC SAFETY ON TWO CONTINENTS in Gothenburg, Sweden, 9-11 September 1987

- Opening
- Traffic Safety - Open Session
- Traffic Safety - General
Proceedings of ROADS AND TRAFFIC SAFETY ON TWO CONTINENTS in Gothenburg, Sweden, 9-11 September 1987

- Opening
- Traffic Safety - Open Session
- Traffic Safety - General
PREFACE

The Swedish Road and Traffic Research Institute (VTI) and the US Transportation Research Board (TRB) of the National Research Council were jointly organising this international conference. The objective was to cover the present and future road research with special emphasis on the Strategic Highway Research Program (SHRP), as well as the research concerning drivers and vehicles as related to highway safety.

Under development for 2-3 years, SHRP is a fully funded, $150 million (US), five year program of research directed at asphalt, concrete and structures, highway operations, and long term pavement performance.

In the different road safety sessions there were presentations of actual research in different countries and discussions of the differences that exist between Europe and the USA, trying to explain the reasons for them and examine whether they are reasonable and acceptable.

In the sessions of roads, the emphasis on the Strategic Highway Research Program (SHRP) was intended. Presentations did highlight differences between European and US practices and needs, and the discussions was concentrated on how to promote international involvement in SHRP and application of its research.

Linköping January 1988

Kenneth Asp

Proceedings of ROADS AND TRAFFIC SAFETY ON TWO CONTINENTS in Gothenburg, Sweden, 9-11 September 1987:

VTI RAPPORT 328 A
- Opening
- Traffic Safety - Open Session
- Traffic Safety - General

VTI RAPPORT 329 A
- Long Term Pavement Performance
- Asphalt

VTI RAPPORT 330 A
- Highway Operations
- Concrete and Structures

VTI RAPPORT 331 A
- Driver Behaviour and Licensing
- Alcohol and Drugs
- Driving and Elderly

VTI RAPPORT 332 A
- Speed
- Vehicle Performance
- Crashworthiness
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>I</td>
</tr>
<tr>
<td>PROGRAM</td>
<td>II</td>
</tr>
</tbody>
</table>

## OPENING

**SAFETY AND SHRP FROM THE VIEWPOINT OF THE STATES**  
Mr John R Tabb, President of AASHTO

**THE STRATEGIC HIGHWAY RESEARCH PROGRAM:**  
WHERE IT CAME FROM, AND WHERE IT IS GOING  
Dr Damian Kulash, Executive Director of SHRP,  
Prof Thomas D Larson, Chairman of SHRP, USA

**EUROPEAN TRENDS IN ROAD SAFETY AND ROAD SAFETY RESEARCH**  
Prof Niels O Jørgensen, Technical University, Denmark

**HIGHWAY SAFETY RESEARCH IN THE FHWA AND THE UNITED STATES**  
Mr David K Phillips, Associate Administrator, R & D Technology, Federal Highway Administration, USA

**PROMETHEUS - THE EUROPEAN AUTOMOTIVE INDUSTRY RESEARCH PROJECT**  
Tage Karlsson, AB Volvo, Sweden

## TRAFFIC SAFETY - OPEN SESSION

**HIGHWAYS THROUGH TOWNS - ROAD WITH SAFETY AND ENVIRONMENTAL PRIORITY**  
Dr Otto Schiøtz, The Road Directorate, Denmark

**VOLVO SAFETY DESIGN PHILOSOPHY**  
Anders Eriksson, Volvo Car Corp, Sweden

VTI RAPPORT 328 A
IMPROVEMENT OF SAFETY BELT USE IN THE NETHERLANDS
Dr Fred Wegman, Jan Mulder & Chad M Gundy, Institute for Road Safety Research (SWOV), The Netherlands

ROAD TRAFFIC SIGNING ON TWO CONTINENTS - A CALL FOR HARMONIZATION
Dr Michael Bernard, Swiss Lighting Assoc (SLG), 3 M EUROPE Switzerland

ROAD SIGN RESEARCH IN WEST GERMANY
Prof Dr Siegfried Giesa, Hessisches Landesamt für Strassenbau, The Federal Republic of Germany

TRAFFIC SAFETY - GENERAL

THE OECD ROAD TRANSPORT RESEARCH PROGRAMME
Director General Hans Sandebring, VTI and Chairman of the OECD road transport research programme

TRAFFIC SAFETY RESEARCH POLICY IN THE UNITED STATES
K B Johns, Director, Technical Activities, Transportation Research Board

LA RECHERCHE EN SÉCURITÉ ROUTIÈRE EN FRANCE
(R and D policy in France in the field of road safety)
Director General Georges Dobias, Institut National de Recherche sur les Transports et leur Sécurité (INRETS), France

ROAD SAFETY RESEARCH IN THE FEDERAL REPUBLIC OF GERMANY
Prof Dr Heinrich Praxenthaler, Head of Bundesanstalt für Strassenwesen (BAST), The Federal Republic of Germany

ROAD USER SAFETY - POSSIBLE EUROPEAN RESEARCH CO-OPERATION
Dr Anthony Hitchcock, Head of Safety and Transportation Group, Transport and Road Research Laboratory (TRRL), United Kingdom
ABSTRACT

Papers presented at the seminar were as follows: Safety and SHRP from the viewpoint of the States (Tabb, J); The Strategic Highway Research Program: Where it came from, and where it is going (Kulash, D and Larsson, T); European Trends in Road Safety and Road Safety Research (Joergensen, N); Highway Safety Research in the FHWA and the United States (Phillips, D); PROMETHEUS. The European Automotive Industry Research Project (Karlsson, T); Highways through Towns. Road with Safety and Environmental Priority (Schioetz, D); Volvo Safety Design Philosophy (Eriksson, A); Improvement of Safety Belt Use in the Netherlands (Wegman, F, Mulder, J and Gundy, C); Road Traffic Signing on Two Continents. A Call for Harmonization (Bernard, M); Road Sign Research in West Germany (Giesa, S); The OECD Road Transport Research Programme (Sandebring, H); Traffic Safety Research Policy in the United States (Johns, K.B); R and D Policy in France in the Field of Road Safety (Dobias, G); Road Safety Research in the Federal Republic of Germany (Praxenthaler, H); Road User Safety. Possible European Research Cooperation (Hitchcock, A).
## WEDNESDAY SEPTEMBER 9

### OPENING

- **9.30**
  - Opening speeches
    - Mr A Norling, County Governor, Gothenburg, Sweden
  - Objectives of the conference
    - Mr K.B. Johns, Director, Transportation Research Board, TRB, USA
    - Mr Hans Sandebring, Director General, The Swedish Road and Traffic Research Institute (VTI), Sweden

- **11.15**
  - European Trends in Road Safety and Road Safety Research
    - Professor N O Jorgensen, Technical University, Denmark

- **11.45**
  - Traffic Safety Research in the FHWA and the United States
    - Mr David Phillips, Associate Administrator, R & D Technology, Federal Highway Administration, USA

- **12.30**
  - **LUNCH**

### LONG TERM PAVEMENT PERFORMANCE

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker(s)</th>
</tr>
</thead>
</table>
| 14.00—17.00 | Chairman: Dir Kaare Flaate, Head of the National Road Research Laboratory, Norway  
Mr James Brown, Engineer of Pavement Design, Texas, State Dept of Highways and Public Transportation, USA  
Mr Ray Forsyth, Chief Transportation Lab, California Dept of Transportation, USA  
Pavement Management Research in the Federal Republic of Germany  
Mr James Brown, Engineer of Pavement Design, Texas, State Dept of Highways and Public Transportation, USA  
Mr Ray Forsyth, Chief Transportation Lab, California Dept of Transportation, USA  
Mr James Brown, Engineer of Pavement Design, Texas, State Dept of Highways and Public Transportation, USA  
Mr Ray Forsyth, Chief Transportation Lab, California Dept of Transportation, USA  
Pavement Management Research in the Federal Republic of Germany  
Mr James Brown, Engineer of Pavement Design, Texas, State Dept of Highways and Public Transportation, USA  
Mr Ray Forsyth, Chief Transportation Lab, California Dept of Transportation, USA  
Pavement Management Research in the Federal Republic of Germany  
Mr James Brown, Engineer of Pavement Design, Texas, State Dept of Highways and Public Transportation, USA  
Mr Ray Forsyth, Chief Transportation Lab, California Dept of Transportation, USA  
Pavement Management Research in the Federal Republic of Germany  
Mr James Brown, Engineer of Pavement Design, Texas, State Dept of Highways and Public Transportation, USA  
Mr Ray Forsyth, Chief Transportation Lab, California Dept of Transportation, USA |

### TRAFFIC SAFETY — GENERAL

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker(s)</th>
</tr>
</thead>
</table>
| 14.00—17.00 | Chairman: Dir David Phillips, Federal Highway Administration, USA  
The OECD Road Transport Research Programme  
Director General Hans Sandebring, VTI, and Chairman of the OECD Road Transport Research Programme  
Traffic Safety Research Policy in the United States  
Mr K.B. Johns, Transportation Research Board (TRB), USA  
R & D Policy in France in the field of Road Safety  
Director General G Dobias, Institut National de Recherche sur les Transports et leur Sécurité (INRETS), France  
Road Safety Research in the Federal Republic of Germany  
Prof Dr H Praxenthaler, Head of Bundesanstalt für Strassenwesen (BAST), the Federal Republic of Germany  
Road Safety Research — Possible European Cooperation  
Dr A Hutchcock, Head of Safety and Transportation Group, Transport and Road Research Laboratory (TRRL), U.K.  
Discussion on how to improve the cooperation between Europe and the United States within the field of traffic safety research. |

### DRIVER BEHAVIOUR AND LICENSING

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker(s)</th>
</tr>
</thead>
</table>
| 14.00—17.00 | Chairman: Prof Kåre Rumar, The Swedish Road and Traffic Research Institute  
A Method for Studying the Effect of Visual Field Defects, which could be a Tool, when formulating Standards for Visual Fields  
Dr Per Lövsund, Dep of traffic safety, Chalmers technology, Sweden  
Crash Avoidance Models  
Dr Wade Allen, Principal Research Engineer, Systems Technology Inc, USA  
Driver Risk Perception in Spain and the USA  
Dr Michael Sivak, University of Michigan, USA  
Theoretical Requirements for Drivers License in Austria  
Dr Ch. Michalik, Kuratorium für Verkehrssicherheit, Wien  
Why can we expect New Scandinavian Driver Education Programmes to set International Standards and Improve Future Skills of New Drivers?  
Dr Birger Nyaegard, VTI, Sweden |

Discussion
## THURSDAY SEPTEMBER 10

### ASPHALT

- **8.30—12.00**
  - **Chairman:** Mr Francis Francois, Executive Dir of AASHTO, USA
  - **Asphalt Characteristics Portion of SHRP**
    - Mr Joseph L. Goodrich, senior Research Chemist, Chevron Co, USA
  - **Asphalt Characteristics Portion of SHRP**
    - Dr Thomas Larson, Penn State University, USA
  - French research on the methods of characterization of asphalt, polymer modified binders, asphalt mixes
  - Prof Dr Techn F Bohm, Technische Hochschule Darmstadt, the Federal Republic of Germany
  - Mix Design in the United Kingdom
  - Dr Richard Salter, University of Birmingham, UK
  - Panel discussion

### ALCOHOL AND DRUGS

- **8.30—12.00**
  - **Chairman:** Dir General George Dobias, INRETS, France
  - **Effects of Minimum Drinking Age on Fatalities in the United States**
    - Mr John H Lacey, Program manager — Alcohol Studies, Univ of North Carolina, USA
  - **Driving and Drinking: Institutional and Social Aspects of Law Enforcement**
    - Dr Jayet Marie Chantal, Institut National de Recherche sur les transports et leur securite (INRETS), France
  - **The Drinking and Driving Problem in Norway**
    - Dr Alf Glad, Institute of Transport Economics, Etterstad, Oslo
  - **Road Sign Research in the Federal Republic of Germany**
    - Dr Otto Schiotz, The Road Directorate, Denmark
  - **Volvo Safety Design Philosophy**
    - Anders Eriksson, Volvo Car Corp, Sweden
  - Discussion

### TRAFFIC SAFETY

- **08.30—12.00**
  - **Chairman:** Dr A Hitchcock, TRRL and Chairman of the COST Technical Committee on Transport
  - **Highway through Towns — Road with Safety and Environmental Priority**
    - Dr Otto Schiotz, The Road Directorate, Denmark
  - **Volvo Safety Design Philosophy**
    - Anders Eriksson, Volvo Car Corp, Sweden
  - An Evaluation Study of the Effectiveness of a Combination of Enforcement and Information on Improving Seat Belt use
    - Dr C M Gundy, Institute for Road Safety Research (SWOV), Netherlands
  - **Road Traffic Signing on Two Continents — A call for Harmonization**
    - Dr Michael Bernhard, Swiss Lighting Assoc (SLG), 3 M Europe Switzerland
  - **Road Sign Research in the Federal Republic of Germany**
    - Dr Siegfried Giesa, Hessisches Landesamt für Strassenbau, the Federal Republic of Germany
  - Discussion

### HIGHWAY OPERATIONS

- **12.00**
  - **LUNCH**

### DRIVING AND THE ELDERLY

- **13.30—17.00**
  - **Chairman:** Dir K.B. Johns, Transportation Research Board, USA
  - **Experiences in Fatalities by Age and Road User Groups — USA vs Western Europe 1970—1983**
    - Prof Ruediger Lamm, Clarkson University, USA
  - **Driving and the Elderly**
    - Dr Stephen R Godwin, Senior Program officer, Transportation Research Board, USA
  - **Driving and the Elderly**
    - Prof Dr Günter Kroj, Bundesanstalt für Strassenwesen (BAST), the Federal Republic of Germany
  - **Computer Controlled Suspension (CCS)**
    - Lars Runo Tillback, Volvo Car Corp, Sweden
  - **Driving and the Elderly**
    - Prof Dr Günter Kroj, Bundesanstalt für Strassenwesen (BAST), the Federal Republic of Germany
  - **Discussion**

### VEHICLE PERFORMANCE

- **13.30—17.00**
  - **Chairman:** Prof Dr H Praxenthaler, Head of the Road and Traffic Research Laboratory (BAST), the Federal Republic of Germany
  - **Social, Economic and Institutional Impediments to the Harmonization of Vehicle Safety Standards**
    - Dr Christopher Wilson, Department of Transport, Canada
  - **Computer Controlled Suspension (CCS)**
    - Lars Runo Tillback, Volvo Car Corp, Sweden
  - **Driving and the Elderly**
    - Prof Dr Günter Kroj, Bundesanstalt für Strassenwesen (BAST), the Federal Republic of Germany
  - **Discussion**

---

**19.00** Presentation of the winner of the 1987 International Volvo Traffic Safety Award and music played by the Gothenburg Philharmonic Ensemble

**20.00** COCKTAIL AND DINNER
<table>
<thead>
<tr>
<th>FRIDAY SEPTEMBER 11</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONCRETE AND STRUCTURES</strong></td>
</tr>
<tr>
<td>8.30—12.00</td>
</tr>
<tr>
<td><em>Chairman:</em> Dir Ivar Schacke, Head of the Danish Road Research Laboratory, Denmark</td>
</tr>
<tr>
<td>Concrete and Structure Portion of SHRP</td>
</tr>
<tr>
<td>Mr Howard Newton, Research Director, Virginia Highway &amp; Transportation Research Council, USA</td>
</tr>
<tr>
<td>Development in the Netherlands in the field of concrete and structures and concrete block paving</td>
</tr>
<tr>
<td>Dr Van der Vring, The Netherlands</td>
</tr>
<tr>
<td>Durability of Road and Bridge Structures of Concrete Nordic experiences</td>
</tr>
<tr>
<td>Dr Bo Göran Hellers, Head of Swedish Cement and Concrete Research Institute, Sweden</td>
</tr>
<tr>
<td>Norwegian Practice for Concrete Bridge Deck Protection</td>
</tr>
<tr>
<td>Dr Erling K. Hansen and Dr John E Haga, Norwegian Road Research Laboratory</td>
</tr>
<tr>
<td>The use of 2 metre square Precast Concrete Rafts as Temporary, Reusable and Cost-Effective Roads</td>
</tr>
<tr>
<td>Dr John W Bull, University of Newcastle upon Tyne, United Kingdom</td>
</tr>
<tr>
<td>Panel discussion</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**12.00 LUNCH AND CLOSING REMARKS**
SAFETY AND SHRP FROM THE VIEWPOINT OF THE STATES

John R. Tabb, President, American Association of State Highway and Transportation Officials, and Director of the Mississippi Highway Department

In the United States the primary responsibility for the design, construction, maintenance and operation of the nation's highways lies within the governments of the 50 states. As the builders and owners of America's highways, the highway agencies in the states have always been concerned about highway safety, and from the early 1900's have been involved in highway research.

Through increased attention to highway design and a commitment to both building more freeway-type highways and rehabilitating older highways, coupled with increased attention to traffic engineering improvements, the state highway agencies that comprise AASHTO have made major contributions toward the nation's achievement in holding traffic deaths steady in recent years while vehicle miles of travel have tripled. The states believe that further increases in highway safety can be achieved by greater attention to vehicles and their drivers, and are increasing their activities in this area. This paper will examine the past and future involvement of the states and AASHTO in achieving ever safer highway travel in the United States.

There is a clear linkage between the quality of our pavements and their durability, which means that if the SHRP program is successful highway safety should again be furthered. The states and AASHTO were the key actors in bringing SHRP to reality, and the program cannot succeed without the interest and continuing involvement of the state highway agencies. This paper will also discuss why the states have been so strong in support of SHRP, what we expect to obtain from the research, why AASHTO and the states have invited other nations around the world to become involved in the SHRP effort, and the increasing international activity of AASHTO.
SAFETY AND SHRP FROM THE VIEW POINT OF THE STATES

John R Tabb, President, American Association of State Highway and Transportation Officials, and Director, Mississippi Highway Department September 9, 1987

It is my honor and privilege to address the opening session of this historic conference on "Roads and Traffic Safety on Two Continents", and in so doing to comment on the topics of road safety and the Strategic Highway Research Program (SHRP) from the standpoint of the state departments of highways and transportation in the United States.

In the United States the primary responsibility for the design, construction, maintenance and operation of the nation's highways lies with the governments of the 50 states, one of which is my state of Mississippi. Since 1916 the Federal government has been a partner with the states in the construction of our highway system, providing both technical assistance and substantial funding that is matched by the states and our local governments. Today, the Federal-aid highway system that has resulted from this Federal-state partnership totals some 843,000 miles of a grand total of 3.9 million miles of roads and streets in the United States. That 843,000 miles carried nearly 80 percent of our 1985 total 1.4 billion vehicle miles of traffic.

As the builders and owners of America's highways, the highway agencies in the states have always been concerned about highway safety and from the early 1900's have been involved in highway research. Our first state highway agency was created in 1893, and in that same year the Federal government began a small highway research effort that eventually led to the creation of today's Federal Highway Administration. As America entered the 20th century we were just beginning to plan and build our highway network to accommodate that new phenomenon, the automobile, and later the motor truck. We initially had no profession of highway engineering, but were able to draw on railroad engineering and adapt much from that field to the construction of roads for automobiles and trucks.

By 1914, our state highway engineers were building roads in most of our nation. They felt the need to develop common standards, and to confer with each other on the technical, administrative and public finance problems involved with developing our state highways and shaping them into a national system. In that same year the state highway agencies founded AASHTO, to help them improve their technical and administrative abilities, to cooperatively develop and publish standards for constructing and operating our highways, and to assist in establishment of a national highway system. These are still major roles of AASHTO, which in the 1970's broadened its interests to also include the air, public transit, railroad and water modes of transportation, in addition to highways. In 1916, AASHTO worked with the Congress to help establish the Federal-aid highway program, to help assure a nation-wide highway system by providing funding assistance to those states who would find it difficult or impossible to build adequate highways on their own.

Since the early 1900's our state highway engineers have worked to build roads upon which motor vehicles can be safely operated. Our early roads
were designed to accommodate the early automobiles, and in many cases with the passage of years these roads became inadequate as automobile designs and operating speeds improved. From the beginning of our highway construction programs, assumptions had to be made about the ability of drivers to control their vehicles and the reasonableness of their driving judgments. Some of our assumptions here proved in error, and as a result our highway designs were sometimes not as forgiving of poor driver judgments as experience later proved necessary. As the number of vehicles increased geometrically over the years our highways became heavily crowded, causing delays and increasing accidents. The field of traffic engineering was invented, and with it great strides in safety were made.

As the century has progressed, our state highway agencies in conjunction with the Federal Highway Administration and its predecessor agencies have learned from our mistakes, as have the automobile and truck manufacturers. We improved our highway designs, undertook reconstruction of older dangerous roads, developed the concept of four-lane divided highways with limited or no access except through properly designed interchanges, and launched the 43,500 mile Interstate system that today provides far safer passage for vehicles and their occupants than was ever possible on our earlier two-lane facilities. Vehicle manufacturers have designed better braking equipment and more reliable engines and have included a host of safety features in their vehicles that help drivers and passengers to move more safely.

Through increased attention to highway design and a commitment to both building more freeway-type highways and rehabilitating older highways, coupled with increased attention to traffic engineering improvements, the state highway agencies that comprise AASHTO have made major contributions toward the nation's achievement in holding traffic deaths steady in recent years while vehicle miles of travel have tripled. The fatality rate per 100 million miles of travel has been sharply cut over the years, from about 16 in 1930 to under 2.5 today. In 1970 we had some 53,000 deaths on our highways, which by 1986 was lowered to about 46,000.

Our highway fatalities per 100 million vehicle miles of travel have gone down each year since 1981. There were 2.47 highway deaths per 100 million vehicle miles of travel in 1985, which is less than one-half the 1966 fatality rate of 5.72 deaths per 100 million miles. The 1986 fatality rate appears to have been comparable to the 1985 statistics.

Clearly, America's highways are safer today than ever before. But our state highway agencies, working with the Federal Highway Administration, drivers, and the motor vehicle industry, can still do more. The states believe that one important way we can further increase highway safety is by giving greater attention to vehicles and their drivers. With tougher enforcement and major publicity campaigns, our state governments are currently making a frontal assault on motorists driving while under the influence of alcohol and drugs. We are moving to implement a recent law passed by Congress that will clamp down on poor truck drivers, by imposition of tighter licensing standards that will include requirements for demonstrating driving skills. We are devising more effective programs to assure that trucks are mechanically sound and to remove vehicles with faulty brakes and other equipment from our roads.
The use of passenger restraint systems is becoming more widespread in the United States, with nearly two-thirds of the states now having passed mandatory seat belt laws. These laws now apply to over 180 million Americans, and the National Highway Traffic Safety Administration estimates that since the first seat belt law was passed in 1984 these devices have saved some 1,450 lives. The effectiveness of these new state seat belt laws was demonstrated in 1986 when states which had no belt use laws saw highway fatalities increase in absolute terms by 13 percent, compared to a 2 percent increase in states with such laws.

No discussion of highway safety in the United States would be complete without commenting on the recent change in our national mandated speed limit, which was set in the 1970's at 55 MPH mainly to conserve fuel. In recent years it was evident that while the 55 MPH speed limit was saving lives, it also was being disregarded with increasing frequency by American drivers on our Interstate and other divided, four-lane highways. The disrespect for the 55 MPH law was widespread, and in the judgment of our state highway agencies was breeding increased general disregard for other traffic laws and utilizing an excessive amount of the law enforcement effort. We accordingly recommended a change to 65 MPH on the Interstates and similar highways. We were not alone in making this recommendation, and ultimately by the narrowest of margins the Congress agreed this year to a 65 MPH limit on the Interstate highways in rural areas.

The urbanized states in the eastern United States where traffic is very heavy and the 55 MPH limit is judged to be proper will probably not increase their speed limit to 65 MPH. Many other states have already implemented a 65 MPH limit on their rural interstates, including my state of Mississippi. Will this action increase highway fatalities? We believe any increase will be small, if we can now properly enforce the new limit. There is also evidence in some states that the 65 MPH limit on our Interstate highways will decrease overall fatalities, by drawing onto the Interstate system traffic from lower standard highways with lower construction standards that have lower speed limits. The Interstate highways are safer for vehicles, and if drivers use these highways more and the lower level highways less, overall highway safety may be improved. In any case, the massive public acceptance of the new 65 MPH limit has demonstrated that our Congress responded to public opinion making the speed limit change.

Over the past 15 years both our state highway agencies and AASHTO have become more involved with highway safety. We have created a committee within AASHTO that works in this area and are currently exploring ways to make it more effective. Many highway agencies have restructured their organizations to assure that highway safety issues are addressed routinely on all projects by highway design engineers as well as traffic engineers. Through AASHTO's National Cooperative Highway Research Program, which is conducted for us by the Transportation Research Board, we have funded many safety-related research projects in an effort to further improve the quality of our engineering. Guard rails are receiving increased attention, as are efforts to improve the placement and design of roadside appurtenances for safety reasons. Reflective delineation of pavement edges and better lane marking techniques have been widely adopted, and considerable work is ongoing to improve signing practices.
I mentioned that changes and improvements in automobiles and other vehicles in the early 1900's posed special problems for our highways. This is still true, as today our highway engineers struggle to design highways and safety appurtenances that will serve both the much lighter automobiles born out of the energy crisis of the 1970's, and the heavier trucks that our motor carriers are operating nationwide. There is a clear linkage between the design and manufacture of vehicles, the design, construction and maintenance of our highways, and the safety of both driver and passengers. We need to improve that linkage, and perhaps this conference can help further this goal.

Our state highway agencies and AASHTO believe that further gains in highway safety can also be achieved by better pavement engineering. There is also a clear linkage between highway safety and the quality of our pavements and their durability, particularly in this era of small cars with small tires, and the growing volume of traffic on our roads. Pavement durability is especially a problem in crowded urban areas, where prolonged and frequent traffic disruptions caused by pavement repair and rehabilitation work can create highway safety problems.

The states have made a strong commitment to improving the quality of our pavements, most recently through our unanimous support of SHRP, the Strategic Highway Research Program. If the SHRP effort is successful, highway safety should be furthered. This will be true because we will have learned to build better pavements, ones that will last longer under traffic, and which will thereby reduce pavement condition as a contributing cause to highway accidents and fatalities.

While SHRP can have a positive impact on highway safety, our state highway agencies had many additional reasons for sponsoring this new research program and expending much energy and many dollars to bring it into being. The leaders of our highway agencies were aware that the level of highway research in the United States was low, and that while we were successfully solving small problems through our own state research and the cooperative efforts made through our National Cooperative Highway Research Program, major research on important questions was just not occurring. The Federal Highway Administration's research program, important though it is, was also not getting at some basic issues we believe needed attention.

We gave our full support to the Strategic Transportation Research Study undertaken by the Transportation Research Board, which led to the SHRP program. AASHTO undertook an effort to refine the recommendations of the STRS study, and to produce a research plan for SHRP. Finally, we agreed to set aside an additional 1/4 of 1% of our Federal-aid highway dollars, to fund the SHRP effort at some $30 million a year over the next five years. We did all of these things for several reasons.

1. We believe there is need to gain better understanding of asphalt and portland cement, so that we can build better and more durable pavements.

2. We believe that the establishment of a long term pavement test program extending to widely dispersed and varied test sections is needed to help us better understand pavement design characteristics and learn better pavement design techniques.

3. We believe that there are better techniques for handling snow and ice
on our highways, and that we can do more to protect bridge decks against damage by salt and other chemicals.

4. We believe that with a shift in emphasis in our nation from new highway construction to the rehabilitation and restoration of our existing highways, we need to develop better understanding of the effectiveness of different maintenance techniques and practices.

While each of these topics has and could have been researched further in a series of small research efforts, in our judgment the problems are so large and the possible benefits so great that the better course is a large, well-funded, highly focused research effort. For all of these reasons, we have given our strongest possible support to the creation and implementation of the SHRP research.

I will not go into the details of the SHRP research program, since others will be doing that during this Conference. But I do want to address one aspect of SHRP which is both relevant and important to this international Conference.

In the years since its founding, AASHTO has focused almost entirely on the United States. As we undertook the research design effort for SHRP, and now its implementation, our state highway agencies and AASHTO decided it was time to look beyond our national borders and reach out to other nations. We know that many other nations are well advanced in highway technology, and that we can learn from them. We also believe that by pooling our efforts in the SHRP program all of us can benefit; therefore, from the outset AASHTO has worked to obtain the involvement of other nations in the design of the SHRP experiments and now in their implementation. The unprecedented international highway research effort that is evolving holds great promise, and it has convinced AASHTO that we need to be more involved on the international scene.

It is this new vision within AASHTO that has brought me here to Sweden and caused us to take an active part in this Conference. It is that same vision that has moved AASHTO to send its first-ever delegation to the Permanent International Association of Road Congresses (PIARC) meeting next week in Belgium and to become active in that organization.

As individual nations we have each made highway travel possible for our people and have improved its safety as the years have passed. Through Conferences such as this one we believe that all of us can benefit, and that closer international cooperation can bring even better and safer highway travel for everyone. It is in that spirit we approach this Conference, and we look forward to its deliberations and findings.

Thank you for inviting me to appear before you.
SHRP: CURRENT STATUS AND FUTURE PLANS

Damian J. Kulash
Executive Director
SHRP

ABSTRACT:

The Strategic Highway Research Program, whose origin and scope have been described by Thomas Larson, has evolved organizationally, financially, and technically during the past year.

Organizationally, SHRP is now a unit of the National Research Council, which is the operating unit of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. This is not a government organization, but an independent, nonprofit organization whose purpose is to bring scientific and technical information to bear on public decisions. State and federal governments chose this institution for SHRP because of its independence, technical quality, and ability to move quickly.

Financially, SHRP has been given program funds of approximately $150 million when the U.S. Congress passed a highway bill in April, 1987. This funding provides SHRP with the necessary research and administrative funds from now until the program concludes in 1992.

Technically, SHRP's program has evolved in several stages. First, the program's scope was set out in America's Highways: Accelerating the Search for Innovation, Transportation Research Board Special Report No.202. Second, a research approach was developed in SHRP: Research Plans, published in May, 1986. Third, the SHRP Executive Committee and their technical advisory committees have developed contract plans based on these earlier works. Summaries of these first nine SHRP research contracts will be signed in September and October, 1987. A status report on this activity is provided. Additional contracts are planned on a quarterly basis throughout SHRP's five-year life.

The creation and execution of the SHRP program reflect an exceptional determination, on the part of managers in U.S. transportation agencies, to confront some of their most difficult, pervasive, and expensive problems. Keeping this research focused and productive will be difficult, in the context of this highly decentralized industry. The keys to making it achieve its full potential are sustaining the active top-management attention that created the program, and effectively involving the industries that will ultimately produce the innovative materials and technologies growing out of SHRP research.
- maintenance cost effectiveness
- protection of concrete bridge components
- cement and concrete in highway pavements and structures
- control of snow and ice on highways

State and federal government agencies enthusiastically agreed that more work in these areas was necessary and valuable. The American Association of State Highway and Transportation Officials conducted a further study to refine the research scope, and launched a legislative drive to fund the program. Earlier this year, these steps resulted in the creation of the Strategic Highway Research Program as a fully operational program. One year ago we hired Damian Kulash to serve as Executive Director of that program, and I will ask him to summarize activities during this past year.
ORIGIN AND DEVELOPMENT OF SHRP

Thomas D. Larsson

Professor, Government & Management

Pennsylvania State University

ABSTRACT:

Five years ago, various transportation leaders in the United States were concerned about the lack of attention being given to innovation in the U.S. highway sector. Problems were widespread and were the subject of extensive media attention. Solutions were evasive, particularly as support for highway research, which had always compared poorly with that in other industries, had been falling to record-low levels. There was widespread concern about the problem, but little consensus on how to solve it.

Under support from the Federal Highway Administration, the transportation Research Board brought together a group of leaders from highway agencies, industry, and universities. They explored the unique features of the problem, and crafted the solution which forms our program here today. I served as chariman of this Strategic Transportation Research Study.

Innovation, which is critical to any healthy industry, cannot be produced by any simple formula. Each industry and each company must find its own approach, based upon its own needs, capabilities, and situation. Highways are no exception.

The highway context has some unique features that affect how innovation occurs here. First, the U.S. highway industry is a highly decentralized one, in terms of its organizational structure. It involves many hundreds of independent agencies, contractors, and suppliers. Second, most of the materials used in this industry are bulky, low-valued commodities. Many are mined and delivered with little, if any, manufacturing of the natural material. Third, it is a geographically dispersed industry. The U.S. has four million miles of paved road that span virtually every corner of the country. And finally, it is a public-sector industry. Budgets, procurement practices, and construction decisions must all clearly serve the public interest.

The Strategic Transportation Research Study examined highway research activities in this context, and found that the various federal, state, and cooperative research activities then underway were valuable and should be continued. But they missed some of the biggest opportunities for innovation, because no single institution had the money or the responsibility to address them. We identified six such areas, each of which promised large dollar payoffs and each of which was currently receiving little attention. These six are:

- asphalt
The Strategic Highway Research Program: 
Where It Came From, and Where It is Going 

by 
Damian J. Kulash 
and 
Thomas D. Larson 

The biggest problems our roads face is not corrosion by salt, not wear by heavy trucks, not cracking during sub-zero weather, nor rutting in intense heat. The biggest problem they face is indifference — indifference about roads, indifference about the people who manage them, and indifference about the new ideas going into roads. 

Indifference led the United States, just a few years back, to a road system that was deteriorating. Indifference was reflected by declining investment in roads. During the seventies, state disbursements for roads in the United States (in constant dollars) dropped from 48 billion to 29 billion, even as ever record volumes of people and goods moved on these roads. Indifference lulled us into cutting our investment in road research in half: it fell (in constant dollars) from $110 million in 1972 to $55 million a decade later. This indifference was reflected by the declining percentage of engineering students that chose civil engineering majors: 20 percent in 1976; 13 percent in 1984. In short, the late
seventies and early eighties brought an erosion in our roads, in new ideas, and in the recruitment of people that are essential to a dynamic industry.

Then we woke up. In 1982, the public, the United States Congress, and the mass media suddenly awakened to the immense importance of our highway transportation system. U.S. expenditures for highway transportation — private and public — are twice as great as U.S. expenditures for defense. One sixth of the gross national product of the United States goes into the highway transportation system. More than 90 percent of U.S. industrial output moves over the road system. Our roads are our economic backbone. We could not afford to be indifferent about them. New attention was directed to the money, the innovation, and the people involved with our highway system.

Four years ago, the U.S. Congress passed the Surface Transportation Assistance Act of 1982, which increased the motor fuel tax by five cents per gallon and pumped 5.4 billion dollars more per year into federal highway and transit programs. Since then, 35 states have also increased their highway user fees. This new infusion of resources over the last four years has started to bring new life to the industry. Materials suppliers, contractors, public officials, and engineering students have started paying more attention. We've started to turn the corner from indifference to new ideas, new talent, and better financing.
This comeback brings more than money: It also brings a new push for innovation in the highway industry. About five years ago, many of the nation's highway leaders were concerned about innovation. Top officials in state highway agencies were frustrated by costly, often unexplained failures. They were frustrated when their research staff couldn't solve them. At the same time, highway research programs and institutions were stretched dangerously thin. In 1982, the U.S. was spending about one fifth of one percent of its highway-construction resources on research. That is neglect, by any measure. High tech industries, like computers and aerospace, spend 10 to 50 times as much of their gross sales resource on research as we do. Even low-tech industries like mining, steel, and paper spend about eight times as much of their gross sales revenue on research as we do. Further, the skimpy available research dollars are spread far and wide. Many of the urgent problems they attack are specific to a particular climate, type of material, or other local feature. (This is an essential activity which we do well. But, it's not the only path to innovation.) The available resources are also scattered throughout fifty states, several federal agencies, various private companies, and elsewhere. Typically, highway research is designed in separate packages costing $100,000 to $200,000. This is generally adequate to identify what has been done on a specific problem, and to evaluate some possible new approaches. This institutional approach has served us well and must be continued. Each of the many agencies involved in highway construction confronts unique problems stemming from their designs, loadings, materials, or climates. Each needs a strong problem-solving capability to be productive and innovative.
But, what is lacking in this structure is a capability to attack fundamental problems that cut across, yet interact with, local conditions. No single agency now has the money, or the responsibility to solve some of these biggest, most costly, most widespread problems. This is where SHRP comes in. It will not replace the important problem-solving research that is now done by states, the Federal Highway Administration, universities, and others. It will fill a gap that these organizations can't address. SHRP will focus exclusively on four national problem areas. Each is an area where the nation spends billions of dollars each year, and where innovative approaches will yield big savings. These four research areas are also over where numerous site-specific factors influence performance. Only a large, systematic, and consistent approach in these areas can produce results that have national significance. The four areas are:

1. **Long Term Pavement Performance** — The U. S. spends $20 billion per year on pavements, and more and more of this is going into replacement of existing pavements. Although we typically design these pavements to last 20 years, our actual experience varies a lot. Some roads last 30 years. Some fail in two.

Much of our current pavement-design know-how came out of the AASHTO Road Test, conducted almost 30 years ago. This was a massive experiment, costing around $100 million in today's dollars. Six test loops were built, each containing sections with different designs and
Each of the six test loops was subjected to different axle loadings by running test vehicles of known weight. This experiment produced design equations that tied together the key design, materials, and traffic variables. They have been applied in hundreds of billions of dollars of pavement construction, both here and abroad. This experiment is counted among the biggest successes in the history of highway research, and justifiably so. But valuable as it is, it was inherently limited. It took place in one location — Ottawa, Illinois — and thus reflects only one set of climate and sub-grade soils. It was an accelerated test, and thus cannot reflect the effect of age, and it's interaction with climate and traffic. It was a test to failure, and may not accurately reflect the effect of normal maintenance practices. Because of these inherent limitations, many continue to question whether the results of the AASHTO Road Test apply to their specific area or materials. The only way we are going to resolve these questions is through a broader road test. Such a test must include varied climates, sub-base soils, pavement ages, and maintenance treatments. This experiment, by its nature, would have to be located in several regions, and monitored for many years. SHRP plans to do exactly this, using around 2,000 pavement sections located throughout the United States and indeed throughout the world. These sections will be carefully selected to span the full range of variables to be studied. Their traffic and condition will be carefully and consistently monitored. The resulting data will be analyzed to produce pavement design relationships that can be applied
with greater confidence in varied settings. Even if these new designs save us only a few percent, in terms of reduced construction costs, this will amount to savings of hundreds of millions of dollars a year. It is a difficult project to launch, to coordinate, and to maintain, but we can't afford not to do it.

2. **Asphalt Materials** — The United States has been building asphalt pavements for the past century, and we have developed extensive knowledge of how different asphaltic materials perform in specific mixtures and applications. Nevertheless, premature failures of asphalt pavements, even though they are not common, are costly and disruptive. Many of these failures occur because of errors in the mix design or during construction. Such errors can and should be reduced through better training and knowledge sharing, and these steps are being taken by different programs and organizations. But part of the problem is the inability of our product specifications to pin down all the key properties that affect performance. Different asphalts of the same grade behave differently. A large amount of knowledge and training is needed to work around these differences—too much, we think. We are asking more than we can reasonably expect from decentralized field staff dealing with varied materials and diverse situations.
SHRP's initial concentration is on the production of improved asphaltic materials — through more performance-oriented specifications and through development of improved asphaltic binders. This will result in greater uniformity among asphalts meeting identical specifications. It will yield a better understanding of asphalt's fundamental characteristics, and how these affect pavement performance. It will develop asphalt testing procedures that more closely predict pavement performance.

These are difficult steps to achieve, because public agencies, paving contractors, and material suppliers must all work together if they are to be successful. Thus far, we are pleased to say, the cooperation between these various industries and agencies have been excellent, and we look forward to seeing a working partnership between SHRP and industry as we push for innovation in this area.

3. **Cement and Structures** — The durability of concrete pavements and concrete bridge components could be substantially improved through research. In the case of concrete pavements, SHRP will begin this research by analyzing the microstructure of fresh cement pastes and by studying the fundamental chemical processes that occur during cement hydration. SHRP will also focus on ways to minimize deterioration of existing concrete pavements due to freezing and thawing, particularly D-cracking and alkali-silica reactivity. Another key focus is on non-destructive testing during the construction phase. Here, SHRP
will combine new and current tests to develop a quality assurance system for acceptance, form-stripping, and placing in service on concrete pavements.

Concrete bridge components are subject to repair and premature deterioration because of corrosion caused by salt applications. The salt penetrates the concrete and corrodes the embedded reinforcement. As the reinforcing steel corrodes, it expands and causes spalling in the concrete. Once it starts, this process is structurally damaging and difficult to stop. It is also expensive. We now face some $20 billion dollars of needed rehabilitation, and this figure is growing by $500 million per year. SHRP will develop and refine electrochemical and other techniques for protecting and rehabilitating existing bridge components. It will develop improved tests for assessing:
- rates of corrosion,
- the presence of deterioration,
- the integrity of membranes,
- the presence and effectiveness of sealers,
- the permeability of concrete, and
- the chloride-ion content of concrete.

These improved diagnostic processes will be coupled with further development of cathodic protection and other techniques.
4. **Highway Operations**

Maintaining our highways, and keeping them free of snow and ice, requires constant attention. These are labor-intensive tasks. They are also tasks that are performed by field workers with little supervision, working in highly decentralized organizations. Workers often get the necessary know-how through their own experience, through their supervisor's rules of thumb, or through recommendations passed along by their co-workers.

There has been surprisingly little systematic testing and evaluation of the different products used in highway maintenance, whether they be patching materials, sealants, or surface dressings. Given the large size of this market, that's surprising.

We need some form of consistent product and process evaluation to make highway maintenance more cost effective. Many of our current practices have evolved without systematic evaluation. What works for one agency may or may not work well for another because they have different amounts of staff expertise, have different product needs, use contractors for different functions, or have different procurement practices. Reliable, comparable evaluation of competing techniques or products is needed. SHRP will evaluate chip seals, slurry seals, and other surface dressings so that their cost and performance can be compared. Similarly, SHRP will evaluate materials and equipment for surface repairs.
The use of salt to de-ice highways has increased tenfold since the mid 50's. This rapid rise in salt use has been accompanied by deterioration of bridges, pavements, and vehicles, and it creates environmental problems as well. Innovative ways to apply non-chemical energy at the ice-pavement interface could keep highways free of ice and snow, using less salt. Improved physical snow-removal techniques will help also. In addition, use of modern sensor and communications technologies can make our snow-removal operations more efficient. SHRP will be doing research in all of these areas. In some cases, SHRP will explore fundamental properties of the ice-pavement bond: how it can be prevented, and how it can be destroyed. It is too early to say exactly what may grow out of this research. Perhaps pavement surface additives that retard ice bonding. Perhaps additives to salt that will make it more effective, or less damaging. Perhaps devices that use laser or microwave radiation to prevent or break ice bonding. There are many potentially promising, innovative approaches. Not all of these technologies will prove economical and effective, and SHRP is structured to identify and develop the most promising possibilities.

These four areas—asphalt, pavement performance, cement and structures, and highway operations—are where SHRP will be concentrating. This focus grew out of an overall review of highway research—the Strategic Transportation Research Study which was done by TRB starting five years ago. This study drew together a blue ribbon committee of state highway
leaders, academic leaders, and industry research executives. They pinpointed the four areas that I have just described. During the last two years detailed research plans were developed in each of these areas. In May, 1986, these Research Plans were published by the National Cooperative Highway Research Program, and distributed widely. They continue to be the technical blueprint for SHRP.

SHRP also took on a new organizational identity this past year. The states, through the American Association of State Highway and Transportation Officials, signed an agreement with the Federal Highway Administration and the National Research Council to make SHRP a unit of the National Research Council. SHRP is headed by a 15-member Executive Committee, which includes government, universities, industry, and other organizations. This committee is chaired by Dr. Thomas Larson, who recently completed an eight-year term as Secretary of Transportation in Pennsylvania.

In September, 1986 SHRP hired Damian Kulash as Executive Director, who had been serving as director of special projects at the Transportation Research Board. He replaced Gary Byrd, who had served as SHRP's interim director.

Events have accelerated rapidly since April, 1987, when the U.S. Congress approved $150 million for the 5-year SHRP program. With the program's funding secured, SHRP has been extraordinarily busy hiring the staff and arranging the initial research contracts.
In May, 1987 the SHRP Executive Committee approved SHRP's FY 1988 program. It includes 29 contracts that cover all four technical areas of SHRP. Nine of these will begin about the time of the Gothenberg meeting. Although FY 88 will be a start-up year of less-than-average spending for SHRP, it is the biggest year for contracting. Most SHRP contracts will be multi-year agreements. Many of the contractors that join the SHRP team this year will be the same ones introducing innovative materials or services three or four years from now. Widespread use of multi-year contracts gives SHRP the potential to keep development on the fast track, without interrupting progress, to pin down the details of next steps, and to put them out to competitive bid.

Meanwhile, the design of next steps can take place in parallel with ongoing research, and contractors on the team can continue uninterrupted if they are performing well and making progress. This offers substantially more continuity than does conventional, step-at-time contracting, where research plans are detailed in advance and executed through a series of intermittent design and performance phases. By bringing this additional continuity to the research process, SHRP offers a greater prospect of security. We believe that this will stimulate contractors to make the investment in facilities, technical expertise, and management that are necessary for success. It will help to build lasting professional and institutional capability in various areas of highway technology that will live beyond SHRP's brief life.

At the same time, the availability of contract funds in future years is not automatic or guaranteed. Instead, out-year funding depends upon a contractor's performance and progress. To the maximum extent possible,
SHRP Program Announcements (Requests for Proposals) set out performance and progress criteria that establish the basis upon which funding decisions for future years will be made. Performance criteria may include the ability to stick to the proposed work plan, schedule, and budget, or to a mutually agreed-upon improvement to the proposed plan. They may include the contractor's responsiveness and flexibility in modifying plans to incorporate improvements requested by SHRP, reflecting insights gleaned through SHRP's Executive Committee or Advisory Committees. A contractor's progress toward the development of usable innovation also depends on good fortune. Some of SHRP's technical areas will prove to be ones of rapid advancement. Other areas will prove to be stubbornly resistant to new insights.

SHRP's Executive Committee, which has the responsibility to keep the research program on the productive track, must periodically evaluate the activities and accomplishments of the research team. It must decide which activities to continue, which to modify, and which to curtail. Careful use of these controls is essential to keep SHRP targeted on areas with the greatest practical payoffs. This will take hard-nosed management by the SHRP Executive Committee, by the SHRP staff, and by the research contractors themselves. It involves balancing the bottom-up view of where technological change is feasible with the top-down view of where this change is worthwhile. New technologies may require new specifications or standards, new designs, new training, new contracting approaches, new
procurement processes, or new staff capabilities. The exceptional potential of some new technologies will warrant these difficult changes. Other technologies will need to be refined until their demands upon users become more manageable. These will be tough decisions. To make them wisely, SHRP will continue to rely on active participation of management leaders and technical experts throughout the world's highway community.

Indeed, opportunities like this meeting offer us an opportunity not only to describe SHRP in greater detail to you, but to learn more about the research that has been done in your countries so that we can build upon it. We look forward to a valuable, two-way exchange of information during the next three days.

SHRP's Executive Committee has also established a policy to encourage international cooperation through the appointment of national SHRP coordinators, the creation of special assistant positions so that professionals in other countries can gain direct staff involvement in SHRP, encouragement of joint venture between United States and foreign researchers, encourage long-term pavement performance studies that are complementary to SHRP, and begin SHRP contract activities with an appropriate recognition of work done throughout the world.

I believe that we have much to learn from each other, and I believe that this meeting will give us a valuable opportunity to do this.
EUROPEAN TRENDS IN ROAD SAFETY AND ROAD SAFETY RESEARCH
Niels O. Jørgensen
Technical University of Denmark

ABSTRACT

Recent trends in the road safety situation in Europe is outlined. Through many years fatality rates have been declining, approaching an asymptotic level. This implies that in the coming years we are not likely to experience the same reduction in accidents as we did in the 1970's. The overall trend may change if motor traffic is still increasing.

Safety research has so far mostly been accident research. The concept of accidents as realizations of stochastic processes has dominated statistical analysis. In recent years however, it has become clear that because of "bias-by-selection" traditional statistical methods are too optimistic when results of practical accident countermeasures are evaluated. Also, under some circumstances "accident migration" or geographical displacement of risk may lead to overestimation of countermeasure benefits. The methodology of accident analysis is in a critical phase.

On top of this come the ideas of risk compensation: road users tend to offset the effects of safety measures through behaviour which tends to maintain the overall risk at a constant level. There is some evidence to support these ideas.

One answer to the analytical difficulties has been "surrogate measures" - first of all the traffic conflict technique. Although heavily criticised there is still progress in this field.

A recent development in research into road user accident factors is a change from emphasis on perception and skill to emphasis on cognition. The distinction between skill-based, rule-based and knowledge-based functions of driving offers interesting possibilities for improved insight into errors leading to accidents. Fairly elaborate decision models of the driving task are being tested.

More traditional lines of research are still under development: Full scale testing of vehicle collisions, paralleled by elaborate computer programmes for collision simulation; studies of speeds and speed limits; roadside surveys of alcohol consumption by road users; reconstruction of highways through villages; the impact of heavy vehicles on road safety; 2-wheeler accidents etc. etc.
1. INTRODUCTION

The title of this paper is wider than the actual content. Three items have been chosen for discussion: Accident trends, Accident study problems and Road User studies.

2. TRAFFIC SAFETY TRENDS

2.1 Smeed's Approach

There is so far no well developed theory which allows broad estimates of future accidents as a function of motorization, population, economic market conditions etc. On the other hand, these factors undoubtedly influence road accidents.

A well known suggestion by Smeed (ref. 1) connects traffic fatalities, motorization and population in the formula

\[ \frac{F}{V} = 3 \cdot 10^{-4} \left( \frac{V}{P} \right)^{-2/3} \]

where F is the number of fatalities per year, V is number of motor vehicles and P is population.

This formula has been remarkably successful in describing accident statistics under certain circumstances. It was developed to describe the variation in accident rates between European countries in 1938. 40 years later it was still a reasonable description of statistics when nations were compared at a point in time.

However, if we look at the nations separately they do not follow the Smeed formula (fig. 1).

The changes in fatality rates as a function of changes in motorization are much larger than Smeed's formula suggests. At least at higher degrees of motorization (>200 cars per 1000 inhabitants) the connection seems to be much steeper than Smeed's formula indicates. In fact, quite recently Sweden has experienced a continuous reduction in fatality rate at unchanged motorization.
2.2 An Alternative Approach

An alternative approach to the question of interpreting trends and estimating future accidents is suggested here. Consider simply for a number of industrialized countries the development of fatality rates over time. Fig. 2 shows curves for some countries in Western Europe together with USA. This graph suggests an almost exponential reduction in fatality rates over time, but apparently levelling off near values of 2-4 fatalities per year per 10000 cars. (Rates per car instead of per carkm are used only because they are more easily available).

The curves might be interpreted in this way: Over a long span of time motor traffic has become an integral part of life in Western countries. During this process society has adjusted itself to the risks through the application of safety programs. These programs are in fact fairly similar in different countries which suggests similar developments. This could be thought of as a maturing process which is more directly dependant
on time than on the degree of motorization. This process may have started at different points in time in different countries.

A numerical illustration corresponding to fig. 2 is given in table 1. In this table the fatality rates have been computed for 12 countries in Western Europe and in USA. These individual rates are averaged for 3 points in time to illustrate that fatality rates have become much smaller and more uniform during a 20 year period.

Table 1

<table>
<thead>
<tr>
<th>12 European Countries + USA</th>
<th>1965</th>
<th>1975</th>
<th>1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>15.7</td>
<td>7.5</td>
<td>3.9</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>8.1</td>
<td>2.7</td>
<td>1.2</td>
</tr>
<tr>
<td>S.D./Average</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Source: ECE and IRF statistics.

Fig. 2. Source: ECE and IRF statistics.
Suppose that it is true, that fatality rates are stabilizing during the next decade - not necessarily on the same numerical level for all countries. An important consequence would then be that the absolute number of fatalities would be roughly proportional to the number of cars in a country. To illustrate: the four Nordic countries have from 1980 to 1985 experienced almost stability in fatality rates. A small reduction in fatality rates which did occur, was not sufficient to counterbalance the increase in motor vehicles. Therefore, they have together had a slight increase in the absolute number of fatalities as opposed to other regions in Europe, which have had reductions. The Nordic trend may well be the trend also in other countries in the years to come.

Therefore, the interpretation of the trends given here suggests, that the large reductions in the absolute number of fatalities which many countries experienced from 1975 to 1985 are not likely to be repeated from 1985 to 1995. The number of fatalities may be almost directly proportional to the number of cars.

This conclusion is only likely to be true as long as the traffic system is not changed profoundly but is still dominated by road users who are allowed to go almost everywhere and to act - and fail - independently. A major technological breakthrough in traffic control might change this and reduce the fatality rates significantly. However no such thing is anticipated in the near future. Also, major policy changes which seriously limit the freedom to use private cars e.g. in urban areas might influence the overall level of safety importantly.

3. ACCIDENT STUDIES

3.1 The Safety Paradox of Road Traffic

Traffic accidents are an important plague to modern society - the main cause of death in certain age groups and ranging high for all age groups. However, at the same time and from an individual point of view traffic death is a very rare event! In the industrialized countries the amount of driving performed for each accidental death corresponds to some 3000 years of driving by the average car driver. Even for the injury accidents, a driving activity of some 25 years per accident is typical.

The paradox then is, that although from a social point of view the total accident deaths and injuries are completely unacceptable, the system appears very safe on the individual level. So why should the individual change behaviour to improve safety?
3.2 Accident Analysis Methods

The law of the rare events - Poisson's law - has been underlying most accident analysis methods for decades. Accident analysis is often of a comparative nature like "Before-and-After" studies, studies using control groups to balance out external effects etc. Ideally this would open up for the use of a large group of standard statistical methods.

However, the phenomena under study such as accidents at a special group of road intersections are quite naturally selected due to high numbers of accidents. But because of the stochastic variation in accidents they may have been selected because of randomly high accident values rather than underlying high risk factors. The intersections under study is thus subject to a bias-by-selection. Theoretically this means that standard statistical methods are not valid because they usually require random sampling, but the selection is biased. Practically, the implication of this is a tendency to overestimate the effects of accident countermeasures when standard methods are used. This bias-by-selection (also named "Regression-to-the-Mean") causes difficulties because it is rarely possible to establish precisely the extent of the bias. Research results in this field come mainly from Canada, UK and Sweden (Ref. 2, 3, 4).

Another difficulty in accident analysis is the so-called "Accident Migration". The question is: Is it conceivable that when accident countermeasures have been used successfully at one location this somehow generates accidents nearby?? Some empirical studies from the UK pointed in that direction (Ref. 5). Possible mechanisms underlying such a phenomenon have mostly been of a speculative nature. A recent study from Canada (Ref. 6) worked on data from a number of intersections in an urban area of which some had been treated with yield lines and others left unchanged and seen as a control group. The indication was an improvement in the experimental group but a real increase in the control group i.e. an accident migration. Here, a possible mechanism was that some drivers having got used to the new type of regulation in the experimental group were surprised at the "old" regulations and thus generated "new" accidents in the control group. Detailed analysis of the types of accidents supported this conjecture.

So far, no predictive theory of accident migration is known. This complicates the use of methods based on control groups.
3.3 Accident Compensation Behaviour

It is usually accepted among accident researchers that actions taken to improve safety occasionally is offset by road user behaviour. An example is that a standard improvement on a rural highway could mean a risk reduction given unchanged behaviour. But the improvements lead to higher speeds thus reducing the potential accident gain. After all, the purpose of roads is mobility with safety requirements as a restriction on mobility.

Following this line of thought researchers mainly from Canada and Britain (Ref. 7, 8) have postulated that there exists an attempted level of risk for the individual so that whenever the actual risk level is changed the individual will compensate one way or another to bring the actual risk level back to the attempted level. This theory - named Risk Homeostasis Theory - is intriguing and would - if proven - profoundly change road safety work. The implication would be that the only possible line of work would be to influence the individual attempted level or risk.

It is very complicated to verify or falsify this theory which is not predictive in a narrow sense. It might be thought of more like a general principle - such as "le Chatelier's Principle" in Chemistry or Darwin's "Survival of the Fittest". Considering the fact, that during recent periods the total overall risk level was reduced in many European countries it is hard to see the theory working strictly.

3.4 Accident Surrogate Measures

The fact that accidents are rare events also means that detailed studies - on top of all analytical difficulties - suffer from too few data. Much work has been done in order to develop measures of risk which do not require actual accidents.

The most successful so far is "The Traffic Conflict Technique". The basic idea is that there is - broadly speaking - a continuous transition from the trivial give way-manoeuvre through more and more critical conflict and "near-miss" events to the actual collision, see fig. 3. So the study of traffic conflicts might reveal the real risks! The idea - originally outlined in USA - was further developed in different European countries. A recent Swedish dissertation (Ref. 9) has shown that it is possible to define a severity index on serious conflicts which bridges the gap between critical events and accidents of different severity. It still remains to be seen to what extent the improved concept will overcome earlier problems in practical applications.
Another aspect of this idea is that in countries where accident statistics are not available, traffic conflict studies would provide a good first basis for pointing out problems. Also, carrying out conflict studies could be an important education for technici-ans with little insight in the field (Ref. 10).

4. ROAD USER STUDIES

The classical approach has been to disclose accident agglomerations in which erroneous road user behaviour is an important factor. Well known results are high accident numbers related to alcohol, to young male car drivers, to motorcyclists and to elderly pedestrians.

One type of intervention has been to analyze the driving task, define required skills and develop training programmes. However, drunken driving is not solved this way and young drivers are often very skilled drivers. Furthermore Swedish results have suggested (Ref. 11) that inexperienced and experienced drivers are equally good in estimating how risky a given traffic environment is. So skills, however useful, are not the sole answer.

Man-machine interface studies from other fields - notably largescale process plants - have led a Danish researcher (Ref. 12) to classify behaviour at three levels: skill-based, rule-based and knowledge-based.
These concepts seem to offer new possibilities for explaining different aspects of road user behaviour and risk. These levels might be interpreted in this way: Skill-based behaviour is e.g. practicing elementary steering or braking functions, rule-based behaviour could be the choice to give way or to accept right-of-way considering the prevailing conditions and rules, while knowledge-based behaviour could be picking the route to a destination, to refrain from a drink before driving when considering the possible consequences etc.

Rather complicated and detailed models of the driver's decision making are developed in these years (Ref. 13), see fig. 4.

Fig. 4. A hierarchical risk model for traffic participants. Source: Ref. 13.
The important trend is the researchers' interest in higher level mental functions, where attitudes and values may determine the strategic choices for travel: means of transport, route selection, time budget (speed choice), going only when sober etc. One perspective of research in this field might be the development of a Defensive Travelling Strategy at the cognitive level as distinguished from the earlier Defensive Driving Courses which operated more at the skill-based and/or rule-based level. Stated simplified: Why teach drivers evasive manoeuvres and defensive tactics when the issue is a strategy to avoid the difficult situations? Or: The issue is to influence risk attitudes in order to lower the tolerated level of risk. This would influence the strategic choices in travelling.

Another important perspective is that developments in the field of Road User Information Systems should be governed not only by technological possibilities and what could conceivably appear useful to a driver. It is important that information systems are designed from a basic knowledge of what information is actually used by drivers. Only in this case should we expect information systems to improve safety and mobility.

Therefore it appears important that results in particular from cognitive research should influence the choice of information to be presented to a road user. A Danish study showed a marked reduction in spare cognitive capacity for car drivers entering a complicated road environment (Ref. 14). Such results should influence the design of information systems.

5. CONCLUDING REMARKS

It seems important to note, that trends in accident rates have appeared to be positive so far but that an asymptotic low level is approached. This implies that if no major breakthrough in the safety work is achieved, we shall see accident figures increase in proportion to road travel. The situation presents us with a real challenge.

The theoretical problems in accident studies appear more complicated than was foreseen a decade ago. Not only must the "Bias-by-Selection" problem find theoretical analytical solutions but empirical work must clarify to what extent "Accident Migration" and "Risk Homeostasis" must be considered seriously in accident preventive work. Since so many decisions in the safety field depend on accident analysis the questions must be answered.
The trends in road user studies indicate an increasing interest in the cognitive field rather than in perception or skill aspects of road user behaviour. The perspectives are that programs directed to influence attitudes and values will have higher priority. Also, the technologically advanced systems of road user information should be profoundly influenced by these research results.

6. REFERENCES


ABSTRACT:

Highway research in the United States is carried out under the Nationally Coordinated Program of Research, Development, and Technology, (NCP). This program includes research conducted by the Federal Government, State and local governments, and the private sector. The NCP addresses: highway safety, traffic operations, pavements, structures, materials, highway operations, motor carrier transport and planning. In each of these categories, specific areas are designated as emphasis areas for Federal funding. This presentation will concentrate on two topics of major interest in the United States: The Strategic Highway Research Program (SHRP) and Highway Safety. The discussion will center on the Federal Highway Administration's role in SHRP and recent developments in the United States, highway transport that affects safety including the 55 MPH speed limit, development in pedestrian safety, the safety of motor carriers, and improved roadside safety hardware.
HIGHWAY SAFETY RESEARCH IN THE FHWA AND THE UNITED STATES

by

David K. Phillips
Associate Administrator for Research, Development and Technology
Federal Highway Administration
USA

BACKGROUND

The U.S. Highway System

In their breadth and complexity, the physical makeup and administrative structure of the U.S. highway system are perhaps unique in the world. The United States has 3.9 million miles of roads and streets—more than half of them paved—and 576,000 bridges. Almost 159 million licensed drivers (86 percent of the driving population) amassed 1.8 trillion vehicle-miles of travel last year in 177 million motor vehicles, of which 136 million were automobiles and 41 million were buses and trucks.

Except for the six percent of roads on public lands (such as national forests and military reservations) which fall under the jurisdiction of the Federal Government, highways in the U.S. are owned and operated by State or local governments (e.g., cities, counties). The Federal role in highways is therefore largely one of coordination among the States. This coordination is effected through the Federal-aid funding system whereby segments of State and local highways which constitute major through and feeder routes are constructed or rehabilitated using a combination of Federal and State funds. (Funding of maintenance is solely the responsibility of the State or local governments.) The Federal-aid system of highways consists of 22 percent of total road mileage but carries 79 percent of total travel. The 44,000-mile Interstate System alone constitutes only one percent of the mileage but carries 21 percent of the travel.

Of the estimated $64 billion in annual revenues for highways, over half is derived from highway-user taxes on fuel and large vehicles. The $40 billion in State and local revenues come from a variety of sources: highway-user taxes, property taxes, bonds and general fund appropriations (i.e., general tax revenues). The $15 billion in Federal revenues for highways are derived almost exclusively from highway-user taxes and are lodged in the Federal Highway Trust Fund, a fund dedicated to highway-related expenditures. Almost 2/3 of this is derived from the $.09/gal Federal gasoline tax, of which $.08 goes to highways and $.01 to mass transit.

The total annual expenditures for highways in the U.S. by all units of government amount to over $63 billion, of which $30

1 All figures are for 1986 unless otherwise noted.
2 In U.S. usage a billion = 1,000,000,000.
billion is for capital outlay (construction, engineering, and property acquisition), $17 billion is for maintenance and $16 billion is for debt retirement, administration, and enforcement. An additional $1 billion from the Trust Fund is for mass transit.

Federal coordination of highways and administration of Federal-aid funding from the Trust Fund is entrusted to the Federal Highway Administration (FHWA), an agency of the U.S. Department of Transportation (USDOT). However, FHWA does not have sole responsibility for highway traffic matters in the U.S. FHWA is responsible for highway and truck matters but a parallel agency within USDOT, the National Highway Traffic Safety Administration (NHTSA), has responsibility for driver and vehicle safety.

FHWA Role in Highway Research

Because part of the Federal coordination role involves setting engineering standards, FHWA has always held a central role in highway research—in fact, the agency which evolved into FHWA began as the Office of Road Inquiry in 1893. FHWA has a major role in solving U.S. highway problems, coordinating current research efforts with other agencies and transferring technology to practitioners. This role is carried out within FHWA by the Offices of Research, Development, and Technology (RD&T), a part of FHWA headquarters in Washington, D.C.

Most of the highway research performed in the U.S. uses Federal-aid funds. Because of its responsibility for administering these funds, FHWA finds itself involved in some capacity in almost 80 percent of the $140 million in highway research performed annually in the U.S. Consequently, the need arose for a mechanism to better carry out this coordination function.

Nationally Coordinated Program

In 1987, FHWA established the Nationally Coordinated Program (NCP) of Highway Research, Development, and Technology (RD&T) as the framework for cataloging, monitoring, coordinating, and reviewing progress in the entire field of federally-assisted highway RD&T. The major categories of the NCP are shown in Table 1. (Each of these categories is further broken down into specific program areas but these are too numerous to list here.)

Table 1 — Nationally Coordinated Program Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Highway Safety</td>
</tr>
<tr>
<td>B.</td>
<td>Traffic Operations</td>
</tr>
<tr>
<td>C.</td>
<td>Pavements</td>
</tr>
<tr>
<td>D.</td>
<td>Structures</td>
</tr>
<tr>
<td>E.</td>
<td>Materials and Highway Operations</td>
</tr>
<tr>
<td>F.</td>
<td>Policy and Planning</td>
</tr>
<tr>
<td>G.</td>
<td>Motor Carrier Transportation</td>
</tr>
<tr>
<td>H.</td>
<td>R&amp;D Management and Coordination</td>
</tr>
<tr>
<td>I.</td>
<td>Other (training and local assistance)</td>
</tr>
</tbody>
</table>
U.S. Highway Research Programs

Highway research in the U.S. is performed under a number of different programs, of which the major ones are:

- Highway Planning and Research (HPR) program;
- National Cooperative Highway Research Program (NCHRP);
- Strategic Highway Research Program (SHRP);
- FHWA programs;
- Other Highway Research.

All but the last one utilize Highway Trust Fund monies and are therefore included in the NCP. Figure 1 shows the complex relationships among the programs and the agencies (bold outlines) which direct or monitor them. Those in the NCP are enclosed in the dashed line.

Highway Planning and Research (HP&R) Program

A large portion of U.S. highway research is supported cooperatively by the individual States and the Federal Government through the HP&R program. Each State may use up to two percent of its Federal-aid highway apportionment for conducting highway planning or research activities. An average of about 30 percent is currently used for research with the greater amount going to planning. Although FHWA provides technical review and coordination, the individual States initiate and carry out the research either with their own staff or by contracting with private or public research organizations. The HP&R program is funded with approximately $46 million annually.

National Cooperative Highway Research Program (NCHRP)

NCHRP is a cooperative program sponsored jointly by the American Association of State Highway and Transportation Officials (AASHTO), FHWA and the Transportation Research Board (TRB), a division of the National Research Council (NRC). Research activities are selected by a special committee of AASHTO, approved by the member State highway officials, and administered by TRB. Under this program, States voluntarily pool 4.5 percent of their Federal-aid HP&R funds to finance RD&T activities of national significance. The FHWA RD&T staff provide technical overview and coordination. However, program selection and composition remain the prerogative of AASHTO and the participating State highway agencies. NCHRP funding has averaged $7 million annually.

Strategic Highway Research Program (SHRP)

SHRP is a $150 million, 5-year program, structured to address six critical national research needs: Pavement Performance, Asphalt, Maintenance Cost-Effectiveness, Control of Snow and Ice, Cement and Concrete, and Concrete Bridge Protection. This program is funded out of the Highway Trust Fund as a result of legislation enacted in 1987. SHRP is an independent unit of NRC and is administered through a cooperative agreement among FHWA, AASHTO, and NRC.
Although SHRP is to be funded at an average rate of $30 million/year, it is expected that all of the approximately 50 in-depth investigations will be initiated within the first 2 years.

FHWA Programs

FHWA's own research programs are of two types: research carried out under contract by others and research conducted by the RD&T staff.

A significant portion of FHWA RD&T activities are carried out by contracts with private or public entities but conceived and monitored by FHWA's staff. The contract program primarily serves to address long-term national emphasis areas not covered by the other programs such as SHRP. The provision of training and technical assistance to State and local agencies is also related to the contract program. A part of the cost of providing training is recovered through course charges.

The FHWA staff RD&T program, too, provides a quick response capability for addressing immediate problems as well as conducting feasibility studies for new major concepts, and some long-term studies. This capability is aided by the various laboratories located at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, Virginia, near Washington, D.C.

The annual funding for FHWA's RD&T contract program averages somewhat over $20 million; training and local assistance is another $6 million and the staff research program (including salaries) is $2 million.

Other Highway Research

In addition to research funded under the HP&R program, some research activities are funded wholly by the individual States and do not utilize any Federal funds. Most of these activities deal with local or unique problems. The funds involved are estimated to average about $15 million annually.

There are many other highway-related research efforts which are diffused among numerous agencies and organizations, each of whose individual contributions is relatively small but the sum of which is significant. They include Federal, non-Federal and private activities. NHTSA performs research on accident reporting systems and identification of high-accident locations using Trust Fund monies. Other USDOT agencies also fund some highway-related research, such as the Federal Aviation Administration's work on airfield pavements, some of which is applicable to highways. Similarly, other Federal agencies, such as the National Bureau of Standards, the Army Corps of Engineers, the Air Force, and the National Forest Service perform research on materials, airfields, and highways. Cities and counties contribute resources to research, often in the form of data or test beds. Quasi-public organizations, such as the National Science Foundation, support research applicable to highways.
Private sector and industry associations, particularly materials manufacturers, perform research on products and processes. Because these efforts are so spread out and much of the work is applicable to other forms of transportation as well as highways it is difficult to quantify. However, it has been estimated that in 1982 these sources accounted for approximately $13 million in highway research. Whether this has grown or diminished since then is impossible to say.

With the preceding as background, attention can now be focused on portions of the U.S. research program more specifically related to the subjects of this conference: SHRP and safety research.

FHWA ROLE IN SHRP

This discussion will not attempt to describe SHRP in detail as that is being covered quite adequately by others at this conference. It will, rather, be limited specifically to the role played by FHWA.

Because SHRP is funded with Federal funds, FHWA has a responsibility to ensure cooperation and prevent duplication of effort. FHWA staff has been closely involved in the development of SHRP, working closely with TRB and NCHRP. FHWA provided funding and technical support in the form of loaned staff and liaison representatives to each of the technical advisory committees. FHWA staff will serve on each of the expert task groups which will review proposals and make recommendations for contractor selection. Through an FHWA contract, support was provided for the experimental design of the Long-Term Pavement Performance (LTPP) program.

Another role for FHWA is to provide for effective coordination and liaison of SHRP with the NCP. In this regard, the existence of SHRP has relieved FHWA of the need to conduct certain studies. Through FHWA coordination with SHRP, some FHWA resources are being diverted to support other aspects of pavements, materials and structures research (which are not covered by the SHRP), as well as additional studies in traffic operations. Among these is a project on truck-pavement interaction including tire and axle considerations.

On the other hand, because SHRP has neither the function nor the funds for technology transfer, FHWA will undertake the responsibility for translating the results of the SHRP research into practice.

Finally, FHWA is responsible for the accelerated testing portion of the LTPP. FHWA's new accelerated loading facility (ALF) at TFHRC will play a major role in this effort. In addition, FHWA participates in the full-scale testing activities taking place under the auspices of the Road Transport Research Program of the Organisation for Economic Co-operation and Development (OECD) and is pursuing cooperative testing activities with many others in the international highway community.
U.S. HIGHWAY SAFETY RESEARCH

As mentioned previously, responsibility for highway and traffic matters is divided between the Federal Highway Administration and the National Highway Traffic Safety Administration (NHTSA) within USDOT, as is the safety research associated with them. Of the three major elements of highway transportation—the vehicle, the driver, and the highway—FHWA is responsible for research on all highway-related elements, both on-road and off-road, as well as motor carrier issues; NHTSA is responsible for research on all other driver and vehicle matters. Because such elements as traffic control devices and visibility elements are highway-based, research on their design and driver reaction is part of FHWA's responsibility.

Managing the system of roads and streets in the United States presents many new challenges. Much of the 3.9 million mile system has reached the limits of its life span and is in need of replacement. At the same time, the demands on the system are increasing; in 1986, 177 million vehicles travelled a record 1.8 trillion vehicle-miles. By the turn of the century, this figure is projected to reach 3 trillion vehicle miles. In 1985, the United States experienced an historically low fatality rate of 2.5 deaths per 100 million miles driven. This rate was truly hard earned, the result of more than 20 years of conscientious work by industry, government agencies at all levels, and public spirited organizations. Yet even at such a relatively low death rate, 75,000 Americans will die on the highway each year if travel reaches its projected level by the end of the century.

In addition, available funds to correct those locations needing improvement are diminishing. This is where research plays a major role and, whether the highway program emphasizes new construction or re-construction, safety is a critical factor.

The remainder of this paper will concentrate on the highway aspects of U.S. safety research. The NCP covers a broad spectrum of highway safety issues including design, traffic control, improved driver visibility, special highway users and accident analysis. This discussion will identify past achievements in these areas, current activities and future plans.

Design

Research in design includes both geometric design and roadside safety. The aim of research in geometric design is to prevent accidents. While significant accomplishments have been made in this direction, in some instances this goal is impossible to achieve. This is particularly true when vehicles leave the roadway. Under these circumstances the objective is to reduce the consequences of such accidents.

Over the years research has developed major improvements in the design of roadside safety hardware. Crash cushions, breakaway sign and luminaire supports, improved guardrails, bridge rails and median barriers have all been developed and implemented.
Unfortunately, most designs evolved from consideration of the then standard size American passenger car (4,500-lb) which no longer exists. During the past 10 years, the vehicle population in the United States has changed drastically. Light-duty (pick-up) trucks and vans are increasing in number, and the size, weight, and presence of large trucks has increased, whereas half of the passenger cars weigh less than 2,000 lbs. As a result, a significant amount of roadside hardware needs to be upgraded.

To address this problem, the Federal and State Governments are cooperatively identifying new test criteria to accommodate both the small vehicle and the large truck in developing and testing new hardware. In addition to improvements in standard designs, several new designs have been developed and are in service.

Geometric Design

Some of the most effective programs for accident reduction relate to improved geometric design. Past research has demonstrated the significant safety benefits of access control. The controlled-access Interstate System has half the fatality rate of non-controlled access facilities. However, it is not cost-effective to provide access control on all facilities. As a result, other improvements (such as adequate lane width, provision of shoulders and improved roadway alignment) have been identified and implemented as safety improvements.

A good deal of work had been done in the past on design aspects (as well as traffic control devices) of railroad-highway grade crossings resulting in the development of a handbook and a resource allocation/users guide as well as demonstrations of rail-highway corridor and low-cost improvements.

Guardrails and Median Barriers

New developments in barriers include the modified thrie beam, the self restoring barrier (SERB) guardrail, the New Jersey heavy vehicle median barrier, and the Texas "tall wall."

The modified thrie beam incorporated a 14-inch blockout with a triangular piece cut from the web of the blockout. (See figure 2.) The SERB guardrail is another new barrier developed in the United States having the feature of being self-restoring or self-maintaining after impact. When struck the tubular thrie beam rail deflects backward and upward. After the vehicle has been redirected, the rail drops in place by gravity, automatically prepared for the next collision. (See Figure 3.) This barrier has been installed at high volume locations where the accident experience has been high and where maintenance is difficult, costly, and risky. Both the modified thrie beam and the SERB are capable of safely redirecting vehicles from an 1,800-lb minicompact to a 40,000-lb bus.

The New Jersey barrier is a 42-inch concrete safety shape which safely redirects both large and small vehicles travelling at high speed. The Texas tall wall is a 90-inch concrete wall which, in
tests, redirected an 80,000-lb gasoline tank truck travelling at 53 mph without spillage. The International Barrier Corporation (IBC) barrier, consisting of two 42-inch corrugated side panels (with a thrie beam shape) and a 44-inch top lid enclosing a volume of sand or gravel, is currently being evaluated and shows promise for reducing large vehicle rollover.

Bridge Rails

Currently the focus of roadside safety research is on bridge rails and luminaire supports. Until recently, bridge rails were the only roadside barrier that was not crash tested. The specifications for bridge rails in the United States were based solely on geometric and strength requirements. Recent research demonstrated that some commonly used bridge rails presented serious problems such as wheel, bumper, and hood snagging and rail penetration.

As a result, efforts are now underway to develop a new bridge rail specification which includes a crash testing requirement. The specification will be based on the concept of multiple performance levels, i.e., various levels of performance that consider facility type, average daily traffic, and percent of trucks. In the future, the concept of multiple performance levels will be extended to guardrails and median barriers. Research will be directed at the design and testing of rails that meet these performance levels. In the meantime video tapes are being prepared on correct installation and maintenance procedures for bridge rail transitions and terminals.

Breakaway Structures

Breakaway structures include sign and luminaire supports and crash cushions. Luminaire supports in the United States are designed to break away when struck by a vehicle. Recently the crash test specification for luminaire supports was changed to account for the downsizing of the automobile fleet, and a tougher acceptance criterion was proposed.

In the design of roadside hardware, U.S. industry is also extensively involved. Crash cushions are now almost exclusively designed, tested, and installed by the private sector. The same situation exists with luminaire supports and to a lesser extent with sign supports. In all of these cases industry tests its designs to specifications developed by AASHTO and submits the test results for approval to the agency with jurisdiction over its use. Once approved, the company is free to market its product to State and local agencies.

Skidding

Accident rates increase fourfold on wet pavements, primarily involving skidding either as the primary cause or as a result of emergency maneuvers. Although skidding is an interaction between vehicle and pavement, FHWA research concentrates on improving the pavement surface.
Past research has shown how to build and maintain skid-resistant pavements and has developed special surface treatments for both new and existing pavements. Approaches differ according to climate and the availability of aggregates resistant to polishing. Current research is concerned with effects of very thin waterfilms, short-term weather changes, seasonal changes in skid resistance, and provision of adequate skid resistance on critical sections such as curves, ramps, etc.

States are required to monitor the skid resistance of their road networks. Skid resistance is also among the data to be collected under SHRP.

Traffic Control

Traffic Control Devices

Design and maintenance of traffic control devices (signs, signals, and markings) must be responsive to the characteristics of the motoring public. In the U.S. the driving population as a whole is aging and its response to various traffic control devices is critical to effective design and implementation of new devices. Evaluating drivers' responses to traffic control devices is a major research activity.

Speed Control

Another concept with tremendous safety potential is speed control. Research done in the 1960s demonstrated that motorists were safest when travelling at about the average speed of traffic. This finding was consistent for both freeway and non-freeway facilities. While instituted primarily as an energy saver, the national 55 mph speed limit appeared to result in a saving of lives—up to 5,000 per year by some estimates. One of the major contributions to the apparent safety benefit was the significant reduction in speed variance on high speed facilities.
Due to a change in the law in 1987, States are now permitted to raise the speed limit to 65 mph on rural Interstate highways and some 35 States have done so on some of their roads. Experience with this change is insufficient to report any safety statistics.

Research is now underway to extend the concept of safety at average operating speed by providing real-time speed control. This project, which is similar to the speed control portion of the Dutch "Motorway Control and Signalling System" and the West German "Self-Sufficient Speed Control System," is designed to collect appropriate data on traffic flow and weather conditions, analyze it, and provide the driver with information on the appropriate travel speeds. If successful, the results of this system will provide substantial benefits in terms of traffic flow (particularly in urban areas) and innumerable safety benefits. In fact, it is anticipated that a successful speed control system will provide safety benefits comparable to that of access control.

Driver Visibility

Another important item in traffic control is nighttime visibility of traffic devices. Current standards require the use of retroreflective materials for signs and pavement markings but do not specify the required minimum maintained level of retroreflectivity. Because of the disproportionate number of nighttime fatalities (60 percent of fatalities with only 25 percent of travel) there is a need to investigate the effect of improved retroreflectivity on nighttime safety.

The basic requirement for visibility of traffic control devices is that they be understood in time to permit the proper response. Driver characteristics (visual acuity, contrast sensitivity, glare response, etc.) will be examined to determine the minimum distances at which traffic control devices should be conspicuous, visible, and comprehended. A range of drivers (varying in age, visual ability, and reaction capability) will be tested.

Efforts are currently underway to provide a prediction model of sign maintenance needs. This sign maintenance management system used in concert with the information on retroreflectivity will allow sign visibility standards to be implemented in a practical and cost-effective manner. A rapid field measurement technique is being developed to assess compliance with minimum retroreflectivity standards.

Special Highway Users

Pedestrians and Bicyclists

Pedestrian and bicycle safety is a major concern as 20 percent of all fatalities are pedestrians and bicyclists. Using criteria developed by local agencies, a handbook was developed which offers guidance on criteria to be used to designate bicycle routes on highways including planning procedures, desirable route characteristics, and recommended maintenance practices. The handbook also includes use of freeway shoulders, liability concerns, and bicycle route mapping techniques.
Currently two major national programs on pedestrian safety have been initiated. "Operation Pedsaver" is being done by the National Safety Council (a privately funded organization) under contract to FHWA and NHTSA. This program will combine pedestrian safety improvement in the fields of engineering (e.g., symbolic signals), education, and enforcement and will emphasize the coordination and involvement of local authorities.

Associated with this effort is an activity sponsored jointly by the American Association of Retired Persons (AARP) and FHWA which developed a slide tape presentation entitled "Safety Steps for Pedestrians." Directed at the older American, this presentation provides useful information on organizing local pedestrian safety efforts and on techniques older pedestrians can use to increase their safety in traffic. Through AARP, at least 50,000 Americans over the age of 50 will be exposed to this program.

Motor Carriers

Truck size and weight limits imposed by the States have varied to meet local needs and conditions to the point where the lack of uniformity became a severe hindrance to interstate commerce. Over the years, Congress attempted to bring some uniformity to these limits on the Interstate Highway System and other designated Federal-aid highways. Proposals are seriously being considered at the State and Federal levels to make further changes to these limits. At the same time, the overall truck population is growing. Trucks comprise over 30 percent of the vehicle population on many major arterials. As a result, the safe accommodation of these trucks has become a major safety issue in the U.S.

In recent years, safety research in the area of truck size and weight has concentrated on the possible safety impacts of larger trucks and the safe accommodation of all large trucks on our highways. Also under study is the impact of future changes in size and weight limits on truck configurations and how new configurations will influence truck safety.

Several studies are examining the interaction of trucks with various highway elements. One of the more obvious highway design issues related to large trucks is their limited maneuverability, especially in urban areas where long combination vehicles often have difficulty negotiating turns at intersections. A computer program was recently developed to aid in design by providing the ability to examine a truck's effective width while turning.

Another recent study examined freeway interchange ramps with a history of truck accidents. Design problems related to degree of curvature and transition into the curve were identified as primary accident causes. Recommended improvements include the use of spiral transitions, avoiding abrupt changes in curvature, the removal of curbing on the outside of the curve, and longer deceleration lanes.

Research was also conducted to develop a warning system for trucks on steep downgrades. A weight-specific speed sign that advises
truck drivers of a safe speed of descent based on the truck's weight has been designed and tested; a training course on its use is being developed.

A systematic review of geometric and traffic control device design standards relative to truck operating characteristics is now planned. Research results will provide the basis for changes in design standards.

**Accident Analysis**

Over the years accident research has concentrated on collecting data related to specific perceived problems rather than collecting large quantities of general accident data for analysis. Past work on narrow bridges led to a change in policy which now encourages continuing shoulders across the full length of bridges. Similar work on urban arterials indicated a need to consider land use when establishing on-street parking.

While in these instances useful information has been obtained, the excessive time and cost of accident studies remains a serious consideration. Current research in this area is directed at identifying safety measures other than accidents that can be effectively used as an equivalent to nondestructive testing for problem identification and countermeasure evaluation. Traffic conflicts and other surrogate measures have been studied and validated. Several States are evaluating traffic conflicts in addition to accidents as measures of effectiveness.

Future FHWA work will concentrate on coordinated national data bases to alleviate the need for ad hoc data collection. In keeping with the delineation of responsibilities within USDOT, this activity will be concerned solely with the impact of the highway facility on accident causation. However, it will also focus on special users, such as large trucks and small cars, in relation to highway elements. For example, a study is planned to evaluate the feasibility of a nationwide uniform truck accident reporting system.

**Conclusion**

Highway safety is a primary goal of the U.S. highway program. Research at all levels of Government as well as in the private sector is directed at continued improvements in this area. The past record is encouraging and the challenge for continued improvements with reduced overall resources will be met with similar success.
Figure 1. Major U.S. Highway Research Programs
Figure 2. Modified Thrie-Beam Guardrail
Design Details

Figure 3. Self-Restoring Barrier (SERB) Guardrail
PROMETHEUS - The European Automotive Industry Research Project

Tage Karlsson, AB Volvo, Sweden

The Greek Mythology tells us about the Titan PROMETHEUS. Our entire technology and culture rest upon his stealing the fire from heaven and bringing it to mankind.

Steam engines, piston engines, gas turbines, jet engines and rockets; all depend on the fire and without the daring feat of PROMETHEUS we wouldn't have much of traffic and transport today. Ships freight billions of tons between continents, jet planes move millions of passengers from and to large cities and trucks transport goods directly, quickly, reliably and with great flexibility to industries and consumer markets. Four hundred million cars in the world do the major part of passenger transport today and all trends indicate that the personal mobility realized with the car will lead to a continued increase of the number of automobiles until every person has access to this freedom of moving around.

The transport industry has enabled and stimulated economical growth and is itself a major part of the economy. But, the transport based on the combustion engine has also brought problems. When burning fossil fuels they emit hydrocarbons and oxides of nitrogen, carbon and sulphur which pollute the air hurting plants and beings. A quarter of a million of people are killed in road traffic related accidents world wide every year and several millions are injured. The ever increasing number of motor vehicles causes congestions and loss of time and efficiency. On top of this we have the worry of the depletion of the fossil fuels.

During the last decades remarkable progress has been made in some of these problem areas. Highway vehicles are no longer the major contaminators of the air and continued legislation and technical development will see to it that this development will go on. New discoveries of petroleum have kept the proven reserves at a comfortable level and if the dark horse of carbon dioxide pollution should prove to be as dangerous as some seers say there are the alternatives of alcohol and hydrogen being researched.

Despite great progress being made also regarding safety and congestions there is much more to be done and it need to be done in Europe. Seven percent of the of the world live in Western Europe but we have 22 percent of the traffic fatalities. This distortion is of course because China and India have very few cars but to accept that as an excuse would mean to give a license to motor vehicle drivers to kill people on the roads; an absolutely unacceptable thought. Congestions are a major cause of accidents but they are also bringing about higher consumption of fuel, detrimental effects on the environment, loss of efficiency and the time they consume is a strong negative factor in the quality of life of people suffering the congestions.

We need a Program for European Traffic with Highest Efficiency and Unprecedented Safety. Say PROM for Program and add the initial letters of the following important words of this sequence and you get the word, acronym as is the term, PROMETHEUS. The European automotive industry has called upon this veteran to come and help solve some of the problems his first contribution, the fire, has led to.
PROMETHEUS is an ambitious attempt to make great strides in traffic safety and efficiency by a cooperative effort to introduce the new information technology into the traffic system. The vehicles and the automotive industry are only two parts of this system, others being the roads, the communication channels, the services to the traffic, the law makers and standardisation organisations, the authorities, the science community, the supplier industries, the drivers, the passengers and all other trafficants on the roads, just to name a few. There are more, or rather, no part of the entire society and infrastructure can be excluded.

In order to get such a gigantic program under way there has to be priorities and limitations. Geographical and political reasons made Western Europe a very natural first ambition for PROMETHEUS. During the initial year of PROMETHEUS, starting the first of October 1986, the automotive industry in cooperation with research institutions and authorities has tried to define the tasks ahead. After the definition year other industries will be invited to take part in the work. The cooperation between the different automotive companies is defined as precompetitive and the relations when entering the areas of technical and industrial rights as well as other aspects of the working together are regulated in a Cooperation Agreement.

PROMETHEUS is structured in seven sub projects three of which are worked on directly and led by the automotive industry namely those dealing with communication between vehicles on the road, communications between the vehicles and the road and other surroundings and the third which is the new equipment and the function of the vehicles needed to manage this greatly automatic communication. This is a great problem complex since automatic communication per se is insufficient. There has to be some kind of reaction affecting the behaviour of the vehicle, sometimes automatic as well.

There are several ideas about how the new functions of the vehicles are to be technically realized but no one knows as yet which methods will be the best, cheapest and most reliable. In some cases great technical progress is needed in order to realize the dreams. In other words there are needed a lot of basic research and tests for selecting the best routes. Such research is best being done at universities and other research institutions.

If safety in traffic is to increase by the use of advanced communication between the different vehicles as well as between the vehicles and their surroundings it is a must that vehicles, roads and communication channels are compatible all over Europe. Only the government controlled road and communication authorities can assume the responsibility for this.

Because of these reasons authorities and institutions have been asked to assume the responsibility for four sub projects dealing with artificial intelligence, computer hardware, communication techniques and the road itself and it's future.

There are two parallel groups leading the PROMETHEUS effort. One is the International Steering Committee composed of representatives from eleven of the fourteen automotive companies that have started the project. Matra, Peugeot and Renault from France, Rover from Great Britain, Fiat from Italy and Saab-Scania and Volvo from Sweden in all eleven companies from five countries form the International Steering Committee. In addition to these companies Jaguar and Rolls Royce are
represented by Rover and Alfa Romeo is represented by Fiat making a total of fourteen companies.

The other body directing PROMETHEUS is the PROCOUNCIL made up of representatives nominated by the governments of the host countries of the participating companies. PROCOUNCIL is filling an extremely important function in securing the cooperation from the lawmakers and the authorities as well as in getting the government financing for the work which is outside the domains of the industry. The number of members is not limited as it is for the International Steering Committee and consequently it is possible and desirable that new member countries in the PROMETHEUS project will have members in the PROCOUNCIL.

The actual research work is being done within a number of Lead Packages which in turn are split into more sub groups. During the definition year as an example the three areas handled by the automotive industry has been split into 39 Lead Packages led by 35 Lead Researchers and in addition 179 Researchers from the different companies have participated in meetings all over Europe. The four basic research projects led by four international coordinators have had a similar organisation into sub projects and they have also had a hectic meeting program. From the start of the definition year some 350-400 people have actively participated in the work of PROMETHEUS.

The organisation within each country differs from country to country but due to the all encompassing effect of PROMETHEUS on research, industrial development, education, laws and standards and international competitiveness it is necessary to have some kind of national coordination. In Sweden for instance we have a National Steering Committee composed of representatives from The National Road Authority, The National Tele Communications Authority, The Authority for Traffic Safety, The Board for Technical Development, The Micro Wave Institute, The University of Linköping in addition to the automotive companies Saab-Scania and Volvo.

The end of the definition year is approaching and around October first the implementation of the planned research work is to commence. As a preparation for this the organisation of the project has been simplified; of the 39 Lead Packages only 11 remain as an example. Supplier industries will be invited to contribute and other European countries will also be encouraged to get into the act since standardisation of the traffic conditions for only five of the some 25 European countries does not solve the problems of safety and efficiency.

The time horizon of the PROMETHEUS project including the definition year is eight years.

What can we expect from PROMETHEUS? Highest efficiency and unprecedented safety are the main priorities and therefore built into it's name. By introducing the gains of Information Technology into the European traffic system through a dedicated cooperation by all parties concerned: governments, industry, universities, services and the trafficants themselves there should be a remarkable reduction in traffic fatalities and number of injured persons. Tens of thousands of lives will be saved every year and hundreds of thousands will escape the sufferings because of accident injuries. Really, we have no reason to pride ourselves if we do not reduce the number of traffic fatalities to one third of what it is in Europe today. We have to erase the notion that growing affluency and mobility mean more lives lost in traffic. In this respect we should
remember that some 47 percent of the traffic fatalities are unprotected trafficants; pedestrians and riders of two wheel vehicles.

The PROMETHEUS stimulation of the introduction of new communication techniques into the traffic will have profound effects on the efficient use of infrastructure, time and energy. Navigational aids will assist the trafficant to find the way and traffic management based on electronic information gathering will distribute the traffic more efficiently. Localization and continuous communication will facilitate the introduction of the Just in Time concept for industry making the production more efficient by eliminating the warehousing and stocks. Better communication will press down the peak hour effects for a more even use of the roads and the streets by facilitating the use of flex time, staggered working hours and to some extent working at home. Less congestions lead to smoother speed patterns and consequently less fuel consumption having the double effect of both saving energy and the environment.

In order to combine the new methods of communication with traffic; standards, protocols and uniform laws have to be introduced in the whole of Western Europe because different rules in different countries are the opposite of safety and efficiency. By 1992 Europe will finally become a common market and with that hopefully all traffic obstacles at the borders will be eliminated and the unhampered traffic will grow quickly; rapidly increasing the risks if the rules for the traffic are different. Because of this the full cooperation of governments and authorities is a necessary condition for the achievement of the goals of PROMETHEUS.

Democracy is the form of government in all Western Europe and one consequence of this is that the ever growing demand for mobility has to be met. The automotive industry is producing the vehicles but is not making the infrastructure needed for a safe and efficient use of the vehicles. The PROMETHEUS project is an invitation to join the forces of governments, universities and different branches of industry to meet the demands the peoples of Europe have all the rights to make.

Where there is a demand there is a market. A market means that someone is prepared to pay something for a service or for a piece of goods. When discussing PROMETHEUS there often is kind of confusion as to who should pay the merger of traffic and the new information technology; industry or public means. Should the cost be charged to some of the products involved or should it be payed by special fees and taxes. Since roads and means of communication are infrastructure it seems that they should be payed by the governments which in turn finance the outlays by charging fees or taxes. Of course there is no arguing as to the responsibility of the industry to pay for the development of products to be used in the, by public means created, infrastructure.

There are reasons to believe that the cost for PROMETHEUS instead of being a burden will be a great stimulation of technology and economical growth and Europe is in dire need of both to meet the challenges from transocean countries and to alleviate the serious unemployment situation. PROMETHEUS defines the objectives and organizes the forces for a peaceful but aggressive attack in order to satisfy the basic needs of safe and efficient mobility in Europe. PROMETHEUS is an opportunity for European governments, industry and science community to cooperate efficiently for the common good of all the citizens of our area of civilization.
HIGHWAYS THROUGH TOWNS - ROAD WITH SAFETY AND ENVIRONMENTAL PRIORITY

by Otto Schiøtz; M.Sc., Ph.d., Road Directorate, Ministry of Transport, Denmark

Summary

The Danish road standard work has shown a great need for an alternative line and thought in the planning of major traffic roads' passage through minor towns. Up to now, efforts have been concentrated on the construction of by-passes or through-roads with traffic priority. In view of the latest observed stagnation in the number of vehicles-kilometres travelled the limited economic potentialities and the increased opposition to the use of agricultural land or intervention in the recreational areas in cities, there exists a great interest in investigating the possibilities and consequence of slowing down traffic on the main highways by converting the existing main road into so-called through-roads with environmental priority.

In 1981 the Road Directorate issued the publication "Hovedlandeveje gennem byer - et idékatalog" (Main Roads Through Towns - a Catalogue of Ideas) which on the basis of different individual components (bicycle paths, narrowings, staggerings, changes in surface, marking, planting, etc.) shows examples of through-roads with environmental priority. The proposals presented in the catalogue of ideas for overall local solutions are divided into five groups: Prewarning, gates, track crossings, road intersections, speed reducers. All the solutions include combinations of many of the mentioned components.

After the catalogue had been published and in the light of the great interest with which the ideas were met, the Danish Minister of Transport decided to initiate experiments with a reconstruction of 3 main road sections in Skaerbaek (Southern Jutland, 2,900 inhabitants, ADT: 4,000 cars, length: 1,620 m), in Vinderup (Western Jutland, 3,100 inhabitants, ADT: 3,100 cars, length: 1,180 m) and Ugerløse (Western Sealand, 880 inhabitants, ADT: 2,500 cars, length: 880 m).

For these three towns, plan projects have been elaborated and adopted, and the construction works were finished in 1985 (Skaerbaek and Vinderup) and in 1986 (Ugerløse).

The effects of the projects has been thoroughly elucidated through a series of before and after studies which have been taken up by the road Directorate. The first results from the before/after studies will be published during the spring-summer of 1987.

The Road Directorate and Anders Nyvig A/S, Traffic and Transportation Planning Consultants, whom have contributed to the implementation of the pilot projects in 3 minor towns, together were awarded the Volvo Traffic Safety Award in 1986.
1. Introduction

The Danish road standard work has shown a great need for an alternative line of thought in the planning of major traffic roads' passage through minor towns. Up to now, efforts have been concentrated on the construction of by-passes or through-roads with traffic priority. In view of the limited economic potentialities and the increased opposition to the use of agricultural land or intervention in the recreational areas in cities, there exists a great interest in investigating the possibilities and consequence of slowing down traffic on the main highways by converting the existing main road into so-called through-roads with environmental priority.

An experiment has been initiated by the Danish Road Directorate concerning speed reduction on highways passing through 3 towns: the towns of Vinderup, Skærbæk and Ugerløse in the Counties of Ringkøbing, Sønderjylland, and Vestsjælland respectively.

The objectives is by means of full scale experiments to cast light on the effects of establishing through roads that give priority to the environment. For each town the experiment is divided into two projects, namely

- the conversion and reconstruction project
- the consequence evaluation project

The conversion and reconstruction project is described in the Road Directorate's report "3 byer" (3 Towns) of April 1984.

The two main objectives of the consequence evaluation project are

- to measure the effects so as determine whether traffic with environmental priority is desirable
- to develop methods of measurement of road behaviour and of environmental conditions.

2. The Experiment: Three Towns

In connection with the preparation of the "Perspektivplan for hovedlandevejene" (Perspective Plan for Main Roads) the Road Directorate in 1981 published "Hovedlandeveje gennem byer - et idékatalog" (Highways through towns - a catalogue of ideas).
In this report the concept of through traffic with environmental priority was introduced. It was put forth as a traffic conversion by which the throught-own highway is to be changed with a view to the needs of the environment and the light road-users' (pedestrians, cyclist, mopedriders) share of the road area increased, and great importance is attached to the prevention of road accidents.

Environmental priority necessitates that the motor traffic be carried through at a somewhat lower standard; first and foremost the speed will have to be reduced, secondly the motor traffic will be allocated less space.

The catalogue of ideas contained a variety of concrete suggestions to promote the mentioned objectives. These suggestions included mainly measures relating to road design such as traffic islands and bicycle tracks, staggering and narrowing of carriageways, raised carriageways levels and changed road surfaces, but also planting, lighting, etc.

The catalogue of ideas further described how the individual elements could be combined to form design solutions such as

- pre-warnings
- gates
- track crossings
- intersections
- speed reducing measures

Finally the report pointed out the design solutions could and should be combined to form overall solutions for entire road stretches.

According to the Perspective Plan, 307 Danish towns had highway through traffic. It was likely, moreover, that design solutions complying with the principles of environmental priority would be relevant in many of these towns.

The methods, however, were new and not yet proven. So the Danish Minister of Transport decided that full-scale experiments should be implemented in 3 towns to test the principles in a scheme conducted on a cooperative basis between the Road Directorate and the Counties and municipalities in question. The towns of Vinderup, Skærbæk and Ugerløse were chosen for the experiments.

In their own right each of the towns are representative of a number of towns possessing similar characteristics. In Vinderup the highway through road is also the shopping street of the town. In Skærbæk the shopping street intersects the highway. Ugerløse is a somewhat smaller town and the highway takes a more winding route through it.

3. The Research project EMIL

The primary aim of the full-scale experiments in the three towns was to demonstrate how the mentioned traffic conversions and reconstructions would appear physically, and secondly the consequences of the conversion measures were to be monitored closely.
In order to achieve the latter the so-called EMIL project was started (from the Danish equivalent Effects of Through Traffic with "MIlieu" Priority; in the present paper "EMIL" will thus be used as a short form for "Consequence Evaluation of Through Traffic with Environmental Priority").

The EMIL project was conceived to provide to the many questions which arise on the topic of traffic with environmental priority:

- are speeds reduced as expected?
- is safety improved as expected?
- is crossing roads facilitated for pedestrians?
- is shopping affected?
- what happens to pollution and energy consumption?
- what do the inhabitants — and drivers — think?
- and so forth

The primary objective of the project is to cast light on the effects of rebuilding roads according to the principle of environmental priority. An additional objective is to develop and assess methods of measurement for the description of road-user behaviour and environmental impacts.

The study has attempted to analyse almost all the effects of rebuilding the road. Records of the consequences have been divided into six main categories, namely:

- heavy road-user behaviour
- light road-user behaviour
- pollution
- road accidents
- users' opinions
- use and maintenance

In continuation of these questions an investigation has been conducted in the town of Vinderup concerning

- shopping

Accident records have been compiled before the replanning and the after period is now being closely monitored for the same purpose. The afterperiod must be studied for at least 3 years, however, before drawing reliable conclusions as to the safety consequences of the re-building.

To illustrate some of the changes cross-sections before and after the traffic reorganisation is showed. Divided tracks (bicycle track and pavement with no difference in level) were established on both sides of the road all through the town.

**Figure**

Cross-section in the town (before and after the reorganisation)
4. **Traffic Flow**

The traffic censuses before and after the conversion aim two objectives. First of all to establish whether the road-users, as an unintended consequence of the project, have changed their habits and routes of driving; secondly, to provide an opportunity of evaluating a number of the other effects in relation to traffic flow.

The traffic censuses on the highway showed the following results, converted into annual traffic per day, and rounded off.

<table>
<thead>
<tr>
<th>Traffic Intensity</th>
<th>Heavy Road-users</th>
<th>Light Road-users</th>
<th>All Road-users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase</td>
<td>3%</td>
<td>21%</td>
<td>7%</td>
</tr>
</tbody>
</table>

**Annual traffic per day before and after the conversion**

The increase in traffic more or less equals the general trend in the country of the period. The marked increase in the number of light road-users, on the other hand, is probably a result of the conversion.

5. **Speed**

One of the main objectives of through traffic with environmental priority is to reduce the speed of the cars. The influence the conversion has had on the speed has therefore been an important subject in the consequence evaluation.

The purpose of the investigation has been to describe the general speed level before and after the conversion, comprising also speed of various types of motor vehicles.

Finally, by means of supplementary measurements, it has also been sought to establish the influence which the individual measures have had on the achieved speed reduction.

Measurements were made during one week in September 1983 and one week in September 1985. The weather was more or less the same in two periods.

Both measurements were performed before the reduction in Denmark of the general speed limit in built-up areas from 60 to 50 km/h. Consequently this change has had no bearing on the results.

The general speed level in the town is calculated as the average of all measured speeds at four stations in town.

<table>
<thead>
<tr>
<th>Speed Level</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Cars</td>
<td>48</td>
<td>44</td>
</tr>
<tr>
<td>Small Lorries</td>
<td>51</td>
<td>43</td>
</tr>
<tr>
<td>Big Lorries</td>
<td>49</td>
<td>41</td>
</tr>
<tr>
<td>All Vehicles</td>
<td>49</td>
<td>44</td>
</tr>
</tbody>
</table>

**Reduction**

<table>
<thead>
<tr>
<th>Reduction</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Speed levels, both directions, before/after (km/h)
The general speed level has decreased by 5 km/h. Both categories of lorries present a larger decrease, whereas normal passenger cars reduced speed somewhat less.

Speeds have been reduced in Vinderup, especially in the outskirts of the town. Many cars drive at the target of 40 km/h, the differences of speed have been narrowed down, considerably and, by and large, the very high speeds have disappeared.

6. Delays for Main Road Users

One of the main objectives of the replanning of the highway was to reduce the speed of cars. The measurements mentioned above show that this has been achieved.

The delays imposed on passing traffic due to the speed reduction have been determined to be 7 seconds per km, that is 9 seconds in all. This is somewhat less than if all drivers reduced the speed to the target of 40 km/h.

The speed reduction through Vinderup has neither created problems of traffic flow, nor delay problems of any significance to the through traffic.

7. The Car Drivers Opinions

The conversion results in the motor traffic being led through the town at a somewhat lower standard of ease than before. In order to record the drivers' experiences and opinions in this respect, a roadside interview was performed after the conversion.

The drivers' attitudes to through traffic with environmental priority differed considerably:

<table>
<thead>
<tr>
<th></th>
<th>Very Positive</th>
<th>Positive</th>
<th>Negative</th>
<th>Very Negative</th>
<th>Not specified</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>177</td>
<td>431</td>
<td>357</td>
<td>310</td>
<td>42</td>
<td>1317</td>
</tr>
<tr>
<td>%</td>
<td>13</td>
<td>33</td>
<td>27</td>
<td>24</td>
<td>3</td>
<td>100</td>
</tr>
</tbody>
</table>

Drivers' attitudes to environmental priority.

A little more than half of the drivers felt negative and slightly less than half positive towards the principle of environmental priority.

The majority of the drivers who disliked the principle were found in the following groups: drivers above 50 years of age, drivers in large vehicles, and drivers living in Vinderup.

The greater part of drivers who favoured the principle belong to these categories: drivers below 50 years of age, drivers of small vehicles, and drivers living in Vinderup.
8. Fence Effect for Light Road Users.

One of the main objectives in redesigning the highway was to reduce the fence effect for the light road users.

In order to evaluate the result these users were counted before and after the conversion and their delays when crossing the main road were recorded. In addition they were interviewed about their feeling for security.

According to the interview and evaluation, the feeling of security has been markedly strengthened.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
<th>Children</th>
<th>Adults</th>
<th>Elderly</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecure, %</td>
<td>55</td>
<td>21</td>
<td>64</td>
<td>26</td>
<td>70</td>
<td>26</td>
</tr>
<tr>
<td>Secure, %</td>
<td>35</td>
<td>68</td>
<td>30</td>
<td>65</td>
<td>25</td>
<td>66</td>
</tr>
<tr>
<td>Do not know, %</td>
<td>10</td>
<td>11</td>
<td>6</td>
<td>9</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Pedestrians' feeling of security before and after the conversion

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
<th>Children</th>
<th>Adults</th>
<th>Elderly</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecure, %</td>
<td>62</td>
<td>35</td>
<td>71</td>
<td>29</td>
<td>91</td>
<td>20</td>
</tr>
<tr>
<td>Secure, %</td>
<td>24</td>
<td>58</td>
<td>21</td>
<td>65</td>
<td>9</td>
<td>80</td>
</tr>
<tr>
<td>Do not know, %</td>
<td>14</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Cyclists' feeling of security before and after the conversion.

The conversion of the highway through Vinderup into a 40 km/h environmental priority through-traffic road has reduced the fence effect of the road. It has become easier to be light road user in Vinderup.

9. Town Use

The objective of the registration of town use is to provide a structured description of everyday outdoor activities along the main road before and after the conversion and in this way contribute to the evaluation of whether or not the road has become more attractive as a public precinct.

By way of summing up it can be established that
- the number of persons in the main street has increased
- the number of both compulsory and optional activities has increased

The possibilities of creating a rich town life thus seem to have been improved after the conversion.

10. Consequences for the Retail Trades

A main objective of re-designing highways through towns to the environmental priority principle is to make the road and its surroundings a more attractive public space for light road users. Conditions for car drivers, however, are impaired, especially as regards parking.

VTI RAPPORT 328 A
When the through road also functions as a shopping precinct it is essential to evaluate the joint effect in commercial life of these two opposite trends. The middle 500 m of the highway through Vinderup is an example of this type of road. It has therefore been investigated to what extent the conversion has effected the retail trade in Vinderup.

The re-design of the highway through Vinderup has generally only affected the retail trade to a marginal degree.

On balance and in principle the Vinderup shopkeepers favour the conversion partly because the alternative, a by-pass road, is generally considered to be far more disadvantageous to the retail trade.

11. Environmental Consequences.

The effects on the environment and consequences for energy consumption of through traffic with environmental priority were uncertain at project commencement. Due to the relatively low speed range the conversion was not expected to entail any change in the measured noise level. On the other hand it was predicted that the cognitive noise level would rise because of accelerations and decelerations. No significant changes of the level of vibration were expected. Finally, it was reckoned that the air pollution and the energy consumption would increase slightly.

To verify these assumptions all of the mentioned aspects were investigated in depth.

The noise level is unchanged on the main road but both the noise and the vibration levels have increased at the rumble strips.

The air pollution remain the same in the central part of the main road. Along the outskirts the lead concentrations have fallen while the carbon monoxide and nitrogen dioxide contents have risen slightly.

The energy consumption has been reduced a little.

12. Town-inhabitants' Opinions

The overall objective of the re-design of the highway has been to make Vinderup a better place to live in. It is therefore paramount for the total evaluation og the project to investigate the inhabitants' impression of the town and the traffic-related problems before and after the conversion, and especially their attitude to the actual project.

A larger proportion of adult road users feel safer on the main street now - no matter what category they belong in. Cyclists, however, have benefited most from the changes:
<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feel safe as pedestrians</td>
<td>51</td>
<td>80</td>
</tr>
<tr>
<td>Feel safe as cyclists</td>
<td>17</td>
<td>75</td>
</tr>
<tr>
<td>Feel safe as drivers</td>
<td>56</td>
<td>76</td>
</tr>
</tbody>
</table>

Adults' feeling of security, before and after

The inhabitants' general assessment of the conversion is very positive indeed. They find that it has contributed to make the town look nicer, that it has made the drivers reduce the speed and that road safety has been improved for the light road users. Critical remarks concern project constituent elements, first and foremost the street lighting and various details of the traffic islands.

A direct comparison of the responses from before and after the project shows that

- satisfaction at living in Vinderup has increased
- the number and speed of the cars are far more acceptable and the nuisance presented by parked cars is smaller
- the feeling of safety has improved considerably for all categories of road users, but most notably for cyclists
- fewer people fell bothered by noise and air pollution

13. Overall Assessment of Results

The effects of the conversion as regards safety cannot be reliably evaluated as yet. As for the other environmental improvements, however, i.e. the increased feeling of safety, the reduced fence effect and the more pleasing appearance of the road, it can be established that these have been fully achieved.

Motor vehicles drive slower after conversion, especially on the fringes of the town. Many drivers travel at the indicated speed of 40 km/h, the differences of speed have narrowed down considerably and the very high speeds have disappeared almost completely.

At the same time driving pattern is still so smooth as not to have caused any considerable unintended side effects. The noise and vibration levels have only increased outside town, at the rumple strips. The air pollution has only changed insignificantly and both in positive and negative directions. The energy consumption has decreased a little. Finally, no significant effects have been traceable for the retail trade.

The predicted worsened conditions for the through traffic have been held at a tolerable level. Delays in the region of 9 seconds are absolutely insignificant in comparison with the drivers' total travel time.
The success is confirmed by the inhabitants' overall assessment. In their opinion the town has become a better place to live in after the conversion. Both before and after, the overall majority of the inhabitants were content with living in the town, but after the conversion the proportion of those who are very content has increased significantly.

A massive 72% find the town has generally become better to move about in, only 17% think the opposite. Even among "the losers of the game", the drivers, almost one half feel positive towards the through traffic with environmental priority.

14. Background Reports

Individual elements of the EMIL-project in Vinderup are in the reports nos. 43-51 issued by the Road Directorate:

43. What Do the Inhabitants Think? A Questionnaire Survey.
44. Speeds and Traffic Volume.
45. Light Road User Behaviour. Fence Effect.
46. Heavy Road User Behaviour. Fence Effect.
47. Town Use.
49. Air Pollution Consequences. Noise, Air Pollution, Vibrations and Energy Consumption.
50. What Do the Drivers Think? A Roadside Interview, Skærbæk, Vinderup and Ugerløse.
51. What Do the Shopkeepers Think? A Survey of the Retail Trade
ABSTRACT

Volvo Safety Design Philosophy
Anders Ericsson, Volvo Car Corporation

The traffic safety research and development work at Volvo Car Corporation is described. The objective of the Safety Research is to gain increased know-how about the mechanisms behind car accidents and the incidence of occupant injuries and to feed this experience back into the long-term and short-term design and development work. Stringent safety standards, based on the experience from real world accidents, form the basis of the design work with the aim to limit injuries and facilitate speedy rescue work, should an accident occur.

Volvo has - as the first car manufacturer in Europe - set up its own accident investigation commission which follows up road accidents involving Volvo cars. Furthermore, an extensive statistical accident material is collected and analyzed, and various special investigations are carried out.

Volvo's safety work is described as a continuous circle process which starts and ends in the real world traffic environment out on the roads. Accident investigation, laboratory testing, and theoretical model simulations are combined in a conscious research and development strategy. Safety standards based on design and testing. When the testing shows that all safety standards are met, the new design is ready for production and the car goes out on the road. The circle is complete and the work goes on.

Two special items are emphasized in the speech as examples of the safety work carried out by Volvo. First child safety, which for many years has been an extremely important part of Volvo's safety work. Child safety in cars should be a natural feature, but this is unfortunately not always the case. Secondly, the facial injury research is another illustration of the development work, where Volvo has developed a special load sensing dummy face to detect facial injuries, which are becoming increasingly important in modern car safety design.
1. INTRODUCTION

Matters connected with road safety have a long tradition at Volvo. For several decades we have been working systematically to improve the safety aspects of the passenger car.

The laminated glass windscreen, seat belt design and construction, safety features of the body and child safety are all areas in which Volvo has helped to push development ahead.

Volvo's Traffic Accident Research Team has brought a realistic approach to development work which has been of much benefit. The point of departure for our work has always been people themselves. Our task as we see it is to develop the car as a product on the basis of people's requirements and in respect of technical developments and a changing traffic environment.

In the course of our work we have discovered how vital it is to keep the debate alive concerning matters connected with road safety between various parties: the authorities, the car manufacturer and the public at large.

Where safety is concerned Volvo has something of a tradition to support: keeping a step ahead of both competitors and legislation.

2. VOLVO SAFETY DESIGN PHILOSOPHY

Safety has long been one of the primary characteristics of a Volvo car. Safety to Volvo has always meant a high level of safety in a real traffic environment. Volvo Safety Design Philosophy can be explained by a circle as in the figure below.
For many years the Volvo Traffic Accident Research Team has been extensively engaged in researching accidents and increasing its know-how about the crash worthiness properties of complete vehicles and their various design systems, also about various occupant injury mechanisms. This knowledge is used both for short-term and long-term feedback in the development of future vehicles. This feedback is one important source for establishing the requirements for the safety properties of a car. These requirements then provide the basis for the design and development work.

Having the functional laboratory requirements on the complete car is not enough. The car must be divided into various systems and the systems into different subsystems. With this technique, the complete car requirements for different collisions could be broken down into a set of system and subsystem requirements which can be checked in laboratories and which are understandable to the craftsmen and engineers.

The requirements on systems and subsystems form the basis of our development technique within the safety engineering procedure. The two major systems are the body structure system and the interior system. The body structure system covers the "body in white" and the drive-line (engine-transmission-rear axle). The interior system covers all the interior facilities of the car, such as instrument panel, steering wheel, seats and safety belts.

The structure-system requirements are built up around a measuring technique using barrier tests, "body tests" and component tests. During the entire development procedure, analytical tools such as structural mass/spring models and finite-element calculations are used to further optimize the mechanical engineering.

The basic development technique for the interior system is a crash simulator in which intrusion and deceleration can be reproduced. With such a technique the development of the interior does not depend on the outcome of crash-testing complete cars. Just as in the case of the structure system, the interior system uses several subsystem tests. Calculations and mathematical models are made in parallel.

After back and forth between design and interior engineering departments, in which performance, weight and cost are optimized, the complete car is ready for the evaluation and certification phase.

During production control, many systems and subsystems (e.g. seatbelts, windshields, seats, sunvisors) are tested and complete cars are sampled out for crash tests.

The circle is closed and the new car is ready for the actual traffic environment. The Volvo Traffic Accident Research Group can start its investigation work to evaluate the safety performance of the car and to gain more knowledge for further improvements.
3. VOLVO TRAFFIC ACCIDENT RESEARCH

The purpose of the traffic accident research work done by Volvo is to acquire know-how about the mechanisms behind the accidents and the incidence of personal injury so that the safety properties of existing and planned vehicle designs can be gradually developed and adapted to the changing traffic environment and to the properties, requirements and ability of the human being. This overall purpose can be more concretely broken down into the following subsidiary aims:

- Clarifying the reason-association behind the incidence of accidents as vehicle engineering measures.
- Clarifying the mechanisms behind the incidence of personal injury in accidents as basis for injury-preventive measures.
- Identifying the need for safety improving measures and indicating feasible implementation methods and design solutions.
- Providing specifications for stipulating the safety properties of vehicles and their components.
- Providing the crash-safety laboratory with experience of accidents and injuries as well as the function of different vehicle components in real traffic accidents as a basis for the experimental development of injury-preventing systems.
- Evaluation in what way stipulated safety requirements are fulfilled in the actual traffic environment.

The safety research is based on a systems view not only to the extent that accidents and injuries are regarded as the outcome of a disturbance in the interplay between the various components in a human-machine-environmental system, but also to the extent that traffic accident investigations, laboratory experiments and theoretical model simulations are combined in a conscious research and development strategy.

Traditionally a road traffic accident is usually divided into three phases; pre-crash, crash and post-crash.

For natural reasons, activities at the Volvo Crash Centre are engaged in the actual collision phase and the injury-preventive safety. All three phases of an accident sequence are studied in the accident investigations. Nevertheless, most of the data compiled is concentrated on those factors of the vehicle, environment and the occupants which can be thought to affect the incidence of the injuries and the safety of the car occupants at the time an accident occurs.

To ensure that the compiled accident data is both quantitatively and qualitatively adequate when bearing in mind the purpose of the activities, not only are in-depth studies made, but also less detailed but quantitatively considerably more extensive accident investigations carried out.
3.1 In depth studies - Accident Commission

When a personal injury accident occurs with a Volvo car within an area of maximum 100 km distance from the Volvo Car Corporation in Gothenburg (approx 1 hour car journey), the Volvo Accident Commission is called to the scene of the accident. The alarm is received either from the emergency service, the breakdown service or the police in one of the 11 police districts within the defined area.

The members of the Accident Commission are specially trained and have experience of accident investigations. They are on round the clock stand by and are prepared to go to the scene of the accident any time day or night every day of the week. As a rule one or two investigators visit the scene of the accident to accumulate information and make a preliminary analysis. The circumstances surrounding the accident are documented at the scene of the accident with photographs, measurements and interviews with police, rescue personnel, occupants and any witnesses. A preliminary technical investigation is immediately carried out on the spot.

Investigations at the scene of the accident are of great importance for several reasons. In the follow-up analysis, the investigator has a better idea of how the accident happened and the movement patterns of the occupants in the car. Witnesses, people involved in the accident, investigation police and others with valuable information are often still at the scene of the accident. The ongoing investigations and analyses of the Accident Commission are considerably facilitated by having these contacts at such an early stage. Moreover, it is essential to get an opportunity to examine the deformations of the vehicles involved first before the recovery work starts. Vehicle accident recovery and removal work can give rise to damage which, since the reason for their incidence is unknown, can make the investigating analytical work difficult.

The knowledge and experience acquired by the researchers in their investigation at the scene of the accident is of great importance in understanding the reason why the accident occurred and also for interpreting the occupant injury mechanisms. The knowledge is also valuable generally speaking when analysing different accident material, even such accidents where no investigation has been carried out at the scene of the accident.

The damaged Volvo cars are transported to the nearest Volvo dealer or, in special cases, to the Volvo Car Corporation Crash Safety Centre where they are extensively analysed.
Assessed in connection with the investigation at the scene of the accident is the extent to which errors in the traffic environment resulted in the accident happening or influenced the consequences of the accident. These observations are passed on to the responsible road authority within the area in question. Copious material describing the consequences of a collision involving various environmental objects (pillars, road fences etc) is compiled and used in order to influence the responsible road authority.

Not only are investigations carried out within the above-mentioned investigatory area. In depth studies are also made in other parts of Sweden and, when accidents of particular interest occur, also in other European countries. These accident investigations necessarily become after-the-fact and usually concern special, limited safety topics. Information about accidents comes primarily from the police, the Swedish Road Safety Office, and also from our insurance and service inspectors. They all know the types of accidents and their severity we are interested in. The focus of this interest changes as new problem areas are dealt with.

The accident in depth studies comprise about 100 cases annually. The accidents are not selected according to some statistical selection method. Studied are all the more serious accidents with Volvo cars within the 100 km limit zone which come to the notice of the police or the emergency service and who in their turn pass on information to the Volvo Accident Commission. Outside of this area are studied only those accidents which are judged to be of interest for the safety areas being currently studied by the Accident Research Department.

The possibilities of drawing any statistically based conclusions from the in depth study material are thereby limited. But of course is is not regarded as necessary. The purpose of the in depth studies is partly to give rise to hypotheses which can subsequently be tried out in the larger statistical accident material and in the crash safety laboratory, and partly to test precise hypotheses within special safety areas. Often the indications obtained via in depth studies are clear enough to be able to draw conclusions about the incidence of accidents and about the function of the various vehicle components, without the backup of copious statistical material.

The department responsible for the accident investigations thereby acquires experience and a detailed know-how as well as a "feeling" for the various casual connections behind the incidence of accidents and injuries, something which is invaluable in all analyses and safety work. The accident in depth studies thus function as a most valuable and rich source of knowledge in addition to the statistical accident material.
3.2 Statistical accident investigations

Our statistical accident material is less detailed but quantitatively considerably more extensive than the in depth studies. The material is accumulated via collaboration with Volvo workshops and the Volvia Insurance Company accident inspectors all around Sweden. Volvia currently has approx. 430,000 cars covered by its motorcar damage warranty. About 50,000 (12%) of these each year meet with some kind of accident, most of them very slight. We select from these accidents all those involving repair costs which exceed a certain value. In this way we annually get about 2,000 of the "most serious" accidents with Volvo cars in Sweden. The majority of the occupants in these cars escape uninjured or with slight injuries. Only in about 15-20 % of the cases has an occupant suffered moderate or more severe injuries.

Today we have a total of about 13,000 accidents documented in our accidents statistics containing information of about 20,000 occupants.

Workshops and accident inspectors supply us with photographs and certain measurements concerning the damaged car to enable us to determine the extent of the deformations. Through a detailed questionnaire issued to those who were traveling in the car, data is obtained concerning the circumstances of the accident (type of road, speed limit, weather conditions, etc), the accident phase (braking, collision sequence, collision objects, etc), information about the occupants (sex, age, location in vehicle, use of seatbelts, etc) together with their own descriptions of any personal injuries.

When it comes to accidents involving personal injuries, information is complemented with a medical report (after permission has been granted by the injured) or where applicable an autopsy report. Responsibility for accumulating, analysing, coding and filing this medical injury data lies with the physician associated with the team.

The questionnaire also contains a number of indication queries which, if appropriate, are answered by marking with a cross in a box. The questionnaire has been intentionally formulated for the purpose of minimizing as far as possible the number of questions. The indications queries are of the type: Restrain child?, Did a door fly open during the accident?, Was anyone ejected from the car during the accident? etc.

Those questions which are answered are followed up by a more comprehensive questionnaire, which have been specially formulated to cover the questions involved.
On average about 200 items of information on each accident are filed. The material is analysed among other things with help of the statistical programme SAS (Statistical Analyses System) which provides large scope for processing statistics, correlational and regressional analyses, inter related tests, graphical presentations, etc.

As previous mentioned, the criterion for selection when statistically collecting accident data is that the repair costs (and thereby to a certain extent the collision's complexity) exceed a certain value. With this system we get in the most serious accidents with Volvo cars, reported to Volvia. Since in spite of this more than 80% of the material involves light collisions involving none or only minor injuries (AIS 0-1), we should have a fairly good picture of almost all collisions sufficiently severe to generate AIS 2 degree and more serious injuries. In this material injury risks and injury reducing effects are generally calculated on moderate and more serious personal injuries (AIS 2-6) and always in relation to a given degree of crash severity. This minimises the risk of the selection criterion chosen (the repair cost limit) causing statistical bias in connection with such evaluations.

3.3 Special Investigations

Different types of special studies are also carried out in addition to the In Depth Studies and the Statistical Accident Investigations of Volvo cars. The purpose of these special investigations is to supplement both the previously mentioned activities in areas not covered by them.

Acquired knowledge of the traffic accident picture in other countries also has an important part to play. Since the traffic environment varies in different countries and thereby also the accident type classification and similar parameters - it is important to get to know this in order to make good and generally applicable assessments.

Another important complement to the know-how about the properties of Volvo cars from a traffic safety point of view is a knowledge of the potentialities of other design solutions. That is why we study to a certain extent also accidents in which other vehicles are involved. The information acquired here is of great value when developing new products and systems.

Special projects within various sectors are also being carried out during various periods of time, often in collaboration with expertise outside Volvo. Developed within these projects is a deepened know-how about certain special areas, such as child safety, the problem related to facial injuries and so on.
In depth studies of accidents, statistical follow-up of accidents and experience gained from different special studies together constitute the foundation for the analyses which form the basis for the requirement stipulation and development of safe vehicles of the Volvo Car Corporation.

### 3.4 Analyses work

As a general rule the traffic accident material must be regarded as data for "unplanned experiments". The majority of laboratory experiments are so-called "controlled" experiments in which different independant variables are conciously manipulated and the effects on the dependant variable observed, either for individual trial objects or in a random division of trial objects in an experimental group and in a control group. If the experiment is carried out in the right way, conclusions can be drawn concerning the cause-effect relationship between the independant variables and the dependant variable.

The cornerstone of this type of controlled experiments is that one or several of the independant variables are conciously varied while the remainder are kept constant. Such a methodique naturally cannot be applied to traffic accidents. Even if we tried to simulate the controlled experiment as far as possible, and even if we arrive at strong correlations between the different variables using the most sofisticated regression-analytic methods, we still cannot be sure that the results express true causal relationships.

It is essential when analysing car accidents to have a deep and detailed knowledge of the various interactive factors and the complicated tie-ups behind the incidence of accidents and injuries in order to be able to assess, compare and develop the safety properties of cars and their components.
It is particularly important here to have an insight into which factors are inherent to the dynamic driving properties of the car, which are related to the actual crash safety properties and which are related to how the car has been driven, utilization of the various protection systems, the driver characteristics and the circumstances of the accident as such.

Detailed information about the collision configuration (type of accident), the collision force (the deformation properties of the collision objects and the deceleration), the use of seatbelts and other protection systems as well as the extent of the personal injuries, degree of difficulty and possible incidence mechanisms, are of decisive importance in order to make a correct analysis of car accidents.

To ensure representative results, a comprehensive accident material must be broken down to accurately delineated collision types. The material should be compiled in accordance with systematical principles, proceeding from a clearly defined target, and analysed with great care, and thoroughly examined to make sure that results are not biased by disturbing background variables which can give rise to apparent relationships.

Required for this is a great measure of care when generalising the results.

4. THE CIRCLE IS CLOSED

Volvo traffic accident research is based on a systems view not only to the extent that accidents and injuries are regarded as the consequence of disturbance in the interplay between the various components in a human-machine-environment system, but also to the extent that traffic accident investigations, laboratory experiments and theoretical model simulations are combined in a conscious research and development strategy.
The knowledge gained from traffic accident research is used in establishing the requirements for the safety properties of a car.

These requirements then provide the basis for the work of design and development. Collision tests form a part of this work and the experience gained by traffic accidents research is utilized.

Later the car is produced and sold to the customers. This means that it begins to be exposed to actual traffic environments. We can now follow up the road accidents in which our car is involved and so obtain information on how well we have succeeded in suiting our car to the actual traffic environment.

5. TWO EXAMPLES FROM THE SPECIAL INVESTIGATIONS

5.1 The child in the Volvo car

Experience gained from the Volvo Accident Investigations material described above gives us knowledge of the way children travel in cars and injury risks for different modes of travel.
The accident study material for the years 1976-1986 covers approx 1 000 serious road accidents in which at least one child was an occupant of the car. The material involves Volvo cars of the 140/160, 240/260, 340/360 and 740/760 models.

In the figure below the percentage of children in different age groups using some type of safety equipment is shown. Safety equipment is recognized as infant seats, child seats, booster cushions and seat belts.

The accident material described above is used to analyse the injury risk for restrained and unrestrained children.

<table>
<thead>
<tr>
<th>Restraint</th>
<th>AIS 1 %</th>
<th>AIS 2-3 %</th>
<th>AIS 4-6 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>25.9</td>
<td>4.4</td>
<td>0.8</td>
</tr>
<tr>
<td>No</td>
<td>30.9</td>
<td>8.3</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Restraint effectiveness | 16% | 47% | 60%
We can see that there is a restraint effectiveness at all AIS-levels. A restraint effectiveness of 50% can be calculated for injuries of a severity level AIS 2-6.

The injury rate for children using rearward facing child seats is extremely low compared to other modes of travel. For children using child seats and for children using booster cushions there are no injuries more severe than AIS 3.

We can calculate the effectiveness in reducing AIS 2-6 injuries for seat belts to 58% and for booster cushion to 63%.

If we compare children in the age group 1-4 years depending on whether they have travelled in a child seat or travelled unrestrained we can calculate a very high effectiveness for the child seat in reducing minor as well as severe injuries. The effectiveness in reducing AIS 2-6 injuries is about 90%.

5.2 Facial injury occurrence in traffic accidents and its detection by a load sensing face

Facial injuries are becoming more important in car safety design. This does not mean that the number or severity of injuries in the face are increasing. In fact, they are both decreasing as a consequence of improved restraint systems, improved car interior design, the increasing number of seat belt wearers etc.

However, it is not possible to totally eliminate facial injuries. The proportion of the less severe injuries in the facial area is therefore growing, which must be accounted for by new test methods in product safety development.

Head injuries have traditionally been divided into two different groups depending on the injury mechanism, i.e. acceleration and pressure induced trauma.

Most safety research has concentrated on the severe head injuries. These could be detected by means of acceleration levels measured at the center of gravity of the head. Another method used is the rotational acceleration measurement.

The less severe head injuries, for example fractures of different facial bones, have until recently not been possible to measure. Here, the force or pressure applied must be evaluated. Various attempts have been made; deformable foam systems and strain gage force transducers are only two of several methods. However these methods have proved insufficient.
A load sensing face that utilizes thin piezoelectric pressure sensitive film was developed and presented by Volvo in 1986. The dummy facial area is covered by 52 of these sensors, each measuring the force applied to the different facial segments. An on-board data acquisition system stores the data from all sensors. After the test, a host computer retrieves the data and presents the force-time histories from each individual sensor. The load sensing face can be used to associate the applied force with facial bone fractures and other connected injuries such as contusions.

An accident study was made to try to answer the following questions regarding facial injuries:
- what is the proportion of severe to moderate injuries?
- which facial regions are most often injured?
- is there a difference between driver and passenger?

Volvo's analysis showed that approx 10% of the belted drivers that where injured in frontal to oblique/frontal accidents, sustained injuries in the facial area. It can be noted that the majority of the facial injuries was coded AIS 1 and to some extent AIS 2.

The driver facial injuries were then studied to establish which region had been injured. The injuries were divided into groups; laceration, abrasion, contusion, fracture and others. We found that the less severe lacerations dominated the number of injuries. The most complicated of these injuries, the fractures and the contusions, are presented from a severity, a locational and a proportional point of view in the figure below.

[Diagram showing facial injuries and their percentages]
Investigations of passengers statistics shows that less than 6% of the belted passengers injured in frontal to oblique/frontal accidents sustained injuries in the facial area. The facial injuries of the passengers did not exceed the AIS level of 3 at all, and only 4% of them exceeded AIS 2. Also among the passengers were the less severe lacerations dominating and fractures occurred in even fewer cases than among the drivers. Compared with the drivers, the front seat passengers sustained less frequent and less severe injuries. This can be explained by the absence of a steering wheel and thus a longer available deceleration distance for the passenger.

The analysis revealed that the majority of facial injuries is coded by the lowest AIS levels. The AIS scale is mainly a means of estimation the threat to life risk. The AIS in its present form, however, does not adequately measure the level of disability or the actual harm sustained by the individual. A disability scale that would complement the AIS and provide the link between injury assessment and societal costs is being pursued.

The various areas of the face are significantly different with respect to anatomical design, strength of the facial bone and the overlying soft tissue. Combined, this presents a complicated problem, i.e., the injury threshold differ substantially. The thresholds are also dependant upon how the force is applied. One should take into account both the impacted surface characteristics, as well as the impact direction, the specific pressure and the duration of the force subjected to the face.

We believe that the load sensing face is an excellent tool to evaluate injury thresholds and that it can find extensive use in future biomechanical research. This correlation between biomechanical data and measured parameters such as force or pressure to the facial segments, is necessary to make it possible to understand how to further improve the interior safety design.

With the help of the load sensing face it is possible to develop new concepts for increasing safety inside the car. Two such projects, recently revealed, are the mechanical pre-tensioner and the Eurobag, an airbag which is optimized for use in combination with seat belts. The mechanical pre-tensioner reduces the slack in the belt within the space of a few thousandths of a second, and helps to return the forward motion of the occupant in a collision. Eurobag is a fully integrated steering wheel airbag system which, in the same short space of time, activates and protects the driver from impact against the steering wheel.
6. CONCLUSION

The objective of the safety research at Volvo Car Corporation is to gain increased know-how about the mechanism behind car accidents and the incidence of occupant injuries and to feed this experience back into the long-term and short-term design and development work. Stringent safety standards, based on the experience from real world accidents, form the basis of the design work with the aim to limit the chances of accidents ever occurring and to limit injuries and facilitate speedy rescue work, should an accident occur.

Volvo’s safety work can be described as a continuous circle process which starts and ends in the real world traffic environment out on the roads. Accident investigations, laboratory testing and theoretical model simulations are combined in a conscious research and development strategy. Safety standards based on the field experience form the basis of development work, design and testing. When the testing shows that all safety standards are met, the new design is ready for production and the car goes out on the road. The circle is complete and the work goes on.

For the future safety work the following points are considered to be of importance:

It is important with harmonizing legislation on e.g. child safety and side impact as well as increased conformity between Europe and the US.

New legislation must be carefully introduced and not changed too often - the product design, development and testing procedure is a comparatively slow and costly process. It is difficult with big changes in the meantime.

Increased biomechanical know-how is important both for car manufacturer and authorities/legislators.
An evaluation study of the effectiveness of a combination of enforcement and information on improving seat belt use.

C.M. Gundy  
Institute for road safety research SWOV  
The Netherlands

In 1984 an intensive campaign, intended to increase seat belt use, was conducted in the Dutch province of Friesland. The campaign consisted of police enforcement, coverage by the (mass) media, demonstrations, etc. Simultaneously a national publicity campaign was performed which, however, was less intensive and did not include enforcement.

Multiple time series of measurements were made in Friesland, as well as in a control area, before, during and after the campaign. During these measurements seat belt use was observed and drivers were asked to answer a written survey. Analysis of the observations showed an immediate improvement in seat belt use of about 25 percentage points in Friesland. One year afterwards there was still an improvement of 12 - 15 percentage points above base rate. The control area showed only marginal fluctuations.

Older drivers, female drivers and drivers on trips outside built up areas were found to be more frequent seat belt users. There was, however, no interaction found between these effects and treatment.

The written survey had a response of about 46 %, with seat belt users and male drivers overrepresented. No bias was found in interaction with region or measurement series.

Further analysis of the survey showed relatively well informed Frisian respondents, who reported higher usage rates and who were somewhat more positive about legislation, enforcement and information campaigns about seat belt use.
IMPROVEMENT OF SAFETY BELT USE IN THE NETHERLANDS
Fred Wegman, Jan Mulder & Chad Gundy
Institute for Road Safety Research SWOV, The Netherlands

1. INTRODUCTION

In the plan new ways are indicated to call the attention of civilians and authorities to improve road safety. This appears a.o. from the introduction of an incentive program for local authorities, after the example of the "-10%-program" in France. The program fits in the policy of the Coordinating Minister for Road Safety to make local and provincial authorities pay more attention to road safety.
Another main stream is the choice for a limited number of favourable points of action. For the following themes a new policy will be executed: alcohol and traffic, speed-behaviour on roads with a 50-km or an 80-km speed limit, safety belts and crash helmets, black-spots, young and inexperienced road users, aged people in traffic.
Worth mentioning of the plan is also that the Government has pledged to achieve that there will be 25% less casualties in the year 2000. For the present governmental period this has been translated into 200 fatalities less in 1990 (than in 1985: 1438) and 1500 less in-patients (in 1985: 14520). In 1986, however the number of fatalities rose by 6% and that of in-patients by 1%.
The improvement of the use of safety belts is considered one of the favourable points of action. After the introduction of the mandatory use of safety belts for front occupants in 1975 the theme safety belts has had some attention, if not very much, in politics. A national information campaign was held regularly.
Policy makers directed their attention especially to legislation on the mandatory presence of safety belts (child's seats!) and use on back seats.
The use of safety belts hardly changed in the Netherlands and there have not been reasons to expect a change without far reaching measures.
Renewed attention for the improvement of the use of safety belts has been roused also by developments outside the Netherlands. Reports from the Federal Republic of Germany and from the United Kingdom informed us that use rates of over 90% had been reached in those countries. The rates did not appear to go down in the course of years (Marburger et al., 1986 and 1987, Scott and Willis, 1985, Department of Transport, 1986).
Herewith the Dutch rates of 67% outside built-up areas and 50% inside built-up areas contrast sharply (Fig. 1).
Arising questions were:
- which possibilities have been proven successful in and outside the Netherlands to stimulate the use of safety belts?
- is it realistic to expect to reach usage rates of 90-100% in the Netherlands?
In this contribution the use of safety belts in the Netherlands will be described and the possibilities to stimulate the use will be discussed. Research on the effect on safety belt use of combined information and enforcement actions on a regional scale in the Netherlands will be reported.

The contribution ends with conclusions and recommendations for policy and research.

2. SAFETY BELTS IN THE NETHERLANDS

In June 1975 the use of safety belts became mandatory for front seat occupants of cars that had come on the road since January 1971. Between 1975 and 1979 the presence of belts in cars rose from 70% to a 100%. SWOV reports yearly on the use of safety belts, most recently in 1987 (Arnoldus & Scholtens, 1987). The following data have been taken from this report. Before mandatory safety belt use the use rate of drivers of cars, in which belts were present, was 13% in built-up areas and 28% outside built-up areas. Within one year the rates rose to 49% and 67% respectively. The development of the rates is shown in Fig. 2. In 1980 the highest rates have been measured: 57% inside and 73% outside built-up areas. In later years rates have come down and remained more or less constant: 50% inside and 67% outside built-up areas. Passengers use belts more often than drivers (some percents only). The use rate has hardly been different with a passenger in the front seat (some percents more if there is one) in later years. Differences in use rate between men and women are small (Fig. 3). Young men (<25 years) wear the belt less than older men (>25 years). Older women (>50 years) wear the belt more than younger women (<50 years).

Drivers of older cars use the belt less than those of newer cars. The average use rate of drivers of cars younger than one year was 72% outside and 55% inside built-up areas in 1985, whereas the use rates in cars older than 8 years were 55% and 41% resp. It has not been established to what extent this fact is connected with the age of the drivers, but it seems plausible.

There appear to be important differences in use rates between the survey sites: the extremes are found in The Hague (inside built-up area) 30% and Eindhoven (on a motorway) 82%. On motorways the rate is highest and it goes down as roads of a lower order are concerned.

To summarize: from the development of the use rate in the Netherlands it is apparent that the mandatory use of the belt and the publicity going with introduction were important measures to stimulate the use. But it is also clear that making the use mandatory is not sufficient to bring about a complete compliance. It is not known whether in later years measures to stimulate belt use were effective. If they were, they counteracted a further decrease of belt use.
3. CHARACTERISTICS OF BELT USE

The results of the surveys in the Netherlands are in accordance with reports in the literature on factors influencing belt use (Jonah & Lawson, 1985, Marburger & Meyer, 1986, Plaizier, 1986) from countries with mandatory belt use. Plaizier distinguishes demographic, situational and psychologic influencing factors and discusses some dozens. On the basis of literature he gives a list of motives in favour and against belt use, but it was not possible to rank them according to their importance based on research results (Table 1).

It is important to realize that there are interactions between the influencing factors, e.g. average younger drivers use older cars, a ride on the motorway is longer, women are relatively more often passengers with a male driver than the other way round etc. This arouses the question whether the factors are causally or spuriously correlated with belt use.

An other problem is that many of the data are obtained by asking persons (vehicle owners, licence holders, drivers) after the motives of their said behaviour, without the possibility to relate the answers to their actual behaviour.

For example in the Netherlands research (not yet published) has been done, asking licence holders whether they had used their safety belts during their last ten trips. From the answers it appears that 65.7% used their belts during 8 or more of their last ten trips, 14.7% used them 3 to 7 times and 19.6% 2 times or less. Comparison of these figures with the current figures makes it clear that the answers are giving too rosy a picture of the situation.

The real motives not to wear a belt are not sufficiently known to be reckoned with in policy design. Nor is it clear to what extent the change of a certain motive influences the use of belts (positively). But one can certainly make use of the existing knowledge on influencing factors to carry out effective belt use stimulating programmes.

Interesting research might be a.o.:
- use of safety belts at night (with a high share of single-vehicle accidents) in connection with the use of alcohol and the age of drivers and passengers;
- the audience effect, that is the influence of the passenger on the use of the belt by the driver (and the other way round);
- insight in the decision process of non-wearers, distinguished in incidental and consistent non-wearers;
- possible explanations for the differences (factor 2%) in belt use on the survey sites.

In a number of studies use of a belt and driving behaviour have been related. Risky behaviour has been made operational via gap acceptance, drive with shorter headway, responses to yellow/red traffic lights, speed in sharp curves etc.

The different researches (Evans et al., 1982, O'Neill et al., 1985, and Mackay, 1985) indicate that the use of a belt does not influence driving behaviour significantly and that non-users apparently take greater risks in traffic than users. From American research some indication has come that non-users are more often involved in accidents than users and have more violation points (Wasielewski, 1984, Evans et al., 1983).

From these results two conclusions can be drawn:
- The results do not confirm the risk-compensation theory
(Peltzman, Adams) in so far as the use of belts would lead to
taking more risks in traffic, but the opposite seems more
apparent: belt-users take (took?) less risks.
- The results can be seen as a confirmation of the selective-
recruitment theory: "that as belt use rises each new group of
users is successively more likely to be involved in potentially
injury-producing accidents" (Hedlund, 1985).
If this theory is proven true it means a more than proportional
effect on the reduction of the number of casualties with the
rising use of belts. An application of the Law of Increasing
Return.

4. EFFECTIVENESS OF SAFETY BELT LAWS

Mandatory safety belt use induced a considerable increase of the
use of belts. In the Netherlands there was a rise of 40%. In other
countries too there was such a substantial rise (Vaaje, 1985).
The next question is then whether the higher use of safety belts
really has resulted in less casualties or less serious injuries
of the casualties.
From theoretical considerations and laboratory research it is
proven that belts could reduce the severity of injuries
considerably. Belts prevent car occupants from being thrown out
of the car and from being injured consequently and prevent serious
injuries caused by the contact of the car occupants with the
interior of the car.
There is however, no proportional relationship between use and
effectiveness of the mandatory belt law ("belt law performance").
Research to prove this is done best by comparing the distribution
of injuries of a large crash population among users and non-users.
This kind of research has last been done in the Netherlands in
1977. It has led to the conclusion that the effectiveness rate
(=fatalities saved by use of belts, compared to non-use) cannot
be expected to be lower than 60% (SWOV, 1978).
When using matched comparisons in research the question always
remains how far important influencing factors have really been
matched. When using national statistical data and comparing a
situation "with and without safety belt use" or, more often,
"before and after legislation" one always has to eliminate the
influence of other factors, e.g. by controlling for trends.

In his contribution to the "Workshop Effectiveness of Safety Belt
Use Laws" in November 1985 Hedlund presents the results of
research from 12 jurisdictions. They are summarized in Table 2.
They show a relatively large variation between countries in
effectiveness of safety belt use laws. Several explanations are
possible for this phenomenon. The effectiveness of belts is
dependent on the distribution of accident types and on the nature
of the accidents: the collision partner, the collision speeds, the
vehicle impact point, the passive safety of the vehicle etc.
Consequently there are differences between countries. It also
means that the effectiveness does not have to remain stable in the
course of time. Differences can be caused by the different extents
of mis-use or mis-functioning of belts. In the Netherlands no
research has been done in this field.
Finally differences in effectiveness can also be the consequence
of methodological problems in the research, e.g. if there is no
(sufficient) correction for trends or for seasonal fluctuations. The results Hedlund collected show that the higher the usage rate after legislation the higher the effectiveness is. This seems to be a confirmation of the selective-recruitment theory.

The Dutch estimations of the effectiveness need to be recalibrated, because the basic data date from 1977. International cooperation is recommended and "the double pair comparison method" (Evans, 1986) can then be used as a standard.

Such a recalibration is needed because different estimations of effectiveness can result in important differences in the number of casualties saved by belt use. Uncertainty makes it more difficult to explain national trends of the number of casualties in the course of time.

If there are 750 fatalities among car occupants and the effectiveness is estimated to be 60%, 200 more fatalities are saved by the belt than if the effectiveness is 40%.

5. STIMULATION OF THE USE OF SAFETY BELTS

It is too simple to hold the German and British national characteristics responsible for the high usage rates in their countries, after the introduction of mandatory safety belt use (to which Germany added a "Verwarnungsgeld" in 1984). As far as we know the high rates have not been predicted, nor can they be explained. This makes it more difficult to answer the question to what degree use rates of over 90% are realistic in the Netherlands.

However, the policy in the Netherlands is directed at a substantial and continuous rise of the safety belt use rate. Point of departure is the national legislation on mandatory safety belt use on front seats. In the framework of Dutch safety legislation the possibility has been mentioned to suppress mandatory use (because the law is not self-enforcing and enforcement is too labour-intensive), but it is not expected that this opinion will prevail. If mandatory use were to be suppressed a lower use would be expected and consequently a higher number of casualties. Worse: the discussion alone on this idea would have a negative effect on the use rate of belts.

The heart of the policy to stimulate safety belt use will be the habit forming: drivers must make it a habit to wear the belt, always and everywhere (Knapper et al., 1976). This means that all the arguments in favour of non-use (see Table 1) would no longer be acceptable.

Policy will have to be directed also to the individual decision process of drivers and passengers by influencing the (subjective) cost benefit appraisal of usage.

From (social) psychology several models are known which can be used as a basis to change the behaviour, as indicated above (Rooyers, 1985). The existing positive attitude towards use, legislation and policy to stimulate safety belt use can be exploited.

On the basis of current knowledge a program to stimulate safety belt use will have to consist of the following steps:
- the target group (Dutch drivers and passengers, perhaps divided in subgroups) has to be made conscious of the problem (draw the attention, explain the problem);
- the target group has to be convinced of the effectiveness of belt use (influencing the individual considerations of advantages and disadvantages of belt use);
- reward the use and punish non-use (effect behavioural change and maintain it).

When the program is executed general research findings can be used to raise the effectiveness and efficiency of such a program (rewards are more effective than punishments, combine information and motivation etc.). An important (negative) element herein is that rewarding use in the sense of making it bodily felt that a belt is effective in the prevention or reduction of injuries is hardly possible (15 fatalities in cars per billion km travelled in 1985 in the Netherlands). This lack of individual feedback may explain the non-existence of risk-compensation.

To stimulate belt use by rewarding drivers and passengers for wearing the belt has not been tested in the Netherlands. It has been tested in the U.S., as described by Geller (1984) in a review. It has to be kept in mind that there was no mandatory belt use in the U.S. and that low use rates were measured, in comparison with the Netherlands.

A wide variety of rewarding systems has been tested: gifts, raffle tickets (with the possibility to win a car!), an attractive parking place, discounts for special purchases etc. A number of examples is given where companies stimulate safety belt use by their employees (also from the economic point of view that companies have an interest in lowering the number of traffic casualties among their employees).

The American findings prove that the use of belts rises considerably by distributing rewards. The positive effect remained, though it decreased in the long run.

For the Dutch circumstances too it is interesting to test different rewarding based programs. The odds to win a reward and the nature and size of the prices would have to be varied. The duration and the various ways of execution (direct or indirect, delayed or immediate etc.) of the programs would also have to be diversified.

There are well-known possibilities of punishment. Insurance companies e.g. can pay less compensation in case no belts were used by the casualties. In the Netherlands this is already possible, but it is hardly known and may mean a missed chance in stimulating belt use.

Police enforcement and ensuing sanctions are another possible way of punishment.

Public information by itself is expected to have little effect, enforcement by itself, on such a level that the perceived risk of being caught is high enough cannot practically be executed. Now a combination of enforcement with information (on police enforcement), like it is executed in the Canadian STEP program (Jonah et al., 1982), is considered. Our conceptual model is to be found in Fig. 4.
6. EVALUATION OF DUTCH EXPERIMENTS TO IMPROVE SAFETY BELT USE

In the Netherlands improving road safety was mainly considered a responsibility of the national government. In the past national information campaigns for belt use have been held several times. SWOV regularly executed surveys on the use of safety belts, as mentioned before. The effects of the campaigns however, have never been explicitly evaluated. In the last years a tendency has developed to give more attention to road safety also on a regional level. Therefore so-called regional organs for road safety were installed. The province of Friesland was the first and decided to start a campaign to stimulate the use of safety belts. SWOV was invited to evaluate the campaign.

The evaluation of the campaign, conducted by Gundy (1986) was in fact an attempt to replicate the results of studies conducted by Jonah et al. (Jonah et al., 1982; Jonah & Grant, 1985) in Ottawa, Canada. They found that intensive enforcement and publicity campaigns result in immediate and impressive improvements in safety belt use. In addition to that the following questions had to be answered:

- Is there a differential effectiveness for different categories of drivers or for different patterns of safety belt use?
- Is there a negative public reaction to the campaign and if so what is its intensity and duration?
- Are some sources of information more effective than others?

The campaign was conducted in the Dutch province of Friesland, a primarily agrarian region with a population of 600,000 inhabitants. It requested the cooperation of more than 20 local, independent police forces who invested about 2800 man hours in enforcement activities (only 12% of the time originally budgetted). The campaign was extensively covered by regional and local newspapers and the regional radio station. To dramatize the necessity of safety belt use demonstrations were given with cars falling from a height of 10 meters and with collision simulators. Furthermore, local chapters of the Dutch Road Safety Association (VVN) supplied the public with folders, stickers etc.

As control region the northern part of the province of North Holland (otherwise known as West Friesland) was used, physically separated from Friesland by the IJsselmeer. Simultaneously a national safety belt publicity campaign was conducted which covered both Friesland and West-Friesland.

In Friesland as well in West-Friesland measurements were made in five waves in a period lasting from several months before treatment until twelve months after the end of it. Afterwards a sixth measurement wave was conducted, 24 months after the end of treatment. During a measurement wave the safety belt use of individual car drivers during work days was observed at traffic intersections equally spread over inside and outside built-up areas. Every other driver was handed a written survey and asked to return it by mail except in the sixth measurement wave. A total of 28,688 observations were made, 14,012 survey forms were handed out and 46% of them were returned.
Fig. 5 shows the usage rates, broken down by region, measurement wave and measurement location. It can be seen that as a result of the campaign there is an improvement in belt usage in the treatment region for both inside and outside built-up areas. There is no dramatic change in safety belt use in the control region. Log linear analysis found significant driver, sex and age effects: safety belts are relatively less often used by male drivers and younger drivers. No age or sex interaction with treatment was found: all age and sex groups were equally affected. However no plausible and demonstrable explanation was found for the apparent dip in safety belt use 6 months after the campaign had ended.

The sixth measurement wave, conducted 24 months after the campaign had ended, shows usage rates on approximately the same level as in April 1984, half a year after the campaign had ended. It should be mentioned that the Frisian police conducted enforcement activities in April 1986 at the same level as during the campaign. This however was not made known to the public. Because there was no written survey this time, it was not possible to check whether the public was aware of the police activities or not. If so, one can conclude that repeated short applications of enforcement tend to counteract backsliding. If not, it means the campaign has a smaller dissipation in time than supposed in the outset.

When the survey data were processed there appeared to be a certain selectivity: users and, to a smaller extent, male drivers are over-represented. There is no relationship with region or wave.

The survey covered a large quantity of variables, like the self-mentioning of circumstances when the belt is used, the reasons for non-use, the extent to which something had been read, heard or seen on the enforcement and or information campaign, whether legislation, enforcement and information are (or are not) acceptable and effective means to improve safety belt use etc. The main specific regional change in the pattern of answers was related to the fact that the respondents are reasonably well informed on the existence of the campaign, and by a vast number of information channels. This means that they had heard about it over the radio, had discussed it with other persons, had read about it in newspapers etc.

After the campaign drivers in Friesland also appear to state more often that they use their belts. They are fairly positive about legislation, enforcement and information and are relatively often of the opinion that much attention is paid to the belt. Apparently there are more positive than negative side effects.

This research has shown that an intensive campaign, in which enforcement and information go together can produce a considerable change in safety belt use, even for a year after the end of the campaign. The major result of the Jonah et al. study is clearly confirmed. Their other finding: a temporary negative public reaction could not be confirmed. On the contrary there was a small, measurable, positive reaction for more than a year after the campaign had ended. No difference has been found in effectiveness for the kind of trip or driver-type: a general, non-specific, growth in the use of belts seems to have come into existence. Most drivers appear to have been reached by (local) mass media and by word of mouth. Only few indicate to have been checked by the
police or even to have seen a check, though it was said that the chance to be checked during the campaign had grown. The organisation of exertions by the police and the motivation of the police for this kind of campaigns appear to be a difficult problem and much can be done to make their exertions more visible for the public. It is even possible that it is less important what the police does and the extent to which it is active as long as the road user has the impression that there is a strict control. The results show that some habit forming has taken place with a change of opinion going with it. It can be hoped that this campaign will end in a more stable change in behaviour, based on the possibility that drivers ascribe the fact that they use their belts more often, to their own sense instead of to the threat of punishment.

The fair success of the campaign in Friesland has caused a growing interest for the subject in other provinces. In the province of Gelderland a similar campaign was conducted in the months of March and April 1987. Police enforcement was intensified and information was given. Similar demonstrations as those in Friesland tried to convince the public of the necessity to wear a belt. Though no report has been published yet, from preliminary results a considerable improvement of user rates can be deducted (from +60% to 80%). The effect of this campaign is comparable to that of the Friesland-campaign, which again shows that a combination of enforcement with information can result in no little improvement in use rates. Interviewees say they wear their belts more often after the campaign, like in Friesland. No measurements are available yet to deduce the effect in the long term.

In the province of Drenthe police enforcement was intensified, but there was no or hardly any publicity. The police were induced to use the belt, assuming that they thus would be motivated to be more severe. Information meetings and demonstrations were held for them. Though there was, indeed, an intensified reinforcement, where non-use was immediately booked, measurements indicate that use has hardly grown. This might mean that intensified enforcement by itself is not an effective means to improve safety belt use, but that it is rather the combination with information that results in improvement.

The above shows that specific police enforcement of belt use, supported by information can induce a fair improvement of safety belt use rates. It is also clear that such a positive effect can be maintained for a longer period. Still an almost complete compliance is not reached, like it was done in the United Kingdom and the Federal Republic of Germany.

7. CONCLUSIONS AND RECOMMENDATIONS

1. Making the use of safety belts mandatory (1975) raised the use rate in the Netherlands by 40%. In the last few years safety belt use has remained more or less unchanged. There is no complete compliance with the mandatory use. From literature and on the basis of Dutch observations it is apparent that a number of factors and circumstances influence safety belt use.
Less is known on the measure of the influence and to what extent the changing of one of the factors (e.g. comfort, enforcement, information, knowledge on the effectiveness of belt use, social pressure etc.) influences the use rate. Recommended is to do more research on the individual decision process of non-users, the incidental and the consistent non-user groups.

2. From a lot of countries mandatory safety belt use has been reported to have stimulated belt use and that this has diminished the number of casualties. The extent of decrease appears to be different. The difference can partly be attributed to the use of different methods of research. Recommended is international cooperation to make it possible to compare the effectiveness of mandatory belt use in various countries. No confirmation of the risk-compensation theory has been found, in so far as the use of belts is supposed to lead to more risk taking in traffic. Some justification has been found for the selective recruitment theory.

3. Safety belt use stimulating programs should be based on adequate legislation on mandatory belt use and should be directed at habit forming, if they are aimed at a long-lasting raise of belt use. They are to be directed at the individual decision process by positively influencing the subjective appraisal of cost-benefit of belt use.

4. Three possibilities to influence this process appear promising. On the basis of Dutch experiments we expect that a combination of police enforcement and information, according to the model in Fig. 4, will effect a considerable improvement of belt use for a longer period. Recommendation: Further research into the effectiveness of different programs, in which the composing elements of public information and police enforcement are varied to reach an optimal mixture.

5. A second possibility is to reward users. No experience has been gained in this field in the Netherlands. From American research positive effects appear to have been reached, persisting for some time. Experiments are recommended with varying rewards and varying chances.

6. To experience an accident from which one escapes convinced of the necessity to use a belt does not happen too often. Recommended is to replace the experience by using collision simulators. It might be considered to have candidates for a driving license experience a collision simulation (with and without belt use).

7. As long as the decision to wear a belt at the beginning of a trip has to be left to the individual there is the possibility that no belt is used. There are possibilities to influence this choice in the design of cars and belts. Developments in the field of airbags and automatic restraints besides the possibilities to adjust the belt to individual wishes and to use more comfortable materials are to be considered.
National governments are to direct developments in this field and to make it more attractive for industry and research to operate innovatory.

Why state upper limits for environmental pollution for car emissions and dates for their introduction and not do that for the development of effective, user friendly, cheap and automatic belts?

LITERATURE


**Fig. 1. Usage rates in NL, FRG and UK.**

![Graph showing usage rates in NL, FRG, and UK over the years 1981 to 1987.](VTI_RAPPORT_328_A)
Fig. 2. Belt usage in the Netherlands.

Fig. 3. Usage rates inside and outside built-up areas (1984-'86).
Fig. 4. Conceptual model for the improvement of safety belt use.

Fig. 5. Usage rates in Friesland and control region.
<table>
<thead>
<tr>
<th>INTRINSIC MOTIVES FOR THE USE OF SAFETY BELTS</th>
<th>INTRINSIC MOTIVES AGAINST THE USE OF SAFETY BELTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of safety</td>
<td>Feeling of invulnerability, low estimation of the chance of an accident</td>
</tr>
<tr>
<td>Need of protection</td>
<td>Generation of general latent anxiety</td>
</tr>
<tr>
<td>Strictness and habit formation</td>
<td>Specific fear of drowning, burning or crushing</td>
</tr>
<tr>
<td>Anxiety for accidents</td>
<td>Indifference, laziness</td>
</tr>
<tr>
<td>Strive for peace of mind, limitation of sense of guilt</td>
<td>Forgetfulness</td>
</tr>
<tr>
<td>Medical self care</td>
<td>Disturbance of driving pleasure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXTRINSIC MOTIVES FOR THE USE OF SAFETY BELTS</th>
<th>EXTRINSIC MOTIVES AGAINST THE USE OF SAFETY BELTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Law abidance</td>
<td>Feeling of deprivation of freedom by legislation</td>
</tr>
<tr>
<td>Avoidance of being fined with intensive surveillance</td>
<td>Lack of police enforcement, small subjective chance of being caught</td>
</tr>
<tr>
<td>Social pressure of family and friends</td>
<td>Ridiculous appearance, shame, threat of prestige as a capable driver</td>
</tr>
<tr>
<td>Effectiveness of belts</td>
<td>Uncomfortable in short distances</td>
</tr>
<tr>
<td>Comfort of belts</td>
<td></td>
</tr>
<tr>
<td>Ease of operation</td>
<td></td>
</tr>
<tr>
<td>Assessment of danger in traffic situations</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1. Motives for and against the use of safety belts.**
(Source: Plaizier, 1986).

<table>
<thead>
<tr>
<th>Country or State</th>
<th>usage %</th>
<th>fatality</th>
<th>injury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre post</td>
<td>years</td>
<td>count</td>
</tr>
<tr>
<td></td>
<td>law</td>
<td>law</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>15</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>Victoria</td>
<td>15</td>
<td>48</td>
<td>4</td>
</tr>
<tr>
<td>Canada</td>
<td>24</td>
<td>50</td>
<td>11</td>
</tr>
<tr>
<td>New York</td>
<td>16</td>
<td>57</td>
<td>1</td>
</tr>
<tr>
<td>Denmark</td>
<td>19</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>Switzerland</td>
<td>37</td>
<td>76</td>
<td>2</td>
</tr>
<tr>
<td>Israel</td>
<td>10</td>
<td>80</td>
<td>4</td>
</tr>
<tr>
<td>Sweden</td>
<td>35</td>
<td>84</td>
<td>2</td>
</tr>
<tr>
<td>New Zealand</td>
<td>33</td>
<td>86</td>
<td>4</td>
</tr>
<tr>
<td>Norway</td>
<td>59</td>
<td>87</td>
<td>2</td>
</tr>
<tr>
<td>Germany</td>
<td>58</td>
<td>92</td>
<td>1</td>
</tr>
<tr>
<td>UK</td>
<td>40</td>
<td>94</td>
<td>4</td>
</tr>
</tbody>
</table>

Years: total data collection period, pre- and post-law
Count: aproximate number of occupant casualties during the data collection period
Perf. : estimated belt law performance
Injury: defined differently in different countries
* driver only, 2 years of data

**Table 2. Belt usage changes and casualty reduction performance of belt use laws.** (Source: Hedlund, 1985)
ROAD TRAFFIC SIGNING ON TWO CONTINENTS - A CALL FOR HARMONIZATION

by Michael Bernhard, Traffic Engineer SVI ITE, Switzerland

SUMMARY

With today's travel possibilities, any-one can hire a vehicle any-where and drive in foreign countries on different continents at any time.

Road signing is the means of giving such drivers the necessary messages allowing them to drive safely and thus ensure the safety of local populations as well as their own! It must be easily understood, seen in time and recognized early enough for correct decision-making at all times, day and night. In addition, the state of maintenance of road signing is often such that the essential messages are not always perceived as they should be.

The present paper will outline the international legal documents from which national legislation is derived, and show where some "missing links" still need to be clarified between the different systems used today on roads of the two continents which are the Americas and Europe.

Road sign visibility, legibility, brightness etc. are essential to their understanding and depend also on many factors such as vehicle lighting systems, language understanding and the use of symbols on signs. In addition, the shapes of certain signs are different and can lead to serious misunderstandings if not correctly used on the road. Colour-codes used on direction signing and also road work signing differ in many countries and also from continent to continent leading to unsafety situations sometimes...

There is still much to be done in the field of harmonization as will be illustrated and it is hoped that the current revisions of the international legal documents will lead to great improvements on the international scene of road signing by the turn of the century.
1. INTRODUCTION

International travel is commonplace in these modern times. More and more people are reverting to hiring motor vehicles far from home in totally new environments with different driver behaviour, road signing systems strange to their habits and, above all, road traffic rules unfamiliar to them. They discover that road signing systems differ even from country to country on a same continent - in particular in Europe.

These systems of message conveyance along roads are the only key to their own personal behaviour at the recurring critical points along their routes, and thus their safety and that of the local inhabitants depends greatly on the quality of road signing. Ask any foreign driver what is the main safety element in their opinion; the answer is invariably the quality or more often than not, the lack of quality of road signing guidance at night!

In fact, local authorities are judged by the state of repair of their road network. Road signs and markings are the ambassadors to this judgement.

The quality of road signing depends on many factors. Design, colours used, size, shape, contrast with the environment, legibility and symbols are all part of the requirements set down in the legal documents of a country. These in turn are based on international legislation and in spite of this, almost every-one is in agreement that a better harmonization is necessary around the world. One does see different signing systems on the two continents under discussion at this TRB - VTI Conference here in Gothenburg. A call for harmonization is necessary, and here is why.

2. INTERNATIONAL LEGISLATION

The well known 1968 United Nations Conventions on Road Traffic and on Road Signs and Signals, better recognized as the "Vienna" Conventions exist now for almost twenty years. Yet they still have to be ratified by numerous governments around the world, which signed them back in 1968 and which have not yet adjusted their
domestic legislation and specifications or standards to the basic clauses of these Vienna Conventions. For the European countries, in addition to the above documents which allow in certain cases for several systems of signs and their interpretation, there are the 1971 European Agreements supplementing them. These Agreements are in fact the harmonization of practices applicable to all Europe. Yet they too, have not all been fully accepted by many governments. In other words, around the world, a large number of countries still use the international legislation elaborated and ratified back in ... 1949.

So, the first step to harmonization around the world is still the same old song: all governments are urgently requested to adhere to - i.e. sign and ratify - the 1968 Conventions and for Europe, to the European Agreements supplementing them. These documents entered into force in 1977 and 1978 respectively, by the way!

Now, the Economic Commission for Europe of the United Nations, responsible for the world-wide legal documents touching on road transport, is currently preparing the amendments to these legal documents. Indeed, traffic conditions have moved ahead since 1968 and there are many international recommendations which have to be added to them. This is an ideal opportunity for governments to make suggestions for improving road signing in general and now is the time to turn these into facts.

The amendments cover all sorts of subjects, ranging from vehicle lighting systems to road signs, signals, message conveyance, minimum technical requirements, in fact anything to do with enhancing road safety and transport comfort.

The amended documents should be the base for all governmental decisions of the future where better harmonization can be achieved.

Road safety will certainly be improved if this call for harmonization is taken notice of. Industry and governments alike are directly concerned!

3. COMMON MARKET SINGLE TREATY ACT

By the year 1992, it is the intention of the European Parliament to remove all non-tariff barriers between the 12 Common Market countries. Thus a free Common Market will take shape sooner than one could imagine a few years ago. How does this influence the road signing systems found today in these 12 countries?
Well, a careful consideration of the 12 different legal requirements for the installation of road signs, horizontal markings and other signals shows that there is a large consensus on many aspects but also large differences regarding the technical standards accepted.

In other words, an urgent call for harmonization is again to be taken heed of before elaborating the final European "code of practice" regarding road signing in the 12 Common Market countries. This work is just starting now and the time is ideal to establish a common practice through legislation and specifications of high quality.

1992 is just around the corner and it is absolutely indispensible that the responsible officials of the 12 governments and the industries concerned get together to elaborate a totally new, modern and efficient Common Market Directive regarding road signing.

This opportunity must not be lost to obtain a high quality road signing system aligned both to the United Nations documents mentioned earlier and to a harmonized system as close to the requirements of both continents, and naturally all other European countries.

The "missing links" between the different national requirements of governments on both sides of the Atlantic are still numerous. Let us look at certain aspects where harmonization is easily attainable.

4. VISIBILITY, LEGIBILITY AND BRIGHTNESS OF ROAD SIGNING

Drivers' understanding of vertical road signing messages depends essentially on the fact that signs are to be easily detected in the often complex environment, recognized and finally read or obeyed at sufficient distances which in turn, depend on the speed of traffic.

As said earlier, during daylight this is not too difficult if the sign is in good condition, but at night the whole situation can become very unpleasant or even dangerous unless the signing is well designed and installed.

In fact the same applies to horizontal markings as well.

There is no way of getting around the problem unless the best quality materials are used in the first place. Modern road signing technology is now at a stage where it is safe to say that one is a long way down the road of progress. Unfortunately, many responsible authorities
are reluctant to accept this fact and still revert to "old-fashioned" methods decided on years ago. Too often the attitude of "we've been doing so since years and why should we change" prevails in discussion regarding the renewal of legislation and maintenance problems.

Here again a call for harmonization requires new thinking and initiative so as to catch up on the technological progress often ignored.

Modern signing materials, both for vertical road signs and for horizontal markings are better in colour, durability, day performance and night visibility than they have ever been.

It is easy to see that the use of high-quality materials which perform better and longer out in the field is the only solution. In other words, harmonization on the two continents should provide for requirements to use high-performance materials on road signs and for road markings in the interest of government budgets and naturally road safety.

Modern economy requires better budget performance on both continents, and energy control makes life of responsible authorities for road signing difficult. It is no longer the case that huge electrical installations can provide for illuminated road signs without reserve. Today, one has to revert to less costly methods and the development of high-technology retroreflective materials allows for the installation of cheaper signs on the road networks of the world. Also, the development of electronic safety systems on vehicles, such as the on-board message transmission of messages, will always rely on the good old traffic signs which have to be easily seen both by day and by night.

The future harmonization of road signing should consider only the installation of retroreflective road signing which can be externally illuminated when or where-ever this is needed. In this way, the colours, durability and efficiency of road signs out in the field will be assured for periods of ten years or more at a time when high-performance materials are specified.

One should not underestimate this last statement, since the question of road sign maintenance is not to be neglected either; more on this later.

Legibility of road signs depends on two main factors: contrast between the letters and the background and, colour recognition. To optimize both these needs the
technical requirements should allow the responsible authorities a choice of combinations of retroreflective materials of different brightnesses for the backgrounds and the lettering for a given sign at a specific location. This is a new trend of thought which still needs some research and development before modifying the existing international specifications and standards commonly referred to at the present time.

International harmonization, therefore should not exclude this future development. However, it should provide for it from now on! There are several factors of direct influence on this and here is a real cause of concern should there not be serious efforts to harmonize certain technical aspects under study now on both continents.

5. INFLUENCE OF VEHICLE LIGHTING ON ROAD SIGNING

Any-one familiar with vehicle lighting questions knows that there are three main dipped (or passing)beam patterns in the world. The American system, the Japanese and the European systems. Discussions on their harmonization have started some time ago, and each continent is doing research on developing a new harmonized type of passing beam pattern. However, it has become obvious that each party feels that the system in use in its part of the world is the best suited for the others ...

Harmonization starts when, as the Oxford dictionary says when there is "a combination or arrangement of parts to form a consistent and orderly whole, agreement and congruity". Well, this has not yet happened as far as the passing beam is concerned.

However, the elaboration of a passing beam satisfactory to all parties on all continents will certainly bring about enhanced road safety at night.

Road signs in Europe should have the same night performance as those in the USA. Well, with the two different vehicle lighting systems prescribed at present, this is certainly not the case! One must not forget that the high performance retroreflective materials used are the same on both continents, and that here at least is a harmonized practice!

As an example, measurements have shown that, at a distance of 184 meters (600 feet) a shoulder-mounted sign to the right edge of the road, made of high-performance encapsulated lens sheeting the luminance is for the USA
passing beam system $37 \text{ Cd/m}^2$ and that of a European passing beam is $17 \text{ Cd/m}^2$. This difference is not to be neglected when discussing harmonization!

In other words, at night, European drivers who drive in general at higher speeds than in the USA, see road signs less well at similar distances than their colleagues on the American continent.

Much has to be done to obtain harmonization of road sign performance at night and the automobile industry and the lighting industry should consider this aspect when developing new vehicle headlamp systems.

Until this has been achieved, road authorities must set up the brightest possible road signing systems, especially in Europe!

6. DIRECTION INDICATION SIGN COLOURS

On the American continent, all of the direction indicators have a green background and white lettering. Here is a perfect example of harmonization.

In Europe, again, the situation is totally different. The colour of the background of such signs gives an indication as to the category of road one drives on. There are in most countries colours reserved for motorway indicators and others for the normal rural roads which can in some cases be divided into main arteries and secondary arteries.

This gives a colourful image to drivers and could be a safety factor should the colours chosen always be the same ...

Well, this is not the fact, and in Europe one sees either blue or green backgrounds for motorways and also blue or green used in some countries for rural roads, not to mention yellow and white backgrounds in others!

A call for harmonization of this has been made many times over the years, but which government is ready to assume the huge investment to make the change to another colour system?

There may just be an opportunity to encourage a common system in Europe - which should choose a similar colour for the motorway systems as the USA to finally obtain harmonization - in the European Single Treaty Act mentioned earlier.
7. TRAFFIC RULES AND ROAD SIGNING

The driving environment on the two continents is in many cases quite different. In Europe, roads are often narrower, more windy; villages and towns are closer and their lay-out more complex as far as roads are concerned. Intersections are less easy to see than in the USA. There, roads are wide, less compactly built-up and in general visibility is far better.

Hence, traffic rules are different regarding same signs in certain cases. This can be confusing to foreign drivers.

For example, in the USA, drivers approaching an intersection with the obligation to give way obtain this message either through a STOP or Yield sign. Often rural intersections even have four yield signs and the sequence of priority is on the first come - first go basis. If this is not the case and one road is has the priority, then those drivers on it receive no message and may just drive on.

In Europe, the system is totally different. There, both the priority and the yield signs exist on each branch of road in the intersection. Without debating which is the better system, it is to be pointed out that this lack of harmonization can lead to confusion and even accidents.

In other cases, it has been noticed that authorities, even when using similar signs, interpret their meaning differently and thus give them a different significance in different countries! Others even invent new signs which do not have any meaning to foreigners and which evidently do not comply with any international document. When driver behaviour depends on them, and fines are given, drivers are generally the loosers...

The basic rules and regulations should be the same on both continents for obvious reasons and a call for the ratification of the above-mentioned legal documents is all the more urgent on both sides of the Atlantic.

8. ROAD SIGN MAINTENANCE

When driving around Europe or in the USA, any-one will see that the level of maintenance of certain, if not numerous road signs, signals and markings is far below what one expects.

Local authorities are still today little concerned with
what happens to their investments, once they are out on the roads. Signs are installed and promptly forgotten, road markings layed down and left to their own for months or even years without a drop of refreshing paint or plastic...

In Europe, usually the best time for well marked roads is from Spring until end of Summer. When the bad season comes around, often the road markings are soiled or even erased. What is left is often destroyed during the winter season especially where snow conditions prevail.

Road signs which are usually made of materials which ensure that they work as required at least for seven to ten years depending on the types of material used, tend to be there at the side of the road up to fifteen or more years. One even sees in certain parts of Europe signs crumbling away from rust!

Governments must be made aware that if signs fail in their duty of conveying messages to drivers, they become a potential accident hazard. They must be made aware of the fact that the initial investments on high quality road signs is finally a cost-effective measure only if at the same time budgets are allocated to regular maintenance programmes. Each community or local authority must possess an inventory of the road furniture which allows it to monitor each year the date of manufacture and state of each individual road sign, of all road markings and naturally of all safety devices along the roads.

9. CONCLUSION

The turn of this century is just around the corner! Road safety is one of the greatest concerns of every authority on both continents, where the toll of road accidents reaches alarming proportions today. Everyone is willing to improve road safety but is frustrated when reviewing the statistics each year.

The time has come where governments sit together to try to harmonize some measures, as has been seen during the 1986 European Year of Road Safety. Many resolutions and recommendations were agreed upon in numerous conferences and symposiums, but the toll of road accidents remained stable, unfortunately.

As has been said earlier, new efforts are initiated on both sides of the Atlantic to find ways of reducing accidents and their severity, sometimes with similar decisions. Everyone is ready to do anything to succeed.
Well, perhaps one resolution could be taken by this conference, namely an urgent call for harmonization as follows:

Governments and competent authorities are urgently requested to take the necessary decisions to improve harmonization of traffic rules, regulations and road signing by:

- Adhering to the existing international Conventions and Agreements in force today;
- Contributing to the work under way to amend them and adapt them to modern traffic conditions in the competent international bodies;
- Adopting common technical criteria for high-performance road signing devices and road safety installations;
- Establishing regular maintenance and replacement programmes for all road furniture in conjunction with road maintenance programmes.

Should these recommendations be heeded, there will certainly be an improvement of the road safety levels in each country on both sides of the Atlantic. It should be possible to achieve this harmonization by the turn of the century, for the safety of our children.
ROAD SIGN RESEARCH IN WEST GERMANY

by Prof. Dr.-Ing. Siegfried Giesa, Director of Roads, Highway Administration.

As in most industrial nations, the building of new roads and highways is on the decrease in the Federal Republic of Germany. In comparison, maintenance and improving the quality of existing roads are becoming increasingly important. The traffic policy objective is, therefore, higher quality instead of quantity. This aim is also of great significance for road signs.

A prerequisite for quality control and quality improvement in road signs is systematic inventory. Various methods of taking inventory have been analysed and assessed, and criteria for the application of individual methods have been established. With regard to light-technology properties, principles for constructional design have been worked out (non-reflective, reflective, highly reflective, illuminated). Furthermore, processes have been developed to improve road signing, continuity in designation of destinations and accurate information on distances are to be ensured. Identification of destinations in road maps is another significant research project. The growth in international traffic in Europe increasingly requires the use of symbols and pictograms on road signs. Suitable pictograms have been prepared. In order to increase safety in areas of road works, principles for nighttime marking of road works have been established. Guidelines have been developed for checking and testing collision-proof (barricades at construction work zones).
ROAD SIGN RESEARCH IN WEST GERMANY
Prof. Dr.-Ing. Siegfried Giesa
Chief Director of Highways
Highway Administration

1. INTRODUCTION

The road network of the Federal Republic of Germany has been well expanded and adapted to the requirements of modern traffic during the past few years. The future requires that existing roads and highways are maintained and, where necessary, improved. The traffic policy objective with regard to roads and highways is more quality instead of quantity.

More quality also applies to the way roads are equipped, i.e. road signs, identification of destinations, markings, safety and crash-prevention equipment. In the interest of safety it is no longer justifiable to renew lane markings only when they are worn out, that road signs are invisible at night because they do not reflect sufficiently, crash barriers along the shoulders of the road are left to just rust away, construction sites are not sufficiently marked at night. Despite a relatively high standard of road equipment in the Federal Republic of Germany, it will still require considerable efforts to fulfil the traffic policy objective of higher quality in this sector as well.

2. INVENTORY

In the following you will find an outline of current problems and the present level of research in the field of road signs and traffic installations in the Federal Republic of Germany.

More quality for road equipment is hardly a financial problem but rather a management task for road maintenance. In order to be able to fulfil this task it is necessary to systematically compile an inventory of existing road equipment. Recommendations for this process are included in the "Information on Taking Inventory of Road Signs" which was completed by the Roads and Traffic Research Association (FGSV) in 1987. Taking inventory involves the following steps:
- Recording and processing
- Continuous up-dating
- Filing and storing
- Evaluation and presentation

As a rule, inventory should only be taken if there is certainty that it will be continuously up-dated. If the costs of continuation are too high one should check whether it would be more beneficial to record the existing stock at certain intervals, e.g., every 4 years.

We differentiate between several recording methods
- Recording in lists
- Computer-supported recording, i.e., recording where the relevant data is not entered into lists but fed into a micro-computer and later on evaluated with the help of simple programmes.
- Photographic recording
- Video-logging.

The data is recorded under two aspects, i.e., hardware data which represents structural, material and equipment characteristics, and software data which represents sign contents, e.g., information about destinations and distances on road signs, the meaning of a sign.

The main objectives of taking inventory are
- Increased traffic safety
- Increased efficiency
- Improved information on existing equipment (e.g., value of inventory, replacement costs)

The choice of inventory method depends on local conditions, the recording volume and the targets one aims for. If, for example, the inventory value and the replacement requirements for all signs of a medium-sized line-oriented road network are to be determined, one will most probably decide in favour of video-logging with subsequent computer-supported partial recording of invisible properties on account of the large amount of data to be recorded and the extent of territory to be covered.
In this context the question arises how large the sign inventory is on the various types of roads. Representative investigations resulted in the following values (Fig. 1):

- BAB (Federal highways) 15 signs/km
- B roads (National roads) 17.1 signs/km
- L roads (Provincial roads) 16.5 signs/km
- K roads (County roads) 14.1 signs/km
- Urban roads 25.8 signs/km

If we multiply the kilometre values with the actual lengths of roads in the FRG we obtain an inventory of approximately 10.5 million signs.

3. LIGHT-TECHNOLOGY PROPERTIES

In the case of new or replacement signs one has to make decisions on the choice of designs with regard to light-technology properties. The following factors influence this decision:

- Brightness of the road surface at night or in darkness
- Interference effect of the environment
- Viewing distance
- Type of location and amount of dirt accumulation to be expected.

The Highways and Traffic Research Association has, in cooperation with the German Road Construction and Traffic Laboratory (BASt), developed "Recommendations for Selecting the Design with Regard to Luminance Characteristics". These recommendations are summarised in a table (Fig. 2 and Fig. 3) which serves as decision-making aid when road signs should be equipped with Type 1, Type 2 reflective film or when they should be illuminated.

In the case of some road signs which are relevant to safety the requirement is that they are always designed with reflective film 2, e.g. as in the case of signs regulating the right of way or signs before railway crossings (Fig. 4).
Currently photo-mechanical methods are being tested which allow measuring of the quality of the reflective effect of a sign. It is not sufficient to erect a sign of reflective design and do no more about it. It is well known that even the best reflective films will age in the course of time and the moment will come when such a sign has to be replaced as it is no longer sufficiently reflective. Work to find solutions to these problems is still under way and there are no final results available yet.

4. DIRECTIONAL ROAD SIGNS AND PICTOGRAMS

Indication of directions, an important element of traffic control, significantly influences traffic safety. A motorist who has lost his orientation usually has to stop, ask the way, turn round, reverse. All these operations can lead to accidents, particularly as motorists who have lost their way often react unpredictably and angrily.

The requirements set for good traffic-technology directional indication with regard to hardware and software have been laid down for the Federal Republic of Germany in the following two publications:

- Guidelines for Directional Road Signs on Federal Highways (1986)
- Instructions for Signposting on Roads other than Federal Highways (1980)

These are the most important rules laid down in these publications:

- Colour rule

  The colour of the sign - blue, yellow or white - indicates whether the destination can be reached via a Federal highway, a rural road or an urban road (Fig. 5).

- Continuity rule

  A destination that has been indicated once must reappear again and again on the signposts along the road until the destination is reached and must not be lost.
- **Distance rule**

The distance between two destinations A and B must always remain the same, no matter from which point between A and B these two destinations are indicated (Fig. 6).

Although the theoretical principles for good directional signposting have been fixed and practicable instructions are available there are still a variety of flaws in the directional signposting system. The elimination of these faults is much less a technical, but rather a management task.

Increasing international traffic requires that more and more internationally understandable symbols and pictograms are used in signposting. The Highways and Traffic Research Association has developed suitable symbols which are easily recognisable and understandable. The following requirements had to be fulfilled:

- It must be possible to use the symbols in circular, triangular and rectangular road signs.

- There must be sufficient contrast in brightness, colour and shape.

- It must be possible to use the signs analogous to the direction.

- It must be possible to reproduce the symbols in various sizes so that they can also be used for maps, for example.

A further objective was to achieve an optically uniform overall impression of all signs by means of the type of illustration and the graphic style (Fig. 7).

All symbols are developed with the help of a design grid and tested for their nighttime visibility before a reflecting background in a reflecting and a non-reflecting design (Fig. 8).

The fact that the symbols can also be used on maps in a reduced size is to create a close connection between maps and the symbols and pictograms used on directional signposts and other road signs.
Furthermore, pictograms for destinations of pedestrians were developed because a motorist leaving his car in a multi-storey car park will, for example, look for the lift, the escalator or the entrance to the Underground. He is to be guided to his destination by the same system of symbols.

Pictogram development was the stimulus for the German Road Construction and Traffic Laboratory (BASt) to graphically revise the official road signs with the aim of making road signs dating from different periods of time more uniform, sensible and aesthetic in their graphic design (Fig. 9).

5. SAFEGUARDING ROAD WORKS

In the Federal Republic of Germany extensive research has been carried out in the field of safeguarding road works during the past few years.

As serious accidents occurred repeatedly due to collision with barrier equipment Guidelines for the Requirements Regarding Construction and Passive Safety of Barriers were prepared. Barriers must withstand a collision test with a crash speed of 80 ± 2 km. In this collision the barriers and their appertaining warning lights must not cause any hazard for the car passengers or any other persons. This means that in the collision test:

- no parts must enter the passenger cell
- no parts must be hurled away (except light-weight parts of less than 100 g)
- heavy parts may only be dragged along by the colliding vehicle
- individual parts of the vertical structural elements must not separate.

These stringent requirements have resulted in industry developing barriers which offer an extraordinarily high degree of safety in comparison with previous constructions (Fig. 10).

In order to safeguard short-term or mobile construction sites on Federal highways or other high-speed roads, warning trailers have been developed which will warn traffic participants at great distance by means of a luminous arrow. The luminous arrow can be turned and thus allows the use of the warning trailers both
on the right hand and the left hand side. Practice has shown that these warning trailers are very effective (Fig. 11).

In order to prevent collisions with oncoming traffic in areas where traffic is diverted from one lane to another near road works, easily installable crash barriers on a metal foot have been developed which have almost the same effect as normal crash barriers. This construction can also be used to safeguard longer-term work sites along the side of the road and to protect the workers on the site well (Fig. 12).

If the firms working on or alongside the road are not responsible for safeguarding their work sites, tenders for safety measures are sometimes invited separately. The FGSV has prepared Instructions for Describing the Performance of Traffic Safety Installations for bidders; the instructions include text proposals for individual positions of the performance index. The objective is to safeguard work sites as uniformly as possible and correctly from a traffic-technology point of view. A check list contains all elements of safeguarding work sites.

In this context a technical further development in sign construction should be mentioned which can also contribute to increasing passive safety. This is the manufacture of signs from a substrate material without the use of rivets and without any welding of the frame. The signs get their required rigidity from a beading and consequently are without sharp edges. They can easily be fastened to the pole without having a borehole (Fig. 13).

6. INFLUENCING TRAFFIC

Influencing traffic is a complex overall system of a number of partial systems. A multitude of individual traffic-technology measures are to help in "using roads more intelligently" and consequently increase traffic safety and improve the flow of traffic. These measures often cannot be clearly attributed to influencing traffic or traffic flow control as they not only have traffic-technology effects but also include legal traffic aspects.

With light signal installations, which can be viewed as a system influencing traffic in a wider sense, there are currently two problems of special significance in the FRG:
The signal installations are switched off during times of low traffic volume and during the night.

With a view to environment protection the demand is increasing that signal installations are switched off during times of low traffic volume and during the night, as there is the wide-spread opinion that fewer vehicles are stopped this way and consequently fewer exhaust fumes are emitted. One has the impression that questions of traffic safety are treated as a secondary issue. The question of switching signal installations off has been and still is discussed in various committees in the Federal Republic of Germany, with one side pleading for switching off the majority of signs during the night and the other side rejecting this measure, in most cases for safety reasons. The recommendations published in 1985 by the Highways and Traffic Research Association propose that "only such installations are considered for switching off where there is clearly no longer a safety requirement during the times of shut-down. In all other cases light signal installations should be switched off only in a very restricted manner on account of the increased accident hazard".

It is furthermore proposed that the special traffic conditions at nighttime are taken into consideration by installing modified "night programmes" with short cycle times or special traffic-dependent controls.

Turning the engine off at a red light

An additional environmental problem is switching off the engine at a red light. As a motorist stopping in front of a red light normally does not know for how long the red phase is going to last, he should be asked by a blue light to turn off his engine as the red phase will last for more than another 10 seconds. Tests with such installations have shown that approximately 80% of the motorists stopping will follow this request. On the other hand it has been proven that the exhaust fumes emitted when restarting an engine correspond to that of an engine idling for 20 - 30 seconds. This makes the usefulness of such "blue traffic lights" questionable as regards reduced pollution. It must also be taken into consideration that the additional blue light increases the costs for a signal installation by about 20% (Fig. 14).
In order to indicate speed limits to road users and to warn them visually, **speed warning lights** have been installed over the past few years: if a certain speed is exceeded a lamp lights up which indicates the permissible speed (Fig. 15). Measurements show that road users initially reduce their speed in more than 90% of cases and thus fulfill safety requirements. But in the course of time a habit effect can be noticed, particularly with motorists familiar with the locality. The development of mobile speed warning installations is still in process.

In order to influence traffic **changeable road signs** are increasingly used which are controlled according to the traffic situation. This applies particularly to the following signs:

- Hazard signs
- Speed limits
- No overtaking
- Directional signposting

Figs. 16 to 18 illustrate some examples. Signs with fibre optical technology are increasingly penetrating this sector. In the case of directional signposts constructions on which various destinations can be indicated via rotating cylinders have proved to be effective.

Finally the **ARIAM Project** (ARIAM = motorists' radio information based on currently measured data) should be mentioned briefly. In the Frankfort/M. region various recording stations were installed in conjunction with the control system with changeable directional signposts. These stations transmitted data on traffic volume, classified according to passenger cars and trucks, on speeds and time spaces between vehicles to a computer. Thanks to a stored traffic model, the computer is capable of recognising the danger of traffic jams or overloaded road sections from the incoming data. Originally this data was intended to control the changeable directional signposts, but soon the question arose whether the incoming information could be processed by a separate programme and simultaneously transmitted to the traffic news rooms of radio stations. That way it would be possible to transmit information on the traffic situation or traffic warnings almost without any time delays. First tests have shown that a project of this kind can be put into reality and that information on a section of
road can be transmitted 10 to 15 minutes earlier than
the announcements based on information from the
traffic police. A disadvantage of direct information
processing lies in the fact that initially no infor-
mation on the cause of an obstruction can be given;
when and if this is necessary, it can be done later
when the obstruction is known. The test phase has been
completed; ARIAM is to go into operation within the
next few weeks.
Fig 1. Signs per km
Table for selecting the design with regard to luminance properties

<table>
<thead>
<tr>
<th>Brightness of road surface</th>
<th>Slight</th>
<th>Medium</th>
<th>Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brightness is the degree of brightness observed on the road surface from the motorist to the traffic sign</td>
<td>e.g. dark background, calm overall environment, no distraction</td>
<td>e.g. moderately bright background, few other lights, slightly restless environment, moderate distraction</td>
<td>e.g. bright background, many dazzling and other lights, high distraction</td>
</tr>
</tbody>
</table>

Interference effect of the environment

This is the degree of interference experienced by the motorist in recognising traffic signs during darkness as a result of dazzling or other lights in the environment of the traffic sign. Lights in the immediate environment cause greater interference than those at greater distance.

Effect as result of site and dirt accumulation

The effectiveness of signs and installations is influenced by the site and the possible degree of dirt accumulation. We differentiate between the following effectivity categories:

1. Low-level location and little to medium dirt accumulation
2. Normal location next to road with little to medium dirt accumulation or low-level location with great dirt accumulation
3. Overhead signs or normal location level next to road and great dirt accumulation

<table>
<thead>
<tr>
<th>Observation distance (m)</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Medium bright</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bright</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Dark</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Medium bright</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bright</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>e.g. dark residential area, no external light.</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e.g. illuminated residential area, open rural road</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>e.g. bright shopping street, lit federal highway, many dazzling light sources</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

1 = reflective film Type 1
2 = reflective film Type 2
* = illuminated from inside or outside

Fig 2.
## Interference from the Environment

### Street

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>&lt;50 m</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark</td>
<td>1 1 1</td>
<td>1 1 1</td>
<td>1 1 1</td>
</tr>
<tr>
<td>Medium</td>
<td>1 1 1</td>
<td>1 1 1</td>
<td>1 1 *</td>
</tr>
<tr>
<td>Bright</td>
<td>1 1 1</td>
<td>1 1 1</td>
<td>* * *</td>
</tr>
</tbody>
</table>

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>&gt;50 m</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark</td>
<td>1 1 2</td>
<td>2 2 2</td>
<td>2 2 2</td>
</tr>
<tr>
<td>Medium</td>
<td>1 1 2</td>
<td>2 2 2</td>
<td>2 2 *</td>
</tr>
<tr>
<td>Bright</td>
<td>2 2 2</td>
<td>2 2 2</td>
<td>* * *</td>
</tr>
</tbody>
</table>

1 REFLECTIVE  
2 HIGHLY REFLECTIVE  
* ILLUMINATED

---

Fig 3.
Fig 3. (contin)
Fig 4. Signs highly reflective
Fig 5. Calour Rule
Fig 6. Distance Rule
Fig 7.
Fig 3.
Fig 9. Proposal for new signs
Fig 10.
Fig 12.
Fig 13. New Sign construction
Fig 14. Blue Traffic Signal
Fig 15. Speed Warning System
Fig 16. Changeable Traffic Signs
Fig 17. Changeable Traffic Signs
Fig 18. Changeable Traffic Signs
ABSTRACT

Hans Sandebring - VTI

The OECD Road Transport Research Programme

Since 20 years the Organisation for Economic Co-operation and Development, OECD, has had an activity on road and road transport research. It is geared towards a technico-economic approach to solving key road transport issues identified by the 24 member countries.

There are two broad areas of interest:

- The scientific and technical subprogramme
- The information and documentation subprogramme (IRRD - International Road Research Documentation)

The scientific and technical activities concern:

- The assessment of urban and inter-urban strategies
- The development of and management of road traffic control and driver communication systems to enhance network efficiency and quality of service
- The formulation and evaluation of integrated road and traffic safety programmes
- The construction, presentation and rehabilitation of road infrastructure

As a contribution to the 1986 Road Safety Year in the European Community a report was published: "OECD road safety research: a synthesis". It describes the recommendations that have been a result of twenty years of work within the OECD road transport research programme.

There will be a brief presentation of the most important conclusions of the work so far and suggestions for future research cooperation in the safety area.
The OECD Road Transport Research Programme

Director Hans Sandebring, VTI, and chairman of the Steering Committee for the OECD Road Transport Research Programme.

The OECD

The Organization for Economic Co-operation and Development (OECD) was established in Paris at the end of 1960.

There are 24 member countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

The aims of the OECD are:

- to help member countries to achieve the highest sustainable economic growth and employment and a rising standard of living, while maintaining financial stability;

- to contribute to sound economic expansion in member as well as non-member countries in the process of economic development; and

- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis.

Within the OECD there is an activity which centres on road and road transport research, while taking into account the impacts of intermodel aspects on the road transport system as a whole. The programme is geared towards a technico-economic approach to solving key road transport issues identified by the member countries. There are two broad areas of interest:
- The scientific and technical sub-programme: international co-operative projects and studies to provide scientific support for decisions by member governments and international organisations and to assess future strategies concerning roads and road transport problems and the priority policy concerns of member countries;

- The information and documentation sub-programme (IRRD - International Road Research Documentation): a co-operative scheme that provides a mechanism for the systematic world-wide exchange of information on scientific literature and current research programmes.

The scientific and technical activities concern:

- The assessment of urban and inter-urban road transport strategies;

- The development and management of road traffic control and driver communication systems to enhance network efficiency and quality of service;

- The formulation and evaluation of integrated road and traffic safety programmes;

- The construction, preservation and rehabilitation of road infrastructure.

Accomplishments in the Safety Area

In this paper I will concentrate my presentation to the Safety Area.

As a contribution to the 1986 Road Safety Year in the European Community a report was published that summarises the results and conclusions of road safety studies undertaken within the Road Transport Research Programme: "OECD road safety research: a synthesis".

In the report there is a listing of the Scientific Expert Groups, Research Seminars and Symposia that are the result of nearly twenty years of work.

The list illustrates the wide scope of road safety problems areas and the diversity of safety measures. It also illustrates the trends and changing emphasis of road safety needs, research and policies.
The over forty projects are grouped under six broad categories:

**High risk user groups**

The OECD studies chiefly concerned the alcohol and/or drug-impaired driver, the learner and/or young driver, pedestrians and two-wheelers, trucks as well as particular age groups, i.e. children and the elderly. The topics of the study report were:

1968 - Alcohol and Drugs
1970 - Pedestrian Safety
1975 - Young Driver Accidents
1976 - Driver Instruction
1978 - Safety of Two-Wheelers
1978 - The Role of Alcohol and Drugs in Road Accidents
1978 - Special Research Group on Pedestrian Safety
1980 - Safety of Pedestrians and Cyclists
1981 - Guidelines for Driver Instruction
1983 - Impacts of Heavy Freight Vehicles
1983 - Traffic Safety of Children
1985 - Traffic Safety of Elderly Road Users
1987 - Role of Heavy Goods Vehicles in Traffic Accidents

**Road user behaviour, information campaigns, education, training, enforcement**

To take stock of rapidly evolving research in the field of behavioural science as applied to the road user, the following projects were carried out:

1970 - Driver Behaviour
1971 - Road User Perception
1971 - Road Safety Campaigns: Design and Evaluation
1974 - Research on Traffic Law Enforcement
1975 - Manual on Road Safety Campaigns
1976 - Driver Instruction
1981 - Guidelines for Driver Instruction
1985 - Effectiveness of Road Safety Education Programmes
1987 - In-Depth Analysis of Accident Causes with the Help of On-Site Investigations
Aspects of vehicle safety

To avoid overlap with other organisations, the OECD studies on vehicle safety aspects mainly dealt with visibility and lighting issues as well as, recently, safety belt use programmes. The OECD projects treated were:

1970  - Biomechanics of Automobile Accidents
1971  - Lighting, Visibility and Accidents
1975  - Polarised Light for Vehicle Headlamps
1976  - Adverse Weather, Reduced Visibility and Road Safety
1979  - Road Safety at Night
1985  - Effectiveness of Safety Belt Usage Programmes

Aspects of road infrastructure safety and traffic operation

The OECD studies under this heading dealt with road equipment, safety in urban and residential areas, black spot treatments, road design standards and the overriding issue of speed limits. The following topics were assessed:

1969  - Research on Crash Barriers
1971  - Research into Road Safety at Junctions in Urban Areas
1972  - Speed Limits outside Built-Up Areas
1975  - Roadside Obstacles
1976  - Hazardous Road Locations: Identification and Countermeasures
1977  - Geometric Road Design Standards
1979  - Traffic Safety in Residential Areas
1981  - Effects of Speed Limits on Traffic Accidents and Transport Energy Use
1984  - Road Surface Characteristics: their Interaction and their Optimisation

Road safety evaluation

Accident analysis methodologies and evaluation techniques for road safety measures are essential in understanding the accident process, setting priorities, predicting the effectiveness of measures and assessing the effects of implemented safety actions. The OECD studies concern:
1970 - Statistical Methods in the Analysis of Road Accidents
1976 - Multidisciplinary Accident Surveys
1981 - Methods for Evaluating Road Safety Measures
1982 - Short-term and Areawide Evaluation Methods for Safety Measures
1987 - In-Depth Analysis of Accident Causes with the Help of On-Site Investigations

Integration of road safety measures

The two OECD studies:

1979 - Road Safety at Night
1984 - Integrated Road Safety Programmes

assessed the possibilities of co-ordinating, 'packaging' or integrating various road safety actions so that the total safety effect is larger than the aggregate effects of separate measures.

Recently activities have been started on

- The Role of the Insurance System in Road Accident Prevention
- Integrated Urban Area Traffic Safety Planning and Management
- Road User Capacities and Behavioural Adaptions in Adjusting to Changing Traffic Tasks and Accident Risks
- Framework for Consistent Traffic and Accident Statistical Data Bases.

Future of the programme

This autumn there will be a first discussion on the next triennal programme - 1989-91. An inquiry has been distributed to the member countries in order to identify new activities. During the beginning of 1988 the programme will celebrate it's 20th anniversary with a seminar on "Future Directions".

According to my personal opinion there are several important areas for the future work:
- Infrastructure Research: "post Interstate" era - what options are available to cope with road traffic and transport growth?

- Effects of European standardization and market liberalisation.

- Better modal shares.

- Major priority on truck issues and trucking; harmonization between vehicle fleet design and road network characteristics.

- Future of public transportation.

- Communication and information technologies.

In the safety area there are also areas of vital interest for future research:

- Improvement of data bases and international exchange of data.

- Driver reeducation.

- Effects of deregulation on truck safety.

- Participatory and decentralised management of safety programmes.

- Traffic safety programme development in developing countries.

- Research on road user behavioural aspects and changing driver characteristics with use of modern information technology.
TRAFFIC SAFETY RESEARCH POLICY IN THE UNITED STATES

by K. B. Johns, Director, Technical Activities, Transportation Research Board

In its Strategic Transportation Research Study-Highways (STRS-Highways) that led to development of the Strategic Highway Research Program, the TRB Panel found that highway research in the US was grossly underfunded when compared to any other industry. Further, even this limited highway research was being carried out in small bits and pieces in literally thousands of agencies, and suffered from this decentralization. The Panel concluded that six selected areas of highway research deserved and could benefit greatly from a concentrated, adequately-funded program of research if carried out in a timely way.

One might expect a STRS-Safety study to discover similar problems, draw similar conclusions, and suggest similar approaches to more effective traffic safety research. In fact, the case may even be much stronger in traffic safety than in highway research, involving as it does many more agencies and institutions, e.g., enforcement, jurisprudence, social and behavioral groups, medicine, and other human factors aspects.

This paper will identify present policies that inhibit effective safety research and implementation in the US, and suggest approaches to make them more effective in the future. It will also identify the very significant successes in US traffic safety that have occurred despite the shortcomings.
TRAFFIC SAFETY RESEARCH POLICY IN THE UNITED STATES

K. B. Johns, Director, Technical Activities
Transportation Research Board

The basic premise of this paper is that since the beginnings of federal direct involvement in highway safety in the United States in the mid-1960s, there have been major advances in reducing the toll in the face of events that could have increased the losses. But are the advances as great as they could have been with different focuses on programs and on research? We conclude that a more structured approach to safety research in the future could be expected to lead to even more dramatic advances than have thus far been achieved.

Figure 1

Figure 1 shows a graphical representation of what was happening in the United States in highway safety in the year 1969. The actual number of deaths had climbed to an all-time high of 56,400. While the death rate hovered at 5.3 per 100,000,000 vehicle miles, it had shown no real improvement in a decade. Vehicle miles travelled were increasing significantly, but so were fatalities.

1969 offers a good vantage point from which to look at safety in the US. Until the mid-1960s, efforts to improve highway safety were in the hands of the state and local governments. The federal role had been to convene committees of leaders who would meet, view the problem with alarm, and propose actions to be taken by the states that were purely voluntary in nature.

By 1965, however, it became clear to the US Congress that the annual increases in deaths could no longer be tolerated. The Congress held hearings that led to enactment of the first federal law that held that nationwide uniformity and cooperation were essential if the toll was to be reduced. This was the first time that the federal government would mandate uniformity among the states in matters of highway safety.

The very next year led to enactment by the Congress of the Highway Safety Act of 1966, the first comprehensive federal attempt to coordinate state safety efforts through a program that provided federal financial assistance. In addition to the funding provided, the law also called for promulgation of safety standards and prescribed penalties for those states that failed to design safety programs in conformance with those standards.

The standards—ultimately 18 of them—were based on current knowledge that was, of course, extremely limited; it still is to a lesser degree today. They were purposely put in place without waiting for further research, with the
understanding that they would be modified as more knowledge became available. And they have been modified, of course, not only because of new research findings but also to reflect local and national supporting and opposing viewpoints of various groups. But the 1966 Act actually did stimulate greatly increased activity in highway safety research.

One of the problems with the mid-1960s approach was its attempt to attack highway safety on all fronts at the same time. And the attack was blunted by the need to work through a multiplicity of diverse organizational entities in trying to bring about improved safety programs. For example,

- State and local police play major traffic safety roles through enforcement, but this duty is just one among their many responsibilities, some of which carry higher priorities such as crime prevention
- Driver education programs are often in the state and local educational systems as well as commercial private sector firms
- Emergency care for injured rests with many state and local health and emergency response agencies
- The judicial system that deals with offenders is independent of most other agencies, and like the police, has an agenda full of other pressing matters
- State and local government agencies are responsible for design, construction, maintenance, and operation of the highway and street systems
- And variations in state laws make coordination of safety programs difficult, even with their cooperation in the development of the various standards.
But nonetheless, the 1960s saw the beginnings of improvement. Figure 2 tells how the picture had changed by the end of 1985. Fatalities had decreased to 45,600,

some 19% under 1969. Vehicle miles traveled had continued the upward trend, with the result that the death rate per 100,000,000 vehicle miles was down to 2.58, less than half the rate of 1969. If the 1969 rate had continued to 1985, the death toll would have climbed to some 95,000 per year.

Clearly, then, we see a picture of dramatic success in spite of the institutional and knowledge shortcomings. No one really knows how much of this success to ascribe to each of the many factors that have had some influence on it. Again, for example,

- An oil embargo produced shifts in the mileage and death curves for a period, and may have had some lasting influences on behavior
- The fuel-related 55 MPH speed limit had an impact - estimated in a recent TRB study at some 2000 to 4000 lives saved each year
- The automobile industry turned more attention to crash survivability - sometimes with government prodding, and at other times on its own initiative
- The Federal Highway Administration and the state highway agencies vastly improved the forgiving nature of the roadsides, and the understandability of traffic control devices
- Emergency medical response capabilities were greatly expanded and improved
- Accident records systems have been improved to provide better information about hazardous locations and about opportunities for selective enforcement
- Public interest has been aroused through groups such as Mothers Against Drunk Drivers (MADD), Students Against Drunk Drivers (SADD), and others.

These and other positive shifts have taken place in full view of other trends pulling in the opposite direction. Speeds are coming back up toward pre-embargo levels. Trucks are getting bigger and heavier, cars are getting smaller and lighter. Roads are more crowded; repairs and new construction and reconstruction are not keeping pace with needs. Dollars for safety research and safety programs are decreasing regularly, falling far short of needs.

At this point, we have painted a picture of enviable success in not only stopping the increase in highway deaths, but in significantly decreasing them in the face of trends that were working in the other direction. But can any nation ever declare victory when there are still more than 45,000 highway deaths each year? We know we can never get the total down to zero, but what is possible? What is a reasonable goal, and how can it be achieved?
Federal agencies have tried various shifts in program priorities. Alcohol countermeasures, seat belt usage laws, motorcycle helmet use laws, and a variety of others have been emphasized, and may in fact have had positive effects that contribute to the reduction in fatalities and rates. But it is possible that emphasis in the judiciary, driver behavior modification, or enforcement programs could have produced even greater effects.

In a similar way, we have spent research dollars on a variety of efforts hoping for breakthroughs or incremental improvements in one or all. In the view of some experts, literally millions of dollars spent in support of research and local programs in driver education have not only not brought improvement, but may actually have adversely impacted safety by increasing exposure of younger drivers. Driving skills among new drivers, among drivers entering new or different driving environments, and drivers with a wide variety of impairments - vision, mental faculty, language, drug use, age, attitude, to name a few - are learned or improved under actual driving conditions at considerable risk to all roadway users as well as themselves.

So now our picture of optimism based on success is clouded over with pessimism about the things remaining to be done. But if we were the highway safety dictator of the US with absolute power - but with limited resources - what would we do? Without power beyond the US borders, we can't influence those auto manufacturers to emphasize safety in design to the extent we might want to. Without adequate police, we can't detect and arrest all the unskilled and impaired drivers and pedestrians out there. Even if we had enough police, we lack the resources to house all those convicted by judges and juries. Despite a generation of improving our accident records systems, we still can't tell for
sure, for example, the role that large trucks play in accident causation; nor do we know the answers to many other questions as to where best to apply our limited resources. In short, we really don't know where to apply our limited resources to derive the most benefits.

We would continue to support research, of course, but we won't know which areas and projects might produce the biggest payoffs if successful in deriving new knowledge. And even if this research produces usable results, we will lack the resources to package and disseminate them in usable form to the wide variety of skilled and partially-skilled people who need to apply them in safety improvement programs.

The dark clouds of pessimism now bid fair to overwhelm us with unknowns. But there is a ray of sunshine and hope. It seems an appropriate time to pause briefly and take a deep and informed look at where we've been in highway safety research, where we are now, and where we would like to be in some reasonable time frame. TRB did it for a program of highway research in its STRS study, about which you have heard a great deal today. The STRS-Highways panel chaired by Dr. Larson made a very convincing case that the highway "industry" is so fragmented that it could never mount the coordinated research effort required; the same case can be made in highway safety, perhaps even stronger, as safety reaches into more professions and organizations such as law, human factors, auto manufacturing, enforcement, and medicine, as well as engineering, management, materials, and others. The STRS-Highways panel made a very convincing case that highway research was declining, and lagging far behind that of even low-tech, sluggish industries; we would guess that the same case can be made for highway safety research. And while STRS-Highways had, and the succeeding Strategic Highway Research Program has, primary focuses on the savings of dollars through improved materials, design, construction, and maintenance, the case for
highway safety research cannot fail to call attention not only to the staggering financial losses--$48.6 billion in the US in 1985--but to more strongly emphasize the sobering losses of 45,600 lives and 1,700,000 disabling injuries in the same year.

So the ray of hope is represented by a strategic transportation research study for highway safety - a STRS-Safety. From it could come a monumentally important report that could propose an enlightened plan of safety research with the following characteristics.

- It could be more sharply focused on areas with a high probability of big payoff
- It could be concentrated on a few specific goal-oriented areas.
- It could provide for a high concentration of time and money and technical expertise on crucially important and achievable targets
- It could de-emphasize research where it is currently over-supported, and emphasize need for research in areas that are currently under-supported
- It could examine the institutional barriers that currently exist that prevent effective implementation of research results and propose revisions to them
- It could provide the rallying point behind which the diverse interest groups could unite in pursuit of an already common goal - further improvement in highway safety for the benefit of all
- It could insure the involvement of the several interested industries, but be independent of old biases, allegiances, and influences that today inhibit more effective research, and more effective implementation of research findings
And having identified those areas for research with potential for high payoff, it could be the basis for a state and federal short term research program with tremendous rewards not only in financial savings, but in reductions in human suffering and loss of life.

These characteristics, incidentally, are paraphrased from the conclusions in the STRS-Highways report.

If its worth the effort to save dollars in highways, doesn't it make at least as much sense to make the effort to save people? We think so, and think that the time is now.

References


Transportation Research Board Special Report 204, "A Decade of 55"

Transportation Research Board Special Report 202, America's Highways: Accelerating the Search for Innovation"
R AND D POLICY IN FRANCE IN THE FIELD OF ROAD SAFETY

by Georges Dobias, General Director INRETS, France

The R and D policy in France in the field of road safety has to be placed in the general policy of the French Government. The goal is to reduce by one third the number of road fatalities (11,000 fatalities in 1986).

The main objectives are:

- in the field of infrastructure:
  - a new programme of 2,700 km of motorways,
  - a programme to reduce the number of "black spots",
  - a better information and traffic control in interurban areas,

- in the field of vehicles safety, a technical control of older vehicles,

- in the field of drivers' behaviour, a better enforcement of laws, especially those regarding drunk-driving and an improved drivers' training,

- in the field of local policies an increased awareness of safety issues (REAGIR, objective -10%).

The R and D policy main projects are:

- a better knowledge of the part road characteristics play in accidents occurrence,

- the development of new tools for interurban and urban traffic control (expert system, forecasting models, ZELT),

- road information, systems especially in urban areas and in connection with weather forecasts (SEMER),

- the crash protection of vehicles (CEVE),

- the drivers' behaviour according to their alcohol consumption and the results of laws enforcement,

- a new international programm for drivers training,

- tools for developing programmes of local road safety policy (methodology),

- hazardous materials safety programmes (risk - routes),

- the participation in Eureka projects (Prometheus, Europolis, Carminat, Demeter),

- reflexion for PVD road safety programmes.
Communication au Colloque

Roads and Traffic Safety on Two Continents

Gotenburg, Sweden

9-11 septembre 1987

La recherche en sécurité routière en France

G. DOBIAS

Directeur Général de l'INRETS

VTI RAPPORT 328 A
La recherche ne peut-être séparée des objectifs des divers acteurs intervenant dans le domaine de la sécurité routière, pouvoir publics centraux et locaux, associations, industries, assurances.

I. L'INSÉCURITÉ ROUTIÈRE EN FRANCE

Le niveau et l'évolution de l'insécurité routière en FRANCE sont tout à fait préoccupants, comme le montrent les données suivantes relatives aux années 1981 et 1986.

L'année 1986 est exceptionnelle, car le nombre d'accidents corporels et de blessés a continué à diminuer un peu plus lentement qu'au cours des années précédentes, alors que le nombre de tués sur la route a augmenté de 500 soit près de 5%.
**BILAN STATISTIQUE DE LA SECURITE ROUTIERE**

1- Bilan des six dernières années

<table>
<thead>
<tr>
<th>ANNÉES</th>
<th>ACCIDENTS CORPORELS</th>
<th>TUES</th>
<th>BLESSES GRAVES</th>
<th>BLESSES LEGERS</th>
<th>TOTAL BLESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nombre</td>
<td>Evolution</td>
<td>Nombre</td>
<td>Evolution</td>
<td>Nombre</td>
</tr>
<tr>
<td>1981</td>
<td>239 734</td>
<td>-3,8%</td>
<td>12 428</td>
<td>-0,1%</td>
<td>90 973</td>
</tr>
<tr>
<td>1982</td>
<td>230 701</td>
<td>-6,3%</td>
<td>12 410</td>
<td>-3,7%</td>
<td>84 532</td>
</tr>
<tr>
<td>1983</td>
<td>216 139</td>
<td>-6,2%</td>
<td>11 946</td>
<td>-2,2%</td>
<td>79 447</td>
</tr>
<tr>
<td>1984</td>
<td>202 637</td>
<td>-5,7%</td>
<td>11 685</td>
<td>-10,6%</td>
<td>73 314</td>
</tr>
<tr>
<td>1985</td>
<td>191 096</td>
<td>-3,4%</td>
<td>10 447</td>
<td>+4,9%</td>
<td>66 911</td>
</tr>
<tr>
<td>1986</td>
<td>184 626</td>
<td></td>
<td>10 961</td>
<td></td>
<td>63 500</td>
</tr>
</tbody>
</table>

2 - Répartition par type de réseau routier (1986)

<table>
<thead>
<tr>
<th>RÉSEAUX</th>
<th>CIRCULATION ANNUELLE</th>
<th>ACCIDENTS CORPORELS</th>
<th>TUES</th>
<th>BLESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volume *</td>
<td>%</td>
<td>Nombre</td>
<td>%</td>
</tr>
<tr>
<td>Autoroutes (et bretelles)</td>
<td>49</td>
<td>13,3</td>
<td>5 667</td>
<td>3,1</td>
</tr>
<tr>
<td>Routes nationales</td>
<td>96</td>
<td>25,9</td>
<td>36 431</td>
<td>19,7</td>
</tr>
<tr>
<td>Chemins départementaux</td>
<td>167</td>
<td>45,1</td>
<td>57 637</td>
<td>31,2</td>
</tr>
<tr>
<td>Voies communales</td>
<td>58</td>
<td>15,7</td>
<td>43 859</td>
<td>23,8</td>
</tr>
<tr>
<td>Autres</td>
<td>41 012</td>
<td>22,2</td>
<td>914</td>
<td>8,3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>370</td>
<td>100,0</td>
<td>184 626</td>
<td>100,0</td>
</tr>
</tbody>
</table>

* en milliards de kms

3 - Répartition par catégories d'usagers (1986)

<table>
<thead>
<tr>
<th></th>
<th>TUES</th>
<th>BLESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nombre</td>
<td>%</td>
</tr>
<tr>
<td>Piétons</td>
<td>1 639</td>
<td>15,0</td>
</tr>
<tr>
<td>Cyclistes</td>
<td>438</td>
<td>4,0</td>
</tr>
<tr>
<td>Cyclomotoristes</td>
<td>714</td>
<td>6,5</td>
</tr>
<tr>
<td>Motocyclistes</td>
<td>790</td>
<td>7,2</td>
</tr>
<tr>
<td>Voitures tourisme</td>
<td>6 867</td>
<td>62,6</td>
</tr>
<tr>
<td>Véh. utilit et autres</td>
<td>513</td>
<td>4,7</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>10 961</td>
<td>100,0</td>
</tr>
</tbody>
</table>
II LES OBJECTIFS D’ACTION DU GOUVERNEMENT FRANÇAIS

Le gouvernement français s’est fixé un certain nombre d’objectifs destinés à diminuer, d’ici quelques années, de 4000 le nombre de tués sur les routes en diminuant le nombre et la gravité des accidents routiers. A cet effet, les principaux axes de la politique sont :

- la construction de nouvelles autoroutes, compte tenu de leur important degré de sécurité ;

- le lancement des campagnes d’information visant à relever le taux de port de la ceinture de sécurité qui a beaucoup diminué en France, à lutter contre l’alcoolisme au volant et à faire respecter les limitations de vitesse ;

- l’augmentation du nombre de contrôles et l’aggravation des sanctions pénales, notamment pour l’alcoolisme au volant ;

- la décentralisation des décisions au niveau des collectivités locales afin de conduire à une prise en charge de la sécurité routière sur le terrain, à un niveau proche des problèmes concrets ;

- enfin l’amélioration de la formation des conducteurs et des formateurs à la conduite, par la mise en place d’un programme national de formation à la conduite.

III LA RECHERCHE EN SÉCURITÉ ROUTIERE

C’est dans ce contexte que se place la recherche en sécurité routière en France.

Le premier constat est qu’en France, la recherche en sécurité routière est fortement concentrée, dans un organisme de recherche, l’INRETS.

Les conséquences de ce processus sont diverses : cette concentration favorise la création d’un pôle de compétence et d’expertise en permettant d’obtenir une continuité indispensable à l’accumulation du savoir et du savoir-faire ; parallèlement la taille critique peut être atteinte et surtout la recherche peut saisir son objet, l’insécurité routière, sous des angles et à partir de disciplines différentes : en principe les conditions d’une approche système sont réunies, ce qui ne va pas de soi compte tenu des caractéristiques fondamentales de la circulation routière et des processus de production de l’insécurité.
Inversement cette "concentration" relative de la recherche dans un organisme spécialisé présente des dangers qui, sans être spécifiques du domaine, sont pourtant patents : la continuité nécessaire peut aussi devenir parfois manque d'innovation.

Par ailleurs, l'industrie automobile a engagé un effort très important de recherche dans le domaine de la sécurité passive des véhicules, en développant un laboratoire spécifique de biomécanique commun aux deux constructeurs français RNUR et PSA.

Aucun autre acteur, qu'il s'agisse de l'université - en dehors de deux laboratoires universitaires - ou des assurances ou de l'éducation nationale, n'a véritablement développé de recherches dans le domaine de la sécurité routière.

Cette concentration relative de la recherche dans un organisme n'exclut nullement l'existence d'un effort de recherche dans d'autres institutions, par exemple celles qui dépendent plus ou moins directement du Ministère chargé des routes et de la circulation. Qu'il s'agisse du LCPC, organisme de recherche, ou du SETRA, du CETUR et du "réseau technique" on vérifie l'existence d'un effort qui vise l'accroissement de la connaissance mais surtout sa diffusion et sa mise en forme. Au delà des classifications administratives et institutionnelles, il faut reconnaître l'existence d'un continuum "recherche - études - applications", continuum qui n'exprime pas seulement un phénomène de diffusion linéaire mais qui aussi exprime l'apport de l'application proprement dite à la recherche : il ne s'agit pas seulement de validation ou d'évaluation mais aussi d'enrichissement des problématiques, d'affinement des concepts, de spécification des outils et des instruments d'analyse.
IV DOMAINE DE RECHERCHE EN SECURITE ROUTIERE : esquisse d'un état des lieux

Chacun des principaux domaines de la recherche en sécurité routière est ici classé en trois groupes :

. le premier identifie les domaines bien constitués caractérisés par l'importance des acquis, au plan des méthodes et des problématiques comme à celui des résultats utilisés ou utilisables. Dans la plupart des cas la recherche a eu des effets d'entraînement identifiables ; directement ou indirectement elle est relayée dans des actions d'application et de développement sans pour autant perdre son actualité.

. le second identifie les domaines où, pour diverses raisons, on doit hélas regretter une situation de stagnation nullement justifiée au regard des enjeux théoriques et pratiques.

. le troisième propose un inventaire des principales lacunes, les plus criantes, et pourtant trop souvent les moins perçues.

1) Domaines de recherche bien constitués avec acquis importants et développements actuels significatifs.

L'accidentologie dans la perspective de la sécurité primaire. Dès l'origine de la recherche française l'analyse clinique de l'accident s'est imposée. Sa valeur heuristique a été confirmée ; l'ambition de comprendre les processus de genèse de l'accident pourrait, au mépris de la démarche scientifique, généralisante et appauvrissante, nous entraîner sans fin dans le mirage d'une réalité multiforme enrichie par diverses méthodes d'analyse (statistiques, observation des comportements ...) elle suggère des modèles de comportement prenant en compte les interactions route-véhicule-conducteur. Non seulement elle est à la source de développements particulièrement importants (REAGIR), mais elle se prolonge en méthodologies de diagnostic.

Remarquons que c'est à partir de l'accidentologie clinique que de nouvelles voies de recherche peuvent se structurer : ainsi de la recherche sur les interactions entre le conducteur et les caractéristiques de la route et de son environnement qui conduit à la reconnaissance des caractéristiques accidentogènes de l'infrastructure, qui constitue un thème de recherche très important.
Psychologie ergonomique

En amont de ce que lui suggère l'accidentologie la psychologie doit proposer une description des activités mises en jeu par l'opérateur humain considéré comme le régulateur ultime. Puisque explicitement ou non, on attribue l'énorme majorité des accidents et des incidents à "l'erreur humaine" il faut qualifier l'erreur et identifier les facteurs qui la favorisent sans omettre la capacité de récupération, d'évitement et d'adaptation de l'opérateur humain. La psychologie ergonomique contribue à reconnaître les caractéristiques de base des comportements de l'opérateur (acquisition et traitement de l'information, décision, effectuation et gestion de l'action en temps réel) y compris leur variabilité inéluctable : elle conduit nécessairement à rechercher les voies d'une modification des situations de conduite pour qu'elles soient mieux adaptées à l'opérateur humain. Ainsi, à partir d'une recherche de base essentielle qui propose des modèles provisoires de l'activité la psychologie ergonomique trace les perspectives d'applications ambitieuses comme en témoigne le concept de "lisibilité de la route" et celui de "tolérance à l'erreur". La psychologie ergonomique sera, dans l'avenir "prévisible", sollicitée dans deux directions : il lui faudra d'une part spécifier son analyse en ne s'intéressant pas à l'homme moyen entité commode et trompeuse, mais aux opérateurs, hommes et femmes, jeunes et vieux, dans leur diversité ; d'autre part en analysant les conditions de compatibilité entre l'opérateur conducteur et les nouvelles technologies mises à son service (aides à la conduite, par exemple) qui constituent l'un des enjeux des projets EUREKA PROMETHEUS et EUROPOLIS ainsi que des outils tels que l'image de synthèse et la simulation qui sont en cours de développement.

Biomécanique du choc

Ce domaine de recherche essentiel à la sécurité secondaire vise la détermination aussi précise que possible de la tolérance humaine au choc qu'il s'agisse du conducteur, du passager ou du piéton. Il est développé, notamment à l'INRETS et au laboratoire commun des constructeurs en une étroite collaboration européenne à laquelle participent la Suède, la Grande Bretagne, la République Fédérale d'Allemagne, les Pays-Bas et l'Italie au sein du CEVE. Il recourt jusqu'ici à deux grandes familles de méthodes, l'accidentologie biomécanique qui informe sur la réalité des accidents de circulation réalité à la fois stable et évolution en raison même de l'inertie relative des conditions de circulation ; et l'expérimentation proprement dite assortie de ses outils et de ses prolongements, notamment sous forme de modélisation mathématique. L'objet,
le champ d'application, les acteurs particuliers de ce domaine de recherche ont conduit à un développement cohérent dont la productivité est reconnue. Il restera que la sécurité secondaire devrait, dans la perspective de la recherche, être considérée relativement au fonctionnement du système de circulation : l'articulation entre les deux branches de l'accidentologie (accidentologie clinique orientée vers la sécurité primaire, accidentologie biomécanique) pourrait permettre ce décloisonnement.

L'alcool, facteur d'insécurité

On connaît l'immensité du problème de santé publique que représente l'alcoolisme et plus généralement la consommation excessive d'alcool dans un pays comme la France. Sous l'angle de la sécurité routière c'est un aspect particulièrement préoccupant de ce problème de santé publique qui se manifeste. Inévitablement la recherche n'a pu éclairer que certains aspects particuliers d'un problème de société complexe ; encore faut-il reconnaître qu'avec des moyens réduits une compétence a pu être construite et une continuité maintenue. La recherche qui a pu fournir des éléments d'évaluation à éclairer des décisions (réglementations, technologie du contrôle) qui ne porteront leurs fruits que progressivement.

L'organisation du travail comme facteur d'insécurité routière. Les représentations de la circulation et de la sécurité routière restent dominées par l'image de l'automobile instrument de loisir. En fait, directement (transport routier de marchandises et de voyageurs et circulation professionnelle proprement dite) ou indirectement (mobilité domicile-travail) la circulation routière manifeste l'activité économique, production et échanges ; d'ailleurs toutes les prévisions sur le partage intermodal révèlent la part grandissante de la route. Toutes proportions gardées, l'organisation du travail, au sens large du terme, influence la sécurité routière comme elle influence la sécurité industrielle proprement dite. A partir des recherches psychophysiques sur les effets de la fatigue et de l'hypovigilance, les conditions de travail des professionnels de la route se sont imposées comme objet de recherche ; un pôle de compétence a pu se constituer offrant d'ailleurs un des rares exemples d'une approche socio-économique de la sécurité routière. Mais reconnaître cette réalité n'interdit pas de constater la faiblesse des moyens mis en œuvre et l'étroitesse du champ couvert. On notera d'ailleurs une extension obligée, à la marge de la sécurité routière proprement dite : le transport de matières dangereuses qui doit vivifier les approches systémiques et se développer rapidement à l'INRETS.
Psychologie des représentations, des attitudes et des comportements

Au cours des deux dernières décennies la recherche psychosociologique française a développé un ensemble de travaux qui ont un caractère d'originalité par rapport à la recherche internationale. L'étude des représentations sociales et celle des systèmes d'attitude a été appliquée à l'image de l'accident, aux facteurs de risque, à la vitesse, à l'alcool, aux mesures de sécurité ; elle a été rapprochée des comportements de risque, des modes d'usage de l'automobile, de la perception de la légitimité de la réglementation ... Ce domaine de recherche ouvre la sécurité routière sur la dynamique des systèmes de valeur et l'espace proprement culturel de la circulation automobile et de la sécurité ; il se prolonge naturellement dans une réflexion sur la communication sociale dans le domaine de la gestion du risque.

2) Domaines de recherche caractérisés par la stagnation

Nous classerons dans ce cadre des domaines de recherche dont l'enjeu est considérable, aussi bien au plan conceptuel et théorique qu'au plan pratique d'orientation de l'action. La plupart de ces domaines de recherche ont fait l'objet de travaux importants qui ont permis de construire ou d'adapter les méthodes d'analyse et d'expérimentation ; et pourtant l'observateur constate l'absence de progrès que l'absence d'ambition et la médiocrité des moyens permettent d'expliquer.

Identification du risque et recherche épidémiologique

Au delà de l'accidentologie clinique les fichiers des accidents ont permis l'utilisation de méthodes d'analyse statistique qui sont un moyen puissant d'identifier le risque et qui permettent de proposer des bases aux calculs d'évaluation. Malgré l'utilité des outils disponibles (fichier des accidents matériels, échantillon représentatif des procès verbaux d'accidents ...) force est de constater que l'épidémiologie du risque routier est très insuffisamment établie : les données qui sont recueillies à des fins administratives et judiciaires ne sont ni assez fines ni assez fiables pour fonder une recherche épidémiologique comparable à celle qui a pu être édifiée dans certains secteurs de la santé. Un effort est tenté dans ce domaine pour avoir une meilleure connaissance des populations à risque à partir d'un fichier destiné à la recherche.
Circulation routière et situations de conduite

Pourtant, à tout prendre, les accidents sont mieux connus que ne l'est la circulation routière. Une analyse spécifique devrait être consacrée à ce chapitre ; mais dès lors qu'on a reconnu les limites des indicateurs globaux (volume de la circulation par exemple), on constate au plan qualitatif comme au plan quantitatif la pauvreté des descripteurs de la circulation : qu'il s'agisse de différences observables selon les réseaux, selon les types de véhicules, selon les caractéristiques atmosphériques, selon la situation du trafic, selon l'heure de la journée, ou le jour de la semaine ... les informations disponibles sont pauvres dès lors qu'on désire identifier les interactions significatives. Un exemple particulièrement éloquent : les vitesses de circulation, leur distribution fine en fonction de divers paramètres, leurs variations ponctuelles et leurs variations sur le court, le moyen et le long terme sont en réalité insuffisamment connues

Recherches sur l'évaluation

Qu'il s'agisse des méthodes ou qu'il s'agisse des résultats nous disposons dans ce domaine d'une multitude de travaux. Et pourtant, faute d'une clarification rigoureuse des objectifs de l'évaluation, le savoir reste dispersé, peu cumulatif et mal intégré au processus de décision et d'action malgré des progrès réalisés comme en a témoigné le colloque Evaluation 85 organisé à PARIS.

Recherches sur la psychopédagogie de la conduite et sur "l'apprentissage social de l'automobile. Chaque année l'équivalent d'une classe d'âge doit être formé à la conduite automobile par l'institution de "l'auto-école" ; chaque année l'équivalent d'une classe d'âge se présente aux examens du permis de conduire (qui sont donc aujourd'hui la modalité la plus extensive et la plus égalitaire de l'estimation des capacités) ; chaque année les assureurs répètent que le risque généré par la circulation des jeunes conducteurs est très élevé et même qu'il tend à s'accroître.

Dans le domaine de la formation à la conduite, des recherches pédagogiques sont développées, mais elles se heurtent à l'idée que l'obtention du permis de conduire est une modalité qui doit-être réussie par tous après une vingtaine d'heures de leçons. Une innovation intéressante consiste à avancer à 16 au lieu de 18 ans l'apprentissage de la conduite sous réserve d'une formation initiale et que le conducteur novice soit accompagné par un conducteur agréé.
Dans le domaine de la formation à l'école, des recherches d'approche pédagogiques débutent entre l'INRETS et l'Institut National de Recherche Pédagogique en vue de mettre au point des documents pédagogiques intéressant l'ensemble des disciplines enseignées dans les collèges et lycées.

**L'infrastructure routière et les équipements de sécurité**

Les tracés routiers, les dimensionnements des chaussées et des accotements, les équipements de sécurité (barrière, glissière, etc ...) la mise en sécurité d'équipements de signalisation, la protection des divers obstacles font l'objet de multiples recherches de détail destinées à "homogénéiser" la sécurité des itinéraires et à assurer une information et une protection des points singuliers qui sont inévitables.

3) Domaines où la recherche est insuffisante

Je me contenterai d'énumérer pour terminer l'exposé quelques domaines où la recherche me parait insuffisante :

- celui, fondamental, de l'acceptation de l'insécurité routière comme une fatalité normale intéressant essentiellement les autres, mais non soi-même ;

- celui d'une meilleure connaissance, sur longue période, des résultats sociaux et économiques de l'insécurité routière ; à titre d'exemple, notre ignorance est à peu près totale sur le devenir des blessés graves de la route ;

- celui de la gestion de la vitesse de circulation de véhicules de plus en plus rapides, particulièrement mal adaptés aux conducteurs novices ou aux conducteurs agés.

Tout ceci n'est pas qu'une question de moyens financiers, c'est à la fois une question de moyens humains et de pression de la part de l'opinion publique qui n'a pas la même attitude vis-à-vis de la recherche en sécurité routière que vis-à-vis de la recherche médicale, par exemple.
The Federal Republic of Germany is a highly motorized country. The people of Germany appreciate the value of the motorcar, driving approx. 1 billion kilometres every day. And for many, driving a car means more than just mobility; it represents an intense experience. Travel on two wheels has again grown in significance; the bicycle, in particular, has enjoyed an unexpected renaissance in recent years.

The relationship between the car and the environment, however, is not without its tensions and, as our activities show, we are taking these problems very seriously. However, our theme today is road traffic accidents. In contrast to the longer-term effects of the car on the environment, the road traffic accident figures have a direct and dramatic influence on the road traffic scene.

I would like to subdivide my report as follows: What have we achieved in road safety to date, where do we still see scope for further improvement, and what research and investigation measures appear to be of particular importance at present?
The Present Situation
The Federal Republic of Germany has slightly more than 60 million inhabitants. In 1970 - this was the worst year on record - some 19,200 people were killed in road traffic accidents. In 1985, the figure was around 8,400. In 1986, as in many other countries, there was again a slight increase to approx. 8,950 deaths on the road; this increase is not fully compensated by the increase in mileage. The figures for 1987 again show a slight downward trend.

These figures show impressively that in the last 15 years, the number of deaths due to road traffic accidents has been more than halved. It may be of interest to know that even in 1936, roughly the same number of people were killed on the roads in Germany as in 1985. The increase in road safety appears even more impressive when one considers it in relation to mileage. In 1970, the death rate was 3 to 4 times higher than in 1985. As a result, the Federal Republic of Germany has also considerably improved its international position in the accident statistics, but has still not moved into the top group; the safety level in Germany has still not attained the standard of, for example, Great Britain, Switzerland or the Netherlands. (Figure 1)

There are good reasons for describing the accident statistics by comparing the number of road traffic deaths. But this only foreshortens the situation, a fact which becomes particularly apparent when the figures show a sharp drop and, as a result of these successes, begin to lose their warning effect. For
this reason, it is expedient to take a brief look at
the number of accidents involving personal injury.
These figures show that

- The overall total has changed only slightly since
  1970 (Figure 2)
- When related to mileage, however, a considerable
  improvement in safety has been achieved (Figure
  3).

From the wide range of categories, I would merely
like to pick out the following: Pedestrians, chil-
dren and youths, cyclists and motorcyclists, car
passengers.

In 1970, some 6,000 pedestrians were killed; in
1986, there were around 2,000 deaths.

The number of children under 15 years of age killed
in 1970 was roughly five times as high as in
1986. When one takes into consideration the drop in
the number of children, the relationship is 1:3; how-
ever, the number injured in accidents, related
to the number of children, has dropped only slight-
ly since 1970.

Youths aged between 15 and 25 years make up 17% of
the population. The percentage share of fatalities
in this group is roughly twice this figure. This
sad relationship requires no further comment and
gave rise to the measures which will be mentionned
later.

As already said, the use of bicycles and motorcy-
cles has risen precipitously. Although the number
of fatal accidents has dropped sharply, the absol-
ute figures are still alarmingly high: In 1986, over 2,000 cyclists were killed on the road, 800 of whom on bicycles.

In 1970, around 9,000 car drivers and passengers died in road accidents; by 1986, this figure had dropped to just over half the figure. When the mileage is taken into account, the risk of being killed in a car has dropped to around 1/3.

And finally the local distribution of fatalities (1986):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>URBAN</td>
<td>34.7%</td>
</tr>
<tr>
<td>NONURBAN (excluding motorways)</td>
<td>56.8%</td>
</tr>
<tr>
<td>MOTORWAYS</td>
<td>8.5%</td>
</tr>
</tbody>
</table>

Reasons For This Drop
In 1985, a working group at the Federal Highway Research Institute (BASt) completed a report which gave the following primary reasons for this improvement in road safety:

- Improvements in the design of cars for the protection of car occupants, influenced to a certain extent by American safety legislation, but also as a result of new initiatives taken by the automobile industry.

- The legal obligation to wear seat belts. The current level of use on the front seats is as follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>92%</td>
</tr>
<tr>
<td>Nonurban</td>
<td>95%</td>
</tr>
<tr>
<td>Motorways</td>
<td>98%</td>
</tr>
</tbody>
</table>
It is estimated that the deaths of at least 2,500 car occupants have thereby been avoided. The non-wearing of seat belts even on the rear seats is fined since 1986. Although the percentage of those wearing seat belts on the rear seats has doubled, it is still only around 50%.

- The obligation to wear a helmet for the riders of all motorcycles; this obligation is now complied with by almost 100% of motorcyclists.

- Improvements in the road network and its equipment; through the construction of new motorways, more and more traffic is transferring to these roads. An estimate has shown that in 1984, some 10% more deaths would have occurred on the roads if the motorways built since 1970 had not been available.

- Improvements within the towns and villages. Starting with the establishment of pedestrian zones, the traffic has been slowed down and/or separated with the aim of improving both road safety and the quality of life in these areas. It should be noted here that these measures have been criticized more strongly recently as the restrictions on the use of the automobile were considered to be too extensive. The way taken appears, nevertheless, to us the right one.

- Expansion of the emergency services; better organization and training have made it possible to reduce the rescue time from almost half an hour to roughly 10 minutes. The establishment of a nationwide air rescue system has also contributed to this improvement.
The measures already described were superimposed by intensive and concerted education and publicity efforts not only from the state, but primarily from numerous private organizations and institutions; in addition, a series of legislative rules aimed at the road user have been drawn up. We are constantly striving to achieve and maintain a reasonable balance between motivation and regulation. Every road user should have a sense of responsibility for himself and his fellow road users; but he should be aware at the same time that his behaviour is being monitored and may be punished, if necessary.

Scope For Further Improvements in Road Safety
We consider that there is scope for a further limited reduction in accident toll, particularly concerning serious casualties. All the political representatives are pressing for a continuation of these efforts, particularly with reference to countries with a higher standard of safety.

One of our main hopes is the introduction of the driving licence on probation for beginners and of the graduated driving licence for motorcycles. First figures on these measures are encouraging; in one large state in the Federal Republic of Germany, for example, the number of motoring offences committed by beginners has dropped considerably.

In the field of vehicle safety, we consider improvements in the stiffness of the car side structure to be a primary aim; we are also hoping for progress in the difficult field of vehicle compatibility.
There is no question that further safety potential lies in the expansion of motorway construction. Here, however, we are coming up more and more against ecological and also economic barriers.

Oriented to the future are the high-technology approaches of Prometheus; this will be discussed during this conference by competent speakers. We should be aware, however, that the road to realization of the proposed measures will be long, and that we cannot therefore make Prometheus part of our current safety philosophy. I say this here because such tendencies do have a habit of coming up from time to time. We must not be so fascinated with technology that we only look far into the future, thereby overlooking the present-day problems; that would be tantamount to suppressing the current situation and an impermissible exculpation.

Since we are discussing the potential scope and measures for a further improvement in road safety, I should not avoid the question of a speed limit on motorways. First a few figures:

On the basis of one billion vehicle kilometres, the number of deaths on motorways has dropped in the period between 1972 and 1986 from 27.9 to 7.4; in simple terms, this means that the risk of being killed whilst driving on the motorway was almost four times higher than today (Figure 4). It should be conceded, however, that the number of injuries showed a less favourable development (see also Figure 3).

This impressive improvement in the level of safety is also to be seen in absolute figures: In 1972, almost 1,200 deaths occurred, in 1986 approx. 750.
This relatively favourable situation, compared with other road types, and the only small percentage of motorway accidents are the reasons why we do not consider a speed limit for motorways to be the most important measure. On an international scale, the Federal Republic of Germany has a midtable position, still clearly behind Great Britain, Switzerland and the Netherlands, but rather better than France, Italy and Austria, despite the speed limits on the motorways in those countries. The standard of safety in Germany is now scarcely lower than that in the USA (Figure 4).

It is generally accepted that scope for achieving a higher safety standard lies in stricter enforcement of existing legislation. This applies to existing speed limits and, for example, to the restrictions on driving time for heavy goods vehicles.

Accident Research and Road Safety

Accident research has made an indisputable contribution to the improvements in road safety already achieved. In the Federal Republic of Germany, accident research is carried out by various university and private institutions, but also to a great extent by the Federal Highway Research Institute (BASt) which acts as a central authority and is responsible to the Federal Minister of Transport.

As in most countries, these research activities are aimed both at the acquisition of new scientific knowledge and at the development, backing and evaluation of concrete measures. In many cases, the effectiveness of new measures is first examined in limited tests; measures must also be taken, however, for which there is no reliable basis in the form of
research results. In certain areas, e.g. the driving licence on probation, prior tests would appear to be scarcely possible or practicable. In such cases, evaluation research has a major role to play. A scientific instrumentarium was set up years ago which is being constantly further developed. With the greater availability of cost/benefit analyses as decision-taking aids, it is now easier to distinguish between the promising and subordinate alternative measures, and thus to structure the wide range of demands.

Many technical and behavioural questions are today considered and handled on an interdisciplinary basis. This basic demand corresponded to a great extent to the structure of the Federal Highway Research Institute, in which scientists from various disciplines are grouped together so that interdisciplinary research can be promoted.

Illustrating the directions and features of accident research in retrospect is difficult of course. Nevertheless, I would like to make a few basic comments:

In the field of behaviour, our activities were aimed more toward education than enforcement. The road safety education programme with the greatest influence has been "Kind und Verkehr" ("Child and Traffic") which was developed on the basis of extensive scientific preliminary work and carried out by the German Traffic Safety Council (DVR). To date, however, despite considerable efforts, no comprehensive and reliable study has been performed into the effectiveness of the police measures and the sanction strategies.
The focal point of research into vehicle improvements – due not least to the safety philosophy in the United States of America – was on passive safety; furthermore, the concept that risk compensation can be more in the active than in the passive field, has also gained ground.

In the road design sector, a trend was discernable towards the question of whether road safety could be improved by reducing road space, and whether road safety is affected when such restrictions are desirable or necessary for other reasons, in particular environmental.

In 1984, the government issued a new road safety programme, in which the focal points for research are also outlined:

- Identification of acute safety deficits through optimum utilization of available data sources
- Limit values for driver ability and fitness
- Reduction in risk taking and promotion of the sense of responsibility
- Evaluation of new regulations for driving licences
- Safety-orientated solutions in road design
- Maintenance of safety standards in vehicle development
- Optimization of the emergency services
- Further development of the evaluation procedures
It is not surprising when, after 15 or 20 years of programme work, efforts are not primarily concentrated on the study of completely new areas; as a result, many of the projects planned for the next few years are based on earlier studies and are aimed above all at the closer definition and optimization of existing measures and programmes. This accommodates the - sometimes unreflected - demand that research results should be incorporated more directly into the concrete road safety work.

I would now like to illustrate a few complexes and their causal factors in rather more detail, whereby the order should not be regarded as indication of priorities*.

Goods transport on the roads continues to increase, while in the European Community a policy of liberalization has been agreed, i.e. goods transport without quantitative restrictions. But the question of the effects on safety is sometimes avoided. In order to be in a position to estimate this factor, and possibly to develop proposals, a comprehensive safety analysis of goods transport on the roads should be carried out, and in particular an in-depth study of the consequences of road accidents.

The question of the relationship between vision and road safety is becoming increasingly important as more and more older people are driving cars. In our

opinion, we still do not know enough about this problem. In respect of methodology, we also need comprehensive information on the sight defects of drivers who have not been involved in accidents. In a pilot study, we aim to examine how a representative investigation should be set up, and in particular what the population for the study should be. We anticipate obstacles in carrying out our investigation from the data protection laws, a problem which we also encounter in other fields of research.

Drinking and driving, this critical incompatibility is a cause of serious road accidents worldwide. One of the planned projects is intended primarily to compile the existing information on the effects of small quantities of alcohol. This study also has links with the demand which is brought up again and again for a change in the limit of 0.08% currently existing in the Federal Republic of Germany and the complex legal position in this sector. A largescale research project which has recently started and in which we are participating is aimed at investigating the still controversial problem in Germany of whether and how the blood test can be replaced by a breath test.

Research into the stability of or changes in behaviour as a result of education and experience will be carried out by repeating an investigation into road traffic behaviour of a larger group of people whose behaviour, particularly in real traffic situations, was examined in 1980/81.
A number of projects are aimed at influencing the behaviour of road users, for example the continued evaluation research into the "Child and Traffic" programme already mentioned and which has now been successful for many years, investigations into dangers on the way to school when older school-children use bicycles or even motorized two-wheelers, research into methods for reducing the risk-taking of young drivers, how the risk for older people can be kept as low as possible, whilst at the same time ensuring their mobility with the car. In order to examine the effectiveness of police monitoring, studies will be carried out in particular regions as to what controls are carried out and with what intensity, to what extent the inhabitants feel themselves "controlled" and how the accident statistics have changed in relation to the measures taken.

The technical development of automobiles has accelerated rapidly in recent years, and is now characterized by ever more perfected techniques and, in particular, also by the use of electronic aids. However, more and more cars are also attaining speeds which are not any more safely controllable in the man/vehicle/road system. The hypothesis of risk compensation formulated for a long time is now attaining particular topicality in the assessment of technical progress. Accident research must also pursue these relationships, even if this means entering into conflict situations. It must not be satisfied with superficial results; initial observations that vehicles equipped with automatic antilock braking systems are involved in fewer accidents by no means disprove the above-mentioned hypothesis. A main aim of research is to discover what sense of
safety the new systems give the driver, and how this subjective sense of safety affects the objective safety. We also intend to make a greater effort to scale the safety of passenger cars in order to give the consumer an orientation, a system which is already used today in some countries.

Finally, in this sector, the experiments carried out on our own crash test installation are of significance, where we have been working on improving the safety of car occupants for a number of years, and from which we are able to give the government important decision-taking aids. At present, we are concentrating on the development of a side dummy (EUROSID).

The range of projects into accident research continues into the road sector. Attention is concentrated also on general problems, e.g. the safety effect of a shift in the modal split, the advantages and disadvantages of a reduction in road space in the alteration of inner-urban road junctions, examination of the safety effectiveness of "sleeping policemen" and humps, such as are being used to an increasing extent in Germany, and into the effect of pedestrian crossing systems and their safety at night; on an appropriate random sample of road sections, further investigations will be carried out into the benefits of greater use of guard-rails on normal roads.

Despite the successes already mentioned in the emergency rescue services, further improvements are still considered possible. The planned proj-
ects are concerned with the organization of doctors on call for emergencies and the further improvement of communications in the rescue centres.

In the evaluation and assessment of the effects of accidents, an examination and further development of the methods would appear to be necessary. Not only the cost factors should be adapted to the changing conditions; new information such as the inclusion of environmental damage should also be processed and taken into consideration.

The accident is frequently an inadequate parameter, particularly for the assessment of localized and short-term measures. It is therefore planned that a safety definition be developed, taking into account the existing concepts, which covers not only the accident but also dangers, hazards and their conditions. In field tests, system areas such as junctions with a high traffic density, residential roads and urban roads will be comprehensively recorded and illustrated. With this project, we hope to take the first step in moving from primarily accident-orientated research into hazard research, since it is well-known that the absence of accidents is not necessarily a situation of safety.

With this summary, I have attempted to illustrate that sector of our research which is generally contracted out by the Federal Highway Research Institute to external institutes. A not inconsiderable part of the accident and road safety research is also carried out by the staff of the Institute. Main topics of research not mentioned so far include investigations into skid resistance,
the development and evaluation of traffic control measures, and the optimization of environmental compatibility and safety, i.e. in the field of winter maintenance.

In many of these projects, the method of approach is relatively clear and the aim can almost certainly be achieved. With other projects, however, such as those into risk compensation and the effect of educational and publicity measures, the success of the research is less certain. But this must not be allowed to prevent us from carrying out this research, knowing that even partial successes which enable estimates to be made or trends to be detected, can also be of great benefit. This is even more important because our research is intended not only to supply scientific background information for the measures but also to ensure, through a constant flow of information, that the general public and politicians remain confronted by the mass phenomenon of accidents and that they are informed of deficits and unfavourable developments as early as possible.
Getötetenraten seit 1970 (alle Straßen)
fatality rate (total network)
Fig./Abb. 1
Entwicklung der Getötetenraten auf Autobahnen
development of fatality rates (motorways)

Fig./Abb. 4.
ROAD SAFETY RESEARCH - POSSIBLE EUROPEAN CO-OPERATION

by A Hitchcock, PhD, BA, MInstP, MCIT, TRRL (UK), Chairman, COST Technical Committee on Transport, United Kingdom

Because of the international nature of the market in road vehicles in Europe, there is a widely felt desire that safety standards should be so uniform that any vehicle which is legal in one country should be legal in another, or at least that requirements should not conflict. As a common market organization, the European Community in particular is under pressure to reconcile standards in this way, and there are established institutions in both Brussels and Geneva which act as centres for negotiations here, and customary practices by which national administrations and motor companies provide research evidence and/or technical opinion or other persuasive argument to support their conclusions. This conference has sessions which address this topic.

However, there are also laws and practices on other matters which affect road safety which continue to vary between countries, just as they do, to a lesser extent, between the States of USA. They are concerned with such things as driving licences and tests, definitions of traffic offences and perceptions of their gravity and the numbers in speed limits and alcohol-level offences. There is a growing wish within the Community that there should be a similar commonality in the legal systems and practices on these topics, just as in vehicle regulation. Research has its place here, to inform policy - and decision-making, though the matters are not only technical ones.

The paper examines twin hypotheses. In the road safety area, counterintuitive results are sufficiently common for a reliance in common sense or expert opinion to be unsatisfactory. Policy makers need professionally sound analyses of sound statistical data, and the results of controlled experimental observations as a basis for their work. Also, in an international arena, some research can usefully be done either supranationally, some internationally (ie by action concertée), and some nationally. It is argued that the responsibility for research and its support should lie with the nation or state, supranational or federal body which has the power to implement its results.

On this basis, possible topics in the road safety area are discussed as candidates for inclusion in the programmes in the programmes of international bodies such as COST or OEDC, on the one hand, or in, eg, the EEC research framework programmes, on the other. An analysis is made, by way of example, of safety aspects of an existing international research project.
1. BACKGROUND TO ROAD SAFETY RESEARCH IN EUROPE

This paper examines the possibilities of scientific co-operation in the field of road-user safety within the continent of Europe, and especially within the twelve nations of the EC. There is already co-operation at the technical level to harmonize the standards, laws, regulations and directives which determine the legal fitness of a new vehicle for use in European countries and, indeed, world-wide. The present conference exists, in part, to help ensure that this task will be done more easily.

The trade in vehicles is international. Manufacturers wish to ensure that a vehicle which meets the regulations in one country does not, just for that reason, fail to meet them in another. It is possible to harmonize because the prime end which regulation is intended to meet - the reduction of casualties and the amelioration of injuries - is common. While many other considerations are in the minds of those negotiating harmonising changes - a manufacturer gains if his competitors have to fall into step with him, rather than the reverse - evidence about the effects on death and injury of alternative standards, etc, is perceived by all concerned to be relevant, and there is wide-spread interchange of results of technical trials as well as of opinions at the meetings in both Brussels and Geneva.

As a common market organization, the removal of non-tariff barriers to trade is of the very raison d’être of the EC. It is concerned both as broker and as supranational legislator, but its method of operation is largely more appropriate to the former role - it does not carry out many investigations itself, though it does have facilities to make technical investigations, both in its own research establishments and by contract with other organisations.

1.1 Road Safety in the EC

In the vehicle safety field, research has a clear position in the process of supranational legislation: the EC and the international bodies use it as an essential input to their
decisions. There are however other fields where there is also pressure for supranational road safety policy, action and legislation. The experience of the countries, like USA and Sweden, which have the best records in road safety is emphatic that in such areas research is a necessary basis for decision. It is the thesis proposed here that research, supranationally or internationally organized, needs to be carried out as a basis for decision. Moreover the secretariats to the supranational legislature need to include people capable of relating such research to the issues perceived by decision-makers. The area is one in which common-sense is too often only able to explain observations after the event. Expert opinion (especially if the primary expertise is in another area) and political judgment should alike give way to controlled experimental observation. After the reasons for this position have been set out, it will be demonstrated that such research is possible at realistic costs.

1.2 Other European Nations

No doubt, as the EC develops road safety policies, there will be negotiations with the other nations in Europe. If research is being carried out in connection with the formulation of Community policies, or of common national policies within the twelve, it would make both political and technical sense to involve workers in Scandinavia, Austria, Switzerland and the other COST countries, as does happen through the UN in Geneva in the case of vehicle regulation. This is the more so in this field, where some of these countries have achieved considerably greater success in reducing the level of casualties than any of the Community nations except one.

1.3 The example of USA

Curiously, under the pressure of a desire to find common policy themes which help to make them a political unity, the twelve nations of the EEC have chosen to look at common policies mainly in areas where the more closely united States of the USA have agreed to differ. There is almost no Federal organization of road safety publicity in USA; it is possible to get a licence to drive and to continue to drive in one State after being banned in another; the conditions for getting a licence differ greatly from State to State. Speed limit policies differ too (and the divergence is, exceptionally, increasing).

The statements which follow are made by a European on the
basis of individual observations. They are impressions rather than the results of a formal research process.

In USA, the formal role of the Federal Government has some similarity, in the vehicle safety area, to that of the EC. Road safety regulations and enactments are matters of State law, but the Federal Government has a role because of the need to regulate inter-state commerce. Successive Federal Secretaries of Transportation have, however, thought it right to make motor vehicle regulations which save lives and reduce injury as well as eliminate barriers to commerce.

The locus of the US Federal Government in regulation to determine the condition of vehicles in use, or the manner in which they are used, is less obvious in law, and often has to be achieved by making it a condition of federal funding for various relevant projects that there shall be State laws relating to, eg, the condition of tyres or the existence and enforcement of speed-limit laws. But, whatever the constitutional theory, there is to the eyes of the outsider more uniformity than divergence between most State laws concerned with the condition of vehicles and their use. Nor is uniformity unacceptable; these are not matters in which it is felt that the differences between the people of Maine and those of Massachusetts are important.

To this end both the National Highway Transportation Safety Administration and the Federal Highways Administration employ technical experts on their own staff, carry out extensive research in Federal laboratories and support research elsewhere. So do the States, both jointly through such bodies as AASHO and individually. There is some general agreement that the laws which regulate road traffic in the interest of safety should be uniform, so that, for example, one does not find that in North Dakota one is expected to give priority to traffic on the right, while in South Dakota the main road has priority. Nor does one drive on the left in California but on the right in Colorado.

There are many other matters connected with road safety however in which there is no such pressure to uniformity - education and training, publicity, the conditions of driving licences, even in such basic matters as the minimum age or medical conditions of fitness - are all examples. In these areas the Federal Government does support some research, and exchanges of information between State officials and researchers about the impacts of the alternatives. Other bodies, like national professional associations and research
Foundations, do the same. But these are the areas where most of the support of the States, separately or through associations, occurs.

It is an interesting speculation as to whether, as time goes on, the EC will adopt a similar division of local and central activity in this field to that in USA, which is not obviously illogical. If it does, the Community will need research effort on an international or supranational basis, tailored to specific policy questions on such topics as right turn on red, the difference between the use of STOP and YIELD, provision of pedestrian and cycle facilities on E-roads, and the procedures to be followed after an accident. But all this is for the future.

2. POSSIBLE RESEARCH PROJECTS

There is always room for informal comparison of results of research between workers in different institutions - especially if the work is carried out against different institutional and cultural backgrounds - since then the differences in results make it possible to propose hypotheses about the nature of deeper mechanisms. Further, it can be very useful to other governments if, in the course of a series of meetings national experts on some limited field should write a review of the state of their art, or comment formally on their views expressed by one of their number - the safety of elderly pedestrians, perhaps, or evidence of the efficacy of speed limits in reducing accidents, or statistical methods for testing the effect of traffic engineering schemes on safety (a field which only the experts recognise to be full of traps). These are the techniques used by the OECD Road Research Committee, and the European Commission of Ministers of Transport (ECMT)’s Round Tables. There is at least one country where the resulting reports are used as a basis for policy; it has few researchers, because it is rather small. In other larger countries the OECD reports are used as supporting evidence for decisions. Such meetings also have a very positive effect on the supply of valid original ideas by those taking part. OECD and ECMT do their separate tasks well, and there is no point in others trying to supplement them for researchers cannot spend all their time expounding their results to people from other countries, or listening in return - they also have to have time to do research.

However, these processes will not do for supranational policy-making, which raises issues that must be both stated and solved or evaluated supranationally. The related research must
therefore be true action concertée or action directe specified in the centre. The former is the sphere in which the COST organization has had some success in transport research. 

COST has also worked from time to time in the direct mode, though it is arguable that is the role that should be assumed by the new EC "Framework" programme. COST has not yet carried any Road Safety research, however, and the framework is still a name.

Research that would help in making supranational policy can certainly be done by one or other of these routes. Below are listed the six primary areas in which there is some current debate within Europe. For each some possible relevant research is described. It is not suggested that this is the best that can be done, for these are the ideas of one person only and could certainly be improved by debate between researchers in the institutions already mentioned. In each case the nature of the current concern is discussed before the research is described.

2.1 European Driving Licences and Driving Tests

The idea of the interchangability of driving licences between member states was probably first seen as part of the removal of non-tariff barriers for professional drivers who cross frontiers in the course of commerce. What was to be granted to the professional could not readily be denied to the ordinary citizen: indeed this was a positive way in which the Community activity could benefit average Europeans, and so help to attain a common political perspective. But common driving licences imply common topics in driving tests, and common standards of examination. These determine what minimum ability is to be expected of drivers. There are also such matters as minimum (or maximum) ages to drive, medical criteria, and so on. On all these there are strongly-held national beliefs and a great willingness to express expert opinion on the basis of personal or clinical experience, unsupported by objective experiment or epidemiological data.

There is however clear evidence that the accident liability of a newly-licensed driver is high and that it remains high for the first two years or so of his driving experience. It is not clear - though it could be established by examination of accident records, and special extensions of these if necessary - how this excess level varies with such quantities as distance driven and age. It should be possible to model the rates of occurrence of different kinds of accident in different regimes of driver testing/training on the basis that some tests exclude
from the field those who are weak in this or that skill which is associated with this or that accident type. This could be done using the techniques established by Haycock and others in a recent paper (ref 1).

It should also be possible to evaluate the standards of different tests by transporting examiners and running eg, experimental UK driving tests on say, German learner-drivers, randomly selected from those applying for tests.

Put together, these would give some idea how the potential elements of a driving test affected the subsequent performance of a newly-licenced driver. Almost certainly some dearly-loved shibboleths would be exposed, and all would learn salutary lessons.

While such work would not be cheap, it would not be impossibly expensive - at a guess 700-1000 k.ecus (1 ecu is roughly 1US$) over a period of 3-4 years in each of, say six countries, plus 100 k.ecus over 2 years in the others concerned. This assumes that the basic data could be obtained in computerised form from police, licensing authorities, insurance companies and other bodies.

Other approaches are possible. In a private communication (ref 2), Chich suggests that study of the way in which the work of professional drivers is organised - especially of the methods of training them and the institutions through which it is done - would produce valuable additions to the procedures required for the issue of professional licences. He estimated an annual cost of some 800 k.ecus for 2-3 years.

2.2 Speed limits

The current policy issue is the possibility of a common overall maximum limit on all roads. The possibly more important issue, in road safety terms, of common limits on various classes of urban and peri-urban roads, has received less attention. Part of the aim here is a desire to ease the lot of the international traveller by imposing uniform conditions, and uniform expectations of the behaviour of other drivers. Another is an energy-conservation theme.

The research problem here is probably simpler. It is well attested that speed limits do reduce accidents if they also reduce speeds. If they do not - or if, as sometimes happens, the imposition of a limit which is perceived as unreasonable is followed by an increase in speeds - then
accident levels do not fall - and in the paradoxical case they go up. It may be necessary to demonstrate the validity of this result in countries where this has not yet been done - but the existing results could well suffice. Measurement of the effects of particular speed limits on speeds can be readily done where the limit is one which is already customary in the country concerned - care is needed with the selection of controls and the statistical design of the trial, but all this is well established. In the final stages of such a programme it could be proposed to try out (in one region or country only) a limit where none previously existed. Like the original 70mph limit in UK this would need legislation. This is only possible if the merit of the trial is widely accepted. Given full co-operation of the authorities concerned, this is again not very expensive - a great deal could be done in one country for 400-500kucus.

2.3 Effect of EASY, and research into publicity.

In well-run commercial advertising campaigns, it is a matter of routine for the agency organizing the campaign to report back. It may not be able to demonstrate that the sales of the product have increased as a result of its work - and often campaigns are trialled in test areas, eg the area covered by a particular TV station. Agencies find out, as a matter of routine, if people in the area are more aware of the product, have acquired new attitudes to it, or report changes in their behaviour. Road safety advertising is not so different from other advertising that one can afford not to take these simple steps to discover if the message is getting through. European Road Safety Year, however, has come and gone. It was not organized from the centre, by professionals and there was no market research. In as new an area as a multilingual, multinational road safety campaign it is particularly important to know whether, and, if so, what, messages can be imparted to whom.

If there is to be further Community publicity on road safety (and no research yet offers a reason to oppose it) there should be routine monitoring followed by a not-so-routine analysis of an unusual form of campaign. Commercial agencies usually allow 7-15% of budget for market research: here the higher figure may be the more appropriate.

2.4 Common Penalties with European Scope

There are pressures to have court decisions made in one country of the Community enforceable in another, particularly
when the penalty is to suspend the licence to drive - a penalty much more frequently imposed in Europe than across the Atlantic. This would imply some harmonization of sentencing and enforcement policy. One of the driving forces for this pressure may be the natural belief that foreigners are more likely to offend, or more likely to get away with it.

It would help the debate along, (although questions of legal principle are also involved) if one knew how many offences are committed by the people in question, relative to eg, kilometres travelled by them, and what the costs of any excess accidents they have are, in lives and money. It could also be useful to analyze statistically the penalties actually imposed to discover if foreigners or people from another region are treated differently from local people. With the cooperation of the relevant Authorities it would be a relatively simple matter to extract most of the data needed from the relevant records on a sample basis, though a special survey would have to be mounted to determine the distance travelled in each country by a car registered in another country and it would help the analysis if journey purposes and demographic data about the driver(s) were also collected. If the frontier authorities were prepared to allow their staff to be trained to administer the survey (it is a task needing expertise), cost would be 100-200 kacus in total for three or four countries, otherwise 500 to 800 kacus is probably needed.

2.5 Rule of the road

It does not appear that very many people really expect change from the present position, where the people of two of the twelve nations are in a minority in Europe, but in a majority in the world, because they drive on the left. The cost of a change, in either direction, would clearly be very high, and could well be measured in lives as well as money. Nevertheless, many people do consider that it is a dangerous situation, and it ill behoves an author on this topic who is in the European minority to omit it.

It is not known what are the accident liabilities of UK and Irish drivers travelling in continental Europe are, nor if they suffer an enhanced liability to have accidents on their return. Nor is the complementary information about continental visitors to UK and Ireland available. The main reason is the lack of exposure data - one needs to know more about the distances travelled on different sorts of road by visiting drivers, professional and non-professional, both in their own vehicles and in hired ones. It would also be necessary to
identify the accidents involving visitors, as opposed to long-
term foreign residents. The data would need to be collected by
to parallel techniques in several countries: it requires
professional care and discipline, but it is not really
difficult or really expensive - 500k€c to 800k€c should
cover it (given again full co-operation of the relevant local
people). One could then compare the costs of adopting
universal left- or right-side driving with the potential
accident saving, and with the costs and benefits of other
expenditure on road safety. This is the information needed for
a rational decision. The information could also be used for the
analysis described in 2.4 above, though unless it turns out
that there is no enhanced risk due to a temporary change in the
side of the road one drives on, it would not be sufficient for
that.

2.6 PROMETHEUS

The PROMETHEUS project has been set up by some companies in
the European motor industry following an initiative of Daimler-
Benz. It is to apply information technology to motor travel. It
has avowed objectives in the field of road safety, and for that
reason is attracting more attention from Governments than most
Eureka projects. Ref 3 explains that it aims, (among other,
possibly more valuable, objectives) to improve road safety in
these ways:

a. Vehicles are to be provided with "override": on-vehicle
"electric vision" and control computers which will detect
an obstacle ahead, and bring the vehicle to rest or steer
round it.

b. The proponents say "Accidents happen unintentionally.
Critical situations occur as a result of a deficiency in
information ... regarding the movements of other road
users, the required safety distance to other vehicles ..."
and go on to propose, as a first step, on-board vehicle
computers which will communicate with each other, and so
eliminate this lack of knowledge.

c. It is also proposed to reduce the length of journeys by
provision of route information (Jeffries (ref 4) has shown
that, on average, ignorance here increases journey lengths
in UK by 5%) and to provide micro-meteorological
information from the roadside, warning of wet or icy
conditions or of fog.

The cost of PROMETHEUS is comparable with that of the
entire road safety research programmes of all the nations involved over its seven-year life. It would therefore seem worthwhile to estimate the likely benefits of the work from the outset, using all techniques available, and to estimate the effects of each possible variation by the same techniques.

Hitherto, this paper has contained large references to "established techniques" and "not too difficult" analyses. (In practice there will be some hiccoughs.) In this case a first analysis has been done and is reported here in summary form. Ref 5 gives a full account. It concludes that if all the PROMETHEUS instrumentation described above were in full use on all motorized vehicles potentially involved in accidents in Great Britain, and it all worked well, then the maximum fraction of present accidents in Great Britain whose course could be affected lies in the range 4% to 10%. This applies to the early stages of application, where the way the equipment is programmed is controlled by the assumption that not all vehicles, roads, entrances, etc, are equipped. This excludes some possibilities which could in later years reduce accidents by much more. The proponents may be more optimistic in time than in quality: the proposition quoted in 2.6(b) above is, however, false.

However this does not mean that the project is not desirable. Twelve thousand fewer injuries in UK alone, with two hundred and fifty fewer deaths is a very well worthwhile target (and there are also large benefits of other kinds). It is fully half of the effect of the achievement of compulsory seat-belt wearing and over 25% of the potential saving from reducing drink-driving. More to the point, while this estimate is a fair one for the early stages, many times as many accidents could be saved later, if it all works out. The reduction in the annual toll of casualties due to the wearing of front seat belts in UK has on the other hand been achieved, and cannot be increased later.

3. ANALYSIS OF PROMETHEUS PROJECT

The analysis used two existing data bases. One, the so-called STATS 19 file (see ref 6) is a computerised record stretching back nearly 40 years, of every road accident in GB in which someone was hurt and which was reported to the police. It requires the reporting officer to make no judgments; it details some 25 pieces of information about the accident, plus 20 for each vehicle and 15 for each casualty. The second data base was the "at-the-scene" file (ref 7), a record of the
circumstances of accidents which came to the attention of the police or ambulance service and occurred within 25 km of TRRL. Specialised teams worked shifts 168 hours weekly, visited each site and interviewed every driver and rider who was prepared to co-operate. It gives a very complete picture of over 2000 accidents and includes judgments of the nature of the human errors committed classified into over 30 heads.

One group of these errors encompasses the "lack of knowledge" referred to by the originators of PROMETHEUS, and each of the records including such an error was examined to see if its course could have been affected by either of the devices described in 2.6a and b above. The STATS 19 file was used to test the "override" only (2.6a above), and this was done by identifying as "potentially affected by override" all two-vehicle "shunts" - accidents in which one vehicle was impacted in the front and another in the rear. It was found that the ratio of shunts to all two-vehicle accidents was affected by whether the accident happened on a motorway, but was otherwise insensitive. The figure was therefore assumed to apply also to three-plus vehicle accidents.

The estimates by the two methods of the effect of override were mutually consistent. Some further detail is given in the Annex, which shows the classification of errors used in the at-the-scene base, and the incidence of each in the set chosen. It will be seen that each was identified as being "definitely", "probably" or "possibly" present, and in the analysis these were interpreted as probabilities of 100%, 80%, and 40% or 100%, 40%, and 20%. It was necessary to correct for pedestrian, pedal-cycle and single-vehicle accidents. A full account of the analysis is given, as has been said, in ref 5.

4. THE PLACE OF RESEARCH IN EUROPEAN ROAD SAFETY POLICY

The data bases used for this analysis were not collected for the analysis of European projects. They were collected for that routine analysis of national and local policies, proposals and actions in the road safety field without which no policy is implemented generally in UK. If the standard bases are not sufficient for the purpose then special experiments are devised. It has been found by experience that the road-safety field is riddled with counter-intuitive results, and a strict scientific discipline is therefore applied. It has been found necessary to employ technical experts in the Administration for this purpose, as in USA. The UK death rate of vehicle occupants per hundred thousand kilometres driven is the lowest in the
Hitchcock - Road User Safety Research

world: it does not seem likely that this is a coincidence. Similar approaches are adopted at Federal level in USA, and there too the policy is effective by the measure given.

Those who have enjoyed the benefits of this approach are reluctant to enter into politically-based compromises with administrations which do not adopt these principles. It would not be an achievement of which the Commission ought to be proud, if its initiatives evened out the accident rates across Europe at somewhere around the present European average. If, indeed the Community is to take a direct role in matters which affect road safety it needs to employ its own research experts, to use data collected on a consistent base to employ that data to determine its priorities for research and action, and to test its proposals against the acid of experimental method and statistical analysis both before the event, and after it. This need not require additional resources. And it should not be forgotten that European nations outside EEC not only have a concern with the outcome but have been very successful in this field.

ACKNOWLEDGEMENT

Crown Copyright. The views expressed in this paper are not necessarily those of the Department of Transport. Extracts from the text may be reproduced, except for commercial purposes, provided the source is acknowledged. The work in this paper forms part of the programme of the Transport and Road Research Laboratory and the paper is published by permission of the Director.

REFERENCES

2. Chich, M. Private Communication from M Frybourg, Paris 1984
6. Department of Transport. Instructions for the Completion of Road Accident Reports. STATS 20. London 1978
7. Sabey B E. Road Safety in the 80s. in Symposium report, Salford 1983

VTI RAPPORT 328 A
APPENDIX

Road User Errors Identified in At-the-Scene Studies, 1979-81

Of the factors listed below, only those in Class A were thought to be correctible by additional information of the kind provided by PROMETHEUS's inter-vehicle communication. The figures in brackets show the number of occasions in which the fault was judged to have contributed (definitely, probably, possibly) to the accident. In total, responses to interviews were obtained from 1429 car-drivers involved in a total of 1042 accidents.

A. Lack of knowledge.

A1. Failed to look. (10,15,8) Road user failed to look before carrying out the intended manoeuvre.
A2. Inattention. (9,19,22) Road user generally not paying sufficient attention to the task.
A3. Obscured in veh. (5,5,1) View obstructed by something in or on vehicle - eg passenger, misted windscreen, bauble.
A4. Obscured out veh. (2,7,6) View obstructed by something outside the vehicle - eg bus shelter, tree.
A5. In distraction. (10,10,20) Driver distracted by something in the vehicle - eg children, spider.
A6. Out distraction (12,9,26) Driver distracted by something outside vehicle - eg accident, fox.
A7. Vehicle dazzle. (0,0,7) Road user dazzled by vehicle headlights, oncoming or via mirror.
A8. Sun dazzle. (1,3,8) Road user dazzled by the sun.
A9. Speed/distance. (16,26,13) Road user looked and saw hazard, but failed to perceive his or other user's speed and continued with intended manoeuvre.
A10. Too close. (1,7,11) Road user following too closely the vehicle in front.

B. FAILURE OF PERCEPTION
(Information entered visual (eg) field but was not heeded)

B1. Looked, failed to see. (69,34,17) Road user looked but did not perceive the hazard and continued with intended manoeuvre.

C. FAILURE OF JUDGEMENT
(Knowledge was available and perceived but actions chosen were inappropriate.)

C1. Wrong int. (4,3,6) Road user saw other user but misinterpreted his/her intentions.
Hitchcock - Road User Safety Research

C2. **Too fast.** (64,93,89) Road user travelling too fast for conditions - includes weather, traffic, road, own ability.
C3. **Wrong path** (13,18,9) Road user taking wrong line for manoeuvre - includes taking bend on wrong side of road.
C4. **Wrong position.** (0,0,1) In wrong position for intended manoeuvre eg in left-hand lane when turning right.
C5. **Overtaking.** (26,16,4) Road user overtook badly or cut in.
C6. **Lights.** (1,0,2) Appropriate lights not on.
C7. **Signalling.** (0,3,6) Road user gave wrong or no signal.

D. ERROR OF INTENTION
(Road user knowingly carried out improper manoeuvre.)

D1. **Failed to give way.** (188,16,4) Road user failed to give way to another with priority.
D2. **Frustration.** (0,1,7) Road user's action affected by frustration with traffic - eg accepted too small a gap.
D2. **Aggression.** (1,2,1) User's aggression or irresponsibility to others affected accident.
D3. **Road Craft.** (9,50,25) Road user lacked relevant awareness - eg saw situation but failed to appreciate dangers.
D4. **Inex. driving.** (4,8,7) Road user's general inexperience.
D5. **Inex. Vehicle.** (1,8,8) Road User lacked experience with vehicle.

E. IMPAIRMENT & INEXPERIENCE
(Road user failed to perform safe manoeuvre - factors included only if judged to contribute to accident.)

E1. **Fatigue.** (15,14,16) Road user asleep or very tired and this affected accident.
E2. **Illness** (7,1,2) User's performance affected by illness - includes death by natural causes and mental defect.
E3 **Alcohol.** (35,35,43) User known to have consumed alcohol and this affected accident.
E4. **Drugs.** (0,0,8) User known to have taken drugs/medicine prior to accident and this affected it.
E5. **Emotional distress.** (3,9,11) User distressed emotionally - preoccupation and/or lack of concentration and this affected accident.
E6. **Glasses.** (0,1,0) Glasses not worn by user who needed them.