Proceedings of the Conference
STRATEGIC HIGHWAY RESEARCH
PROGRAM AND TRAFFIC SAFETY
ON TWO CONTINENTS in
Gothenburg, Sweden,
September 18 – 20, 1991, Part 4

- Simulation and Measurement of Operator
  and Vehicle Performance
- Strategies to Increase the Use of Restraint
  Systems
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- Simulation and Measurement of Operator
  and Vehicle Performance
- Strategies to Increase the Use of Restraint
  Systems
Abstract (background, aims, methods, results) max 200 words:

Papers presented at the seminar were as follows:
Traffic Measurements by Means of Computer Vision Techniques (Joergensen, N O); Dynamic 3D Highway Modelling (Roberts, A);
Validation of Real-Time Man-in-the-Loop Simulation (Allen, R W, Mitchell, D G, Stein, A C and Hogue, J R);
Measurement of Driver Performance in Training Simulators (Korteling, J E);
Litigation and Driving Simulators (Hulbert, S);
Strategies to Increase the Use of Restraint Systems (Maekinen, T and Hagenzieker, M);
Canadian Seat Belt Wearing Rates, Promotion Programs, and Future Directions (Grant, B A);
Safety Belt Usage in Finland and in the Other Nordic Countries (Valtonen, J);
French Experience in Seat Belt Use (Lassarre, S and Page, Y);
Strategies to Increase the Use of Restraint Systems (Heinrich, H C);
Restraint Use by Car Occupants, Great Britain 1982-91 (Broughton, J);
State of Affairs in the Netherlands (Hagenzieker, M P);
1991 National Campaign to Increase Safety Belt Usage (Knaff, P R).
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.

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 sessions on roads there were presentations which highlighted differences between European and US practices and needs, and the discussions were concentrated on how to promote international involvement in SHRP and application of its research, within the areas of Asphalt, Long Term Pavement Performance (LTPP), Highway Operations and Concrete and Structures.

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.

Linköping October 1991

Kenneth Asp

Proceedings of the Conference STRATEGIC HIGHWAY RESEARCH PROGRAM AND TRAFFIC SAFETY ON TWO CONTINENTS in Gothenburg, Sweden, September 18-20, 1991:

VTI RAPPORT 372A, Part 1
- Opening
- Motorist Information Systems
- Accident Studies and Safety Management

VTI RAPPORT 372A, Part 2
- Roadside Safety Features
- Human Engineering, Training and Traffic Safety

VTI RAPPORT 372A, Part 3
- Operational Roadway and Workzone Research
- Safety and Mobility of Older Drivers

VTI RAPPORT 372A, Part 4
- Simulation and Measurement of Operator and Vehicle Performance
- Strategies to Increase the Use of Restraint Systems

VTI RAPPORT 372A, Part 5
- Asphalt
- Highway Operations and Concrete and Structures

VTI RAPPORT 372A, Part 6
- Long-Term Pavement Performance

VTI RAPPORT 372A
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Validation of Real-Time Man-in-the-Loop Simulation R Wade Allen, David G Mitchell, Anthony C Stein and Jeffrey R Hogue, Systems Technology Inc, USA 17

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Strategies to Increase the Use of Restraint Systems
Tapani Mäkinen, VTT, Finland and Marjan Hagenzieker, SWOV, The Netherlands

Canadian Seat Belt Wearing Rates, Promotion Programs, and Future Directions
Brian A Grant, Transport Canada, Canada

Safety Belt Usage in Finland and in the Other Nordic Countries
Juha Valtonen, Liikenneturva, Finland

French Experience in Seat Belt Use
Sylvain Lassarre, INRETS-DERA and Yves Page, DSCR-ONISR, France

Strategies to Increase the Use of Restraint Systems
Hanns Ch Heinrich, Federal Highway Research Institute (BASt), Germany

Restraint Use by Car Occupants, Great Britain 1982–91
Jeremy Broughton, TRRL, United Kingdom

State of Affairs in The Netherlands
Marjan P Hagenzieker, Institute for Road Safety Research (SWOV), The Netherlands

1991 National Campaign to Increase Safety Belt Usage
P Robert Knaff, KB & Ass, USA
STRATEGIC HIGHWAY RESEARCH PROGRAM AND TRAFFIC SAFETY ON TWO CONTINENTS

Gothenburg, Sweden

September 18-20, 1991

WEDNESDAY SEPTEMBER 18

OPENING

9.00 - 11.30

Chairman: Mrs Gunnel Färm, Director General, Swedish Road and Traffic Research Institute (VTI), Sweden

Opening Speeches
Mr Kjell A Mattsson, Governor of the Province of Gothenburg and Bohus, Sweden
Mrs Gunnel Färm, Director General, Swedish Road and Traffic Research Institute (VTI), Sweden

Research and the International Transportation Community
Dr C Michael Walton, Chairman, Executive Committee, Transportation Research Board, National Academy of Sciences and Engineering, USA

Transport Policies and Traffic Safety in an Integrated Europe
Dr Jan C Terlouw, Secretary General of the European Conference of Ministers of Transport (ECMT), France

Getting SHRP’s Products Into Practice
Dr Damian J Kulash, Executive Director, Strategic Highway Research Program (SHRP), USA

FHWA Role in SHRP Implementation
Mr E Dean Carlson, Executive Director, Federal Highway Administration, USA
(presented by Charles L Miller)

Recent European Initiatives in Research Collaboration
Mr David F Cornelius, Director, Transport and Road Research Laboratory (TRRL), United Kingdom
WEDNESDAY SEPTEMBER 18

ASPHALT

13.00 - 17.00

Chairman: Tord Lindahl, Swedish Road and Traffic Research Institute (VTI), Sweden

The Asphalt Model: Results of the SHRP Asphalt Research Program
D R Jones and T W Kennedy, University of Texas, Austin, Texas, USA

SHRP Asphalt-Aggregate Mix Analysis System
T W Kennedy and R J Cominsky, University of Texas, Austin, Texas; E T Harrigan and R B Leahy, Strategic Highway Research Program, Washington, USA

An Investigation of Asphalt-Aggregate Interaction and Their Sensitivity to Water
C W Curtis, L M Perry and C J Brennan, Auburn University, Auburn, Alabama, USA

Thermal Fatigue Cracking of Asphalt Concrete Pavements - An Experimental Approach
N W Jackson, T S Vinson, and V Janoo, Oregon State University, Corvallis, Oregon, USA

Development of Test Methods for a Performance-Related Bitumen Specification
D A Anderson, The Pennsylvania State University, USA

Characterization of Self Assemblies in Asphalt by NMR Spectroscopy and High Performance Gel Permeation Chromatography
P A Jennings, J A S Pribanic, T M Mendes, and J M Smith, Montana State University, Bozeman, Montana, USA

Asphalt Research in The Netherlands
P C Hopman, Delft University of Technology, Delft; P A J C Kunst, Netherlands Pavement Consultants bv, Hoofdelaken; A C Pronk and J M M Molenaar, Roads and Hydraulic Department of Rijkswaterstaat, Delft, and A A A Molenaar, Delft University of Technology, Delft, The Netherlands
Chairman: Conrad Dudek, Texas A&M University, College Station, USA

Changes in Driver Behaviour as a Function of Handsfree Mobile Phones: A Simulator Study
Håkan Alm and Lena Nilsson, Swedish Road and Traffic Research Institute (VTI), Sweden

Variable-MESSAGE Signs: Legibility and Recognition of Symbols
Colomb, Huberg, Bry, Carta, Laboratoire Central des Ponts et Chaussees, Dore-Picard, Institute National de Recherche sur les Transport et leur Securité, France

The Man and His Wheel: Cognitive and Perceptual Factors
Marcel Wierda, Traffic Research Centre, The Netherlands

Measuring Effects of Variable Message Signing on Route-Choice and Driving Behavior
Richard van der Horst, Wiel Janssen and J E (Hans) Korteling, TNO Institute of Perception, Soesterberg, The Netherlands

Acceptance and Benefits of the Berlin Route Guidance and Information System (LISB)
Jürg M Sparmann, SNV Studiengesellschaft Nahverkehr mbH, Berlin, Germany

Automobile Navigation Safety Issues
Robert L French, R L French & Associates, Ft Worth, Texas, USA

(16.30-17.00 Short business meeting of TRB Committee A3B08, User Information Systems - visitors welcome)
WEDNESDAY SEPTEMBER 18

ACCIDENT STUDIES AND SAFETY MANAGEMENT

13.00 - 17.00

Chairman: Gunnar Carlsson, Swedish Road and Traffic Research Institute (VTI), Sweden

Economic Appraisal and Ranking of Road Safety Measures
Karl-Olov Hedman, Swedish Road and Traffic Research Institute (VTI), Sweden

Traffic Safety on Two Continents - A Ten-Year Analysis of Human and Vehicular Involvements
Rüdiger Lamm, University of Karlsruhe, Germany and Elias M Choueiri, North Country Community College, New York, USA

Description and Testing of a Side Impact Protection System
Jan Ivarsson, Volvo Car Corporation, Sweden

A Critical View of Traffic Safety Management in a Developing Country; A Case Study of Jordan
N M Katamine and M A Salem Kiyassat, University of Jordan, Jordan

Development of a Collision Topology for Evaluation of Collision Avoidance Strategies
Kenneth L Campbell, Daniel F Blower, Dawn L Massie, Patricia F Waller and Arthur C Wolfe, UMTRI, Ann Arbor, Michigan, USA

Comprehensive Safety Management
Michael S Collins, Ergotrans, United Kingdom

The Future of Road Traffic Management: Urgent Global Harmonization Will Affect All Governments
Arthur R Olin, Sweden

Implications of Litigation for Highway and Motor Vehicle Safety Research
P Robert Knaff, K B and Assoc., Silver Spring, MD, USA

The Impact of Litigation on the Federal Highway Administration's Highway Safety Program
Steven E Wermcrantz, Federal Highway Administration, USA
THURSDAY SEPTEMBER 19

ROADSIDE SAFETY FEATURES

9.30 - 17.30

Chairman: Thomas Turbell, Swedish Road and Traffic Research Institute (VTI), Sweden, co-Chairman: Hayes E Ross, Texas Transportation Institute (TTI), USA

Roadside Safety - A Knowledge-based Approach
Abdelkrim Ramache, University of Newcastle Upon Tyne, United Kingdom

Safety Barriers Systems in Germany
Bernd Wolfgang Wink, Volkmann & Rossbach GmbH & Co KG, Germany

Side Impact Crash Testing of Highway Safety Hardware
John F Carney and Malcolm H Ray, Vanderbilt University, Nashville, USA

Safety Assessment of Highway Designs
Malcolm H Ray, Standard & Ray Assoc., Franklin, USA (presented by J F Carney)

The Importance of Using a Range of Vehicle Weights when Testing a Crash Cushion
Michael G Dreznes, Energy Absorption Systems Inc, Chicago, USA

Reliability of Results of Crash Testing Small and Medium Size Cars into Two Segmented Concrete Barriers
Francis P D Navin, University of British Columbia, Vancouver, Canada

13.00 Luncheon

Safe Road Design as Limit State
Francis P D Navin, University of British Columbia, Vancouver, Canada

Status of the United States Efforts in Promoting International Harmonization of Test and Evaluation Procedures for Roadside Safety Features
Harry W Taylor, FHWA, Washington DC, USA

Occupant Risk by Different Severity Criteria
Vittorio Giavotto, Politecnico di Milano, Milan, Italy

Hayes E Ross Jr, Texas Transportation Institute, Texas A&M University, USA

Status of the European Work on Harmonizing Requirements and Test Procedures for Roadside Safety Features
Jacques Boussuge, SETRA, France

WORKSHOP on International Harmonization
Status reports from the ongoing update of the US test procedures and the development of a European Standard within CEN
(This workshop will be followed up in non-public informal meeting between TRB committee A2A04(2) and CEN/TC226/WG1 on Friday morning)
THURSDAY SEPTEMBER 19

HUMAN ENGINEERING TRAINING AND TRAFFIC SAFETY

9.30 - 13.00

Chairman: Alison Smiley, Human Factors North Inc, Toronto, Canada

Development of a Methodology for Measuring Improper Seat Belt Use
Brian A Grant, Road Safety Directorate, Transport Canada, Jocelyn Pedder and Nicholas Shewchenko, Biokinetics and Assoc. Ltd, Ottawa, Canada

Mandatory Hazard Perception Testing as a Means of Reducing Casualty Crashes Amongst Novice Drivers
Michael Hull and Peter Lowe, Vic Roads, Australia

Eye Scanning Rules for Drivers - How Do They Compare With Actual Observed Eye Scanning Behavior?
Helmut T Zwahlen, Ohio University, Athens, Ohio, USA

The Effects of Moderate Heat on Driver Vigilance in a Moving Vehicle
D P Wyon and F Norin, Volvo Car Corporation, Sweden

Position Accuracy When Pushing Pushbuttons in a Car as a Function of Car Speed and Location: Implications for Design
Helmut T Zwahlen, Nuruddin Abdullah and David Kellmeyer, Ohio University, Athens, Ohio, USA

(9.00-9.30 Short meeting of TRB Committee A3B02, Vehicle User Characteristics - visitors welcome)
THURSDAY SEPTEMBER 19

OPERATIONAL ROADWAY AND WORKZONE RESEARCH

14.00 - 17.30

Chairman: Karl-Olov Hedman, Swedish Road and Traffic Research Institute (VTI), Sweden

Overtaking Behaviour on Single Carriageway Roads in the United Kingdom
J G Hunt and T A Mahdi, School of Engineering, UWCC, Cardiff, United Kingdom

Overtaking Behaviour on Two-Lane Rural Roads
Arne Carlsson, Swedish Road and Traffic Research Institute (VTI), Sweden

Time and Space Criterias of Column Following
Milan Vujanic, University of Belgrade, Yugoslavia

Passing Operations on a Recreational Two-Lane, Tow-Way Highway
A R Kaub, University of South Florida, Tampa, USA

Reducing Risk Taking in Passing on Two Way Roads
Krsto Lipovac, Higher Shcool of Internal Affairs, Yugoslavia

Guidelines for Railroad Preemption at Signalized Intersections
Peter S Marshall, Barton-Aschman Ass Inc, Minneapolis, MN and William D Berg, University of Wisconsin-Madison, USA
THURSDAY SEPTEMBER 19

SIMULATION AND MEASUREMENT OF OPERATOR AND VEHICLE PERFORMANCE

9.30 - 13.00

Chairman: R Wade Allen, Systems Technology Inc, USA

Traffic Measurements by Means of Computer Vision Techniques
N O Jørgensen, Institute of Roads, Transport & Town Planning, Denmark

Dynamic 3-D Highway Modelling
Arthur Roberts, NJDOT Research, Trenton, USA (Presented by R Pain)

Validation of Real-Time Man-In-The-Loop Simulation
R Wade Allen, David G Mitchell, Anthony C Stein and Jeffery R Hogue, Systems Technology Inc, Hawthorne, USA

Measurement of Driver Performance in Training Simulators
J E Korteling, TNO, The Netherlands

Litigation and Driving Simulators
Slade Hulbert, Ph D, Consultant, Danville, USA

STRATEGIES TO INCREASE THE USE OF RESTRAINT SYSTEMS

WORKSHOP

14.00 - 17.30

14.00 Opening
14.05 Illustration of background paper
14.15 National reports on seat belt use and countermeasures (10 minutes each)
   - Canada
   - Finland and other Nordic countries
   - France
   - Germany
   - Great Britain
   - Netherlands
   - United States
15.45 Coffee break
16.00 Discussion with speakers and audience
17.00 Concluding remarks and closure

(17.00-17.30 Short business meeting of TRB Committee A3B06, Simulation and Measurement of Operator and Vehicle Performance)
THURSDAY SEPTEMBER 19

LONG-TERM PAVEMENT PERFORMANCE

9.30 - 17.30

Chairman: Hans Jørgen Ertman Larsen, Danish Road Institute, Denmark

Early Evaluations of SHRP LTPP Data and Planning for Sensitivity Analyses
J B Rauhut, Brent Rauhut Engineering, Austin, Texas; M I Darter, Eres Consultants Inc, Savory, Illinois; O Pendleton, Texas A&M University, College Station, Texas; and N F Hawks, Strategic Highway Research Program, Washington, USA

The Specific Pavement Studies: Key Issues and Potential Products
A N Hanna and N F Hawks, Strategic Highway Research Program, Washington, USA

Expected Changes to the AASHTO Design Guide
N F Hawks, Strategic Highway Research Program, Washington, USA

Cost Effectiveness of Asphalt Concrete Overlays - The Canadian Approach
G A Sparks, Clayton, Sparks & Ass Ltd, Saskatoon, Canada; D M Nesbitt, Decision Focus Inc, Los Altos, California; and G Williams, Roads and Transportation Association of Canada, Ottawa, Canada

Long Term Pavement Performance Trials and Data Analysis in The United Kingdom
H R Kerali, University of Birmingham and J F Potter, Transport and Road Research Laboratory, United Kingdom

SHRP-NL: A Research Project Parallel to SHRP
G T H Sweere, SHRP-NL, Delft, The Netherlands

Structural Assessment, Performance and Economic Maintenance of Minor Roads
J Roger Duffell, The Hatfield Polytechnic, United Kingdom

Treatment of Bearing Capacity Results
B Leben and A Petkovsek, Institute for Geotechnic and Roads, Ljubljana, Yugoslavia

A Model of IRI for Jointed Plain Concrete Pavements
P Ceza, J David, J Gonzalez and M Poblete, IDIEM, University of Chile; and P Gutierrez, National Highway Administration, Chile

The High Speed Road Deflection Meter
P W Arnberg and G Magnusson, Swedish Road and Traffic Research Institute (VTI), Sweden

PAVUE: A Real-Time Pavement Distress Analyzer
M W Burke and K Råhs, OPQ Systems AB, Linköping; and P W Arnberg, Swedish Road and Traffic Research Institute (VTI), Sweden
FRIDAY SEPTEMBER 20

SAFETY AND MOBILITY OF OLDER DRIVERS

8.30 - 12.30

Chairman: John Eberhard, TRB Task Force on Safety and Mobility of Older Drivers, USA

Old Hands on the Wheel: Exposure, Accident Experience and Problems of Elderly Drivers
M L Chipman, C G MacGregor, A M Smiley, University of Toronto, M E H Lee-Gosselin, Universite Laval, Quebec, and L Clifford, Ministry of Transportation, Toronto, Canada

More Safety Thanks to Good Orientation — Nothing Works Without Traffic Signs
Henriette Reinsberg, 3M Germany, Germany

Elderly People and Mobile Telephone Use — Effects of Driver Behaviour?
Lena Nilsson and Hékan Alm, VTI, Sweden

Driving Performance in Mild Senile Dementia of the Alzheimer Type (SDAT)
Linda Hunt, Dorothy Edwards, John C Morris and Ada Mui, Irene Walter Johnson Rehabilitation Institute at Washington University Medical Center, St Louis, USA

Discussant:
Robin Barr, National Institute on Aging, US Department of Health and Human Services, Bethesda, Maryland, USA

SYMPOSIUM SESSION:

VISUAL AND COGNITIVE CAPABILITIES IN OLDER DRIVERS: PREDICTING ACCIDENT RISKS

Visual Function and Eye Health: Their Relationship to Older Driver Problems
Michael Sloane, University of Alabama at Birmingham, USA

Attentional and Cognitive Factors in Predicting Older Driver Problems
Karlene Ball, Western Kentucky University, Bowling Green, USA

Attention and Driving Performance in Alzheimer's Dementia
Raja Parasuraman, Catholic University of America, Washington, USA

Older Drivers Handling Road Traffic Informatics: Divided Attention in a Dynamic Driving Simulator
Peter C van Wolffelaar, Wiebo H Brouwer and Talib Rothengatter, Traffic Research Centre, University of Groningen, The Netherlands

Discussant:
Harvey Sterns, Institute for Life-Span Development and Gerontology, University of Akron, Ohio, USA
FRIDAY SEPTEMBER 20

SAFETY AND MOBILITY OF OLDER DRIVERS

13.30 - 16.00

PANEL DISCUSSION:

FEASIBILITY OF INTERNATIONAL PERFORMANCE STANDARDS FOR OLDER DRIVERS

Presiding Officer: John Eberhard, Chairperson, TRB Task Force on Safety and Mobility of Older Drivers, USA

1. A USA Perspective
   Robin Barr, National Institute of Aging, Bethesda, MD, USA

2. A European Community Perspective
   Margaret Greico, Oxford University, United Kingdom
   Kay Axhausen, Imperial College of Science, Technology and Medicine, London, United Kingdom

3. A Scandinavian Perspective: Older Drivers — A Problem for Whom?
   Krister Spolander, Central Bureau of Statistics (SCB), Sweden

4. A Multi-continent Perspective
   Martin Lee-Gosselin, Université Laval Quebec, Canada

Discussion: Invited from prior presenters and all session attendees

(16.00-16.30 Short meeting of TRB Task Force A3T52, Safety and Mobility of Older Drivers, visitors welcome)
Chairman: Torkild Thurmann-Moe, Road Research laboratory, Norway

Closed Track Testing of Maintenance Work Zone Safety Devices
S C Shah, Strategic Highway Research Program, Washington and F R Hanscom, Transportation Research Corporation, Haymarket, Virginia, USA

Innovative Materials for Pavement Surface Repairs: Field Installation and Evaluation
S C Shah, Strategic Highway Research Program, Washington, USA

MINSALT - A 5-Year Study to Minimize the Negative Effects of Salt
Kent Gustafson and Gudrun Öberg, Swedish Road and Traffic Research Institute (VTI), Linköping, Sweden

Deicing Salt - Its Use and Effect on Road Safety and the Living Conditions of Roadside Trees and Shrubs
Siegfried Giesa, Technical University of Darmstadt, Germany

Improving Concrete Pavements Through SHRP Research
Amir N Hanna, Strategic Highway Research Program, Washington, USA

Optimization of Highway Concrete Through Combined Use of Particle Packing Modelling, Rheological Studies, Computer Simulations and Compaction Simulations
J Holm and P J Andersen, G M Idorn Consult A/S, Birkerød, Denmark

High Performance Road-Surfacing Concrete with Good Resistance to Wear by Tyre Studs
Mårten Nilsson, Swedish Road Administration, Sweden

Maintenance and Repair of Highway Concrete Bridges: A Case Study
I Al-Babatain and A M Abbas, Ministry of Communications, Riyadh, Saudi Arabia
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Ekholm Leif  NCC Väst  SWEDEN
Ellebaek Ellen  Fibertex Aps  DENMARK
Engervall Dag  FAS Service AB  SWEDEN
Englund Anders  Trygg Hansa SPP Protectum  SWEDEN
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Fahlström Sven  Nynäns Bitumen AB  SWEDEN
Farstad Karstein  Norwegian Car Ass.  NORGE
Flack James  Atari Games Corporation  USA
Foley Paul  SHRP  USA
Forsberg Inger  VTI  SWEDEN
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Giavotto Vittorio  Dipartimento Di Ingegneria  ITALY
Giesa Siegfried  Technical University Darmstadt  GERMANY
Graham Roland  University of Liverpool  UNITED KINGDOM
Grann Ole  Superfor Construction A/S  DENMARK
Grant Brian  Transport Canada  CANADA
Greico Margaret  Oxford University  UNITED KINGDOM
Gupta Kris  SHRP  USA
Gustafson Kent  VTI  SWEDEN
Gyllensten Siv  VTI  SWEDEN
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Traffic Measurements by Means of Computer Vision Techniques

Niels O. Jørgensen
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Traffic measurements by means of computer vision techniques.
Niels O. Jørgensen
Professor
Technical University of Denmark.

Abstract

The purpose of the equipment is to determine road user movements in (x,y,z,t) coordinates. Two video cameras record movements simultaneously from different angles. The location (x,y,z) of the cameras and of two fix-points visible from the cameras must be known. Vehicles are tracked on the two tapes successively and the position on the screens (pixel numbers) are recorded at short time intervals. From these data positions and speeds are calculated. Expected errors are found to be 10 - 30 cm when camera distances to study object are 50 - 100 m. The equipment is well suited for a number of road user behaviour studies.
TRAFFIC MEASUREMENTS BY MEANS OF COMPUTER VISION TECHNIQUES
Niels O. Jørgensen
Professor
Technical University of Denmark

1. A COMPUTER VISION TECHNIQUE SYSTEM

The purpose of the measuring system described in this paper is to determine movements by vehicles in traffic i.e. determine positions \((x,y,z)\) and time \((t)\).

The basic idea in the computer vision technique (CVT) is illustrated in fig. 1. Suppose that two video cameras are in known positions and are pointing in known directions. An unknown point \((x,y,z)\) is seen by both cameras in directions which form angles - both horizontally and vertically - with the center lines of the cameras. The directions to the point are given through the \((u,v)\) coordinates on the screens. They are represented by the so-called "pixels" on the screens. All pixels correspond to a certain horizontal and vertical angle with the center line. If these angles are recorded it is possible to calculate the values \((x,y,z)\) by ordinary geometric methods.

![Fig. 1: The measuring principle.](image)

The system works from simultaneous video recordings by the two cameras. The recordings are time coordinated so that the video pictures frame by frame are known to represent the same points in time. The working method is illustrated through an example, fig. 2.
In this example the measurements should give the tracks and the speed profile of cars going through a roundabout. The two cameras are in positions from which the movements to be observed are seen by both cameras.

The positions \((x,y,z)\) of the cameras and of two fix-points visible from both cameras must be known in a local coordinate system. Before the traffic recordings start the two fix-points are recorded from both cameras in order to calibrate the system.

![Diagram](image)

**Fig. 2:** Example of the set-up of cameras and fix-points.

The measurements of traffic is done by playing the two tapes successively in the laboratory. Assume that a car is chosen for tracking. A well defined point on the car, say a corner of the roof, must be visible from both cameras. The tape from camera 1 is played. Every \(T\) seconds where \(T\) could be e.g. 0.2 s the chosen point on the car is recorded. This is done using a "mouse" by which a marking cross is placed on the selected point on the screen. The position of the marking cross is then recorded and stored in a computer. The same procedure is made using the tape from camera 2. From the two recordings the \((x,y,z)\) is calculated and stored together with the \(t\)-value.
2. DATA PROCESSING AND ANALYSIS

From a stored series of \((x,y,z,t)\) values it is possible to calculate speeds and accelerations for each car. Depending on camera distances and how well defined the selected observation points are it has been found that the expected errors typically are of the order of 10-30 cm on the position.

If speeds are calculated when the time unit \(T\) is well below 1 second then the standard error on the position becomes important. A random error, say a reduced distance between consecutive points will lead to a slightly increased distance between the next pair of points. Therefore, this error will mean errors in opposite directions for two consecutive sections in the track of a car. To avoid such oscillations moving averages of speeds are used. However, data still show a slight tendency to alternating results, fig. 3.

![Figure 3: Speed profiles through a roundabout.](image)

Another purpose of the observations was to measure the tracks of vehicles going through roundabouts. Fig. 4 shows movements observed in the roundabout shown in fig 2. These measurements are all covered from one choice of locations of the cameras. The expected error on points \((x,y,z)\) in this case is about 10 cm.
Fig. 4: Car tracks through a roundabout.

Fig. 5 gives a sample of speed profiles for a left turn movement in the same roundabout. Again, random fluctuations are seen.


Fig. 5: Speed profiles in a left turn movement.
3. DISCUSSION

The components of the system are basically simple. The quality and efficiency of the system depends mainly on the quality of the cameras, the precision of the location of fix-points and cameras, the laboratory procedures and the software for the processing and plotting of locations, speeds and accelerations.

One main difficulty in using the equipment is to maintain the same observation point of a vehicle during a tracking. The processing of the tapes may be fairly time consuming but can be speeded up by means of both software and hardware.

The equipment is well suited for different types of road user behaviour studies. One virtue of the system is that rather specific location and timing data are available without any detector installations. All road user categories may be observed.

Types of studies suggested for this equipment are tracking of vehicles through intersections and roundabouts, studies of interactions between road users at intersections, gap acceptance studies and tracking studies through curves in order to see possible effects of different roadway markings.

4. ACKNOWLEDGEMENTS

The equipment has been developed by Jørgen Løssøe Engineering in Denmark for and in cooperation with The Institute of Roads, Transport and Town Planning, The Technical University of Denmark. The measurements, the data processing and the data analysis in the examples presented were carried out by Larus Agustsson, civil engineer, in his thesis for the M.Sc. degree.
Dynamic 3D Highway Modelling

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presented by

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Dynamic, in other words, easily movable views, of 3D computer graphics models of highway scenes are coming into greater use, especially in association with high impact and expensive design projects.

Some potential uses for dynamic 3D models, referred to by some as "4D" models, include:

- Aesthetic review of all preliminary design concepts.
- Courtroom vehicle accident review.
- Community review of alternate designs and alignments.
- Long term impact review of effects of landscape growth and placement on the driver's view.
- Noise barrier placement and height checks.
- Sign and exit sight distance evaluation with alternate interchange concepts.
- Traffic control device design and placement standards development (e.g. - construction zone channelizer application, variable message sign application.

The predominant visual resources for highway designers have been two dimensional such as bird's-eye view maps and plans, centerline profiles and a heavy reliance on field trip memory and spatial imagination. Other aids to the process have included occasional wood and foam models, free hand drawings, and recently, some fixed view 3D computer graphic models.

With the advent of higher speed micro computers, specialized graphics chips, parallel processing, and UNIX based software two important new highway visualization capabilities are beginning to be used to an advantage in the United States:

- 3D computer graphic models of conceptual designs are now being inserted into video taped views of actual environments.
- Total 3D computer graphic models of
conceptual design and the environment are being shown with full control of light, climate, and "eye view" movement within the scene.

Several important effects on the highway design world could take place with this new 4D capability. Traffic engineering units will work more effectively with geometric design and right of way units at a preliminary design concept stage. With present methods, many geometric designs are finalized to the disadvantage of maximum view sign placement. Consultants using this technology will be better able to and more often able to communicate visual design concepts using an interactive model. Designers will more accurately make changes to designs with visual models and better avoid large scale errors involving aesthetics and motorist related function. Physical models will be replaced by computer models, gaining changeability, longevity, reduced space, and portability.

Pioneering examples of 4D applications were found in Boston, Massachusetts and Houston, Texas.

2. THE BOSTON CENTRAL ARTERY/TUNNEL PROJECT - CHAPTER 2

Using four work stations for various tasks, a model and an animation of the inside of the Boston tunnel model were made to test the use of wall graphics.

Wallace, Floyd, Associates in association with the joint venture of Bechtel/Parsons Brinkerhoff have worked on the Interstate 90 tunnel design, which is described by a videotape. Peter Brigham of Wallace, Floyd Associates worked on the modeling and videotape process and notes that it represents only one small piece of an immense design project.

Peter Brigham (1) mentions that the video contains computer animated sequences generated to assist ongoing discussions with federal funding agencies and other groups regarding tunnel finishes. Specifically, the sequences depict the proposed extended alignment for Interstate 90 Eastbound from the first segment of the immersed tube tunnel to the Logan Airport exit.

The video is intended primarily as a means of illustrating the driver's visual experience both with
and without graphic treatment to the walls. Three basic graphic concepts were modeled in this exercise:

- A horizontal band of colored tiles
- A random pattern of colored tiles, and
- An airplane symbol to mark the exit to the airport

As the tape starts, the first sequence shows a driver's view, travelling eastbound at forty miles per hour in the right lane of the tunnel. It starts in the first segment of the immersed tube. The first graphic concept, the horizontal band on the right wall, is parallel to the geometry of the roadway. Lines that follow the alignment tend to reinforce the perspective: they help focus the view on the roadway; this is evident looking down the first big curve. The second concept is a random pattern of colored tiles which builds in density as one approaches the middle of the tunnel and then decreases as one moves past the middle. The changes in density help orient the driver, informing him when he has reached the middle of the tunnel. In the fairly straight middle portion of the tunnel, the effect of reinforcing lines is evident: the slightly darker cove areas and the alignment of the light fixtures over the pavement striping produce the same effect as the horizontal band on the right wall: they help focus the driver's eye on the road.

The immersed tube tunnel ends and the tunnel widens quickly to accommodate a two-lane exit to Logan airport. The airplane symbol is easily comprehensible and helps illustrate the direction to which the signage refers.

The second sequence begins with a fixed view in which various pieces of the model appear. Every element is constructed using programs which extract coordinate data for points every ten feet along the alignment. The model, is tied directly to the engineering. When the alignment changes, the model can be updated and when additional detail is added, it is added using the precise geometry of the roadway. Elements such as railings and lane lines must be placed at an exact $y$ and $z$ coordinate and at exact angles of rotation for each axis. Programs have been developed on the CA/T project which enable designers to execute these complex tasks. As we rotate around the model, the various rhythms for different systems is evident; from the road, as seen in the first sequence, these rhythms create patterns which must be coordinated to maximize continuity of the design and assist in orienting the driver.
The last sequence is a quick, rough examination of the airplane symbol. At first, a regularly proportioned airplane was used for the pattern. After examining the view driving through the model, we went back to our modeling software and produced a distorted airplane symbol. The first plane was difficult to see from the driver's oblique angle to it. The elongated image counters the oblique viewing angle so that it can be more easily understood by the driver. This exercise is similar to the use of elongated text painted on the road surface at intersections.

Some of the software and hardware involved include McAuto COGO, XBASIC, VAX Station 3100 running McDonnell Douglas GDS, and Silicon Graphics IRIS 4D/210 GTX workstation running Bechtel software's WALKTHRU.

3. THE HOUSTON WEST LOOP GALLERIA PROJECT - CHAPTER 3

According to Donald Garrison, Schematic and Environmental Engineer for the Texas State Department of Highways and Public Transportation, a videotape was prepared as a method of showing non-engineers on a Task force three highway design alternatives.

The task force was comprised of members of the business community, environmental groups, neighborhoods, park and arboretum officials, consultant engineering firms, and the transit authority. The Department was to develop a design that would satisfy each of these groups and still be able to accommodate 350,000 vehicles per day. Eleven different designs were conceived. The task force chose three designs for full study. The stills in the video tape represent computer modelling of these three options at various locations along the existing freeway. The animation on the videotape is the computer animation of the selected option, the Collector-Distributor System. Much of the detailed work on the modelling was done by Armando Rocha of the CADD unit. The animation by videotape was finished at the Intergraph Corporation.

As the tape starts, the first still view is from a critical point near the existing expressway. In the view showing the three options - elevated, depressed, and collector - distributor - the actual buildings and real environment remain in the view as the 3D computer graphic features are inserted having used common reference points. This yields a more realistic and more flexible way to present the manner in which the
The tape shows the existing expressway and the three conceptual options from five different still view positions. The five positions were chosen from critical sites where options are relevant.

The animated 3D model shows the chosen option — the collector - distributor design. Having been involved with 3D dynamic visualization methods for many years, Texas shows its stars in this advanced presentation for the task force. In the model, as the view moves down the road one sees signs with words and symbols, sign structures, lanes, lane lines, a moving, shaded, color illustration of how this particular version of the collector - distributor concept works between and at interchanges. This would be difficult to describe with such realism in any other way. One can see the reflection of water, bushes, trees, light standards, barriers, retaining walls, all in an accurate vertical and horizontal geometry. Traffic lights, pavement symbols and the way the distributor roadway uses some of its lanes at the intersecting roadways and then rejoins the mainline are displayed in a practical and useful way.

In 3D computer graphic model building, internal designs, such as conduits, pipes, electrical junctions, drainage features, and pavement layers can be added, and interactive capability to peek through the exterior surfaces to review these features often found in bridges and near interchanges is available in some software.

Although a great deal of labor goes into the making of the model, the data inputs are not as intensive as one may originally perceive. As the modelling software develops, shortcuts around heavy data inputs are being discovered. This will add to its more common acceptability and use.
The work stations used to model have not been adequate for real-time review and faster graphic work stations are now available. Also special peripheral equipment is needed for animation production. Specifying a path for review is not labor intensive at all, and some software allows real-time interactive fly-through or drive-through views. The operator in an interactive system has total freedom to move around the model as desired.

4. CONCLUSION - CHAPTER 4

The faster graphic computers now allow rendering of 3D in sections onto videotaped environments in a more practical way. Even if the video taped actual environment is in motion, a dynamic 3D insertion can be rendered properly onto the video tape in a matter of hours instead of days. Any path through an artificial 3D highway model may be viewed in realtime with an acceptable degree of realism and useful detail. The major advantage of these improvements is that dynamic 3D visualization can bring more of the experienced human brain to bear on a design development and review process. The many changes made during the stages of design and review can be entered into the visualized model quickly and accurately. The reviewer can see the full impact of design changes before much money is spent. A new series of design effectiveness tests can be made in the interests of future users of the facility, such as motorists, pedestrians, and maintenance workers.

The extensive use of this new dynamic computer graphics capability promises more appealing and better functioning designs for daily users. New opportunities are offered to direct the billions spent on new highway interchanges on what matters most to people and away from features that are either contradictory or unimportant.

5. ACKNOWLEDGEMENTS - CHAPTER 5

Thanks are given to Wade Allen of Systems Technology, Dale Sutton of Silicon Graphics, Duane Guidry of Intergraph, Peter Rech of Bechtel Software, and John Archdeacon of Gemini Software for their assistance in providing software and hardware capabilities that relate to dynamic 3D highway design.

Dr. Richard Pain volunteered to present this paper in Gothenberg, Sweden which gives the subject matter some
international coverage. This is important and appreciated.

Peter Brigham of Wallace, Floyd Associates was kind enough to provide the Boston Tunnel tape and Don Garrison of the Texas State Department of Highways and Public Transportation was very cooperative in getting the message out through this presentation with the Houston "Galleria" tape. Armando Rocha was quite helpful in providing technical information about the systems used and his discoveries regarding production shortcuts. Other people involved in the "Galleria" tape production are given credits at the end of the tape and they are from both Texas SDHPT and Intergraph.

6. ABSTRACT - CHAPTER 6

Highway designs are becoming more effective aesthetically and functionally, with a potential for savings and greater public acceptance with advanced 3D dynamic computer graphics. More comprehensive and coordinated review of plans and alternatives at conceptual or preliminary stages are now allowed, as a result. The ultimate users of the new highways will receive increased efficiency and safety benefits. Expensive investments in design, construction, and maintenance can provide increased "rates of return" to the public through the higher level of utility.

Two pioneering tapes of 3D dynamic computer graphic models are shown as illustrations. The Boston Artery/Tunnel concepts and the Houston "Galleria" highway options.

7. REFERENCE FOOTNOTES - CHAPTER 7

Photographs were taken of the existing terrain on Interstate 610 in Houston and scanned as backdrops for the new designs.

The elevated expressway option is the least expensive, but developers feel it obstructs the view of Houston's skyline.

The Ocoee Gorge Bypass design includes plans for the 430-foot Brock Mountain Tunnel.

3D MODEL WITH ACTUAL ENVIRONMENT (INTERGRAPH CORP.)

3D MODEL VIEW (INTERGRAPH CORP.)
Validation of Real-Time Man-in-the-Loop Simulation

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VALIDATION OF REAL-TIME MAN-IN-THE-LOOP SIMULATION

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For a simulator to give valid results, whether it be for training, proficiency testing or research applications, it must present the human operator a realistic experience, including both sensory cuing and situational scenarios. Simulation can be checked for fidelity, or sensory realism, by subjective rating techniques. Validity, or objective realism, can be checked at several levels, including the sensory cuing response to control inputs, and measured task performance compared with real world data. The simulator cuing response to control inputs can be broken down into the component reactions of the vehicle dynamics and the cuing device (i.e., visual display, motion platform and control loading system). Measured task performance can be compared with real world performance at several levels, ranging from the dynamic response of the man-machine system, to overall system performance measures such accident rates. This paper discusses various simulator validation issues and gives examples from both ground vehicle and aircraft simulators, with an emphasis on driving simulation.

INTRODUCTION

Simulation is a common approach for aircraft research, training, and certification programs. Simulation is becoming a more common research approach for ground vehicles, e.g. (1-3), and is being considered for training and licensing applications (4). In aerospace applications simulation is easily justified because of cost and safety implications of real flight operations. Ground vehicles are relatively inexpensive to obtain and operate, however, and issues of safety and control of test conditions are usually advanced as justification for simulation programs.

Validation is a critical issue in establishing the credibility of simulator research results and training and licensing applications. Formal procedures have been defined for validating commercial aircraft training simulations (5), and there have been some unpublished efforts to establish procedures for military aircraft simulation. A theory for human performance validation and experimental verification has also been proposed for driving simulators (6).

Validation can involve verification of simulator component response characteristics, operator behavior and operator/simulator performance. In this paper we will review simulation performance issues and consequent validation considerations. Selected examples of validation approaches will be summarized, with emphasis on driving simulation.

BACKGROUND

Simulation validation can cover a wide range of issues associated with the simulation device, the operator, and the combined interactive performance of the operator and simulator:

Simulator component response includes:

- simulated vehicle response behavior (i.e., vehicle dynamics or equations of motion)
- response behavior of the various simulator cuing devices including visual, motion, control force and auditory displays

*Numbers in parentheses refer to references at end of paper.
Operator response includes:

- operator's subjective reaction, sometimes referred to as simulation fidelity
- operator's objective behavior, including perceptual and control responses, judgements and decision making

Overall operator/simulator performance includes:

- transient response to isolated events, and mean and variance response to random inputs
- demonstration of transfer of training, or proficiency testing, to real world performance

Simulator validation is clearly a multidimensional problem as suggested by the above list, and any component procedure should not be considered a panacea. Simulations are developed with certain objectives in mind, and validation procedures are applied that relate to these objectives. In general validation procedures relate to simulation features or applications of interest which should be clearly stated.

There are two additional related issues that should be considered along with validation. These issues are operator motivation and operational scenarios. Drivers and pilots are motivated in their performance by real world incentives involving time (speed) and safety (accuracy). The speed versus accuracy tradeoff is a well known behavioral paradigm, and in simulation the concern is, what incentives are motivating operator behavior? In proficiency testing, operators are motivated to pass the test. In training and research applications incentives must be set up creatively in order to minimize game playing and generally encourage speed/accuracy tradeoffs consistent with real world conditions, e.g. (7). With professional operator populations this is not as much of a problem and is more of concern for the general driver population.

Operational scenarios can have a strong influence on the "realism" of the simulation and thus have some influence on operator motivation. Operational scenarios can be complex, and validating simulation details of situations and operator response to these scenarios, particularly where decision making is involved, can be reasonably complicated. Complex scenario examples in driving simulation include traffic interactions where drivers have to make gap acceptance decisions; piloting examples might include approach and landing under windshear conditions where go-around decisions must be considered.

Finally, it should be noted that there are three methods for validating simulation characteristics. First, if there is some absolute criterion for a given characteristic such as visual display resolution, then the characteristic can be measured. A second validation method involves comparing simulation measurements with results obtained in real vehicles obtained under controlled experimental conditions. A third method, which might be considered the highest form of validation, involves the comparison of simulator behavior with real world results obtained under uncontrolled observational conditions. In this third case, if combined operator/vehicle behavior is being validated, operators are presumably performing under real world conditions with appropriate motivation.

SIMULATOR CONSIDERATIONS

A generic simulator block diagram is given in Fig. 1 that portrays the various components that control and generate visual, motion, control loading, instrument, and auditory display feedback cues to the operator. Operator control inputs to the vehicle dynamics generate accelerations, velocities, positions, and orientations that then provide inputs to the various feedback cuing paths. The operational scenario control generates disturbance inputs to the vehicle dynamics, such as winds and road characteristics (e.g., surface friction and profile) and command inputs to the
visual system data base including road geometry, interacting vehicles, and traffic control devices (i.e., delineation, signs, and signals). Performance measurement then accounts for vehicle and operator behavior, and vehicle interactions with the roadway environment as defined by the scenario control module.

In comparison to aircraft simulation, driving simulation is much more demanding of scenario control because the operator and vehicle interact with the complex roadway environment. Advanced scenario control is essential to simulate meaningful driving tasks and provide useful performance measurement in situations requiring decision making.

The visual and motion display pathways show delay compensation that is intended to counteract response delays and lags in the display generator and motion base. This problem has been analyzed in some depth for driving simulation (8), and display compensation has been developed for aircraft simulation (9). This particular issue is critical to the appropriate closed loop control of the vehicle dynamics as portrayed in Fig. 2. In the real world, the operator experiences only vehicle delay and/or lag in vehicle motion response to control inputs, which for cars is on the order of 0.1-0.2 seconds (10). In the simulator, the operator also experiences the additional delay of the visual and motion cuing devices, which should ideally be small in comparison with vehicle response lags. Significant additional delay can influence control performance and also induce simulator sickness symptoms (11). Validation of simulator components should pay particular attention to this critical aspect of simulator performance, and verify the effectiveness of compensation techniques. Cuing delays are not typically a significant issue for other feedback modalities as they are not used directly for closed loop control.
VALIDATION EXAMPLES

Vehicle Dynamics

Vehicle dynamics directly influence simulator response as perceived by the operator through visual, motion, and control load feedbacks. Standard techniques are available for verifying intended properties of vehicle dynamics as represented by the equations of motion. These procedures include tests for steady state response, dynamic response, and transient response. Recently, a ground vehicle dynamics computer simulation was validated against the field test behavior of instrumented vehicles (12). A summary of validation data for steering inputs is given in Fig. 3.

The steady state response is evaluated as a function of lateral acceleration, since this variable provides the basic limitation in vehicle maneuvering due to tire force saturation characteristics. The test involves driving a vehicle around a circle with slowly increasing speed. Lateral acceleration increases with speed, and larger steering inputs are required with increasing lateral acceleration. The initial slope is due to the vehicle’s basic understeer response due to steering compliance and roll steer effects. As the vehicle’s tires begin to saturate at higher lateral accelerations the steering angle required to stay on the turn circle increases dramatically as the vehicle plows out. Understeer and plowout are common automobile handling characteristics that should be validated as indicated in Fig. 3 if they were intended to be implemented in the vehicle dynamics.

The transfer function measurements illustrated in Fig. 3b are an important validation method for complex vehicle dynamics. For a ground vehicle the yaw rate, roll rate and lateral acceleration transfer functions represent characteristics in the lateral/directional dynamics (i.e., the directional and roll modes), the steering system, and side force delays in the tire model. The transfer functions are obtained by applying a sinusoidal steering input of increasing frequency to the vehicle; FFT (Fast Fourier Transform) procedures are then applied to the resultant waveforms to obtain transfer functions between the steering input and the vehicle response variables. The match between the field test and computer simulation represents a fairly accurate description of the vehicle dynamics under low lateral acceleration conditions (i.e., less than 10 feet/sec/sec), or well below limiting conditions where the response is fairly linear.

The transient response validation in Fig. 3c carries the vehicle dynamics out to the limit maneuver regions where the front and rear tires are fully saturated (on the order of 25-30 ft/sec/sec lateral acceleration). The transient maneuver combines the basic vehicle dynamics with the nonlinear characteristics of the tires under limit performance maneuvering conditions to validate vehicle dynamics that are important to crash avoidance situations. The maneuver resulting from the steering input is basically a double lane change, and the field test steering profile was used in the computer simulation to produce the simulation response.
Figure 3. Comparison of Instrumented Vehicle and Computer Simulation Data for Vehicle Dynamics Validation (Adapted from Ref. 12)
Visual Display System Response

As noted previously, CGI (Computer Generated Imagery) systems can result in significant delays in the visual cuing feedback to the operator, and techniques have been developed for compensating for the effects of these transport delays (9). Techniques have also been developed for identifying the visual feedback delays and the resulting effect of compensation (13). The procedure involves instrumenting the display with a photo sensor as indicated in Fig. 4a and exciting the visual variables with a sinusoidal waveform of increasing frequency such as that used for the vehicle dynamics validation above. FFT procedures are then used to evaluate transfer functions between the inputs to the CGI and resulting visual display response.

The results of the above test are illustrated in Fig. 4. Without compensating the CGI input signals, the pitch axis transfer function phase lag indicates an equivalent transport delay of 57 msec (Fig. 4b). With the display compensation algorithm active, the phase delay is essentially eliminated (Fig. 4c).

Visual Display System Resolution

Measures of visual response should include not only the dynamic fidelity of the response, but also the resolution provided by the visual system. Ability to resolve details on CGIs can be important for some applications. For aircraft, this has proven to be a critically important element in the pilot’s ability to hover a helicopter with any precision (14). Measurement of visual acuity on the NASA Ames Vertical Motion Simulator (VMS) was performed by programming a three-bar chart into the visual data base (Fig. 5a) of a Singer-Link Digital Image Generator (DIG I) (15). This pattern determines the resolution or visual acuity in terms of spatial frequency (cycles/mrad) or minutes of arc, where 1 arcmin is normal 20/20 vision.

Results of the above resolution assessment are shown in Fig. 5b. Two visibility levels, corresponding to runway visual range (RVR) of unlimited and 250 ft, were evaluated; the best resolution was about 4.5 arcmin, meaning the pilots’ ability to resolve fine detail on the DIG I was considerably worse than 20/20 vision. In the driving environment, highway signs are designed to be read at distances requiring high acuity, which is probably beyond the effective resolution of current CGIs.

Motion System Response

The ideal motion response for a simulator would be that which replicates the motions experienced in the real world. Since this is not possible, it is necessary to reach a compromise between accuracy of the motion response and full utilization of the motion system. Washouts are required at low frequencies to remove the commanded accelerations, rates, and displacements and return the motion base to center position in a reasonable time. High-frequency lags are unavoidable, as the mass and inertia characteristics of the motion base, in combination with the bandwidths of the actuators, introduce an effective time delay. The combination of these compromises in the motion system response should be minimized, to the extent possible, around the frequencies of human motion sensing (16), typically 0.5-10 rad/s.

A simulation fidelity study for an Army UH-60 utility helicopter (17) illustrates the differences that can exist (Fig. 6). The frequency-response dynamics of an instrumented helicopter were identified (circles on Fig. 6) and were found to compare favorably with the math model (solid lines). The phase response of the cab, however, differs greatly (dashed lines) due to the washout at low frequencies and lags at high frequencies. As a result, the cab response, which is meant to transmit at least a fraction of the actual vehicle’s response over some range of frequencies, matches in phase at only a single frequency.

Control Loading

Steering system torque feedback to the driver in automobiles results from the wheel aligning torque arising from lateral tire forces. This feedback provides the driver a direct feedback of
Pitch and Height

CRT:
Light
Dark

Yaw and Lat. Pos.

Aperture of Visual Display Sensor

Image Motion (deg of freedom)

Roll Axis

Roll Input

a) Photo-Sensor Placement

b) Throughput Delay (approx. 57 msec)
   in the Pitch Axis

c) Successful Compensated CGI Pitch Axis
   Display Throughput Delay

Figure 4. Transfer Function Measure of Visual Display Throughput Delay
a) Three-Bar Resolution Chart Programmed Into Visual Data Base

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<th>Bars</th>
<th>RVR</th>
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<td>Horiz</td>
<td>RVR = 250 ft</td>
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b) Resolution Results

Figure 5. Resolution Test for CGI Visual Display
the consequences of steering inputs on vehicle maneuvering response, and is perceived much sooner than motion or visual feedbacks of vehicle motion (18). Tests were conducted in a simple fixed base driving simulator with a high frequency control loading system (19) and compared with similar tests conducted in an instrumented vehicle with a servo steering system (20). The tests involved applying random wind-gust-like inputs to the steering system, to which the driver had to respond to minimize lane deviations.

Fourier transform techniques were used to obtain transfer functions for the combined driver/vehicle response in the above tests. The transfer functions were then evaluated to determine the effective driver delay in response to the random input disturbance. The time delay results are compared in Fig. 7 for simulation conditions involving no steering torque feedback (spring restraint only) and with two levels of active steering feel system feedback, as well as results obtained with the instrumented vehicle. As indicated by Fig. 7, the instrumented vehicle results compare quite favorably with the simulation condition involving high steering torque feedback. It has been noted that the human proprioceptive system provides feedback with the shortest time delay to the human operator (18). The Fig. 7 results suggest that good control loading cuing can allow for driver control responsiveness to the equivalent of random wind disturbance in a fixed base simulator similar to that achieved in a real test vehicle.

Driver/Vehicle Performance

An extensive study was conducted of the effects of delineation visibility on driver lane keeping ability. The study involved both simulation and open highway testing (21). Visibility was controlled in the laboratory simulator by regulating how far in front of the vehicle the delineation was visible. In the real world tests were conducted on a mountain highway at night under two conditions: 1) after the spring thaw when the painted road markings were nearly worn off from tire chains during the winter and 2) after the road markings were freshly painted.

The results of the study were assessed in terms of the influence of road marking contrast on lateral lane deviation variability, as summarized in Fig. 8. Data from the real world highway tests are compared with a performance model, derived from the simulation tests, that relates visibility distance to contrast threshold. The lateral lane deviation variability clearly decreases with road marking contrast, and the simulation performance model is consistent with the real world measurements.
Figure 7. Effect of Steering System Torque Feedback on Effective Driver Time Delay

Figure 8. The Influence of Road Marking Contrast or Driver/Vehicle Lateral Lane Deviations in an Instrumented Vehicle as Compared with a Simulation Performance Model.
Decision Making

A study was conducted on the effects of alcohol intoxication on driver decision making behavior (22). A signal light task was set up in both a laboratory simulator and an in-vehicle experiment conducted on a driving range. Signal timings, when the yellow caution light first appeared, were set as a function of distance from the intersection and speed over a range from long, which required the driver to stop to avoid running the red light, to short, which allowed the driver to easily make the signal without violating the red light.

In Fig. 9 the probability of drivers going through the intersection without stopping is plotted as a function of time-to-go to the intersection (i.e., distance to the intersection divided by vehicle speed). Here we see that the probability of going increases with decreasing time-to-go to the intersection. The operating characteristics are nearly identical for the simulation and driving range experiments (22). Note also that the experimental results are reasonably consistent with real world results obtained in observational studies (23, 24), thus allowing an additional degree of simulation validation. In the experimental study monetary rewards and penalties were used to motivate drivers to minimize driving time by not stopping at signals, but also to avoid getting tickets for running the red light. The comparison with observation of real world driving behavior would suggest that the experimental subjects were reasonably motivated.

Subjective Opinions/Ratings

In addition to quantitative measures of validation, it is essential that the qualitative opinions of the operator in the simulator be consistent with those for the same vehicle, in the same situation, in the real world. A comparison of flight vs. simulator subjective opinions was conducted for a model of a highly augmented vertical-takeoff-and-landing (VTOL) vehicle to look at this issue (25). The aircraft was simulated on the NASA Ames Vertical Motion Simulator (VMS) and three pilots rated the vehicle’s response for precision hovering tasks using Cooper-Harper Handling Qualities Ratings (HQRs) (26) as the simulated response dynamics were varied from sluggish to crisp (27). The simulator characteristics were unchanged. A similar study was performed by the Canadian National Research Council with a variable-stability helicopter (25) with five pilots.
An example of results from this study is shown in Fig. 10. This figure shows the range of pilot-assigned Handling Qualities Ratings as a function of roll attitude Bandwidth (a measure of crispness of response (27)). For flight compared to simulation, the spread in the ratings is smaller, and the dynamics required to obtain satisfactory ratings are considerably lower. On the average the simulation was given poorer handling quality ratings than the real vehicle, which suggests a poor simulator validation.

**Figure 10. Comparison of Subjective Handling Qualities Ratings from Flight and Simulation of a Hovering VTOL Aircraft**

**CONCLUDING REMARKS**

Simulation validation is a complex, multifaceted concern with no single approach. A given validation approach relates to specific simulator features and applications, and there is no single methodology that will provide a panacea for overall validity. Some simulation features, such as vehicle dynamics and cuing device response, can be validated with traditional engineering methods for identification of dynamic systems. When combined operator/vehicle performance is of concern, then behavioral experiments must be designed to compare simulator results with experimental data obtained from instrumented vehicles and test ranges or with real world observational data. Observational data are ideal in one sense, because the operators are performing with appropriate real world motivations.

Several examples of validation approaches have been given, some of which indicate good correspondence between simulation and desired behavior or results, and other cases where there is a significant shortcoming in the validation comparison. It is possible for simulations to be a valid representation of real world conditions for one application and set of characteristics, but lacking in other respects. Validation procedures must not be considered a panacea, and must be designed to specifically address situations and characteristics of interest.

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Measurement of Driver Performance in Training Simulators

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MEASUREMENT OF DRIVER PERFORMANCE IN TRAINING SIMULATORS

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ABSTRACT

One important advantage of simulators for training purposes is that they can easily be equipped with additional systems that automatically measure task performance. Driver training with utilization of these systems may provide two major advantages above more usual training on a driving simulator: the objectivity of performance evaluation by the instructors and the quality of behavioral feedback to the student may be increased. Because many simulator manufacturers have a strong engineering conceptualization of simulator usage these systems often do not meet the high expectations. For example simulators used for training tracked vehicle drivers of the Royal Dutch Army were equipped with a Performance Evaluation and Feedback (PEF) system which were developed by the manufacturer. The large quantity of detailed output of this system was not easy to comprehend and seemed to lack significance for driver training. The present paper is the result of a study aimed at improvement of these PEF systems and at formulating guidelines for the development of these systems.

First the major shortcomings of existing PEF systems will be reported. These are mainly based on lacking application of knowledge concerning the driving task and concerning the way student drivers learn skills in a simulator. More important for the present purposes, however, is the manner in which relevant knowledge may be implemented in a PEF system for a driving simulator. Therefore seven principles that may be crucial for a successful development of performance evaluation and feedback systems for training simulators will be presented. These principles refer to:

- task analysis
- the validity of the simulator for different subtasks
- the relevance of subtasks and of performance measures
- the evaluation difficulty of subtasks
- the manner of metric construction
- the comprehensibility of scores
- the ergonomics of data-presentation

In the design of a PEF system these principles should be systematically applied. For the Dutch driving simulator this was done accordingly. The new PEF system that resulted was based on a selection of the nine most relevant subtasks each combined with critical and objective performance measures. The main characteristics of the system will be presented.
MEASUREMENT OF DRIVER PERFORMANCE IN TRAINING SIMULATORS
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1. INTRODUCTION

For the training of tracked-vehicle drivers (Leopard 2 and YPR-765) of the Netherlands Royal Army, two full-scale driving simulators were developed. These simulators include, among other things, a computer-generated and collimated image, a six degrees-of-freedom moving-base system and an instruction panel.

In order to enhance the efficiency of the instructor's task, both simulators also are equipped with a so-called Performance and Marking (PAM) system, which automatically measures driving performance. Training with utilization of such a PAM system may provide two major advantages above usual training on a driving simulator: explicit feedback to the student and more objective performance judgements by the instructors (Korteling, 1990a). Feedback is primarily relevant for the student, who needs "knowledge of results" (e.g., Adams, 1979, 1987; Schmidt, 1975, 1988), and objectivity is primarily relevant for the instructor, who wants to make up an objective representation of the strong and weak points of a student's driving behavior. These advantages are strongly related. Objective performance data, for example, enable the instructors to improve the quality of their instructions, which in turn implies that knowledge of results (for the student) is enhanced.

On the first acquaintance with the PAM system it was noticed that the large quantity of detailed output was not easy to comprehend and seemed to lack significance for driver training. Therefore the TNO Institute for Perception was asked by the Netherlands Army to evaluate the system and to give recommendations for improvement. In the present paper, the original version of the PAM system will be described and shortcomings of the system will be outlined. Furthermore a design of a more appropriate and user-friendly system for performance evaluation and feedback (PEF system) will be presented. This PEF system is based on general theoretical principles combined with existing knowledge of the driving task (Korteling, 1990b; Korteling & Padmos, 1990). Both the critique of the original and the design of a new system will proceed according to seven principles that are crucial for a successful development of automated performance evaluation and feedback systems for training simulators.

Because PAM/PEF systems for training simulators have only recently been developed and therefore knowledge concerning maximization of their efficiency still is minimally available, the present paper and the more extended reports (Korteling, 1990a; Korteling, 1991) may be regarded as a first step
for improvement of the effectiveness of these kinds of systems.

2. THE PAM SYSTEM

This section gives a brief description of the main characteristics of the original PAM system.

Feedback of the PAM system consists of a pattern of scores on predefined aspects of driving behavior related to objective criteria. In its original form the system monitors *route driving*, consisting of road and terrain driving, and what may be called *obstacle driving*, i.e., water wading, driving on a low loader, over ditches, over solid blocks a "step up" or a "sloping block", etc. The last two obstacles refer to a concrete object with vertical sides or steep sloping sides, respectively, including a traverse.

The sets of performance measures, monitored by the PAM system, for route driving and obstacle driving are different. For route driving, mean and/or peak values or frequencies are measured (Fig. 1). The route driven is divided into normal (straight or curved) sections and junctions. For each single section of normal road or junction, all these variables are separately measured, stored and presented. Since a route, usually consisting of many of these sections, is intended to take about 5 minutes to drive, the corresponding output will often be huge, with printouts exceeding a meter for only one PAM evaluation.

For obstacle driving, performance on the different measures is more qualitatively assessed, such as very fast, good gear, hard bang to suspension, or poor heading. These variables are separately measured at critical moments (e.g., first contact) of the different phases in which the obstacles are crossed. These phases are: approach, ascent, traverse, descent, and driving off (Fig. 2).

Driving behavior is evaluated by relating the student's scores on a given trajectory to the results of one expert driver (the expert database) over the same trajectory. Fig. 1 shows the heading and a partial print of a student's driving performance (left part) on a section of straight road (upper part) and across a sloping block (lower part), both related to an expert's (instructor) performance (right part). With respect to route driving the student's performance on each measure is marked by the degree of similarity to the expert performance and the maximum possible mark, ranging from 2 to 12. Measures regarded as important have a higher maximum mark (e.g., speed: 12) than measures regarded as less important (e.g., gears: 4). Metrics for similarity to expert performance are very arbitrary and lack a sound psychometric basis.

For each route-driving measure, the expert database determines the performances leading to a maximum mark. The sum of the student's marks for all measures within a section of the route (straight/curved, junction) or the obstacle (approach, ascent, traverse, descent, or drive off) is expressed as a percentage showing how close the student comes to the criteria in the expert database. Two points are added when there are no crashes
**Fig. 1. Partial prints (two sections) for Route and Obstacle driving.**

**Database:** Vlasakkers  
**Total mark:** 63%

<table>
<thead>
<tr>
<th>Route</th>
<th>Mark</th>
<th>Step: 61%</th>
<th>Time: 0.08</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>function</td>
<td>mean</td>
<td>maximum</td>
</tr>
<tr>
<td>No crash 2</td>
<td>speed</td>
<td>kph</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>RPM</td>
<td>*100</td>
<td>17.72</td>
</tr>
<tr>
<td></td>
<td>acceleration</td>
<td>%</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>brake</td>
<td>%</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>slip</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>slide</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>deviation</td>
<td>mtre</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>indicators</td>
<td>%</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>verge</td>
<td>#</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>suspension</td>
<td>%</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>gear</td>
<td>#</td>
<td>VA</td>
</tr>
</tbody>
</table>

**PROGRAMMED OBSTACLE/ROUTE**

<table>
<thead>
<tr>
<th>Obstacle mark: 100%</th>
<th>Time taken: 0.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>speed: 3.0 kph</td>
<td>brake: 100%</td>
</tr>
<tr>
<td>gear: V2</td>
<td>accel: 76%</td>
</tr>
<tr>
<td>speed at slope: 6.5 kph</td>
<td>pitch rate: 41.72d/sec</td>
</tr>
</tbody>
</table>

**Sloping Block**

<table>
<thead>
<tr>
<th>Approach</th>
<th>Obstacle mark: 55%</th>
<th>Time taken: 0.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>good speed</td>
<td>3.0 no brake</td>
<td>17 good heading</td>
</tr>
<tr>
<td>good gear</td>
<td>V2 no brake</td>
<td>60 good steer</td>
</tr>
<tr>
<td>very fast</td>
<td>2.6 hard bang to suspension</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ascent</th>
<th>Obstacle mark: 100%</th>
<th>Time taken: 0.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>good speed</td>
<td>2.2 no brake</td>
<td>0 poor heading</td>
</tr>
<tr>
<td>good gear</td>
<td>V2 no brake</td>
<td>0 no steer</td>
</tr>
<tr>
<td>very slow</td>
<td>2.0 low pitch</td>
<td>29.59</td>
</tr>
<tr>
<td>smooth ride</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crossing</th>
<th>Obstacle mark: 55%</th>
<th>Time taken: 0.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>very fast</td>
<td>7.6 hard brake</td>
<td>100 over heading</td>
</tr>
<tr>
<td>good gear</td>
<td>V2 over accel</td>
<td>80 good steer</td>
</tr>
<tr>
<td>very fast</td>
<td>7.5 good pitch</td>
<td>45.04</td>
</tr>
<tr>
<td>hard bang to suspension</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Descent</th>
<th>Obstacle mark: 100%</th>
<th>Time taken: 0.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>very fast</td>
<td>9.4 hard brake</td>
<td>100 good heading</td>
</tr>
<tr>
<td>good gear</td>
<td>V2 no brake</td>
<td>0 no steer</td>
</tr>
<tr>
<td>very fast</td>
<td>5.2 low pitch</td>
<td>38.77</td>
</tr>
<tr>
<td>smooth ride</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drive off</th>
<th>Obstacle mark: 100%</th>
<th>Time taken: 0.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>good speed</td>
<td>3.3 good brake</td>
<td>100 good heading</td>
</tr>
<tr>
<td>good gear</td>
<td>V2 no brake</td>
<td>69 good steer</td>
</tr>
</tbody>
</table>

**Student time:** 4.39  
**Instructor time:** 5.00
detected during a section of the PAM route. The marks sum to a compound mark of 100% when a student's driving is the same (within the minimum ranges) as the expert's driving. The mean of all section compound percentages over a complete PAM route is called the total mark, reflecting the general similarity of the driving performance of the student relative to the expert's driving behavior. This means that, despite their different length and/or character, section scores are not weighted.

Fig. 2. Schematic representation of the five phases in which an obstacle (sloping block) is crossed.

3. SHORTCOMINGS OF THE PAM SYSTEM AND SPECIFICATIONS FOR A NEW PERFORMANCE EVALUATION AND FEEDBACK (PEF) SYSTEM

The original PAM system shows problems, ranging from minor shortcomings in the clarity of the output presentation to major flaws in the selection and calculation of appropriate performance measures. The number of specific problems that can be identified is great; it would take too far to go into each particular problem. Therefore the present chapter only discusses these shortcomings on a global level.

This discussion will proceed according to seven principles. These principles are of a general character such that they are also relevant for other kinds of driving simulators. In this section, the manner in which the PAM system does not meet each principle will be briefly discussed. Also, a procedure for selection of (aspects of) subtasks for evaluation will be provided and a more optimal method of measurement will be indicated.
1. Objective performance evaluation and explicit feedback should refer to only those subtasks that can be trained with sufficient functional validity.

The benefit of a performance evaluation and feedback system (PEF) for training increases with the validity of the simulator with regard to the task. Increasing the objectivity and specificity of performance evaluations has no value if the skills that are evaluated differ from the skills needed in the operational system. It will thus be evident that using a PEF system for the training of these kind of subtasks only costs extra time. Therefore, the use of such a system should be limited to the part tasks which are simulated with sufficient validity. Hence, the development of a PEF system should start with a description of the training objectives and a task analysis, in which the task to be trained on the simulator is analyzed into its components, or subtasks. In general the functional validity of the tracked-vehicle simulators differs for different subtasks. Subtasks that mainly consist of procedures and/or require interaction with artificial parts of the task environment generally allow for more valid simulation than subtasks that require interaction with the natural environment (Korteling, 1990b; Korteling & Padmos, 1990). The main problems of the involved tracked-vehicle simulators concern the simulation of the normally available spatial and mechanical information about the natural environment and the degree of variation and density in the simulation of other traffic. Based on two reports (Korteling, 1990b; Korteling and Padmos, 1990), documenting a task analysis and an inventory of the structural problems of the simulators, the following list of subtasks that probably will be trainable with sufficient effectiveness may be taken as a starting point:

**Route driving**
- driving right on straight roads
- driving left on straight roads
- stopping/braking
- gearing
- driving on road curves
- driving on sharp curves and at intersections
- turning on the spot**

**Special actions:**
- narrow passage ("funnel")
- "slalom" course
- vehicle clearing course ("lane change")
- parking the vehicle ("garage")
- parking on a railway wagon
- usage of the short brake levers**

---

1 * Only relevant for the Leopard 2 simulator
** Only relevant for the YPR-765 simulator
driving on visual signals
driving with an image intensifier
parking on a lowloader

Obstacle driving:
step up ("concrete block")
sloping block (Fig. 2)
knife edge
small ditches (slowly)
small ditches (quickly)
large ditch
camber (normal, adverse)
alternating camber
water wading

2. Objective performance evaluation and explicit feedback should refer to the most critical and relevant subtasks of the driving task, while including a broad range of skills necessary for driving performance.

In order to use a PEF system as efficiently as possible, objective evaluation and explicit feedback should aim at the most critical and relevant subtasks. This means that the system should not include trivial and/or overlapping subtasks. Also, the total of PEF measurements has to cover a broad range of driving skills as much as possible. The PAM system in its original form included trivial as well as overlapping subtasks. Moreover, hardly any of the special actions implied in the training of Leopard 2 and YPR-765 drivers (e.g., slalom course, vehicle clearing course) had been chosen for monitoring. In order to select key subtasks such that performance evaluations are valid and useful feedback is provided the instructors working with the simulator were consulted. Seven subtasks were qualified as trivial: turning on the spot, large ditch, small ditches (quickly), driving on visual signals, usage of the short brake levers, driving with a brightness amplifier, and water wading. Therefore these subtasks were discarded from the list above. Primarily, these subtasks demand knowledge about simple procedures or actions in order to be well perform (e.g., Korteling & Padmos, 1990).

There is also overlap between some of the remaining subtasks. The necessary skills for driving on a straight road (keeping a good lateral position) and gearing (choosing the right gear/speed) are largely involved in driving on road curves such that both can be evaluated in a road course with curves. Furthermore, the step up and the sloping block are comparable subtasks that may be evaluated according to the same principles and procedures.

With respect to the special operations, the narrow passage and parking the vehicle do not add much to the vehicle clearing course. In each subtask the driver has to drive between closely separated obstacles. However, only the vehicle clearing course explicitly requires the driver to make some difficult
(re)positioning operations. Also a big overlap exists between the railway wagon and the lowloader. Both tasks require the driver, guided by a marshaller, to park a YPR-765 on a transport vehicle. The lowloader is the most difficult subtask since this vehicle contains a small bump that must be taken (which also causes the marshaller to be out of sight for a moment). Therefore the railway wagon was discarded. For PEF evaluation, the following subtasks remained on the list:

**Route driving**
- stopping/braking
- driving right on straight sections and on curves
- driving left on straight sections
- driving on sharp curves and at intersections

**Special actions:**
- "slalom" course
- vehicle clearing course ("lane change")
- lowloader

**Obstacle driving**
- step up and sloping block
- small ditches (slow)
- camber (normal, adverse, alternating)

3. **Objective performance evaluations should refer to subtasks which are difficult to evaluate by the instructor.**

The original PAM system provides information that is already evident for the instructor anyway, such as the number of crashes or the use of direction indicators. In addition, the system does not monitor subtasks that are difficult to evaluate from the instructor's point of view, such as gas control, steering performance, and smooth driving. However, all subtasks in the list above are difficult to evaluate objectively for the instructor. Consequently all subtasks on the list above may be maintained.

4. **Performance evaluation and feedback should focus on the measures that reflect the most critical aspects of subtasks.**

Because different subtasks are based on different perceptual information and actions (task variables), the most critical aspects of a subtask may be different for different subtasks. For example, speed control on an YPR-765 becomes very critical when driving in sharp curves, whereas this subtask is of secondary importance on straight roads. This means that for different subtasks different critical variables are relevant to represent the quality of driving performance. This issue was not addressed in the original PAM system. In the PAM system, the same broad range of variables was mea-
sured for nearly every maneuver. The only differentiation that has been made is the differentiation between route driving and obstacle driving. Consequently many performance measures that were presented gave no information or gave useless information concerning the subtasks involved. Based on a task analysis (Korteling, 1990b), and consultations of instructors, the most critical (important, difficult, and time consuming) task variables were selected for the remaining list of subtasks. It may be expected that feedback concerning these task variables is especially useful to the student. With reference to the YPR, Table I shows these critical variables for each of the selected subtasks.

Table I The selected subtasks and their critical task variables for the YPR-765.

<table>
<thead>
<tr>
<th>SUBTASK</th>
<th>CRITICAL TASK VARIABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Route driving</strong></td>
<td></td>
</tr>
<tr>
<td>Stopping</td>
<td>lateral position (steer control)</td>
</tr>
<tr>
<td>Driving right straight/curves</td>
<td>lateral position (steer control)</td>
</tr>
<tr>
<td>Driving left/straight</td>
<td>lateral position (steer control)</td>
</tr>
<tr>
<td>Sharp curves and intersections</td>
<td>lateral position (steer control)</td>
</tr>
<tr>
<td><strong>Special actions</strong></td>
<td></td>
</tr>
<tr>
<td>&quot;Slalom&quot; course</td>
<td>lateral position (steer control)</td>
</tr>
<tr>
<td></td>
<td>longitudinal speed (gas control)</td>
</tr>
<tr>
<td>Vehicle clearing course</td>
<td>lateral pos. (steer/gas control)</td>
</tr>
<tr>
<td></td>
<td>longitudinal speed (gas control)</td>
</tr>
<tr>
<td>Lowloader</td>
<td>smoothness (gas/brake control)</td>
</tr>
<tr>
<td></td>
<td>long. speed (gas/brake control)</td>
</tr>
<tr>
<td></td>
<td>following signals of marshaller</td>
</tr>
<tr>
<td><strong>Obstacles</strong></td>
<td></td>
</tr>
<tr>
<td>Step up and sloping block</td>
<td>smoothness (gas/brake control)</td>
</tr>
<tr>
<td></td>
<td>long. speed (gas/brake control)</td>
</tr>
<tr>
<td>Small ditches (slow)</td>
<td>smoothness (gas/brake control)</td>
</tr>
<tr>
<td></td>
<td>long. speed (gas/brake control)</td>
</tr>
<tr>
<td>Camber (adverse, alternating)</td>
<td>lateral position (steer control)</td>
</tr>
</tbody>
</table>

5. If possible, performance measures and criteria should be defined according to objective principles, based on characteristics of the vehicle, task analysis, and formal rules for driving behavior. In its original form, performance criteria of the PAM system were based on the assumption that for every part of a trajectory and for every variable measured there is one optimal value, which may be prouced.
by any expert. Apart from the variability of the expert's performance, the falseness of this assumption is demonstrated by the fact that many parts of the driving task can be performed satisfactorily using different strategies. Therefore objective and unambiguous principles should be developed in order to operationalize the measurement of driving performance. Knowledge of the vehicle and the driving task offers the most substantial opportunities for this. There usually are objective limits within which the value of variables should be kept, given the driving situation (e.g., RPM while turning on the spot: 1500-2000; speed in urban roads: < 30 mph, when turning left or right the direction indicator should be used; and when approaching the step up or the sloping block, driving speed should be decreased until one drives at a foot-pace and these objects should be taken as smoothly as possible. The relevant measures and criteria may easily be implemented in a new PEF system, such that performance can be judged without the intermediary of an instructor.

Below, these kinds of absolute performance measures and criteria will be defined globally for selected subtasks for the YPR-765. A more detailed description can be found elsewhere (Korteling, 1990a, 1991).

**Stopping/braking**
When an YPR-765 driver stops he has to release the gas pedal and pull the two braking levers such that the vehicle stops in a straight course. The maintenance of a straight course while stopping is an especially difficult and important aspect of this subtask. The degree to which this is accomplished may be measured by calculating the standard deviation of the vehicle's course during the time both brake levers are pulled and the vehicle's deceleration exceeds a specific value. The mean value of all measured standard deviations during the PEF route may represent stopping performance.

**Driving right on straight sections and in curves**
With respect to lateral position the student should drive always as stable as possible on the right side of his lane and he should not drive into the verge. The degree to which this is accomplished may be measured by separately calculating the root-mean-squared (RMS) error of the vehicle relative to the right edge of the road and the total longitudinal distance over which the vehicle drives on the verge. A high RMS error reflects poor steering performance. Vehicle reference points for RMS calculations may be located at the longitudinal middle of the vehicle model. By measuring the distance of verge driving instead of the duration or frequency, the speed as well as the time of verge driving is taken into consideration. The higher the speed and the longer the duration, the higher this index.

**Driving left on straight sections**
This subtask contains the same kind of measures as the prior one, except left and right have to be interchanged.
**Sharp curves and intersections**

Since gear choice is mainly determined by the radius of the curve and the width of the road, performance may be evaluated according to the criteria based on these variables. The system should then "know" rules like: when the curve radius of a road with a width of \( y \) m is between \( r_1 \) and \( r_2 \) m, the curve should be driven in gear position \( z \). The duration of driving in a wrong gear has to be rated over the total PEF trajectory.

**Slalom course**

A slalom course usually consists of a number of beacons in a row. The driver has to steer his vehicle in gear "1" around the beacons without hitting them. Since there are many ways to drive a slalom course correctly (Fig. 3) it is not possible to define an absolute criterion for lateral position that is more valid than the number of hit beacons.

![Fig. 3 Two possible manners of driving the slalom course.](image)

As a consequence of the limited field of view in the involved simulators and the absence of mirrors which enable the driver to monitor his own driving behavior, intrinsic performance feedback in this subtask is very scarce. In order to enhance performance feedback to the student, a clear audible signal in the driver's cabin should indicate the moment the vehicle hits a beacon.

Also, the time taken to drive the course may be measured in order to represent the efficiency of driving performance.

**Vehicle clearing course**

A vehicle clearing course consists mostly of one lane change to the right or left and one again to the original lane (Fig. 4). The driver has to steer the vehicle as well as possible in the middle of the lanes marked out by cones. By proper gas control he also has to maintain a specific gear position. Task performance may thus be indicated by three absolute criteria: 1. the RMS error relative to the midline of the lanes, 2. the duration of driving in a wrong gear, and 3. driving speed. In order to enhance performance feedback to the student, a clear audible signal (see slalom course) in the driver's cabin should indicate the moment the vehicle hits a cone.
Lowloader
A lowloader is a heavy truck designed to transport tracked-vehicles (Fig. 5). Since there is just enough space for one YPR-765 vehicle, the driver has to follow signals of a marshaller when parking his vehicle on a lowloader or when driving off. Ascending as well as descending, should be performed very carefully. This may be accomplished by maintaining a low driving speed and accurate brake pedal usage. When this is not appropriately done, jolts may be found in the acceleration profiles of the surge, heave, and pitch degrees of freedom.
Also the RMS error relative to the (virtual and extended) midline of the lowloader has to be measured.
Finally the fluency, or rapidness, of driving behavior determines the quality of task performance. Therefore mean driving speed during this subtask should also be monitored.

Fig. 5 Schematic representation of the lowloader.
Step up and sloping block
Performance on crossing the step up and the sloping block (Fig. 6) is mainly determined by the smoothness and fluency of driving. Therefore, for this subtask, the same compound smoothness-measure and speed measure may be calculated as for driving on and off the lowloader.

![Fig. 6 Schematic representation of the sloping block.](image)

Slowly crossing small ditches
For crossing small ditches, smoothness and fluency of driving are also the critical performance variables. Therefore, for this subtask, the same compound smoothness and speed measure (using the same start and end points) may be calculated as for the lowloader and crossing the step up and sloping block.

Camber (adverse, alternating)
Camber driving may include a normal camber, an adverse camber and a section with continuously changing cambers (alternating). The main problem of driving over a camber or an adverse camber is to keep the vehicle in the optimal lateral position. Therefore the RMS error relative to the right edge of the road is the best representation of task performance (see section "Driving right on straight sections and in curves"). For the alternating camber the problem is to maintain a straight and stable course by steering against continually changing lateral slopes of the road. This means that over this section just the standard deviation (deviations relative to ones own mean lateral position) should be measured.

6. Measures, scores and criteria should be easy to comprehend and implications for behavioral improvement should be clear.
With the original PAM system it was often obscure what exactly was measured. For example, when the print in Fig. 2 shows mean and maximum scores on "steering" or "braking" the metrics and criteria that have been used to calculate the scores are unclear. When it is unclear which aspects of particular actions are measured, one prominent goal of a system for performance evaluation and feedback is not attained, namely: enhancing
the clarity and specificity of behavioral feedback. Consequently the student still has to improve his driving performance by inefficient trial and error learning. Secondly the prints consisted of weighted basic scores that only became meaningful after comparing them to the expert’s scores and relating them to their respective weights. These requirements make the interpretation of scores and marks on the different PAM measures difficult. The efficiency of a performance evaluation system will increase substantially when it is clear to the instructor as well as to the student which aspects of driving behavior are measured. In addition, the scores and marks on prints should be specific and easily interpretable. Therefore two kinds of indications of the quality of a student’s performance relative to the described absolute criteria may be presented. First, simple raw scores, such as the number of cones hit or the number of gear changes. Second, transformed scores indicating the quality of driving behavior according to a certain scale (such as the "good old" point system formerly used at Dutch elementary schools). Raw scores provide absolute information about the concrete consequences of a student’s driving actions. Transformed scores directly provide information concerning the level of a student’s driving skills as related to the driving performances of the other students. The system can do this by relating scores to the performance of other students. This relation can easily be made when scores of prior students with the same training experience are saved. The most unambiguous transformed feedback then will be the presentation of percentile scores based on the scores of the students with the same level of prior training. It would be optimal to present scores on subtasks in both manners, raw as well as transformed. However, with reference to RMS error and Compound smoothness, the meanings of the raw scores will not be clear to most students. Therefore the latter kind of scores should only be presented after transforming them to a percentile score. For the three task clusters - route driving, special actions and obstacles - separate total scores have to be calculated. The most obvious cluster score is simply the mean of the relevant percentile scores. However, the subtasks within a task cluster and the measures within a subtask are not always of equal significance. This means that the scores for the different measures have to be weighted. The same applies for the three task clusters, although, for the present case, it was not considered necessary to combine these cluster scores to one total score. In consultation with the instructors working with the YPR-765 simulator, weights were determined such that within each task cluster the sum of the weights was 1.0 and the individual weights reflected the relative importance of the implicated measures. By adding the products of the percentile scores and their weights for all measures within a cluster the system can compute mean scores for the three task clusters. Because weighing of raw scores will affect the interpretation of total scores, the weights have to be presented clearly on the printout, for example, as percentages.
7. Performance data should be presented in a simple and self-explanatory format; irrelevant information should not be provided.

The output data of the original PAM system, were poorly organized such that it took a substantial amount of effort to get an overview of the performance data. A few causes of this poor ergonomics were dealt with in relation to the earlier discussed principles. For example, a clear output presentation is considerably hampered by the many irrelevant behavioral data per given section (principle 4). This problem was worsened because each PAM route was divided into many small parts, for each of which performance was evaluated according to the complete set of route driving variables.

The user friendliness and the effectiveness of a PEF system will improve substantially when the output only contains relevant information, which is presented such that the meaning with respect to driving behavior becomes immediately clear. Thus a print should contain the names of the different clusters, subtasks and measures and the weights, raw scores and marks. For each evaluation the instructor should only have to type in the date, the name of the involved PEF database, and the name/number of the student. This information should also be presented on the print. The data should also be accessible immediately after only one or two of the three clusters of a PEF circuit have been driven. In that case the print should not contain anything about the other clusters. When different clusters are driven on different days, the print of the last day should also contain the (saved) data concerning the prior clusters. Therefore, for the different clusters, different dates may be seen on the print.

4. CONCLUSIONS

The original system developed for automated performance measurement for the training of drivers on two tracked-vehicle simulators, may be characterized by a strong engineering approach. The Performance an Marking (PAM) system has not taken into account the human factors of performance evaluation and feedback. Therefore, this system showed many problems, ranging from minor shortcomings in the clarity of the output presentation to major flaws in the selection and calculation of appropriate performance measures.

Based on a framework of seven principles, which were stepwise applied, the present paper showed how a specific new system for automated performance evaluation and feedback (PEF) may be developed. Table II presents a summary of the main conclusions of the former sections concerning a PEF system for the YPR-765 driving simulator of the Dutch Royal Army. If properly implemented, this system would provide a pattern of objective grades on relevant aspects of a students driving behavior, which is easy to comprehend. Moreover, this system would enhance the feedback to the student (knowledge of results). Apart from objective evaluation, the pattern
of grades would also enable knowledge of progress and of persistent shortcomings in the students driving skills, such that the output may also be used for remedial teaching objectives (for example, when lessons are continued on the operational tracked-vehicle). The PEF system as described does not contain criteria for examination. Criteria, or cut-off scores, provide immediate information concerning the question whether or not a student's driving performance is sufficient with respect to specific training objectives. Based on these, it can be decided whether or not a student should be admitted to the next training phases. This kind of criterion may only be implemented after empirical investigation.

Table II A summary of the subtasks, weights, performance measures, metrics and output presentation that should be included in a new PEF system.

<table>
<thead>
<tr>
<th>TASK</th>
<th>WEIGHT (%)</th>
<th>MEASURE</th>
<th>FEEDBACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route Driving</td>
<td>(50)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving left straight</td>
<td>20</td>
<td>RMS error</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Distance (m) verge driving</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Driving right straight/curves</td>
<td>20</td>
<td>RMS error</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Distance (m) verge driving</td>
<td>raw+transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Duration (s) in wrong gear</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Sharp curves and intersections</td>
<td>20</td>
<td>RMS error</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Distance (m) verge driving</td>
<td>raw+transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Duration (s) in wrong gear</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Special Actions</td>
<td>(33)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Slalom&quot; course</td>
<td>8</td>
<td>Number of beacons hit</td>
<td>raw+transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Time needed (s)</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Vehicle clearing course</td>
<td>26</td>
<td>RMS error</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Duration (s) in wrong gear</td>
<td>raw+transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Driving speed</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Lowloader</td>
<td>18</td>
<td>RMS error</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Compound smoothness</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Driving speed (km/h)</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Obstacles</td>
<td>(17)</td>
<td></td>
<td></td>
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<tr>
<td>Step up and steep slopes</td>
<td>24</td>
<td>Compound smoothness</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Driving speed (km/h)</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Small ditches (slow)</td>
<td>24</td>
<td>Compound smoothness</td>
<td>transf</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Driving speed (km/h)</td>
<td>raw+transf</td>
</tr>
<tr>
<td>Camber: normal/adverse</td>
<td>24</td>
<td>RMS error</td>
<td>transf</td>
</tr>
<tr>
<td>Camber: alternating</td>
<td>12</td>
<td>RMS deviation</td>
<td>transf</td>
</tr>
</tbody>
</table>
REFERENCES

Litigation and Driving Simulators

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LITIGATION AND DRIVING SIMULATORS
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INTRODUCTION

In the United States the increase in civil litigation about personal injury accidents has drawn more and more attention in the court rooms to the area of Human Factors (Ergonomics). Human Factors (H.F.) experts are permitted to give opinions about who caused the accident (the ultimate issue). Seldom do the members of the jury (most trials are jury trials) actually visit the scene. In fact they are expressly prohibited from doing so unless a group visit is allowed. Therefore, the jury and/or the judge have to be informed by use of "demonstrative evidence." Until recently, most demonstrative evidence was in the form of sketches, survey plans, still photos, motion pictures, videos, and scale models. The videos are either live action scenes or less often animation scenes from models. As computer aided animation developed for use by engineers, architects and designers, the juries began to see simple videos of dynamic scenes created by computer aided animation.

This paper is focused on traffic accident litigation where in addition to the sketches, models, etc., the juries now are seeing computer-generated video scenes in color that re-create the accident as it could have been seen by the persons involved as well as "bird's eye" views and interior views. To date, these scenes have been "passive" but the future may well hold "interactive," computer-generated, real time video presentations where the jury could "drive" through the accident.

ADMISSIBILITY

Whenever demonstrative evidence in any form is offered into evidence, it can be challenged and the judge has to make a ruling either to allow the jury to see it or keep it out of the court room. Typically, a judge must be convinced that the photos, movies, etc. fairly and accurately depict the accident and the accident scene. Various experts are called upon to testify regarding the accuracy of the demonstrative evidence. These experts include surveyors (licensed), model makers, forensic photographers, artists and now to that list will be added computer programmers or engineers qualified to attest to the accuracy of various computer programs. The ultimate basis for the acceptability of demonstrative evidence will likely continue to be the expertise of the person...
whose opinions are being demonstrated who in turn will contribute to testimony of the photographer, artist, model maker or computer programmer.

The above mentioned conclusions are supported and backed with citations of court rulings in a comprehensive article published in 1988 and titled: "Admissibility of Computer-Generated Visual Evidence: State of the Art" by Kathleen G. Fadeley and Laureen Buckert in the LPBA Journal, Fall 1988, pp. 21-27. In their article they state that only recently (previous five years) has computer technology advanced to the stage where visual reconstructions are practical for courtroom use. The authors state: "These simulations are beneficial because they enhance expert testimony by simplifying issues and showing the jury cause and effect in pictures, thereby satisfying the old adage that 'seeing is believing.' " Another way of saying that is that the visual simulations are a surrogate jury visit to the scene of the accident. Visual simulations are of course much more than that, they can depict dynamic scenes from inside the vehicles, for example, which jury visits would seldom if ever include.

Regarding admissibility of computer-generated visual evidence, the authors set forth their conclusions that in addition to meeting the usual basic requirements of relevancy, materiality and competency, three other tests or standards may be required by the courts: One, "the Frye standard of general acceptance in the relevant scientific community" and two, a relevancy balancing analysis under the Federal Rules of Evidence or similar state rules; and three; the tests for 'demonstrative evidence.' " The authors cite a definition from Black's Law Dictionary, 389 (5th ed. 1979), namely, demonstrative evidence is, "that evidence addressed directly to the senses without intervention of testimony."

The applicability of the Frye Rule according to the authors has to do not only with the computer-generated evidence being generally accepted in the scientific community but as an alternative, being considered as "novel scientific evidence." As the "novelty" decreases, this aspect of the Frye Rule is less relevant.

An earlier article (1986) by Elaine M. Chaney in the Indiana Law Review volume 19, pp. 735-759, gives detailed consideration of the legal aspects of admissibility of computer-generated visual simulations. The author in conclusion states:

Litigation is becoming more sophisticated, and in response, the evidence needed to prove a case is becoming equally sophisticated. Computer simulations have tremendous potential to aid an attorney in proving a case. But such evidence can only be an aid if it is admitted at trial. Thus, whenever an attorney considers using a simulation,
he should carefully prepare an admissibility argument. There are three standards for admission that the court may employ: common law principles of demonstrative evidence, the Frye standard of general acceptance in the relevant scientific community, and the relevancy/balancing test suggested in Rule 403 of the Federal Rules of Evidence.

Under the principles of demonstrative evidence, the attorney should stress that the simulation is offered to illustrate and clarify expert testimony. Further, the attorney should demonstrate the relevance of the evidence; that is, its logical tendency to make a fact in issue more or less probable. Most jurisdictions have readily admitted demonstrative evidence; thus, the likelihood of successful admission of a computer simulation is great.

Under the Frye standard, the litigator faces the greatest admissibility challenge. This standard is more conservative than the others, and it imposes the special burden of general acceptance. Admission of simulations is not precluded by this standard. However, if the attorney irrefutably establishes the accuracy of the simulation and the credibility of the expert and further demonstrates that the simulation is based upon theories long recognized under the principles of physics and mathematics, there is great possibility of a favorable admission decision.

Under a relevancy standard, the litigator should address three issues: authentication requirements, relevancy requirements, and procedural requirements. Authentication requirements can be met by evidence describing the process or system used in formulating the evidence and by showing that it produces accurate results. Relevancy requirements will be satisfied generally if the evidence is persuasive or indicative that a fact in controversy did or did not exist because the conclusion in question may be logically inferred from that evidence. Procedural requirements will primarily be satisfied if the simulation and pertinent data are provided to opposing counsel before trial, thereby ensuring an adequate basis for cross-examination. If the litigator focuses on these requirements, he should have the simulation admitted under the relevancy standard. Because simulations have great potential to aid in the clear presentation of complex information, attorneys with cases that lend themselves to computer simulation evidence should consider this novel technique - they might like the result.
POSSIBLE FUTURE USES OF INTERACTIVE SIMULATIONS

To date there is no record of any attempt to introduce a computer-generated simulation of visual scenes with which the viewer (members of a jury) could interact. Scale models and plan view drawing lend themselves to some degree of jury interaction. For example, scale model vehicles can be moved on model terrain landscapes. Scale cut-outs of vehicles can be moved on plan view drawings of a roadway location. In at least one trial in the State of Washington the court admitted into evidence an inverted periscope (devised by this writer) that the jury could move along a model terrain roadway and thereby see "driver's eye views" from wherever they chose and at whatever speeds they chose. It, therefore, is not unlikely that a computer-generated image device permitting real-time interaction by a jury member would be admitted by a court.

The cost of such a device need not be prohibitive depending on how detailed (complex) the visual scene would be and the range of interaction to be provided to the jury member. One can visualize a jury being able to "drive" an accident scene and/or "walk" on a roadway in order to experience not only a single example of path and speed but a great variety of combinations. There will be legal complications concerning the admissibility standards and criteria for interactive computer-generated visual simulation devices but they will be dealt with and are in the foreseeable future. In fact, such devices may already (in simple form) be in use in courtrooms and in jury deliberation chambers behind the closed doors thereto.

ACKNOWLEDGEMENTS

I wish to acknowledge the assistance of the following:

1. Mr. Geoffrey J. Germane*, accident reconstruction engineer who provided the bases for the computer-generated scenes involved in a case I was also involved in. This video tape was presented along with this paper.

2. The Viewpoint Animation Engineering Company** who produced the computer-generated video referred to above.

3. The Forensics Technologies International Corporation*** who provided written material and an example video of their computer-generated traffic collision scenes. This tape was shown along with presentation of this paper.
VTI-TRB International Conference “Traffic safety on two continents”

Workshop on
“Strategies to increase the use of restraint systems”

Thursday 19th September 1991

Chairman : Paul Wesemann
Secretariat : Tapani Mäkinen & Marjan Hagenzieker

Programme

14.00 Opening

14.05 Illustration of background paper Tapani Mäkinen

14.15 National reports on seat belt use and countermeasures (10 minutes each)

* Canada  Brian A. Grant
* Finland  Juha Valtonen
* France  Yves Page & Sylvain Lassarre
* Germany  Hanns Ch. Heinrich
* Great Britain  Jeremy Broughton
* Netherlands  Marjan Hagenzieker
* United States  Robert Knaff

15.45 Coffee break

16.00 Discussion with speakers and audience

17.00 Concluding remarks and closure
Workshop on "Strategies to increase the use of restraint systems"
Gothenburg 19 September 1991

List of speakers

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Strategies to Increase the Use of Restraint Systems

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Technical Research Center of Finland (VTT)
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and

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Institute for Road Safety Research (SWOV)
The Netherlands
1

Background paper prepared for the workshop:

STRATEGIES TO INCREASE THE USE OF RESTRAINT SYSTEMS

Tapani Mäkinen, VTT
Marjan Hagenzieker, SWOV

1. Restraint use

1.1 Restraint use is still a current issue

Seat belts for protecting car drivers and passengers have been under evolution for almost half a century and the safety effects of seat belts are beyond doubt nowadays. Despite this fact belt use rates are still far below 100% level in most countries. Especially the promotion of back seat belt use is a current topic due to the low user rates.

Also other means to protect car occupants such as air bags, fully automatic seat belts and child restraint systems are still "coming" but they are beyond the scope of this review due to the paucity of data and publications regarding user rates. Moreover, the promotion of child restraint use and the installation of airbags possibly require partly different methods than improving seat belt use. It is also possible that not all the problems related to a widespread use of fully automatic seat belts and air bags are totally solved yet.

Our review (see also Mäkinen & al., 1991) focuses first on some countries with relatively high user rates, then we review some measures that have been used (or could have been used more effectively) to increase wearing rates. Thirdly we'll take a closer look at the countries with high seat belt user rates to see whether they have some factors in common which could explain the progress made. Accordingly we'll produce some statements in this paragraph about the effectiveness of various countermeasures in the promotion of seat belt use. These statements are expressed in a rather provocative manner to stimulate discussion. We hope that the individual contributors will elaborate upon these statements in their presentations. Finally we will list some proposals for future action.

1.2 Seat belt use rates in some countries

The method of measuring seat belt use in most countries is almost exclusively observational. It has been realized either by unobtrusive observation or by stopping cars at suitable sites (obtrusive observation). There is a lot of variation in the time and sites selected for the observation. This variation is sometimes noticeable also within countries.

Seat belt usage figures are usually based on day-time measurements during working days. The differences in belt use are greatest between urban (streets) and rural areas (highways).
The results are normally presented by that distinction. There is little data available on the accuracy of unobtrusive observations, probably because of the obvious simplicity of the observation task.

Figure 1 shows safety belt use trends on front seats in- and outside urban areas for some countries: Canada (CAN), Finland (SF), France (F) (West-) Germany (D), Great-Britain (GB) and The Netherlands (NL). Presenting figures in comparative graphs is problematic. Besides variations in data collection, the way data is presented in research literature also varies from country to country. The depicted data represent belt use rates for drivers in case of CAN, GB, NL, while for D, F and SF, the data represent the combined figures for drivers and front seat passengers. For Canada variations in belt use between different provinces were greater than between rural and urban areas. Therefore average figures are presented. Also, in the data on locations outside urban areas motorways are included for CAN, F, SF, NL and but excluded for D and GB.

Strictly speaking a straight comparison of the figures between various countries is not possible or should be made with caution because of variations in data collection methods. But relative comparisons of figures between countries over time may reveal important trends.

No graph is presented to indicate belt user rates on rear seats simply because no systematic observations over time are yet available for most countries. In general, however, seat belt use for rear seats is much lower than for front seats, usually in the range of 10 to 50%.

2.1 Applied countermeasures

In many countries the following countermeasures have been applied - alone or in combination with each other - to increase the use of safety belts:

a. **Public information** is often considered as a precondition for behavioral change or sustaining behaviour. The public needs to be provided with information about the (new) behaviour and its relative advantages. Media presentation serve to inform and persuade car occupants.

b. **Mandatory use by means of legislation.** The process of legislation usually starts by making the installation of belts mandatory; after an interval of several years their use is made compulsory as well.

c. **Legal sanctions.** In the countries reviewed in this paper criminal sanctions for non-use, in the form of fines, are applied. Sometimes also private law sanctions (liability for damage in case of accidents) are applied.

d. **Enforcement.** If threatened legal consequences or certain probabilities of these consequences are to serve as deterrents, they must be credible. Therefore, enforcement can be regarded as an important countermeasure. It is our
impression that enforcement is not applied regularly or structurally as a countermeasure in most countries. Usually enforcement is applied incidentally either in the form of short term local campaigns or in the connection of other surveillance activities.

e. **Incentives.** Actions which bring rewards are generally repeated, whereas those with unrewarding or punishing outcomes tend to be discarded. Sometimes incentive programs have been applied to increase the (voluntary) use of safety belts.

2.2 The effectiveness of various countermeasures

**Public information**

It seems that public information campaigns have been effective in isolation only before law changes to "prepare" public opinion for the new behaviour. When public information have been **combined** with other measures such as law change, legal sanctions and enforcement, better results have probably been achieved than if these measures had been resorted in isolation. Actually it doesn't make any sense to think of law change and other comparative measures without informing the public about them.

The exploration of drivers' motives have not led to fruitful approaches, since motives for nonuse are both various and often situational. Accordingly the number of target groups would be great. Through combining information and other activities habituation for using belts may be developed and a habit may finally be seen as a motivating factor for usage.

**THE EFFECTS OF INFORMATION IN INCREASING BELT USE RATES ARE STEPWISE: FIRST, BEFORE THE LAW CHANGE INFORMATION PREPARES THE PUBLIC FOR THE NEW BEHAVIOUR AND AFTER THE LAW CHANGE INFORMATION IS EFFECTIVE IN COMBINATION WITH OTHER MEASURES.**

**Legislation**

One thing in safety belt use promotion goes above everything. Without legislative efforts no good results are achieved nationwide. Currently there are seat belt laws which prescribe wearing mandatory in one form or another in about 40 countries. Most countries adopted the law in the first half of 1970's. Some countries waited longer (or are still waiting: some states in the USA). The process of legislation regarding belt use in rear seats started much later. To date in some countries the belt use law for rear seats is already in effect (e.g. France, Germany and Scandinavian countries).

**LEGISLATION PRESCRIBING THE MANDATORY USE OF SAFETY BELTS IS A NECESSARY PREREQUISITE TO RAISE USER RATES OVER 60% LEVEL. WITHOUT LEGISLATION EFFORTS TO REACH HIGH NATIONWIDE USER RATES ARE FRUITLESS.**
Sanctions

It has been found that introducing sanctions some time after the law became into effect accelerated user rates even more (Finland, Germany). However, little is known about application policies of these sanctions.

THROUGH PRESCRIBING SANCTIONS FOR NON USE THE EFFECTS OF SEAT BELT LAWS ARE STRENGTHENED.

Enforcement

Especially the role of publicity and enforcement or the combination of them are worth discussion. So far the real effects of enforcement have been mainly mediated through the mere possibility of enforcement (= subjective risk of detection) has been enough to affect belt use. The role of so called primary enforcement (enforcement which is focused mainly on seat belt use) has probably been a minor one in most countries. Various studies have shown that (a combination of public information) and primary enforcement can raise user rates substantially, and also for a relatively long period (more than one year).

UP TO NOW THE POSSIBILITIES OF SELECTIVE OR PRIMARY ENFORCEMENT IN THE PROMOTION OF SEAT BELT USE HAS BEEN LARGELY NEGLECTED.

Incentives

During the past few years incentives, especially in the form of rewarding drivers for using a seat belt have yielded promising results. By rewarding drivers either collectively or individually one has been able to raise user rates. So far the results apply only to isolated communities like military camps, factories, etc. Also the permanency of the effects - which is also the case with other types of efforts (e.g. enforcement campaigns) - of incentives is insecure.

INCENTIVE PROGRAMS HAVE SO FAR BEEN APPLIED IN RELATIVELY ISOLATED, SMALL COMMUNITIES. THE GENERALIZATION OF THE RESULTS TO NATIONWIDE APPLICATION IS QUESTIONABLE DUE TO THE LACK OF LARGE SCALE EXPERIMENTS.

3. Proposals for future action

The solution for high user rates is possibly found in the combination of four factors: 1) law making usage obligatory, 2) publicity a) before law change: preparing people for law change and b) after law change: increasing the subjective risk of apprehension 3) increasing the objective risk of detection from nonuse 4) producing comfortable, user friendly restraint systems. In principle if these four factors can guarantee sufficient habituation for wearing a belt, no complicated theories are necessary. Probably the combination of these four
factors will also be effective in promoting the use of rear seat belts. It is therefore important to use experiences from the promotion of front seat belt use for future actions to improve rear seat belt wearing.

HABITUATION IS A VERY IMPORTANT MEDIATING FACTOR FOR SEAT BELT USE. ONCE A HABIT IS FORMED, IT IS RELATIVELY EASY TO MAINTAIN HIGH USER RATES.

From a political point of view, however, more efforts are needed to activate decision makers and the police to take the promotion of belt use seriously.

BY INCREASING THE AWARENESS OF DECISION MAKERS AND THE POLICE ABOUT THE COST EFFECTIVENESS OF BELT USE, USER RATES CAN BE IMPROVED CONSIDERABLY.

The proposed actions imply many coercive measures. The question can be raised whether this can be allowed or is desired in most cultural settings, because none of them value the "free will" of human being. On the other hand, countermeasures such as incentive programs may also impose political problems, namely, whether one should reward actions that are already mandatory in many countries.

Reference:

Figure 1A. Safety belt use outside urban areas in Germany (D), Great-Britain (GB), The Netherlands (NL), Finland (SF) and France (F) 1972-1990.

Figure 1B. Safety belt use in urban areas in Germany (D), Great-Britain (GB), The Netherlands (NL), Finland (SF), France (F) and Canada (CAN) 1972-1990.

* Data from BASt Germany; TRRL Great-Britain; SWOV Netherlands; INRETS France; Liikenneturva Finland; Transport Canada
Canadian Seat Belt Wearing Rates, Promotion Programs, and Future Directions

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Canada
Canadian Seat Belt Wearing Rates, Promotion Programs, and Future Directions

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Ottawa, Canada

1. SEAT BELT WEARING RATES

1.1 Background

In Canada, the ten provincial and two territorial governments have the authority to require vehicle occupants to wear seat belts and each has chosen to do so at a different time. The first province to require the use of seat belts was Ontario in 1976, with Quebec, British Columbia and Saskatchewan enacting legislation by the end of 1977 (these provinces have 77% of the current licensed drivers). It was not until 1982 that additional provinces began passing seat belt wearing legislation, and it took until 1991 for all provinces and territories to pass legislation requiring seat belt use. Table 1 presents the year in which seat belt and child restraint use was required in each province. In addition, the provincial governments are also responsible for enforcement of the law. Large increases in seat belt use from year to year are generally traceable to an additional province passing legislation, or an individual province conducting a major seat belt program.

All provinces allow for primary enforcement of their seat belt wearing laws, that is, vehicles may be stopped and a citation issued if the occupants are not wearing seat belts. The current seat belt laws require that where a seat belt is provided in the vehicle it must be used, and federal government vehicle standards have required that a seat belt be installed at all seating positions of automobiles and light trucks since the late 1960's.

1.2 National driver seat belt survey

Each year, in late October, a national survey of seat belt use is conducted (starting in 1991 a survey will also be conducted in June). The observational survey, which collects approximately 50,000 observations, is conducted from 7:00 to 17:00 Monday to Saturday, and from 12:00 to 17:00 on Sunday (Arora, 1975). A stratified sampling plan was created to produce a representative sample from 178 sites located in cities and towns ranging in size from 5,000 inhabitants to major


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Table 1: Year of implementation of seat belt and child restraint laws.¹

<table>
<thead>
<tr>
<th>Province or Territory</th>
<th>Seat Belt Law</th>
<th>Child Restraint Law</th>
<th>%age Licensed Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>1976</td>
<td>1892</td>
<td>36.0</td>
</tr>
<tr>
<td>Quebec:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front seat only</td>
<td>1976</td>
<td>1983</td>
<td>23.0</td>
</tr>
<tr>
<td>All occupants</td>
<td>1990</td>
<td>1990</td>
<td></td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>1977</td>
<td>1980</td>
<td>3.6</td>
</tr>
<tr>
<td>British Columbia</td>
<td>1977</td>
<td>1985</td>
<td>14.6</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>1982</td>
<td>1982</td>
<td>1.8</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>1983</td>
<td>1983</td>
<td>2.5</td>
</tr>
<tr>
<td>Manitoba</td>
<td>1984</td>
<td>1984</td>
<td>3.6</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>1985</td>
<td>1985</td>
<td>3.3</td>
</tr>
<tr>
<td>Alberta</td>
<td>1987</td>
<td>1985</td>
<td>10.6</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>1988</td>
<td>1985</td>
<td>0.5</td>
</tr>
<tr>
<td>Northwest Territories</td>
<td>1989</td>
<td>1989</td>
<td>1.1</td>
</tr>
<tr>
<td>Yukon</td>
<td>1991</td>
<td>1991</td>
<td>0.2</td>
</tr>
</tbody>
</table>

N=17 455 542

¹ Laws apply to all seating positions except Quebec

The seat belt wearing rates for drivers from 1980 to 1990 are presented in Figure 1 (Transport Canada, 1991). The data in the figure show that there has been a steady increase in seat belt use from 36% in 1980 to 82% in 1990. Figure 2 presents the wearing rates by province for the year 1990. The data in this figure demonstrate the variability in seat belt use from province to province with a range of 65% to 94%. Not only is 1990 the year with the highest seat belt wearing rate to date, but the Figure 2 data show that six provinces had wearing rates greater than 80% and two provinces had rates over 90%, record levels of belt use in the country. The highest rate was for the province of Quebec where the seat belt wearing rate reached 94%.
In recent years data on the seat belt use of drivers of light trucks and passenger vans have been collected. The wearing rates for these two classes of vehicles were 78% for passenger vans and 68% for light trucks, both of which have increased.
over the previous year (1989) when belt use was 65% for passenger vans and 52% for light trucks.

1.3 Passenger and evening seat belt use

Data on the seat belt use of passengers is not routinely collected in Canada except for children and these data are discussed below. However, a study conducted in 1987 (Grant, 1989) in one urban area provides some insight into both passenger seat belt use (front outboard position where the shoulder belt is available) and evening seat belt use (20:00 to 22:00), a period not normally covered by national surveys. Figure 3 shows that passenger seat belt use was marginally lower than driver seat belt use in the daytime, but the differential was greater in the evening. Belt use in the evening was also lower than in the daytime.

![Figure 3. Seat belt wearing rate in the daytime and evening for drivers and passengers before and after a selective traffic enforcement program (STEP)](image)

1.4 Child restraint belt use

Four surveys conducted in 1984, 1985, 1987, and 1989 (Dawson, Jonah & Arora, 1986; Transport Canada, 1985, 1986, 1988, 1990) have been conducted to determine the use of child restraints and seat belts by children (occupants under 16 years of age). Figure 4 present the data from these surveys. Seat belt and child restraint use has increased since the 1984 survey, but is lower than that for drivers. In the 1989 survey 85% of children under 1 were restrained in an appropriate restraint system, but the percentage drops to 67% for those 1 to 4 years old, 60% for those 5 to 9 years, and was 68% for those 10 to 15 years old. Transport Canada data also indicate that child restraints, for children under 5 years of age are
used correctly in only 58% of the cases. Failure to use a tether strap, which fastens the top of the child restraint to the vehicle, is the main form of misuse. The child restraint data are collected at the same time as the national seat belt survey, but at only 130 of the sites. In these surveys observers collect data for 8 hours at each site divided into 2 hour blocks of time randomly distributed throughout the week. Observers look inside the vehicle while it is stopped at a traffic light and if children are present the driver is asked for their ages. The type of restraint used is noted along with the type of misuse, if present.

![Figure 4. Percentage of children in appropriate restraint system by age.](image)

2. COUNTERMEASURES AND EFFECTIVENESS

Four major types of programs for increasing seat belt use have been evaluated in Canada. The first, the effects of legislation, may be seen in the changes in seat belt wearing rates before and after the introduction of seat use legislation. The second type of program, Selective Traffic Enforcement Programs (STEP), have been evaluated in both regional and provincial programs. One innovative STEP included the use of incentives. Two other smaller scale programs, public posting (feedback) of seat belt use and employer based seat belt programs have also been evaluated. Programs which include either enforcement or education have generally not been conducted in Canada, because it has been argued that they would not be successful.
2.1 Legislation

The implementation of seat belt wearing laws at different times in Canadian provinces provides several opportunities to see the effects of their implementation. Figure 5 shows that the immediate effect of mandating seat belt use in three provinces (Newfoundland, New Brunswick and Nova Scotia) was to increase the seat belt wearing rate by 60 percentage points in each province.

Another example of the effect of seat belt legislation can be seen in data from the province of Alberta which are shown in Figure 6 for the period 1980 to 1990. When Alberta mandated the use of seat belts in 1987 seat belt use rose from 28% to 74%. It increased to 83% the following year, but dropped to 45% in 1989 when the seat belt law was declared invalid. In 1990, with the validity of the seat belt law accepted by a higher court, the seat belt wearing rate rose to 88%.
However, there is evidence that high belt use will not be maintained without the presence of enforcement. Provinces which adopted seat belt use laws in the mid 1970's had large increases in belt use, but these gains were lost without the addition of effective enforcement programs. Belt use in provinces with legislation was only 44% in 1980, although this was still significantly higher than in provinces without legislation which had a seat belt use rate of 9%.

2.3 Selective Traffic Enforcement Programs (STEP)

Selective Traffic Enforcement Programs can be viewed as having three major components, education, enforcement, and evaluation. The theory behind STEP is that it is more effective to inform people, and encourage voluntary use, before applying the enforcement. In this way those who do not wear their seat belts are given a fair chance to change their behaviour. When the police start enforcing the law those who still refuse to wear a seat belt are unable to claim that they have been caught by overzealous police action, and therefore there is less likelihood criticism about the program.

2.3.1 Education

The educational part of the STEP is generally provided through the use of either paid or free publicity. Free publicity is generated through the use of press conferences to announce the program, and through the provision of written materials describing the importance of wearing seat belts, how they work, and why they work. The generation of ongoing publicity throughout the program is important in order to maintain contact with the target population. One way to do
this is to provide the news media with information on the level of police enforcement and the changes in seat belt use.

The other method of obtaining publicity is through the use of paid advertising. With paid advertising specific messages can be delivered to target groups. Paid advertising can be very expensive, but it may be necessary to reach target groups in the case of very large programs. To reduce the costs of advertising the government of Quebec solicited sponsors for their major seat belt program (Dussault, 1990). Money raised from the sponsors paid for supplements inserted in all newspapers in the provinces. In addition, advertisements were placed on television and radio.

2.3.2 Enforcement

The enforcement of the seat belt wearing law is critical for the success of a STEP program. For the enforcement phase to be successful it must be more intensive than normal and it must be perceived as more intense than normal. The most effective way to achieve this is to ensure that when enforcement activities are conducted they are highly visible. For example, roadside checkpoints are both highly visible and very efficient because a large number of vehicles can be checked in a relatively short time, and those not checked are clearly aware that the police are enforcing the seat belt law because of the preceding publicity. The high visibility checks may allow some vehicle occupants to buckle their seat belts prior to being checked, but that is acceptable because the goal of the enforcement is to ensure that people are aware that the law is being enforced and to encourage the use of seat belts.

An important aspect of the enforcement component of a STEP is the need for strong support from the police who must conduct the enforcement activities. The police come face-to-face with the public and they need to be assured that what they are doing is important in the promotion of safe driving and is perceived to be important by the general public. Frequently, the police perceive the enforcement of a seat belt law as a nuisance charge and therefore are reluctant participants in a STEP; this can be overcome by ensuring that the police are aware of the relative importance of seat belts in saving lives.

In the Quebec program efforts were made to reach all 12,000 police officers in the province (Dussault, 1990). This was accomplished by having program representatives meet face-to-face with representatives from 270 police units (municipal police forces and provincial police forces). At these meetings representatives were provided with an 11 minute video tape which was to be shown to all police officers in the province. An information booklet was also provided to ensure that all police officers were aware of the program goals.
2.3.3 Evaluation

Evaluation of a STEP is necessary for a number of reasons. Most importantly, the evaluation is needed to determine whether or not the program was successful in increasing the level of seat belt use. Equally important, is the need to provide feedback about the program to the community and to the police. If the police are aware that their activities have been successful then they are more likely to participate in future programs. The available data indicate that single STEPs generally do not maintain wearing rates and therefore program organizers need information to be able solicit support for future programs. Providing feedback to the community about the success of the program is also likely to increase support. In addition, during the program, information on the increasing level of belt use indicates that the program is being taken seriously, and that there is an increased probability of being stopped if you are not wearing a seat belt.

2.4.4 Long-term application of STEPs

A series of STEPs, which were conducted in the Regional Municipality of Ottawa-Carleton over eight years, demonstrate that repeated programs can produce increases in seat belt use, that there are declines in belt use following the end of a program, but that new programs continue to increase the use rate. There is also evidence from these studies that the STEP affects most vehicle occupant groups. The Regional Municipality of Ottawa-Carleton, with approximately 600,000 residents, consists of 6 cities including the capital of Canada, Ottawa, as well as, rural areas.

The overall results of the three STEPs are presented in Figure 7. The first STEP produced an increase in seat belt use from 58.3% to 76.5% (Jonah, Dawson & Smith, 1982). The second program consisted of three separate STEPS, which varied in length from 4 weeks to 4 days, conducted over one year. Each of these STEPs increased seat belt use, and the overall program resulted in an increase in belt use from 66% to 84% (Jonah & Grant, 1985). The third major STEP was conducted in 1987, and lasted one month; seat belt use increased from 79% to 87% (Grant, 1989). Data presented in Figure 3 show that the STEP increased the belt use of both drivers and passengers and of those observed in the daytime and in the evening. Data collected in this last STEP also indicated that the program had no effect on the belt use of those leaving drinking establishments late at night (10:00 to 1:30) and that their wearing rate was significantly lower, at approximately 61%, than the general population of drivers.
Figure 7. Effect of repeated STEPs from 1979 to 1987 (percentages in the STEP city are based on approximately 3000 observations and in the control city 2000 observations.

2.4.5 Major Programs

2.4.2.1 Quebec Program

The 1987 Quebec STEP (Dussault, 1990) required the coordination of over 12,000 police officers in provincial and municipal police forces. As described earlier extensive efforts were made to ensure that all police personnel were aware of the importance of the program and the importance of seat belt use. The program was introduced to residents of the province by a series of press conferences and it was preceded and followed by public information announcements on radio and television, with additional information presented on billboards and in newspapers. The cost of the public information program was estimated at just under one million dollars.

During the program the police issued over 1,467 citations each day for not wearing seat belts, 3.4 times the number issued per day prior to the program. In addition, as an incentive to encourage belt use, promotional vouchers, which could be exchanged for free items (average value of $1.18), were distributed by police at seat belt check points during the final week. The vouchers had a tear-off portion which could be used to enter a draw for larger prizes (8 prizes with an average value of $3,000 each). The police distributed 226,830 of the vouchers.

Figure 8 presents the changes in seat belt wearing rates as a result of the program. A small scale STEP in a few communities in 1986 increased seat belt use in that year to 68% from 53%. The major province wide STEP was conducted in 1987 and increased seat belt use to 86%. Seat belt use remained high, at 82% in the
following year and continued semi annual enforcement programs have further increased the seat belt wearing rate to 94% in 1990.

![Graph showing seat belt use rate from 1980 to 1990](image)

**Figure 8.** Effect of major STEP on seat belt use in Quebec. STEP introduced in 1987

### 2.4.2.2 Other Programs

A major program conducted in the province of British Columbia in 1983 resulted in seat belt use increasing from 58% to 73%. The program required the coordination of a large number of different police departments and community groups. One of the unique activities in this program was to encourage community groups to organize local activities promoting seat belt use during the program (B.C. Research, 1983). More recently, British Columbia has conducted a major impaired driving enforcement program and coupled it with seat belt promotion. The program resulted in seat belt use increasing from 80% to 85%. The program used extensive media advertising which was provided by the Broadcasters Association.

### 2.5 Public Posting (Feedback)

Posting the percentage of seat belt use on a large sign is another technique for increasing seat belt use. In this method a large sign is installed at a high volume intersection and carries the message "Drivers wearing seat belts yesterday ___%". The percentage of drivers wearing seat belts is determined by observational surveys. The first example of this was reported by Nau and Van Houten (1981), but they were unable to demonstrate consistent increases in seat belt use. Their study was conducted in an area without a seat belt use law, and further evaluations were conducted in another region where vehicle occupants were required to wear seat belts. Grant, Jonah, Wilde and Ackersville-Monte (1983) were able to demonstrate a positive effect on belt use of publicly posting seat belt wearing rates.
in different locations in two different cities. In general, the technique increased seat belt use by about 10% at the locations where it was used. Although not a major a program this technique may be used effectively with other programs.

2.6 Employer Based Seat Belt Programs

Employer based seat belt programs are conducted at the work site. These programs were initiated in the United States as incentive programs and the majority of them have been evaluated in areas without seat belt legislation. Geller et al. (1987) reviews the effects of 28 of these programs. In Canada, employer based programs have been evaluated in areas where there is seat belt use legislation and have not generally included the use of incentives.

The programs consist of four main elements. The initial step is to establish both union and management support for the program. Observers collect data on the seat belt use of those entering the site and these data are used to monitor the program. The seat belt use rate is posted on a large sign located at the entrance to provide staff with feedback about the program. The educational component is delivered through the use promotional materials posted around the work site and circulated to all employees, and through a 45 minute meeting. During the meeting an audio-visual presentation is given and participants have the opportunity to ask questions about seat belts. The purpose of the audio visual presentations is to show how seat belts work to prevent injuries in different types of accidents.

Grant (1990) describes the results of one of these programs conducted at a government training centre. Figure 9 presents the results from this study. Seat belt use increased from a baseline level of 65% to 79% following the installation of a feedback sign and the distribution of a letter from the Centre's management describing the benefits of seat belt use. A further increase to 82% was measured during the educational phase. Belt use declined after the program, but remained above baseline levels. Larger increases in belt use were observed for passengers (45% to 76%). Seat belt use at a control location remained relatively constant at about 52% during the program.

The employer program was also conducted at 3 industrial sites (Grant, 1987) including a large factory located a major metropolitan area. Belt use increased from 35% to 84% at one location (see Figure 10), from 55% to 84% at the second location, and from 3.3% to 66% at the third location. These programs were relatively short, varying from 2 to 3 weeks. Belt use did decline after the programs, but remained above baseline levels.
Figure 9. Changes in seat belt use during an employer based seat belt program conducted at a government training centre.

Figure 10. Changes in seat belt use during an employer based seat belt program conducted at an industrial plant.
3. **FUTURE ACTION**

Seat belt use in Canada has been increasing steadily over the past 10 years. These increases are the result of major activities like the passage of legislation mandating all vehicle occupants to wear seat belts and Selective Traffic Enforcement Programs (STEPS) which combine education and enforcement. There is evidence that other activities like public posting of the seat belt wearing rate and employer based seat belt programs can contribute to the gains in seat belt use.

It has been argued that reaching 80% seat belt use may be easier than moving from 80 to 95% use. Canada is now at the stage of trying to convince this last 15% of nonusers of seat belts to buckle up. The province of Quebec has shown that a seat belt use rate of 95% is possible and so current planning is directed at the last, but hardest group to convince. In addition, there is evidence that passengers are less likely to wear seat belts than drivers and so efforts are needed to convince these people of the benefits of seat belt use. The following section describes some of the current and planned activities within Canada which it is hoped will provide the means of reaching a 95% seat belt use rate for all vehicle occupants.

3.1 **Target enforcement**

Research has shown that sub-groups of drivers are resistant to the efforts to date to encourage seat belt use. For example, drivers leaving drinking establishments have been shown to have lower seat belt use rates than other drivers (Grant, 1989; Malenfant & Van Houten, 1986; Preusser, Williams & Lund, 1986). The research has shown that when STEPs are conducted these drivers do not increase their belt use when other groups show increases. It has also been shown that those who drive while impaired are less likely to wear seat belts than those who do not drive when impaired (Transport Canada, unpublished roadside survey data; Wilson, 1989) and that these drivers may have a variety of unsafe driving practises.

Directing programs at these problem groups, whether they be STEPs or other programs, is necessary if the seat belt wearing rate is to be increased. There is some data to suggest that these drivers may be the ones most likely to have accidents and therefore there is a greater likelihood of reducing the injuries and fatalities resulting from accidents if this group can be convinced to wear seat belts. Police will need to be more aware of how to identify members of the problem groups using variables such as location and time of day. In addition, it will be necessary to ensure that the identified groups are aware that there will be increased police enforcement.

Data presented earlier indicated that people who drive light trucks and vans are less likely to wear seat belts. Additional effort will be needed to convince this
group of vehicle occupants of the need to wear seat belts, although it is not clear whether there is simply a need for education or whether additional enforcement will be needed.

3.2 Police education

If enforcement programs are to be used to increase seat belt use then it is important to ensure that police officers receive training on how and why seat belts are effective for reducing injuries and fatalities. In addition, they must be shown the relevance of their enforcement activities to the goal of reducing the injuries and fatalities which occur on the roads. The police also need to be reassured that enforcing a seat belt law is viewed by the general public as an effective use of their time. The collection of survey data can be useful in keeping the police informed about public attitudes and the success of programs in which they participate.

3.3 Exemptions

In most Canadian jurisdictions some groups of drivers are exempt from wearing seat belts. These include taxi drivers, police officers, delivery truck drivers, and those who can obtain a certificate from their doctor indicating that wearing a seat belt may cause injury as the result of a medical condition. It is estimated that these groups may represent 5% of drivers, and therefore, as seat belt use nears the 90% level it is important to ensure that exemptions are provided only where they are truly needed. Efforts are currently underway in Canada to reduce the number of drivers who are exempt from the belt use laws, and to reduce the use of medical exemptions. There are very few medical conditions for which wearing a seat belt is more dangerous than not wearing one.

3.4 National seat belt use target: 95% by 95

The Canadian Conference of Ministers of Transport has set a goal of 95% seat belt use in the country by 1995. This means that the governments of all 10 provinces, 2 territories and the federal government are committed to establishing programs needed to reach the target. Rather than establish a national program each government has created a program committee which will coordinate their activities. The provincial committees are better able to coordinate activities within their jurisdiction, particularly those requiring police enforcement, than a centrally located committee could. Efforts are also being made to coordinate information between the provinces and to reduce the duplication of activities, particularly in the production of educational materials.
3.5 Passenger seat belt use (rear seat)

As indicated in the data presented earlier passenger seat belt use is somewhat lower than that for drivers. It is anticipated that additional promotion and enforcement efforts will have to be used to encourage passengers to buckle their seat belts, likely in the form of STEPs. Enforcement of rear seat belt use has been difficult because of problems associated with seeing the belts. However, with the increased installation of shoulder belts in the rear seats of cars this will become less of a problem. Data on passenger seat belt use will be collected in future national surveys.

3.6 Proper use of child restraints

The data presented earlier indicated that children frequently do not wear seat belts and that child restraint systems, child seats or infant carriers, are frequently not used properly thereby reducing their effectiveness. Currently, research is underway to develop more effective methodologies for measuring improper use of child restraints so that corrective action can be taken through educational programs, the manufacturers, and the use of STEPs.
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Safety Belt Usage in Finland and in the Other Nordic Countries

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SAFETY BELT USAGE IN FINLAND AND IN THE OTHER NORDIC COUNTRIES

Legislation has played a significant role in increasing safety belt usage in all the Nordic countries. Publicity and enforcement have, however, been required to support the legislation.

The development of safety belt regulations has been nearly similar in all these countries, both in terms of their content and dates of implementation. The principal features of the development of safety belt regulations in these countries are shown in Table 1.

Table 1 The development of safety belt regulations in the Nordic countries /1./

<table>
<thead>
<tr>
<th>Compulsory installation of safety belts</th>
<th>FINLAND</th>
<th>SWEDEN</th>
<th>NORWAY</th>
<th>DENMARK</th>
<th>ICELAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>- front seats</td>
<td>1.1.-71</td>
<td>1.1.-73</td>
<td>1.1.-71</td>
<td>1.7.-69</td>
<td>1.1.-69</td>
</tr>
<tr>
<td>- back seat</td>
<td>1.1.-81</td>
<td>1.1.-73</td>
<td>1.1.-84</td>
<td>1.4.-89</td>
<td>1.1.-89</td>
</tr>
</tbody>
</table>

Compulsory use of safety belts in front seats

<table>
<thead>
<tr>
<th>Adults (≥ 15 yrs.)</th>
<th>1.7.-75</th>
<th>1.1.-75</th>
<th>1.9.-75</th>
<th>1.1.-76</th>
<th>1.10.-81</th>
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</thead>
<tbody>
<tr>
<td>Children</td>
<td>1.4.-82</td>
<td>1.4.-88</td>
<td>1.10.-88</td>
<td>1.10.-90</td>
<td>1.10.-81</td>
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</table>

Compulsory use of safety belts in back seats

<table>
<thead>
<tr>
<th>Adults (≥ 15 yrs.)</th>
<th>1.11.-87</th>
<th>1.7.-86</th>
<th>1.3.-85</th>
<th>1.10.-90</th>
<th>1.10.-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>1.11.-87</td>
<td>1.4.-88</td>
<td>1.10.-88</td>
<td>1.10.-90</td>
<td>1.10.-90</td>
</tr>
</tbody>
</table>

(1) models -69 ->
(2) models -70 ->
(3) of 3 years of age or older

Safety belt usage in the front seats

The first legislative step was the compulsory installation of safety belts in the front seats of private cars. In Finland this step was taken in 1971. Measurements of the safety belt usage rate began in Finland as long ago as in the 1960s. The voluntary use of safety belts was minimal. Outside urban areas it rose to only about 20 per cent (Figure 1.)
The development of safety belt usage in Finland is a very good example for the effect of legislation. Safety belt usage in front seats became compulsory on 1.7.1975. The measure raised the safety belt usage rate to about 60 per cent. But this increase in the usage rate was followed by a gradual decline. One reason for this trend of development was that failure to use safety belts was not a punishable offence.

Neglecting to use a safety belt became a punishable offence on 1.4.1982, after which the safety belt usage rate has been at about 90 per cent. Neglecting to use a safety belt is more common in urban areas than it is outside them. In urban traffic, safety belts are not regarded as being as necessary and their use in that environment is experienced as being inconvenient (Figure 1).
Safety belt usage in the back seats

The installation of safety belts in the back seats of new private cars has been compulsory in Finland since 1981. In Sweden it became compulsory earlier than in the other countries (-73 and applies yearmodels 70->).

The compulsory use of safety belts fitted in the back seats of private cars came into effect in Finland on 1st November 1987. Surveillance measures on safety belt usage were performed to study the effect of this amendment to the safety belt law.

Figure 2  Safety belt usage in Finland in the back seats of private cars before and after the amendment to the safety belt law /2./

Only about a month before the law came into effect, safety belts were being used by 27 per cent of adult back seat passengers for whom safety belts were installed (Figure 2). Usage had not increased much at all from the level of the previous measurement (one year before), even though the forthcoming change in the safety belt law was generally known at that time and its benefits had been publicized by a large campaign.

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Only the coming into force of the law increased the safety belt usage rate significantly. About a month after the amendment had been in effect, the safety belt usage rate among adult back seat passengers for whom safety belts were installed had risen to 66 per cent. About a year after the law became effective, the usage rate was still at about the same level.

A very similar trend of development was reported /3./ in Sweden, where the effect of a publicity campaign on safety belt usage was first studied in 1984. The study was extended when a decision was made to introduce legislation making it compulsory to use safety belts in the back seats. The use of safety belts by adults had risen to about 24 per cent while it was still voluntary. In connection with the law coming into effect, the usage rate rose by 36 percentage points (to 60 per cent).

Safety belt regulations and children

Taking account of children in the safety belt regulations has been a problem. Safety belts were not regarded as being safe for children; rather, it was believed that children were safe on a back seat. The question of juridical liability was also a problem.

For these reasons, the safety belt regulations initially only applied to adults, i.e. those aged 15 years and over. In Sweden and Norway the obligation additionally did not apply to adults less than 150 cm in height.

On 1.4.1982 in Finland the compulsory use of safety belts (or safety equipment) in the front seats was extended to encompass children. Similarly, the compulsory use of safety belts in the back seats (1.11.1987) also applied to children from the outset. In Sweden and Norway compulsory safety belt usage in the back seats initially applied only to adults; it was extended to encompass children a couple of years later.

In Finland the problem of juridical liability has been solved by making the driver responsible for the safety belt usage of persons less than 15 years of age. If, however, the father, mother or guardian of a child is present in the car, the responsibility for the child’s safety belt usage rests with him or her.
How much can increased safety belt usage improve traffic safety?

In Finland almost all road traffic accidents in which the driver or passenger of a motor vehicle is killed are investigated by road accident investigation teams. On the basis of this material we know, for instance, that only about 55 per cent of private car drivers killed in accidents were definitely wearing their safety belts at the time of their accidents.

![Diagram of safety belt usage and assessed effect](image)

**Figure 3** Drivers and passengers killed in accidents investigated by road accident investigation teams in 1985-1989 in Finland - Safety belt usage and its assessed effect /2./

The road accident investigation teams also assessed how the safety belts had affected the outcome of the accidents or the effect that they would have had if they had been in use. According to these assessments in the years 1985-1989, of all the drivers and passengers whom were not wearing safety belts when killed in vans and private cars, the use of safety belts would have saved the lives of 18 per cent definitely, 31 per cent probably, and 49 per cent possibly. In other words, if everyone travelling in vans and private cars in Finland had always been wearing their safety belts, almost a quarter (23 per cent) of all the traffic fatalities that occurred in these vehicles might not have happened (an average of 70 lives a year). VTI RAPPORT 372A
Why are safety belts not used?

In the accidents investigated by the road accident investigation teams, one can observe many factors connected with the neglect to use safety belts. These include:

- drivers involved in one-vehicle accidents used their safety belts less frequently than those primarily responsible for collisions, who in turn used their safety belts less often than those involved in collisions and assessed as being the less responsible party.

- drivers in their cars by themselves used their safety belts less often than those who were accompanied by passengers.

- drivers under the influence of alcohol used their safety belts less often than those with no alcohol in their blood.

- drivers, whose attitude were assessed as being a background cause of the accident used their safety belts less often than other drivers involved in accidents.

In Finland was recently carried out a small interview study /4./ in which were asked private car drivers who neglected to use their safety belts the reason why they did so. Most of the reasons put forward by the drivers indicated some degree of slight indifference:

- "I forgot to fasten it."
- "A safety belt isn’t necessary on a journey like this."

In a number of cases safety belts were regarded as being uncomfortable or inconvenient to use. But there were also about one in five of those interviewed, who said that they were strongly opposed to the wearing of safety belts.
How can safety belt usage be increased

In the Nordic countries, where the safety belt usage rate has been measured at over 80 per cent, and even near 100 per cent at best, in the front seats and at 50-70 per cent in the back seats, increasing safety belt usage by the presented conventional means will not be easy. However, as is clear from the accidents investigated by the road accident investigation teams, it is worth trying to increase the usage of safety belts.

Private cars carrying at most one passenger in addition to the driver account for the majority of passenger kilometreage. There are passengers travelling in the back seats of comparatively few cars. Thus, a decline of a few percentage points in the front seat safety belt usage rate means as great loss as that which back seat safety belt usage has yielded when measured using the kilometreage driven without safety belts.

Some categories of vehicles are still not subject to compulsory safety belt usage. In Finland, safety belt usage is resisted tooth and nail by those involved in commercial transport. For this reason, for instance, the drivers and back seat passengers of taxis are not covered by compulsory usage regulations. Nevertheless, the benefits of safety belts are indisputable also in the case of trucks.

At present, fastening one’s safety belt is an extra inconvenience when setting off on a journey. In my opinion, technical solutions can be used both to make it easier to use safety belts and to make it more difficult to neglect their use. One such solution may be the automatic fastening of safety belts. I would rather see effective (sufficiently disturbing) warning lights and audible alarms to indicate that safety belts are unfastened being made compulsory in cars as cheaper solution. One possibility it would be to prevent the car engine from starting or the vehicle from moving off if the safety belts are not fastened. In this manner it would actually be easy to prevent "unnecessary" traffic fatalities. On the other hand, the problem of how to improve passive safety in addition to safety belt usage will be more difficult and more expensive to solve.

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French Experience in Seat Belt Use

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France

and

Yves Page
DSCR-ONISR
France
I - Introduction

In the 1960s, the seat belt was highly thought of as effective safety equipment to protect the occupants of private cars in a collision. Since then, France has taken legal action to introduce seat belts gradually. The government, working through the bodies responsible for dealing with road safety problems, has backed up the regulations making wearing seat belts obligatory by mounting campaigns to inform people about them, to encourage and check on their use, and to punish those who do not use them. The campaigns were aimed at making drivers and passengers of private vehicles aware of the effectiveness of this system of protection by restraint in a collision and to mobilize the public to make more use of it.

A Road Safety "Dashboard" has been set up which monitors such indicators of driver behaviour as seat belt use levels, which makes it possible to evaluate the impact and effectiveness of legal measures taken to increase the wearing of seat belts in private vehicles.

As well as the seat belt regulations, the strategies employed to reinforce the wearing of seat belts by using information and encouragement campaigns, and checks by the police and gendarmerie are described here along with their timetables and intensities. The data will be analyzed to evaluate the effectiveness of these road safety measures by examining the annual chronological series of the rates of seat belt wearing by front-seat occupants of private vehicles in both the rural and in urban areas from 1972-1991, alongside the timetable of implementation of the backup measures taken.

II - Timetable of Legal Measures

In France, as seat belts come high on the list of road safety programmes selected by the ELECTRE method of multicriteria aggregation of preferences (OECD, 1981), a series of regulations covering the installation and wearing of seat belts has been taken since 1970, using a gradualist approach (See Table 1).
<table>
<thead>
<tr>
<th>Implementation</th>
<th>Installation</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avril 1970</td>
<td>Front seats of new private vehicles</td>
<td></td>
</tr>
<tr>
<td>1er Juillet 1973</td>
<td>Front seats of private vehicles in rural areas</td>
<td></td>
</tr>
<tr>
<td>(decrees of 28/6/1973)</td>
<td>Front seats of private vehicles in urban areas</td>
<td></td>
</tr>
<tr>
<td>1er Janvier 1975</td>
<td>Front seats of vans *</td>
<td></td>
</tr>
<tr>
<td>1er Octobre 1977</td>
<td>Back seats of new private cars + 3-point inertia-reel belt in front seat of new cars</td>
<td></td>
</tr>
<tr>
<td>1er Octobre 1978</td>
<td>Back seats of new private cars</td>
<td></td>
</tr>
<tr>
<td>(decrees of 1/08/1977)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1er Octobre 1979</td>
<td>Back seats of private cars</td>
<td></td>
</tr>
<tr>
<td>(decree of 26/9/1979)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Décembre 1989</td>
<td>Front seats of vans</td>
<td></td>
</tr>
<tr>
<td>1er Décembre 1990</td>
<td>Back seats of private cars</td>
<td></td>
</tr>
</tbody>
</table>

* Maximum weight < 3.5 T

Table 1: Dates of implementation of obligatory installation and use of seat belts in France (Source: Journal Officiel).

The first phase ran from April 1970 to August 1977, with the gradual installation in the front seats of private vehicles built before 1967 of seat belts attached to three anchorage points (which had been obligatory since 1/01/64) and a legal requirement to wear them at first in the rural areas, where accidents are more serious, then in urban areas during the night. The use of seat belts and nationwide speed limits were two of the major safety measures taken in 1973 which halted the upward trend of traffic accidents and road deaths (Lassarre, 1986).

The second phase, from August 1977 until now, saw the introduction under EEC directives of three-point inertia-reel belts* in the front seats and fixed three-point belts in the rear (anchoring points have been obligatory since 1/09/72). From October 1979 seat belts had to be worn in the front seats on the whole road network at all times, and from October 1990 in the rear seats. A decree of September 1979 made a few exceptions to these requirements to take account of personal physical size and medical or professional reasons.

* The inertia-reel belt is a technical advance in user comfort and especially protection, as it must hug the body to be efficient.
III - Strategies to Encourage Seat Belt Use

Legal enforcement was chosen as the best way to make passengers use their seat belts. However, to ensure maximum effectiveness, specific operations were needed to raise public awareness, and strategies were adopted to optimize seat belt use by acting directly on the user (Dejeammes, Lassarre, 1986). We can divide these government-sponsored operations since 1973 into three categories:

1. Information
2. Raising awareness and incentives
3. Enforcement.

Each of these types of operation has been used either continuously or intermittently to explain the reasons behind the regulations, to revive flagging driver motivation or to heighten public consciousness of road safety and courtesy.

III.1 - Communication Strategies

Communication campaigns are always linked to slogans which are brief and explicit but not backed up by arguments, and which are obviously varied according to the message to be put across (information, awareness-raising, encouragement, remotivation, message as part of a multi-theme campaign...), to public attitudes towards seat belts, to the relative importance of new legal measures, to the advertising media most suitable at the time and to the target audience. The media used were as varied as possible (TV, radio, the press, stickers, pamphlets, demonstration models, messages on the roads...) but with a strong preference for radio, TV and large posters, so as to reach the greatest number of people. These publicity campaigns were mounted either at national level or in the recent framework (1987) of the Departmental Plans for Road Safety Action called PDASR (DSCR, 1990) and local programme contracts (formerly Objectif -10%).

The campaigns attempted to reconcile the demands of short-term action, inspired by political marketing, with the development of studies and research on cost/efficiency ratios, but with an increasing tilt towards production budgets (L'Hoste, 1982). They were most often characterized by the repetition of slogans angled at the human factor, by the brevity of the message and by monitoring through the use of opinion polls. A summary and descriptive table of the seat belt campaigns is given in Annexe 1.
The information campaigns follow a recurrent three-cycle pattern, in which we see phases of expansion and retraction:

1st cycle
From 1972-79: regular campaigns on seat belts, aimed at informing the public (1972-76) based on the idea of establishing a reflex action in the user ("Clic, Clac") and at making people aware of the new regulations, with the added intention of demonstrating the government's confidence in the effectiveness of the legislation (see results of five years of road safety, 1978) by legitimizing the regulations with demonstrations ("It Saves" and "In 5 years, 20,000 Lives Saved").

From 1979-82: Seat belt campaigns were put on the back burner in favour of the other two major road safety themes: alcohol and speeding.

2nd cycle
From 1982-87: less regular campaigns but with greater shock value to remotivate users, particularly a multi-phase campaign from 1986-87 with the support of local centres, (Objective - 10% then PDASR since 1987), helped to plug a message on the harmful consequences of not wearing seat belts ("Unbuckled Belts: 2,000 Deaths a Year"). The 1986 campaign had a strong and lasting impact on the rate of belt use in the front seats of vehicles.

From 1987-90: another fallow period.

3rd cycle
1990: The theme was taken up again with a campaign which strongly emphasized the wearing of belts in the rear seats, an important new safety measure which had to be explained and made acceptable to users.

The first 10-year cycle (1972-82) concerned the introduction and increase of seat belt use; the second cycle, of eight years, was a follow-up period of reinforcing the use of seat belts in the front seats of vehicles, and the third cycle is to launch the wearing of belts in the rear seats.

III.2 - Incentives

Even though communication and/or information campaigns raise awareness, a pertinent short-term or permanent road safety message (especially concerning seat belts) can be put across by background actions based on socio-cultural group behaviour or lobbies who inspire confidence and whose persuasiveness is enhanced by their authority. Reinforcement measures can also be taken at the level of businesses (training/information conferences), in schools, or by driving
instructors stressing the increased safety provided by the seat belt, its usefulness and its merits (Dejeammes, INRETS, 1986).

Clearly, the deferred and latent long-term effect of this type of encouragement is difficult to evaluate because these actions or "role models" have a slight and isolated impact due to the chosen method of persuasion - continuous and discreet dissemination of information - which is often effective but is spread over a long period.

III.3 - Enforcement

The different decrees adopted in France concerning the wearing of seat belts implied the setting up of a system of checks and penalties to enforce the regulations and, to a certain extent, to change offenders' behaviour by the use of dissuasion and fines. More than the amount of the fine (in France, failure to wear seat belts is a second-level infringement punished by an automatic fine of 230 francs), it is the knowledge that the law exists that modifies behaviour, more than the psychological impact of the checks and the way they are carried out.

The intensity of the checks can be measured by the number of infringements reported by the police and gendarmerie (Table 2) which have been available on a reliable basis since 1983.

<table>
<thead>
<tr>
<th>Year</th>
<th>CRS</th>
<th>Gendarmerie</th>
<th>Police</th>
<th>Total</th>
</tr>
</thead>
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<tr>
<td>1983</td>
<td>14,485*</td>
<td>117,300</td>
<td>38,072</td>
<td>169,857</td>
</tr>
<tr>
<td>1984</td>
<td>15,989*</td>
<td>138,995</td>
<td>32,512</td>
<td>187,496</td>
</tr>
<tr>
<td>1985</td>
<td>18,412*</td>
<td>163,692</td>
<td>33,804</td>
<td>215,908</td>
</tr>
<tr>
<td>1986</td>
<td>28,816*</td>
<td>225,384</td>
<td>83,710</td>
<td>337,910</td>
</tr>
<tr>
<td>1987</td>
<td>32,927</td>
<td>223,383</td>
<td>129,808</td>
<td>353,191</td>
</tr>
<tr>
<td>1988</td>
<td>32,418</td>
<td>238,583</td>
<td>122,490</td>
<td>361,073</td>
</tr>
<tr>
<td>1989</td>
<td>36,155</td>
<td>289,192</td>
<td>124,290</td>
<td>413,482</td>
</tr>
<tr>
<td>1990</td>
<td>37,750</td>
<td>381,895</td>
<td>126,922</td>
<td>508,817</td>
</tr>
</tbody>
</table>

Table 2: Infringements reported annually by law enforcement officers.
(Source: Interior and Defence Ministries). * Estimated figures.

Since 1983, there has been an almost-constant increase in the number of seat belt infringements reported, with a very sharp rise since 1988. This does not mean that fewer people are wearing seat belts but reflects rather a sustained effort by the police and gendarmerie to make increased roadside checks. This interpretation is confirmed by other data on the number of hours devoted to speeding checks (this type of data is not unfortunately available for operations to check seat
belt use), and the number of tickets issued for failing to observe speed limits or for driving with excess alcohol in the blood, and the total number of preventive breathalyser tests.

IV - Assessing the Impact of Operations

In order to follow up on the major 1973 road safety measures (enforcing seat belt use, speed limits and restricting alcohol abuse at the wheel), a tool for assessing the impact of these regulations - the Road Safety Dashboard - was devised (Biecheler, 1976). Indicators of driver behaviour are based on estimates using information drawn from roadside surveys organized according to a sampling design. Analysing the data from different waves of surveys provides annual time series of the estimators of the percentage of occupants wearing belts in the front seats of private vehicles with high precision, given the size of the samples (Annexe 2).

An adjustment between movements in the percentage of occupants using seat belts and the time-scale of the reinforcement operations described above will be used to evaluate their impact on seat belt use.

Three distinct periods stand out (Graph 1). In rural areas, between 1972 and 1979, the wearing of belts in the front seats followed a logistic curve linked to the rate of installation of the equipment in private vehicles. The turning point came in June 1975 with 45% of occupants using seat belts. The rapid increase in belt-wearing during the first four years after the decree making their use obligatory issued in 1973 was sustained by a first wave of campaigns which was intended to make buckling the seat belt a reflex action. A slowing-down appeared in 1977 and a saturation threshold was reached in 1979 despite campaigns justifying the regulations.

A peak came in 1980 with a percentage of 78% of occupants wearing seat belts following the October 1979 decree extending their use over the whole road network and the introduction of inertia-reel belts. Between 1981 and 1986 there came a second period, during which the use rate slipped steadily back to 67%. This progressive disinclination to wear seat belts seems to go hand in hand with a slackening in the intensity of information campaigns. To counteract this trend, a large-scale campaign was launched in the autumn of 1986 stressing the dramatic effects of not wearing belts. Following these shock tactics the slide was halted and the proportion of occupants wearing their seat belts rose by 15 percentage points in four months. Since 1987 the rate has been rising gently by one or two points a year. This advance seems to have been achieved by the roadside checks and the penalties handed out by the Police forces and order in this period, during which the information campaigns have been less strident.
The swings noted in rural areas are even stronger in urban areas. From 1980 to summer 1986, the user rate fell sharply from 55% to 23%. This erosion of respect for seat belt regulations, rapid at first and then slower, was reversed in the autumn of 1986 thanks to a national campaign and by 1987 the rate was back up to its 1980 starting point. Between 1987 and 1991, the proportion of occupants wearing seat belts sagged slightly in 1988 and 1989, but pulled back up in 1990 and 1991, to register 56%.

Graph 1: Rate of occupants wearing belts in the front seats of private vehicles in rural and urban areas.

V - Future Lines of Action

A high proportion of front-seat occupants in private vehicles wear seat belts in rural areas. The use rate in urban areas over short distances remains low. Regional differences modify this view, with a diminution in seat belt use following a North-South axis. Incomplete figures suggest that the use rate in the rear seats is very low, between 10% and 30% according to road category.

Efforts still have to be made to identify the reasons which make persistent offenders fail to buckle their seat belts. Research is now being carried out (Dejeammes, Alauzet, 1990) into the use and the comfort of vehicle protection systems by using questionnaires distributed to drivers at the wheel.

In January 1992, equipment in vehicles to restrain children less than 10 years old will become obligatory. Consciousness-raising and information campaigns are planned to induce vehicle
owners to use these new systems and to reinforce utilization of rear-seat belts. A system to observe the wearing of this rear-seat equipment, which is lacking now and which poses data-gathering problems, should be set up to monitor these new measures.

Bibliography


<table>
<thead>
<tr>
<th>YEAR</th>
<th>PERIOD</th>
<th>MESSAGE</th>
<th>MEDIA</th>
<th>TYPE OF MESSAGE</th>
<th>COMMENTS</th>
<th>CAMPAIGN LINKED WITH</th>
<th>EUROPEAN SEAT BELT CAMPAIGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>October 31-January 15</td>
<td>'What About Your Belt?'</td>
<td>150 roadside posters</td>
<td>Text</td>
<td>505 roadside posters and 150 radio spots</td>
<td>dramatic, emotional</td>
<td>raising awareness on alcohol, speeding and wearing seat belts before summer</td>
</tr>
<tr>
<td>1973/74</td>
<td>May 30-September 2</td>
<td>'Clic, let's Wear Our Belts'</td>
<td>500 roadside posters</td>
<td>Audiovisual</td>
<td>250 roadside posters, 100 radio spots, and 500 posters on buses</td>
<td>informative</td>
<td>scientific stunts</td>
</tr>
<tr>
<td>1974</td>
<td>January-February</td>
<td>'A Little Clic is Better Than A Big Crash'</td>
<td>150 roadside posters</td>
<td>TV</td>
<td>100 TV and 3 film spots run on 40 press adverts</td>
<td>scientific film</td>
<td>campaigns about new regulations on using belts at all times</td>
</tr>
<tr>
<td>1975</td>
<td>April-May</td>
<td>'It Saves Lives'</td>
<td>150 roadside posters</td>
<td>Radio</td>
<td>100 broadcasts of 10 radio spots and 100 roadside posters</td>
<td>dramatic</td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>June 27-August 5</td>
<td>'Three Golden Road Rules: The Main Thing Is To Get There'</td>
<td>150 roadside posters</td>
<td>Print</td>
<td>150 roadside posters, 100 radio spots, and 500 posters on buses</td>
<td>scientific</td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td>January-February</td>
<td>'Let's Keep It Up: A Little Clic Is Better Than A Big Crash'</td>
<td>150 roadside posters</td>
<td>TV</td>
<td>100 TV and 3 film spots run on 40 press adverts</td>
<td>informative</td>
<td></td>
</tr>
<tr>
<td>1978</td>
<td>June 27-August 5</td>
<td>'Belt Buckled, Face Protected'</td>
<td>150 roadside posters</td>
<td>Print</td>
<td>150 roadside posters, 100 radio spots, and 500 posters on buses</td>
<td>transformative</td>
<td></td>
</tr>
<tr>
<td>YEAR</td>
<td>PERIOD</td>
<td>MESSAGE</td>
<td>MEDIA</td>
<td>TYPE OF MESSAGE</td>
<td>COMMENTS</td>
<td></td>
<td></td>
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<td>------</td>
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<td>---------------------------------------------------</td>
<td>--------------------------------------------</td>
<td>-----------------</td>
<td>-----------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>Summer</td>
<td>'Don't Get A Nose Full Of Glass: Even For 100 Yards, Belt Up' 'Make Both Ends Meet: Clic, Even For 100 Yards, Belt Up'</td>
<td>3 TV fictional films road and bus posters pamphlets on seat belts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>February 18-March 13 October 24-November 23 Summer</td>
<td>'If We Want Yo, We Can' 'With Belt' 'Without Belt' (comparative photos)</td>
<td>TV films bus and urban posters small posters, stickers radio adverts</td>
<td></td>
<td>campaign extended overseas 3 summer campaigns linked with speeding and drinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>May 15-31 Summer</td>
<td>'Not Buckling Your Belt: 2,000 Deaths A Year'</td>
<td>TV films (6 channels) 900 radio adverts 1,800 roadside posters</td>
<td></td>
<td>rounding off the 1986 summer campaign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>November-December</td>
<td>'One Life, One Belt'</td>
<td>TV, radio, posters local broadcasts</td>
<td>informative</td>
<td>belt use obligatory in rear seats</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: period, content, media used and type of messages in communication campaigns on seat belts. Source: "Communication and Road Safety: campaigns from 1973 to 1987". (BSCR, 1987).

"Don't Get A Nose Full Of Glass: Even For 100 Yards, Belt Up'

"Make Both Ends Meet: Clic, Even For 100 Yards, Belt Up'
Technical Annexe 2:

Methodology of Roadside Sampling Surveys to Estimate the Rate of Seat Belt Use

The principle of gathering seat belt data is based on roadside observation of the number of vehicles equipped with belts, and their use by the front-seat occupants, using investigators spread over a number of observation points and time periods according to a sampling design.

Working with raw data on the presence or absence of seat belts and whether or not they were being worn, three indicators are estimated: the rate of use, the rate of installation and the proportion of occupants wearing belts, which is equal to the product of the first two indicators and to the ratio between the number of front-seat occupants wearing belts and the total number of occupants of private vehicles, equipped with seat belts or not.

I. Roadside Sampling Surveys

The methodology of surveys has evolved over time and differs according to the category of road network: national and local, motorway, urban.

I.1 Surveys on national and local roads

The design is in three levels: the department, the stretch of road with which an observation point and a time period, randomly sampled, are associated, and the private vehicle and its occupants.

The survey is carried out in a sample of 20 departments which are typical for their consumption of different grades of fuel and their geographical spread throughout the country.

From February 1972 to December 1982, the survey was carried out first every three months, then every four, over a panel (Biecheler, 1978) consisting of:

- 120 observation points (from May 1975) on high traffic-density roads including 70 on national roads (27,300 km) and 50 on local roads (30,700 km),

- 60 observation points on less-used local roads.
Half-hour survey periods are drawn by chance between 6am and 8pm with an even balance between the days of the week. Observation points can be located either in open countryside or in urban areas of less than 5,000 inhabitants.

In January 1983, the panel of observation points was revised on the basis of a new sample of 20 departments (Biecheler, Lassarre, Tan, 1982). Only high traffic-density roads were chosen, falling into four categories:

- national roads:
  - 2 or 3 lanes in rural areas,
  - 2-lane dual carriageways in rural areas
  - 2 or 3 lanes in small urban areas
- local roads

The numbers of observation points per two-month period were 49, 28, 49, 42, with half-hour survey periods in one direction per observation point from 9am to 5pm, leaving aside high traffic-density days and weighting the distribution evenly over the days of the week.

I.2 Surveys on motorways

These surveys started in April 1974 on two categories of motorway (Biecheler, 1976):

- toll or inter-urban motorways,
- non-toll or peri-urban motorways.

From May 1975 to December 1987, vehicles were observed every three months, then every four months, for one-hour periods in one direction at nine points on toll roads and at three points on non-toll roads. Since January 1983, the number of points used was increased to 42 and 28 with 10 minutes of observation per lane in one direction, and at one-month intervals until 1985, then at two-month intervals, with an equal distribution over the days of the week (Biecheler, Lassarre, Tan, 1982).

I.3 Surveys in urban areas

A survey on the main roads of cities of more than 100,000 inhabitants was set up starting in 1980 (Filou, Gourlet, 1988). Cities falling into two categories were chosen, with an even North/South balance and randomly sampled observation points:

- Paris + suburbs: Paris (5), St-Denis (1), Malakoff (1), Levallois-Perret (1),
- Provinces: North: Lille (6), Metz (6), Nantes (6),
  South: Avignon (6), Lyon (6), Toulouse (6).

The frequency of observation was every four months from January 1980 to December 1981, then every six months. Half-hour surveys were taken at the observation points on weekdays between 8am and 7pm.

II. Analysis of the statistics on seat belt use

The aim is to use the statistics from these disparate surveys to establish the two annual series of the rates of seat belt use in rural and urban areas, with the basic problem being how to homogenize, then to adjust the results of the two main survey periods, 1972-1982 and 1983-1991, following the restructuring of the observation points in 1983.

For high traffic-density roads, the annual rates of seat belt use by front-seat occupants are available from 1972 to 1977 (Lassarre, Gourlet, 1978) and from 1978 to 1982 (DES, 1983). From 1983 to 1991 it is necessary to aggregate the annual rates for the three categories of national roads with a weighting according to their annual mileage. The series of rates on high traffic-density roads from 1972 to 1982 is adjusted with that of rates on national roads from 1983 to 1991 by applying a ratio calculated on the turning-point years 1980 to 1984 (Table 1).

For local roads, for the period 1972 to 1977 we use rates estimated for the former local minor roads, from 1978 to 1991 estimated rates for high traffic-density minor roads (DES, 1983) (ONISR, 1991). The adjustment between the two periods 1972 to 1982 and 1983 to 1991 is made as above.

Using the same sources, two homogeneous series relative to the panel are available from 1974 to 1982 and from 1983 to 1991 on toll and no-toll motorways (Table 1) and easily lend themselves to an adjustment between the first and second periods.

An annual rate of occupants using seat belts in rural areas can be calculated by weighting the annual rates obtained for each category of road network: toll motorway (AL), no-toll motorway (AD), national roads (RN) and local roads (CD) according to the number of vehicle-kilometres. The annual mileages for the first three networks are provided by the SETRA (CSTR, 1991). Mileage on 320,000 km of local roads was estimated in 1984 at 145.9 billion vehicle-kilometres (Lassarre, 1989). Mileages for other years is calculated by applying the rates of mileage increase on national roads.
Working with the results of the survey carried out using the sample of six provincial cities plus Paris and three suburban areas (Filou, Gourlet, 1988) (ONISR, 1991), it is possible to establish an annual series of the rates of occupants wearing seat belts in urban areas, using a weighting of 1/5 Paris and 4/5 provinces, which is valid for weekdays on main roads (Table 1).

<table>
<thead>
<tr>
<th>Année</th>
<th>AL</th>
<th>AD</th>
<th>RN</th>
<th>CD</th>
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<th>Urban</th>
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<td>50,0</td>
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<td>73,6</td>
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<td>74,2</td>
<td>66,2</td>
<td>68,9</td>
<td>32,6</td>
</tr>
<tr>
<td>1983</td>
<td>80,8</td>
<td>66,2</td>
<td>73,0</td>
<td>70,1</td>
<td>71,6</td>
<td>31,0</td>
</tr>
<tr>
<td>1984</td>
<td>80,4</td>
<td>66,9</td>
<td>72,1</td>
<td>69,5</td>
<td>71,0</td>
<td>29,0</td>
</tr>
<tr>
<td>1985</td>
<td>75,0</td>
<td>60,5</td>
<td>67,3</td>
<td>66,6</td>
<td>67,1</td>
<td>23,0</td>
</tr>
<tr>
<td>1986</td>
<td>75,5</td>
<td>62,1</td>
<td>69,4</td>
<td>71,5</td>
<td>70,7</td>
<td>32,2</td>
</tr>
<tr>
<td>1987</td>
<td>89,1</td>
<td>80,9</td>
<td>84,1</td>
<td>83,1</td>
<td>83,8</td>
<td>54,4</td>
</tr>
<tr>
<td>1988</td>
<td>88,9</td>
<td>79,4</td>
<td>84,0</td>
<td>83,8</td>
<td>84,1</td>
<td>51,5</td>
</tr>
<tr>
<td>1989</td>
<td>89,9</td>
<td>82,0</td>
<td>85,3</td>
<td>85,0</td>
<td>85,4</td>
<td>51,9</td>
</tr>
<tr>
<td>1990</td>
<td>91,2</td>
<td>83,0</td>
<td>87,0</td>
<td>87,2</td>
<td>87,3</td>
<td>55,4</td>
</tr>
<tr>
<td>1991</td>
<td>89,0</td>
<td>83,1</td>
<td>86,2</td>
<td>86,4</td>
<td>86,4</td>
<td>56,4</td>
</tr>
</tbody>
</table>

Table 1: Rates of seat belt use by front-seat occupants of private vehicles in rural and urban areas from 1972 to 1991 (Source: ONSER, SETRA, ONISR).
Strategies to Increase the Use of Restraint Systems

Hanns Ch Heinrich
Federal Highway Research Institute (BASt)
Germany
The usage rate for seat belts in front seats has reached a level in Germany (old states) which can hardly be increased any further. It has reached 99% on autobahns, 97% on rural roads and 94% in urban areas, i.e., an average of 96% (1990 figures).

The basis of all figures about the usage rate for seat belts are observations in the western part of Germany. These unobtrusive observations have been carried out two times each year during day-time in each case for one week in four selected regions, which are representative for whole Germany regarding socio-demographical aspects.

The extraordinarily high usage rate in Germany, however has been observed since 1984 only when non-compliance with this law became subject to a fine of DM 40. But it would be a misinterpretation of the situation, if we assumed that the introduction of the fine was the only factor leading to the present usage rates. This development was preceded by a decade of public discussions presumably already effecting a decisive change in the basic attitude toward the seat belt so that the introduction of the fine just served to push drivers still a little further in the direction they had been heading for anyway.

What we should not forget is that at the beginning of the 1970s only a fraction of all cars had been equipped with belts:

- Since 01 January 1974, the front seating positions of all cars admitted to traffic for the first time have been required to be equipped with seat belts;
- Since 01 January 1976, the legal requirement of equipping the front seats of cars with seat belts has been extended to all cars (supplementary equipment law);
- Since 01 May 1979, this has also applied to rear seating positions.

On the dates below, legal regulations applying to the usage of belts (or restraint systems) were introduced:

01 January 1976 compulsory belt usage in the front seats of cars (without the imposition of a fine in the case of not complying with this law)

01 August 1984 compulsory belt usage in the rear seats of cars

01 August 1984 a fine of DM 40 for car occupants in front seats not complying with the law

01 July 1986 a fine of DM 40 for car occupants in rear seats not complying with the law.

Aside from that, there were various events and measures likely to influence usage behaviours in the direction desired:
- A total of four campaigns were launched calling upon drivers to use the belt, i.e.
  - June-December 1974
  - March-September 1975
  - June-December 1977

- There have been two leading decisions of the highest courts in Germany with respect to the seat belt:
  - In March 1979, the Federal Supreme Court decided that the failure to fasten one's seat belt amounts to contributory negligence in the case of injuries suffered in an accident.
  - In October 1981, the highest German labour court decided that an employee not using a seat belt cannot make any claims for the continuation of his wage payments should an accident cause his inability to work.

At those times these decisions caused lively responses in the press and a wide public discussion.

If we consider the usage rates over time, two sudden increases in the rates will be found, in both cases in connection with the introduction of legal regulations, i.e. the introduction of compulsory belt usage at the beginning of 1976 and the introduction of the fine for non-compliance in 1984.

Ernst & Brühning (1990) undertook an extensive and careful re-analysis of the 1978-88 accident data in order to estimate the effectiveness on the number of fatalities and injured parties of the introduction of the fine for non-compliance on 01 August 1984. They arrived at the following results:

- Owing to this single measure, a total of 98 car occupants less were killed; "based on the period of a year, this amounts to a reduction of 1,176 killed car occupants." (p. 12). This means for the year of 1985 that without this measure 28 % more car occupants would have been killed.

- In addition, 10,764 car occupants less were injured within the span of a year. For 1985 this means a reduction of 21 %.

- Evidence of a statistical reduction of slightly injured car occupants could not be found. However, it can be assumed that persons who would have suffered minor injuries without the belt remained uninjured and that persons who otherwise would have suffered major or even fatal injuries became the victim of slight injuries only.

- The overall effectiveness of the belt, as was finally determined, amounted to approx. 3,000 to 4,000 fatalities per year. That means that without any belts 3,000 to 4,000 fatalities more would have been deplored per year.

The introduction of the fine for non-compliance with the belt usage law therefore was amazingly effective. The campaigns as such appear to have been of only moderate effect. On the other hand, however, the 1975/76 and 1983/84 campaigns did serve to consciously prepare the ground for the legal regulations and thus probably also helped reinforcing their effectiveness.

There is one point deserving attention in this connection: in 1971, an extensive motivation study was commissioned by the Federal Highway Research Institute (BAST) to clarify the question of the reluctance of drivers to buckle up -- despite the fact that it seemed the reasonable measure to take. The main results of that study was that buckling up reminded drivers of the possible dangers of car driving, a thought they rather cared to suppress--obviously some magical notions are partially also
involved here. The consequence was that in none of the later belt campaigns anxiety or any other sort of negative appeal was used, paying attention instead to strictly neutral and even positive forms of addressing the public, depicting belt usage or buckling up as a good habit and making every effort to avoid arguments possibly causing emotionally undesirable reactions.

We obviously seem to have succeeded. Belt usage has become a natural habit with the vast majority of car drivers, no longer requiring any thought. The act of buckling up in front seats no longer needs a conscious decision. It is now a natural part of car driving in most cases like closing the door.

The development of the replies to four questions asked 1,000 car drivers, respectively, in three representative surveys undertaken in 1985, 1988 and 1990 also confirms this assumption:

<table>
<thead>
<tr>
<th>Question</th>
<th>1985</th>
<th>1988</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>The positive benefits of seat belts are exaggerated</td>
<td>27</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Seat belts are not necessary for cautious drivers</td>
<td>18</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>The belt confines the driver and you can't do anything in an accident</td>
<td>30</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Without belt I would have the feeling to miss something</td>
<td>51</td>
<td>64</td>
<td>72</td>
</tr>
</tbody>
</table>

(according to EMNID, 1985, 1988; Haas, Pfafferott & Schulze, 1991)

And drivers' attitudes toward seat belt usage continued to improve, even beyond 1985.

All the findings reported thus far refer to belt usage in front seating positions. As regards the use of restraint systems in rear seats, both by adults and children, there still is no cause for satisfaction. Seat belt usage in rear seats has been compulsory since 01 August 1984. A fine for non-compliance with this regulation was introduced on 01 July 1986. The data available on the use of seat belts in rear seats for the years of 1984-90 show the following:

### Use of Restraint Systems in %

<table>
<thead>
<tr>
<th>Year</th>
<th>Adults (Drivers)</th>
<th>Adults (Rear Seat)</th>
<th>Children (Rear Seat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>92</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>1985</td>
<td>93</td>
<td>17</td>
<td>31</td>
</tr>
<tr>
<td>1986</td>
<td>95</td>
<td>41</td>
<td>51</td>
</tr>
<tr>
<td>1987</td>
<td>94</td>
<td>42</td>
<td>49</td>
</tr>
<tr>
<td>1988</td>
<td>94</td>
<td>54</td>
<td>57</td>
</tr>
<tr>
<td>1989</td>
<td>96</td>
<td>53</td>
<td>58</td>
</tr>
<tr>
<td>1990</td>
<td>96</td>
<td>47</td>
<td>60</td>
</tr>
</tbody>
</table>
These numbers are regarded to the passengers observed on back seats. It was not under consideration whether the seats were equipped with belts or not. Because of the legal requirements of equipping the back seats of cars with belts since 1979 nearly all cars are actually equipped.

The table shows that, in this case too, the introduction of the fine for non-compliance resulted in a clear increase in the use of rear seat restraint systems but by far not to the same extent as for front seat seat belts in 1984.

On the whole, the following conclusions suggest themselves:

- campaigns alone have only a slight effect on belt usage rates;
- legal measures, especially the fine for non-compliance, have a much clearer effect;
- a maximum effect can be achieved if information campaigns and appeals are used to prepare the ground for the introduction of the legal measures.

References


Entwicklung der Curtanlegequoten 1974 - 1990

Ab 1.1.1976: Curtelnahpflicht für Fahrer und Beifahrer.
Ab 1.5.1984: Einführung eines Verwaltungsabzugs für das Curtanlegen auf Vorderräder.
Ab 1.7.1986: Einführung eines Verwaltungsabzugs für das Curtanlegen auf Rückrädern.

Quelle: Bundesanstalt für Straßenwesen
"The positive benefits of seat belts are exaggerated."

"Seat belts are not necessary for cautious drivers."

"The belt confines the driver and you can't do anything after an accident."

"Without belt I would have the feeling to miss something."
Restraint Use by Car Occupants, Great Britain 1982–91

Jeremy Broughton
Transport and Road Research Laboratory (TRRL)
United Kingdom
RESTRAINT USE BY CAR OCCUPANTS,
GREAT BRITAIN, 1982-91

by J Broughton, TRRL, England

1. Introduction of Seat Belt Regulations

The use by car occupants of seat belts and other restraint systems has developed gradually in Great Britain, as the protection that they offer has become generally recognised. The fitting of seat belts was made compulsory in the front seats of new cars in 1965 (1967 in vans), and successive publicity campaigns were mounted in subsequent years to educate the motoring public as to the advantages of seat belt wearing. From 31 January 1983, under the provisions of the 1981 Transport Act, it became compulsory for the drivers and front seat passengers of cars and vans to wear seat belts.

Once high wearing rates had been achieved among those travelling in the front seats of cars, attention turned to those in the rear. Provision of mounting points for seat belts in the rear of cars was made compulsory in October 1981. This was followed by the requirement that cars manufactured since October 1986 or first registered since April 1987 should be fitted with rear seat belts. The next legislative step was to require any rear seat passenger less than 14 years old to wear a seat belt or alternative restraint system, where available; this took effect on 1 September 1989. Finally, on 1 July 1991 this requirement was extended to all rear seat passengers in cars. Thus, it is now required in Great Britain that each car occupant shall travel restrained where a seat belt or another suitable restraint system is available. There is no requirement that older vehicles without rear seat belts should have them fitted retrospectively.

2. Measuring Seat Belt Wearing Rates

The generic term 'wearing rate' will be applied to the proportion of drivers or passengers who travel restrained, although some types of child restraint cannot literally be worn. It is clearly important to measure these rates accurately, to see how well the various regulations have been observed by the motoring public and to determine whether any remedial action, such as publicity campaigns, may be required to raise the rate.

The first surveys of seat belt wearing were made in the mid-1970's, and these found rates of about 0.3. There was then a gap until February 1982, when a monthly national survey was begun in preparation for the forthcoming regulations. The new survey used over 50 sites, on all types of road and spread throughout Great Britain. Drivers and front seat passengers of cars and vans were observed; the only detail recorded was whether or not a seat belt was worn. Thus, overall wearing rates can be calculated, but the data do not permit any detailed study of the rates, for example

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by age and sex of occupant. As the wearing rate quickly stabilised after the regulations came into force, the survey frequency was reduced to six times per year from June 1984 and to twice yearly (April and October) from 1986.

Between November 1982 and July 1986, TRRL carried out four surveys of restraint use in the rear (TRRL, 1987). Only children were included, but the type of restraint used was recorded in some detail.

From these four surveys developed the current series of TRRL surveys, covering car occupants of all ages and seating positions. Its main objectives are to measure the extent to which car occupants use seat belts and other restraints, and to see whether children use appropriate restraints. Consequently, extensive data have to be collected for each car occupant: age, sex, whether a restraint was being worn and if so of what type. An experiment carried out on the TRRL Small Road System showed that it was possible for experienced observers to reliably record this level of detail, provided that vehicles were stationary or very slow moving. Consequently, it was decided to carry out the survey at suitable junctions in two study areas where suitably experienced staff were available to TRRL: around its main site at Crowthorne, Berkshire and around Nottingham. The alternative of using a national sample of sites was rejected, as it would have provided national coverage of unknown reliability: any inter-regional differences that were found could have been the result of technical factors such as site selection, rather than genuine differences in restraint use. A report has been published which describes the survey methodology and presents detailed results from the first three surveys (Broughton, 1990).

The first of the new TRRL surveys was made in October 1988. The first three were run in parallel with the national survey, but by October 1989 it was clear that the wearing rates for drivers and front seat passengers provided by the two surveys were very similar. Accordingly, the national survey was terminated.

3. Wearing Rates

There has been regular monitoring of front seat belt use in Great Britain since February 1982, whereas regular monitoring in the rear only began in October 1988. The two sets of wearing rates will be discussed separately.

3.1 Front Seat Wearing Rates

The national wearing rates of drivers and front seat passengers found by the national survey and, more recently, the TRRL survey are shown in figure 1. It will be recalled that the surveys in the mid-1970's had found rates of about 0.3; these had risen to almost 0.4 by early 1982 when the regular national survey began. They rose to over 0.5 in January 1983, and to over
In February; a 'plateau' of about 0.95 was achieved in March. It may be noted that the police stated that there would be no prosecutions for seat belt offences during the first three months of the new law (i.e. February-April), so this marked rise was achieved at a time when many drivers were aware that there was no threat of prosecution.

The wearing rates observed in mid-1983 were largely maintained during the subsequent years, although there has been a slight fall from 0.94-0.95 to 0.93-0.94. It was rather disturbing, then, to find a sudden drop in the passenger rate to 0.90 in the latest survey (April 1991). This cannot be explained by technical factors, and it will be of great interest to see in the next survey (October 1991) whether this rate returns to its earlier level.

There has been considerable speculation about the reason for the sustained high wearing rates since 1983. British motorists are not notably law-abiding, and few motoring laws are as widely obeyed as the 1983 seat belt law. One important factor was the succession of publicity campaigns in the 1970's, at a time when the Government was averse to compulsion but was keen to raise wearing rates by persuasion. The various failed attempts in Parliament to pass seat belt legislation also served to maintain public interest. Consequently, when the law finally came into effect, many motorists who had not previously worn a seat belt were already persuaded of its value and were ready to comply with it.

3.1.1 Variations in Front Seat Wearing Rates

Wearing rates decline with road class, and are lower on built-up roads (those with speed limits of at most 40 mph) than on non-built-up roads (speed limits of more than 40 mph). The rates shown in table 1 come from the TRRL survey of October 1989: a similar pattern is shown by the other surveys. When the results from individual sites are used to calculate the national rates (as shown in figure 1), greater weight is given to the major roads and the non-built-up roads (to reflect the greater traffic volumes on these roads), so the means of the wearing rates by road class are slightly lower than the corresponding national rates.

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Driver</th>
<th>Front Seat</th>
<th>Passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.93</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.92</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>C/Unclass</td>
<td>0.89</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Built-up</td>
<td>0.91</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Non-built-up</td>
<td>0.94</td>
<td>0.95</td>
<td></td>
</tr>
</tbody>
</table>
Wearing rates also vary with the age and sex of the car occupant. Table 2 compares rates from the April 1991 survey; this was the first survey to record the age of adult passengers, but the ages of car drivers had been recorded by all six surveys and a similar pattern was found in each. It is clear that men are less willing than women to wear seat belts, and that wearing rates increase with age (among adults).

Table 2

<table>
<thead>
<tr>
<th>Age</th>
<th>Driver</th>
<th>Front Seat Passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17-29</td>
<td>30-59</td>
</tr>
<tr>
<td>Male</td>
<td>0.90</td>
<td>0.91</td>
</tr>
<tr>
<td>Female</td>
<td>0.95</td>
<td>0.96</td>
</tr>
</tbody>
</table>

3.2 Rear Seat Wearing Rates

During each of the current series of seat belt surveys, very many cars are observed, so the wearing rates for drivers are based on many observations and are relatively precise. Far fewer front seat passengers are observed, so their rates are rather less precise; rates calculated for child rear seat passengers are much less precise. Consequently, small differences among the rear seat wearing rates presented below may well not be statistically significant. Table 3 shows the numbers of car occupants observed in the most recent survey, using the age groups from the survey form.

Table 3

<table>
<thead>
<tr>
<th></th>
<th>Driver</th>
<th>Front Seat Passenger</th>
<th>Rear Seat Passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>108</td>
<td>231</td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>82</td>
<td>1142</td>
<td></td>
</tr>
<tr>
<td>5-9</td>
<td>157</td>
<td>975</td>
<td></td>
</tr>
<tr>
<td>10-13</td>
<td>227</td>
<td>492</td>
<td></td>
</tr>
<tr>
<td>14-29</td>
<td>5694</td>
<td>2179</td>
<td>780</td>
</tr>
<tr>
<td>30-59</td>
<td>12405</td>
<td>3247</td>
<td>579</td>
</tr>
<tr>
<td>60-</td>
<td>3253</td>
<td>1528</td>
<td>379</td>
</tr>
<tr>
<td>n.k.</td>
<td>24</td>
<td>25</td>
<td>8</td>
</tr>
</tbody>
</table>

The child rear seat wearing rates found in the six surveys are compared in figure 2. The four age groups are paired, and the
rates for 'newer' cars are presented separately from those for 'all' cars. Newer cars are those which, according to their registration prefix, were first registered since August 1987 and so must be fitted with rear seat belts: the child restraint regulations introduced on 1 September 1989 apply to all of these cars, but not to those older cars with no rear seat belts.

The figure shows that about five-sixths of 0-4 year old children travelling in newer cars are restrained, either wearing a seat belt or using another type of restraint. The proportion for all cars is a little lower, but is slowly converging: the new regulations had no discernible effect on wearing rates that were already relatively high. The proportion of 5-13 year olds who are restrained is rather lower, but did rise significantly in response to the new regulations: the wearing rate has since fallen back slightly.

The TRRL surveys make detailed observation of the type of restraint that children use. These show that the type used is appropriate to the age of child in the great majority of cases; table 4 shows the figures from the latest survey. In addition, the number of unrestrained children is included, according to whether they were travelling seated or carried on the lap of another passenger.

Table 4
The types of child restraint used, April 1991

<table>
<thead>
<tr>
<th>Age 0</th>
<th>0</th>
<th>6</th>
<th>91</th>
<th>2</th>
<th>0</th>
<th>7</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>28</td>
<td>32</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>5-9</td>
<td>139</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>10-13</td>
<td>207</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

The wearing rate for older rear seat passengers has varied somewhat erratically between successive surveys. Among newer cars it has ranged from 0.12 to 0.24, the latter rate being achieved in the latest survey. The wearing rate for all cars has ranged from 0.07 to 0.17, with the lowest rate being recorded in the first survey and the highest in the latest survey. Hence, there has been a gradual upward trend in adult rear seat wearing rates from a very low level in October 1988. The next survey will measure the response to the extension of the rear seat belt.
regulations to adults, from 1 July 1991.

The small numbers of adult rear seat passengers that are observed (table 3) make it difficult to compare their wearing rates precisely by age and sex. Rates are overall higher for women than for men (0.17 and 0.13 in the latest survey), and tend to increase with age.

4. Casualty Reductions

The three sets of seat belt regulations were introduced because of the widespread appreciation that car occupants who wear seat belts face lower risks of death and injury than those who do not. What effect have the new regulations had on casualty totals?

The 1981 Transport Act introduced, in addition to compulsory seat belt wearing, two other sets of regulations: one aimed at reducing drink/driving and the other at improving the safety of trainee motorcyclists. All took effect over a short period, so it is difficult to disentangle the separate effects. Broughton (1990) published the estimates contained in table 5; to provide a context, the table also includes the national casualty totals for 1982, the calendar year which preceded the implementation of the new regulations.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>First Year Casualty Reductions due to the 1981 Transport Act</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Killed</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined effect</td>
<td>490</td>
</tr>
<tr>
<td>Compulsory seat belt wearing alone</td>
<td>370</td>
</tr>
<tr>
<td>1982 casualty total</td>
<td>5934</td>
</tr>
</tbody>
</table>

Much concern was expressed before seat belt wearing became compulsory that other groups of road user would suffer increased casualties as a result. The so-called 'risk compensation hypothesis' predicted that previously unbelted drivers would feel more secure when wearing a belt, would drive more riskily and would consequently cause extra accidents. There is no indication of any increase in casualties among 'vulnerable' road users: in particular, the number of pedestrian casualties did not rise in early 1983.

No analysis has yet been made of the effects of the rear seat regulations. It will only be possible to assess the effects of
the adult regulations in 1993, when complete casualty data are available for the period July 1991-December 1992. It should shortly become possible to assess the effects of the child regulations: unfortunately, the completion of the 1990 accident database for Great Britain has been delayed.

5. Conclusions

One of the major developments in road safety in Great Britain during the last decade has been the increasing use of seat belts by people travelling in cars. This has been achieved by three pieces of legislation, with supporting publicity:

(i) from 31 January 1983 it has been compulsory for drivers and front seat passengers in cars and vans to wear seat belts: the wearing rate rose from its earlier level below 0.4 to 0.95, but has since fallen marginally to 0.93-0.94,

(ii) from 1 September 1989 it has been compulsory for any child up to 13 years old to be restrained when travelling in the rear of a car fitted with rear seat belts, or other child restraints: the wearing rate for 0-4 year olds in such cars continued at about 0.8, the rate for 5-13 year olds rose to 0.8, but has since fallen slightly,

(iii) from 1 July 1991 it has been compulsory for any person to be restrained when travelling in the rear of a car fitted with rear seat belts, or other child restraints: it is too early to judge how the adult wearing rate may have changed, but it had previously been less than one quarter.

6. Acknowledgements

The work described 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.

7. References


Fig 1: Front Seat Wearing Rates, 1982–1991

Fig 2: Child Rear Seat Wearing Rates, 1988–1991
State of Affairs in the Netherlands

Marjan P Hagenzieker
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STATE OF AFFAIRS IN THE NETHERLANDS

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SWOV Institute for Road Safety Research

1. Introduction

In the background paper for this workshop it is stated that restraint use is still a current issue. Although about 40 countries have safety belts laws prescribing usage of belts mandatory, and most drivers will recognize that vehicle safety belts are effective in reducing or preventing injuries, many still do not use safety belts. This paper illustrates the state of affairs in the Netherlands.

1.1. User rates

Table 1 shows an overview of safety belt use rates in the Netherlands 1979 - 1990 for drivers and front seat passengers; since 1989 also for rear seat passengers (data from Verhoef, 1991a;b). The observations are taken each year in October on weekdays as well as on Saturdays and Sundays during daytime hours (7 a.m. - 6 p.m.) at 24 locations in- and outside built-up areas throughout the country. Sample sizes are usually around 2,000 both in and outside built-up areas for drivers, around 1,000 for front seat passengers, and around 200 for rear seat passengers.

Table 1 clearly shows that belt use outside built-up areas is in general about 15% higher than inside built-up areas, for all categories of passengers. In general, user rates for front seat passengers are slightly higher, approx. 2-4 percentage points, than for drivers. User rates on rear seats are much lower than on front seats (also when only cars fitted with rear seat belts are included in the sample), although in one year's time a dramatic increase of 16-17 percentage points in user rates was observed.

In 1990, 93% of new cars (less than one year old) were equipped with safety devices on rear seats, whereas cars of 8 years old or more had these devices in only 18% of the cases (Verhoef, 1991b). Only 10% of the persons of 18 years old or older use a rear seat belt when available. Usage of rear seat belts for children between 5 and 12 years old was 27% in 1990, and for children between 12 and 18 years old 23%; 93% of the children less than 5 years old were
restrained in a special device for children (when present in the car).

Table 1. Percentages belt use for drivers, front- and rear seat passengers in and outside built-up areas in the Netherlands, 1979 - 1990.

<table>
<thead>
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<th>PERCENTAGE BELT USE</th>
<th>BUILT-UP AREAS</th>
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<tr>
<td>1990</td>
<td>59</td>
<td>64</td>
</tr>
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</table>

* total average figure for all age groups (between brackets including cars without rear belts installed)

2. Effectiveness of countermeasures

2.1. Legislation and sanctions

In the Netherlands a safety belt law prescribing usage (on front seats of cars sold in 1971 or later) mandatory and punishable came into effect in June 1975. National belt use rates increased from around a 25% level in 1974 to around 50% in 1975. Since then no steep increase has taken place despite several mass media campaigns. Safety belt use has stabilized at around 60% inside built-up areas and around 80% outside built-up areas for the past few years (Verhoef, 1991a). However, belt use rates are still much lower as compared to those in other European countries, that all showed steep increases in belt use during the 1980s (see Figure 1 backgroundpaper this workshop). Currently, the fine for not using a belt is in the range of Dfl. 35-65 (about $ 17-30).

Recently a law has been enacted that requires all new cars from January 1, 1990 or later to be equipped with rear seat belts in the Netherlands. The use of rear seat belts is not yet (in 1991) mandatory in the Netherlands; but there are plans to extend the required presence of rear seat belts to...
older cars as well and to make their use compulsory in the next few years. Rear seat belt use is accordingly fairly rare in the Netherlands (see Table 1).

2.2. Public information and enforcement

Exact knowledge about the application practices of the police with regard to enforcement as a regular or structural countermeasure to improve seat belt usage is lacking. However, our impression is that enforcement is not applied regularly in the Netherlands. Usually enforcement, in combination with public information, is applied incidentally in the form of (local) campaigns with a relatively short duration (1-2 months).

Several studies were carried out investigating the effects of a combination of enforcement and publicity in various regions in the Netherlands. Campaigns in the provinces Friesland (Gundy, 1986; 1988), Gelderland (Gras & Noordzij, 1987), and Noord-Brabant have been evaluated (Vissers, 1989) using both field observations and questionnaires. These studies all show substantial increases in safety belt use of 20-25 %-points with baseline levels of around 60-65%. During these 2-month campaigns, on average, 15-25 cars per hour were stopped and seat belt use checked by the police (Gundy, 1986; Gras & Noordzij, 1987). Over one year after the end of the campaigns belt use was still 10-15 %-points higher than before the campaigns (Gundy, 1988; Vissers, 1989).

2.3. Incentives

In the Netherlands incentive programs are not a common tool to stimulate seat belt use. Several studies, mainly conducted in the U.S., have shown that incentive programs can be successful in increasing safety belt use. However, these findings must be tempered by the fact that they were carried out in the absence of a safety belt use mandate; therefore, baseline use rates were relatively low (10% to 20%).

Recently an experiment was conducted to investigate the relative efficiency of incentives and enforcement on some military bases in the Netherlands (Hagenzieker, 1991). This study showed that incentive programs can be effective in increasing safety belt use under mandatory conditions, i.e. with relatively high baseline levels of about 60%. Especially so-called individual incentive programs turned out to be effective: an increase of 20 %-points in user rates was established. Group dependent incentives showed at best a short-term effect. The mean effects of enforcement and incentives were of the same magnitude, a medium to
long-term mean increase of 10-15 %-points for both treatment types.

3. Future action

Future attempts in the promotion of safety belt use in the Netherlands should be directed primarily at back seats and at improving the use of restraints among children, but thereby aiming at a radiation-effect on improving the use of seat belts on front seats as well. A law making usage in all cars compulsory may bring a very well opportunity to get attention of the public. New laws use to be able to. From the effects of the policy with regard to seat belts on front seats in the Netherlands it is deduced that a step by step approach in making a law obeyed is not recommendable. What seems to be needed is a combined effort directed at the moment that a new law comes into operation. The public has to be bombarded with all suitable pressure: information, incentives and enforcement, in order to convince them, to promote using belts as the social norm and/or to realise habituation. When using back seats as point of impact, front seats must be integrated in the campaign. Besides, parents on the front seats may not only influence their children on the back seats but the reverse is also possible and the same might happen between friends and relatives. To involve people with little children, also special seats for them should be incorporated in the campaign. Parents are most involved with the safety of little children and they have still more need for information because of the many alternative provisions for transporting them in a car. But the campaigns need not only be directed at children. Belt use on back seats should be obligated for all people.

We recommend therefore to concentrate efforts in promoting seat belt use by taking the opportunity of a new law for usage on back seats. It is necessary then to make the law applicable to every one at once and to guide this by a long lasting campaign on a large scale. That seems to have more perspectives for substantial results than introducing the law at first for new cars without a reasonable motive for an information and enforcement campaign, followed some years later by an obligation to all cars and starting a campaign only by then, meanwhile continuing to conduct the common information and enforcement campaigns directed at front seats year by year.
References


1991 National Campaign to Increase Safety Belt Usage

P Robert Knaff
Dr, Technical Director
KB & Ass
USA
1991 National Campaign to Increase Safety Belt Usage
Background

Since 1980, our nationwide (19-city) estimate of safety belt use by front seat occupants has increased from 11 percent to 49 percent. Nearly all of this increase has followed the passage of safety belt usage laws, beginning in 1984.

However, progress has slowed in recent years. From 1984 to 1987, usage increased by about 28 percentage points but from 1987 to 1990, it increased by only 7 percentage points. This decline in progress is the result of at least two factors. First, there are now fewer new States enacting safety belt usage laws each year. Second, and most important, most of the States which have passed safety belt (or child seat) laws are not actively enforcing these laws and/or providing public information which specifically supports these efforts.

The trend in most States with safety belt laws has been an initial significant increase in belt usage, followed by a modest decline (in the absence of enforcement), and stabilization at rates of 40 to 50 percent. Public information and education programs, without accompanying enforcement, have been ineffective in changing these "post-law stabilization" rates.

Enforcement Can Make a Difference

We know that enforcement, coupled with public information, can make a difference. Projects conducted in New York (e.g. Elmira, Albany and Greece; Illinois (e.g. Danville, Galesburg and Rock Falls); and Texas (e.g. Beaumont, Brownsville, and Laredo) have demonstrated that gains of 10-30 percentage points can be achieved through highly publicized enforcement.

Furthermore, we know that "blitz" or "STEP" (Selective Traffic Enforcement Program) approaches are not the only approaches that will work. Integrated enforcement, which combines safety belt enforcement with other patrol activities, has been found to result in even greater and longer lasting gains in usage rates --when accompanied by supportive efforts to increase public awareness.

No Additional Resources Needed

Demonstration projects conducted in U.S. cities have indicated that integrated enforcement does not require additional resources by police agencies because it does not require an increase in patrol hours. Safety belt citations are written as part of ongoing patrol activity. These findings are important since "integrated" enforcement can be conducted in secondary-law States as well as in primary-law States. Furthermore, these activities can be effective even in situations where resources have already been diminished.
The Canadian Experience

Successful safety belt campaigns in Canada have also emphasized the use of enforcement, combined with enhanced public awareness. During the early part of the past decade, the Canadian Provinces, like most of our States, had been suffering from "post-law stabilization." As a result, the Canadian national usage rate was only about 55 percent. Beginning in the mid-1980's, most of the larger Provinces initiated combined enforcement and public information efforts. As a result, these Provinces (e.g. British Columbia, Alberta, Saskatchewan, Ontario and Quebec) dramatically increased their usage rates and the Canadian national usage rate is now above 80 percent.

The Saskatchewan experience is particularly significant. Average usage rates prior to 1986 had fluctuated around 55 percent for nearly a decade. Following this long period with little progress, programs which combined public information with enforcement were initiated. These efforts increased belt usage in Saskatchewan to its current level of more than 90 percent in just a few years. Both British Columbia and Quebec implemented similar programs and now have usage rates greater than 90 percent, as well.

The common elements of these programs are increased enforcement, highly visible public information, and press conferences. The public information programs and press events have two objectives: (a) to make the public aware of the importance of wearing safety belts; and (b) to make the public aware of the fact that the police will be enforcing the law.

Our Conclusions

Everything we have learned to date indicates that visible enforcement of existing laws offers our greatest potential for achieving our goal of 70 percent usage by 1992.

As a result of our experiences, we have also concluded that:

(1) "blitz" enforcement often results in the most rapid increases in safety belt usage;

(2) techniques which "integrate" the enforcement of safety belt laws with the enforcement of other traffic safety laws may take slightly longer to increase belt usage but these techniques are more cost-effective than blitz approaches and they result in more sustained usage rates;

(3) public information efforts must be present to focus attention on enforcement; but

(4) public information, alone, will not increase usage.
A New NHTSA Program Plan

It has become clear that if we are to reach our goal of 70 percent safety belt usage by 1992, we must take some dramatic steps. Therefore, a major national campaign will be conducted in 1991 and 1992. During this two-year effort, maximum emphasis will be placed on a combined public information and enforcement program centered around the three summer holidays -- Memorial Day, Independence Day and Labor Day.

State and Local Efforts

The core activity of the national campaign will normally entail a 2-week safety belt and child seat enforcement effort surrounding each holiday. States without safety belt laws will be encouraged to enforce their child seat laws and to remind motorists to buckle up as part of their routine traffic stops and other contacts.

Prior notice and publicity about the enforcement effort is a must for public acceptance and program success. Therefore, one week before the enforcement effort begins, police (and/or other State and local officials) will be encouraged to conduct press conferences telling the public about the importance of wearing safety belts (and child seats) and warning them that enforcement will begin in the coming week.

In addition, for 2-3 weeks prior to these press conferences, participating States and localities will conduct public information programs that also point out the importance of safety belt (and child seat) use and the fact that enforcement will be emphasized throughout the summer, to reduce the holiday death toll.

Before Memorial Day, and after both the 4th of July and Labor Day, local jurisdictions will be encouraged to conduct simple, informal observation surveys to measure change in usage. They will also be encouraged to monitor and report the number of citations and warnings issued.

The purpose of the observational surveys is to provide information back to the police and to the local public regarding the success of their endeavors. This information also reinforces the concept that this is a non-punitive effort to safeguard the public's welfare.

We realize that not everyone across the nation will participate in exactly the same manner -- but if we are specific in defining an overall program schedule, there is a much greater chance of that individual efforts will complement each other. Accordingly, we have targeted the following specific dates for the start of each of these efforts:
NATIONAL SAFETY BELT USAGE CAMPAIGN MILESTONES

- May 1: Conduct 1st Informal State/Local Surveys
- May 5: Begin 2-Week Public Information Effort for Phase I (*)
- May 20-27: Buckle Up America Week (Official Kick Off) Include Results of 19-City Survey
- May 20: Begin Phase I State and Local Police Press Conferences (1-Week) Include Survey Results
- May 24: Begin 1st Law Enforcement Effort (10 Days) (*)
- May 27: Memorial Day
- June 2: Begin 3-Week Public Information Effort for Phase II
- June 23: Begin 1-Week of Press Conferences for Phase II
- June 30: Begin 2-Week Enforcement Effort for Phase II
- July 4: Independence Day
- July 15: Conduct Second Informal Surveys
- July 28: Begin 3-Week Public Information Effort for Phase III
- August 18: Begin 1-Week of Phase III Press Conferences
- August 25: Begin 2-Week, Phase III Enforcement Effort
- Sept 2: Labor Day
- Sept 8: Conduct Third Informal Survey
- Sept (25): 1991 Campaign Wrap Up (tentative date); Include Results of 19-City Surveys (at National Level) and Informal Survey (at Local Level)

(*) Memorial Day public information and enforcement periods are shorter than for other holidays due to short lead time.
**National Support for State and Local Efforts**

NHTSA will conduct a number of activities to support and reinforce State and local efforts.

First, a series of major press events will be conducted during the "kick off" week prior to Memorial Day (Buckle Up America Week); throughout the summer months; and during the September "wrap-up" (tentatively scheduled for September 25).

These events will incorporate enforcement, medical, public health, and private sector organizations. Each event will be staged with a different theme. For example, one may be at a trauma center with a group of physicians; another may be staged at a roadside sobriety checkpoint; still another may be at a major tourist attraction. Additional summer events will involve major 70% PLUS awards to organizations and jurisdictions achieving 70 percent belt usage.

To the extent possible, these events will be staged in various locations across the U.S. The idea will be to create an awareness of these events taking place across the nation by staging the events in different locations. Additional national coverage will be generated by making the 70x92 campaign a constant theme in speeches and routine media interviews by senior Department and Agency officials.

Second, specific enforcement-related campaign materials will be developed and distributed to the States. These materials will include TV and radio PSAs, billboards and brochures, each of which relate to the ongoing campaign to increase belt usage.

Third, there will be a general-awareness media and public relations campaign consisting of: (1) new Vince and Larry TV and radio spots distributed in April 1991; (2) safety belt messages aired in rush-hour traffic reports and on "top 40" radio shows in major metropolitan markets; and (3) placement of safety belt messages in magazines and daily media.

Fourth, an effort will be undertaken to establish a national coalition to publicly endorse the national emphasis program -- including the enforcement component.

As part of this national coalition, there will be an effort to mobilize grass roots support for State and local campaigns. This will include support for efforts that are part of the summer emphasis program as well as efforts to conduct occupant protection education and enforcement programs on a continuing basis.

Fifth, the results of the national 19-city survey will be featured in the kick-off and wrap-up events. These results will provide information to the public regarding the impact of the campaign from a national perspective.
Increasing Enforcement

Operation Buckle Down

Several activities will be undertaken to increase enforcement itself. First, a new program entitled "Operation Buckle Down" is being implemented to implement safety belt use and day-to-day safety belt enforcement in participating States. Police executives in these States are being contacted by designated spokespersons and encouraged to adopt a model safety belt enforcement program.

In each "Buckle Down" State, the police spokespersons will seek to gain the participation of the State police/highway patrol and of as many jurisdictions within the State as possible. They will be asked to conduct the coordinated public information, press conference and enforcement efforts during the three holiday periods.

After participation in the national campaign has been addressed, the police spokespersons will meet with police executives throughout the State to encourage them to implement the Model Occupant Protection Enforcement Program developed by the International Association of Chiefs of Police (IACP).

Special Holiday Operations

Much of the success of the implementing the summer campaign rests on the fact that most jurisdictions throughout the nation already conduct special enforcement operations during these holiday periods. As opposed to requesting the commitment of additional police resources (e.g. overtime) for these operations, we are asking that they emphasize safety belt (and child seat) use in both their enforcement and public information support components.

In addition, there are several nationally organized holiday efforts that can help support the campaign at the national, State and local levels. These include "Operation CARE" and "I-75 Alive." Representatives of NHTSA will work closely with the International Association of Chiefs of Police (IACP) and with the planners of national and regional special operations to obtain their participation in the national safety belt campaign.

It is important to emphasize that the success of the campaign does not require additional police man-hours or resources. Police officers can enforce their State's occupant protection laws as part of either normal or special holiday operations.

The success of the campaign does require that public and private-sector resources be directed toward public information programs and press conferences to support the enforcement of safety belt and child seat laws.
# 1991 National Campaign
National, State and Local Activities

## NAT'L SURVEYS
- [X] Kick-off
- [X] Press events
- [X] Wrap-up

### (NATIONAL-LEVEL)
- Media spots, radio promos, traffic reports, etc.
- Campaign-specific S/L media materials
- Operation Buckle Down, media, training, etc.
- National Coalition/Grass-roots mobilization

## STATE & LOCAL ACTIVITIES:
- Surveys
- Media & PR
- Press events
- Enforcement

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April | May | June | July | Aug | Sep

Campaign 9

4-6-91
1991 National Campaign to Increase Safety Belt Usage

Graphics
National Safety Belt Campaign
Background

- 1984 to 1990: SB use increased from 15% to nearly 50% -- an increase of 35 percentage points.

- More than 20,000 lives saved and 500,000 serious injuries prevented by safety belt use (1984-90).

- Most of increase & savings due to passage of SBU laws in 37 States (laws cover nearly 90% of population).

- But, progress has slowed --lack of enforcement
  - 1984-87: usage increased by 28 percentage points.
  - 1988-90: usage increased by 7 percentage points.

- Common trend in most States
  - initial increase in usage to rate of 60-70%.
  - moderate decline to rate of 40-50%.
  - "post-law stabilization" at under 50% usage (public information [without enforcement] has little impact.)
Typical Trend in Post-Law Usage Rates

"Post-Law Stabilization"

Safety Belt Usage Rates

70% 60% 50% 40% 30% 20% 10% 0%

Post-Law

Law Effective

Pre-Law
National Safety Belt Campaign
Enforcement Makes a Difference!

- All of our experience suggests that enforcement -- accompanied by public awareness -- increases usage.

- Some examples of Demonstration Results in U.S. Cities:
  - Elmira, NY 49% to 77% (STEP/blitz)
  - Albany, NY 52% to 64% (STEP/blitz)
  - Greece, NY 49% to 66% (integrated)
  - Danville, IL 38% to 50% (integrated)
  - Galesburg, IL 32% to 50% (integrated)
  - Rock Falls, IL 28% to 38% (integrated)
  - Beaumont, TX 54% to 68% (STEP + integrated)*
  - Laredo, TX 32% to 65% (STEP + integrated)*
  - Brownsville, TX 40% to 57% (STEP + integrated)*
  - Tyler, TX 61% to 78% (STEP + integrated)*

* driver-only rate

(revised 4-6-91)
National Safety Belt Campaign
Enforcement Can Be Implemented at Low Cost

- "Blitz" or "STEP" Programs are not the only programs that will increase usage.
- In fact, programs where safety belt enforcement is "integrated" into enforcement of other traffic laws sustain the highest usage rates.
- "Integrated" enforcement is effective in secondary-law States (as in primary-law States).
- "Integrated" enforcement can be effective -- without requiring additional police resources.
- One effective approach is to combine "integrated" enforcement with occasional "blitz" efforts.
- All SBU enforcement efforts require public awareness (of importance of belt use and presence of enforcement)
National Safety Belt Campaign

The Canadian Experience

- Successful campaigns in Canada have also emphasized enforcement, combined with enhanced public awareness.

- As of 1985, most Provinces had stabilized at about 50-60% usage rates --nationally, usage was about 55%.

- Most large Canadian Provinces implemented STEPs -- which emphasized enforcement, public information, and press conferences held by the police.

- Some typical examples of usage rate increases:
  - British Columbia 41% (1981) to 90% (1990)
  - Quebec 53% (1985) to 93% (1990)
  - Saskatchewan 51% (1985) to 92% (1990)

- Canadian national usage increased from 58% (in 1985) to 80% (in 1990) --and it is still rising.

- Most Provinces are now targeting 95% belt usage.

(revised 4-8-92)
National Safety Belt Campaign
Our Conclusions

- Visible enforcement of safety belt laws offers the greatest potential for increasing SB usage.
- "Blitz" enforcement provides rapid increase in usage.
- "Integrated" enforcement is most cost-effective and results in long-term increases in usage.
- "Integrated" approach with occasional "blitz" provides best combination.

- Public information must accompany enforcement and should make public aware of:
  - life-saving benefits of safety belt use;
  - need for law enforcement to increase use;
  - intent of police to enforce SB use laws.

- Surveys of belt usage should be conducted and used to inform police and public of results of efforts.
National Safety Belt Campaign
An Effort to Achieve 70% Usage by 1992

- It's clear! If we want to reach 70% usage by 1992, dramatic steps must be taken.


- Special emphasis on three summer holiday periods:
  - Memorial Day
  - Independence Day
  - Labor Day

- Encourage "integrated" enforcement year-around.

- Emphasis on four activities:
  - public information
  - press conferences
  - enforcement
  - surveys of belt use

- Coordinate National, State and Local efforts around specific target periods.
National Safety Belt Campaign
State and Local Efforts

- **Holiday Enforcement:** The Foundation of the Program
  - 10-14 days surrounding each holiday. (★)
  - emphasis on both safety belt & child seat use.
  - States without safety belt laws can enforce child safety seat laws and remind motorists to buckle up.

- **Press Conferences:** Announce the Belt Enforcement Effort
  - one-week duration, prior to each enforcement effort.
  - make people aware that the law will be enforced.

- **Public Information:** Increasing Public Awareness
  - 3-4 weeks prior to each enforcement period. (★)
  - emphasize the importance of both SB usage and of intent to enforce the law.

- **Surveys of Belt Use:** Feedback to Police and the Public
  - surveys before, during, and after summer campaign.
  - simple, informal surveys for local information.

(★) Memorial Day enforcement and PI periods slightly curtailed due to short lead-time for preparation.
National Safety Belt Campaign
Proposed Schedule for State/Local Activities

5/01  -  Conduct 1st Informal Survey  
5/05  -  Begin 1st (2-week) Public Information Effort*  
5/20  -  Begin 1st (1-week) Press Conferences (KICK-OFF)  
5/24  -  Begin 1st (10-day) Enforcement Effort*  

MAY 27    MEMORIAL DAY

6/02  -  Begin 2nd (3-week) Public Information Effort  
6/23  -  Begin 2nd (1-week) Press Conferences  
6/30  -  Begin 2nd (2-week) Enforcement Effort  

JULY 4    INDEPENDENCE DAY

7/15  -  Conduct 2nd Informal Survey  
7/28  -  Begin 3rd (3-week) Public Information Effort  
8/18  -  Begin 3rd (1-week) Press Conferences  
8/25  -  Begin 3rd (2-week) Enforcement Effort  

SEPTEMBER 2    LABOR DAY

9/08  -  Conduct 3rd Informal Survey

Schedule  

* Memorial Day enforcement and PI slightly curtailed
National Safety Belt Campaign
Public Information Campaign Components

- Series of National Press Events
  - kick-off during Buckle Up America Week (May 20-27)
  - major press events throughout summer
  - significant 70% PLUS awards every month
  - wrap-up event (September 25)

- Develop & Distribute Campaign-Specific Materials
  - radio and TV PSAs
  - billboard
  - print ad, press release, handout

- General Awareness Media/PR Program
  - new waves of Vince and Larry media materials
  - safety belt messages on rush-hour traffic reports
  - safety belt promotions on radio
  - placement in national print media

- Establish National Coalition to Support Campaign
  - mobilize support at national and grass-roots level

- Report Results of 19-city Index of National Usage
National Safety Belt Campaign
Enforcement Components

- **OPERATION BUCKLE DOWN**
  - up to 30 grants to States with safety belt laws
  - police spokespersons to meet with police executives
    - to promote participation in summer campaigns
    - to promote IACP model enforcement program
  - State-level public information to support effort

- **SPECIAL HOLIDAY OPERATIONS**
  - NHTSA/IACP will encourage safety belt enforcement as part of special holiday operations such as:
    - "Operation CARE"
    - "I-75 Alive"
    - Other State/local holiday efforts
    - DWI Checkpoints/55 mph Speed Projects

- **EMPHASIS ON "INTEGRATED" ENFORCEMENT EFFORTS**
  - holiday emphasis gives appearance of "blitz"
  - integrating SB enforcement into holiday efforts does not require additional police resources
  - public information and press conferences necessary
## 1991 National Campaign

### National, State and Local Activities

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<th>NAT'L SURVEYS</th>
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### State & Local Activities:

- SURVEYS
- MEDIA & PR
- PRESS EVENTS
- ENFORCEMENT

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Campaign 9

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