VEHICLE PRIMARY SAFETY STUDY

FIRST REPORT

STATUS OF RESEARCH

Prepared by Vehicle Design & Research Pty Ltd

for

Vehicle & Equipment Safety Section

Road Safety Bureau

Roads & Traffic Authority of NSW

Report G116-01 July 1991

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INTRODUCTION

This report presents the results of the first stage of a study of crash-avoidance countermeasures for the NSW Road Safety Bureau. The study covers countermeasures related to vehicle design, with particular emphasis on recent technological developments. It does not cover vehicle maintenance issues.

The first stage involved a review of Australian and international literature on crash-avoidance countermeasures. The final stages of the project include an evaluation of the cost-effectiveness of promising countermeasures identified in the first stage of the study and consideration of implementation issues.

CRASH-AVOIDANCE COUNTERMEASURES

In order to identify possible crash-avoidance countermeasures the typical pre-crash sequence of events has been divided into four stages

- Minimise exposure to hazards
- Identify hazards
- Moderate accident avoidance (react to hazards)
- Emergency reaction

Details are set out below. Possible countermeasures which could have an influence on each of these stages are briefly described the following section. More details are contained in the summary of literature in Appendix A. The numbers in brackets correspond to references in Appendix A.

A.MINIMISE EXPOSURE TO HAZARDS

There are several vehicle-related countermeasures which enable the motorist to avoid hazardous circumstances altogether.

A1.Reduce travel by road

Measures which encourage commuters to use other, safer forms of transport can be considered. Commuters might be more willing to use public transport if parking their vehicle at a train/bus station was made easier and more secure. Vehicle-related initiatives include improved parking capabilities and improved theft protection. Improved theft protection also helps to discourage the risky practice of joy-riding.

A2.Early warning of hazards

Commercial radio "traffic reports" can assist motorists by giving them prior notice of accidents and congestion. Inevitably, however, reports of accidents do not reach motorists in time. Intelligent vehicle/highway systems which could give motorists immediate warning are under development.

Intelligent Vehicle/Highway Systems (2,4,6,7,8,11,19,22)

The concept of automated highways is not new but it is moving closer to reality with recent developments in electronics and computer processing. Major research programs are underway in Europe, America and Japan. In general the systems rely on a flow of information between the vehicle and a roadway computer systems and/or other vehicles. The main benefit from such systems is likely to be improved network efficiency (eg increased capacity of roadways) but there will also be safety benefits as the traffic flow is smoothed out and is better able to respond to disturbances. Benefit/cost analysis of such systems is difficult due to the early stage of research and the need for an integrated approach (roads and vehicles need to "talk" to one another and, presumably, only suitably equipped vehicles will be able to join an automated roadway - see Shladover(1989)). One aspect that should be monitored is the possibility of a more severe crash in the event of a catastrophic failure (tyre blow-out?) amongst faster, more closely packed vehicles - increased roadway capacity should not be at the expense of overall road safety.

Other applications of this technology are described below.

A3.Safe loading practices for commercial vehicles

Cargo which falls from trucks onto the roadway (or adjacent vehicles) is generally a nuisance but is understood to be the cause of at least 200 accidents each year. A code of practice for load restraint - the Truck Loading Code - was developed by government and industry representatives in 1981 and it is considered that more attention should be given to compliance with this code.

Overloading of trucks increases the risk of component failure and brake fade. Overloading also results in hazardous, slow moving vehicles in the traffic stream.

B.HAZARD IDENTIFICATION

Motorists need to be alerted to a possible roadway hazard as early as possible. This aspect of accident avoidance probably covers the widest range of accident-avoidance countermeasures.

B1.Driver visibility (2,3,5,6,7,8,15,17)

Australian Design Rules cover mirrors, windscreen and side window transmittance, windscreen wipers (swept area and modes of operation) and windscreen demisting. Non-mechanical means of clearing water from windscreens have been proposed - this should be kept under review in case the ADR needs amendment to provide for such systems.

A military development which might be applicable to highway vehicles is the use of driver vision enhancement systems to improve night vision. These systems , however, seem to be intended for vehicles without headlights!

Improvements in headlight technology should be monitored and ADR46/00 reviewed, if appropriate. In Sweden there is research into ultra-violet headlight systems with corresponding fluorescent treatment of road-users and roadside objects.

The "field of view" provisions of ADR 42/01 are considered to be vague. There might be an opportunity to set performance requirements for the driver's field of view. Edwards (1987, ref 5) reports on the results of a provisional evaluation of the crash-involvement of popular american cars and an objective method of assessing their field of view (developed by Zeidman). Vehicles with better field of view were found to have lower crash involvement.

B2.Roadside warning systems (19,22)

Fog warning signs and similar devices have been used for many years. A further enhancement of such roadside warning systems might be to transmit warnings to motorists via special receivers onboard vehicles. Such systems are likely to be part of an automated highway system but they could be introduced for current vehicles. For example, car radios could be fitted with an emergency channel which over-rode normal programs and was activated by roadside transmitters. CB radios have a potential safety benefit in this area.

B3. Conspicuity of and communication with other vehicles (3,5,7,15,17)

Audible warning devices (horn, reversing alarm) are covered, in general terms, by ADR42/01. It might be appropriate to specify minimum sound levels for warning devices under this ADR.

ADRs cover requirements for vehicle lighting systems such as brake lights, parking lamps and turn signals. Location, colour and intensity are specified.

Daytime running lights (1,14,20,25,26)

Requirements for day-time running lights are specified in ADR45/00 but such lights are not mandatory. Several overseas studies suggest that daytime running lights are highly cost-effective even under "summer" conditions. There is debate about whether low-beam headlights are suitable for daytime use. Three main systems are available:

- Special high intensity "parking" lights which automatically illuminate when the ignition is "on" (and headlights are "off"),
- Devices which automatically illuminate the headlights when the iginition is "on", and
- Devices which simply alert the driver that the headlights are "on" when the iginition is turned off. This type of device is intended to encourage drivers to use headlights during the daytime on a voluntary basis.

Pedestrians and pedal cyclists appear to benefit most from the increased conspicuity of vehicles with daytime running lights (they can see the cars and dodge them!). These vulnerable road-users could wear more conspicuous clothing.

High-mounted brake lights (24)

The USA has required high-mounted stop lights on passenger cars manufactured from 1985 (FMVSS 108). Australian Design Rule 60/00 applies to passenger cars manufactured from 1 July 1989. These lights give the following driver additional warning that the service brakes have been applied. In some circumstances drivers further back in a platoon are also given a warning because they can see the high-mounted stop light of the platoon leader through the windows of vehicles ahead of them. A NHTSA study by Kahane (ref 24) found that vehicles equipped with high-mounted stop lights were 17% less likely to be struck in the rear while braking.

Although these devices are now mandatory on new passenger cars there is an opportunity for retro-fit to older vehicles. Several kits are available for this purpose.

B4.On-vehicle warning systems (3,7,8,11,19)

Various on-vehicle systems are available, or are under development, to provide the driver with warning about a hazard. Braking ADRs require brake failure warning lights. Modern automotive electronics can provide the driver with warning of other problems such as engine faults. Tyre pressure sensors have been tested. The main improvements will probably come from intelligent vehicle/highway systems.

Excess speed warning (4,7,19,22)

Roadside transmitters (or laser reflective stickers) could indicate speed limits. On-board receivers could warn the driver if the speed limit is exceeded.

Lane deviation warning (4,7,19,22)

On-vehicle sensors could detect when a laser-reflective lane marking is crossed and warn the driver of the deviation.

Headway Control (2,3,4,7,19,21,22)

Cruise control devices which endeavour to maintain the speed of the vehicle to a speed pre-selected by the driver have been available in various forms for many years. There may be a small road safety advantage in these devices because the driver does not need to pay too much attention to controlling vehicle speed.

Intelligent cruise (speed) control systems should soon be available. These systems use radar to monitor the vehicle ahead and adjust the speed so that an appropriate headway for the conditions is maintained. The driver could be given a warning about circumstances where a crash is possible (ie closing speed too high). More advanced systems could obtain information about a platoon of traffic and smooth out the traffic flow. In fact, improved traffic flow and increased roadway capacity are likely to be the most tangible benefits from the use of intelligent vehicle/highway systems.

Driver fatigue warning (3,17,19)

Systems which detect signs of driver fatigue have been suggested for commercial vehicle operations. Steering wheel movements, driver's eye movements and lane-keeping have been suggested as possible indicators of fatigue.There is debate about the effectiveness of such devices and doubt about practical applications.

Current research on fatigue detection appears to be aimed at roadside check points - similar in concept to random breath testing operations.

Devices such as tachographs which monitor hours of driving have been in use in Europe and Japan for decades. These devices are used for enforcement of hours-of-driving regulations. "Smart card" technology is being developed to monitor hours of driving - driver's are issued with a plastic ID card with an in-built memory chip which is inserted into a module on the vehicle. The system keeps track of driver performance and hours at the wheel and can be designed to prevent drivers with excess hours from starting the vehicle - it is understood that Malaysia is implementing such a system.

Object detection & warning (7,19)

Devices which detect an object or pedestrian on the roadway and alert the driver are under consideration. There is a strong possibility that drivers will become overloaded with information if the systems are not able to discriminate between serious and trivial hazards.

C.MODERATE ACCIDENT AVOIDANCE

Once a hazard has been identified, steps are taken to avoid it. These steps can include reaction by the driver and automated response.

C1.Driver control of vehicle

Driver reaction is influenced by the performance of the braking system, response to steering inputs and the ease of use of controls. ADRs cover brake performance and location of controls.

Vehicle handling (3,10)

There might be a need to specify some minimum handling requirements, particularly with heavy vehicles and four-wheel-drive vehicles with a high centre of gravity (response to sudden steering inputs, roll-over stability, fail-safe power steering etc).

Four wheel steering (9)

Some passenger cars are now provided with four-wheel steering systems and manufacturers claim improved handling is a safety benefit. Consideration should be given to the need for specifying requirements for such systems, particularly their fail-safe operation.

C2.Automated intervention (7,19,22)

Intelligent vehicle systems provide an opportunity to over-ride the driver's control of the vehicle under extreme circumstances. Such systems carry the risk of inadvertent operation which must be addressed in any performance specifications.

Automated braking (7,19,22)

Radar systems could sense a high closing speed with an object vehicle and actuate the vehicle's brakes. The delay in braking due to driver reaction time (.7 seconds with an alert driver, over 1.5 seconds with an inattentive driver) could be virtually eliminated. Prototype radar sensing devices are available but considerable development is still require for the data processing and brake actuation aspects of this technology (see Shladover (1989)). Automated braking will probably be combined with automated headway control as prt of the intelligent vehicle/highway system.

Automated steering - obstacle avoidance (19,22)

This function relates more to a fully automated highway than a conventional vehicle and roadway. The concept is that a sensing system would identify appropriate obstacles on the roadway and either steer the vehicle around it or apply the brakes. The difficulties in developing the "intelligence" for such a system for use on highway vehicles seem overwhelming. However, space researchers are developing robotic roving vehicles with such "intelligence" for planetary exploration.

D.EMERGENCY REACTION

Extreme avoidance action can take the vehicle to its limits of performance. Under these circumstances the driver might be applying the brakes to the maximum at which he or she feels the vehicle will remain stable. The performance of brakes, tyres and steering/suspension systems becomes critical.

Anti-skid brakes (3,10,12,16,18)

Current brake performance ADRs require the vehicle to meet minimum levels of average deceleration - that is, performance for the overall stopping manoeuvre. Although these levels are relatively high they do not test the vehicle to the extreme that might be encountered under emergency conditions. Loss of control (or fear of loss of control) due to premature lock up of some wheels probably exacerbates many of these extreme circumstances. This is particularly the case with articulated trucks where fear of a jack-knife often influences the driver's reaction.

Anti-skid braking systems provide a means of maintaining directional stability under extreme braking conditions. The driver is freed from the task of deciding whether the level of application of the brakes is such that the limit of adhesion of critical tyres has been reached - a task which is made difficult by braking system characteristics, load distribution, road surface, cornering forces and many other factors. European and US studies (Clarke, 1984) indicate that 10% of articulated truck accidents could have been completely avoided if anti-skid brakes had been fitted to the vehicles concerned.

Brake performance under extreme conditions is also influenced by the performance of individual brakes. In the case of heavy vehicles there is evidence of a substantial problem with out-of-adjustment brakes (Clarke, 1984). Automatic slack adjusters might help in these cases. US studies indicate that more than 23% of truck accidents involve the inability of a truck to stop in time and in 33% of all truck accidents braking systems are a contributing factor.

Emergency handling (3,10)

General vehicle handling issues are discussed above. Some specific items that should be considered are:

- Tyre/wheel performance under extreme conditions - ADRs cover tyre selection and retention on the rim under blow-out conditions but not actual road-holding performance. "Road-holding" is used for the commercial promotion of some tyres but there might be a need for minimum performance levels for tyres at the low end of the range.
- Trailer stability - some combinations become directionally unstable at certain road speeds or under braking. This is difficult to regulate because of the mix or towing vehicles and trailers.

- Performance-limit warning systems, such as imminent roll-over of a truck.

CONCLUSION

The main purpose of this report is to document the range of crash-avoidance countermeasures which are available or are under development. The next stage of the study will examine some of these countermeasures in more detail and attempt to assess their cost-effectiveness. It is acknowledged, however. that such assessments have inherent difficulties (see the second report of this project and references 3,5,6,7,13,15,23).

Acknowledgement: Officers from the Road Safety Bureau Research Library provided assistance with this study and their contribution is appreciated.

APPENDIX A

LITERATURE SURVEY

(1) Attwood, D. (1981) \ "The potential of Daytime Running Lights as a Vehicle Collision Countermeasure", SAE Paper 810190.

This paper presents the results of a comprehensive study of daytime running lights. Experimental results are presented, together with the results of accident analysis. It is concluded that daytime running lights are highly cost-effective. The use of headlights during the daytime is discussed and it is suggested that their intensity is too high.

(2) Berggren, T. (Volvo,1987) \ "Improving Safety in Heavy Trucks", 11th International Technical Conference on Experimental Safety Vehicles, NHTSA.

This address to the conference gives a brief outline of developments in vehicle electronics related to trucks. Head-up displays, axle load indicators, electrically positioned mirrors and driver monitoring equipment are briefly discussed.

(3) Clarke, Leasure, Radlinski & Smith (1987) \ "Heavy Truck Safety Study", NHTSA Report DOT HS 807 109, Mar 87.

This comprehensive report looks at truck accidents, operations and performance. A range of accident-avoidance countermeasures is examined, including brake performance, roll-over stability, trailer stability and steering characteristics. Brake performance is analysed in detail and it is concluded that truck brake system issues were contributing factors in one third of all truck accidents. Overall, vehicle factors (mainly defects) contributed to more than 40% of all heavy vehicle accidents investigated. Anti-skid braking systems would have prevented 10% of truck accidents. In 1984 the average cost of a truck accident was US$10,900 compared with US$2000 for car accidents.

(4) Davies, Peter (1991) \ "Smart Solutions" World Highways, March 91.

This magazine article summaries the various avenues of research into Intelligent Vehicle-Highway Systems. Projects are underway in Europe, Japan and the USA.

(5) Edwards,M (NHTSA,1987) \ "An Investigation of Selected Vehicle design Characteristics Using the Crash Avoidance Research Data File" , 11th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1987.

This paper describes a methodology for using NHTSA's CARDfile accident database to assess the performance of various accident avoidance countermeasures. A key feature of the data is identification of vehicles by make, model and year. The methodology has been applied to amber rear turn signals (3% fewer relevant crashes, compared with red turn signals), location of front turn signals (10% fewer crashes for vehicles with separate turn signals, compared with vehicles with combined headlight/turn signal assemblies and driver's field of view (no statistically significant findings but indications that vehicles with better field of view have lower crash involvement).

(6) Finkelstein,M (NHTSA, 1989) \ "Crash Avoidance", 12th Inter. Technical Conference on Experimental Safety Vehicle, NHTSA 1989.

This address to the conference gives an overview of crash avoidance research. It is pointed out that most crashes involve a number of contributing factors and that even if a single "cause" is identified the crash might have been avoided by treating any one of a number of contributing factors. A difficulty in organising and prioritizing the research in this field is noted. Sources of data for crash research are described and it is concluded that there is sufficient data available for the purpose of making decisions about research priorities but that further work is needed on using this information (ie the methodology of assessing countermeasures).

(7) Fontaine, Malaterre & Van Elslande (INRETS,1989) \ "Accident Reduction With New Driving Aids: Efficiency Assessment" 12th Inter. technical Conference on Experimental Safety Vehicles, NHSTA 1989.

This paper describes a methodology for assessing crash-avoidance countermeasures and the results of assessment of 13 "high tech" countermeasures. A random sample of 350 accidents was selected to test the methodology. Countermeasures were divided into three main categories: detection of objects, evaluation of relative movements and diagnosis of likely intentions. The following devices were assessed (most are theoretical rather than practical at this stage):

- Electric vision (7%)
- Active rear view mirrors (3%)
- Device to detect "hidden" road-users - co-operative detection (8%)
- Trajectory assessment device for intersections - intersection control (16%)
- Road condition warning systems (1%)
- On-Vehicle diagnosis & warning systems (1%)
- Devices to monitor driver condition (5%)
- Doppler radar warning system (7%)
- Lane-change warning system (1%)
- Intelligent cruise control - speed keeping (7%)
- Automated headway control (1%)
- Automated lane keeping (0%)

The percentage figures are the *maximum estimate* of the percentage of "preventable " accidents (apparently three quarters of the 350 accidents studied) that would have been prevented by each device. Note also that there is overlap in the contribution of some devices. Also there is concern that some of the warning systems could overload the driver with information. The results of further analysis by category of accident are also presented.

(8) Franzen & Ilhage, (SAAB-Scania, 1987) \ "Active Safety Research on Intelligent Driver Support Systems", 11th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1987.

This paper reviews information technology research by SAAB-Scania. One area of interest is the use of ultra-violet headlights and corresponding fluorescent coatings on vehicles, pedestrians and roadside objects.

(9) Fukunaga, Irie, Kuroki & Sugasawa (Nissan, 1989) \ "Improved Handling and Stability Using Four-wheel Steering" 11th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1987.

This highly technical paper examines the improvements in handling and stability resulting from carefully designed speed-dependent four-wheel steering systems. The basic concept is that a stable steady-state turning motion is achieved with less energy and lower peak lateral forces on the tyres when the rear wheels steer in the same direction as the front wheels at high vehicle speeds. At low-speeds the rear wheels steer in the opposite direction for improved manoeuvrability.

(10) Grunow,D (TUV Rhienland,1987) \ "Behaviour of Different Coaches During Steering and Braking Manoeuvres" 11th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1987.

The handling of coaches is assessed with the following test procedures: straight-line braking with different longitudinal co-efficients of friction, braking during cornering, steady-state cornering, sinusoidal steering input and step steering input. Various conditions of loading were used during the tests. The procedures could be used as a basis for assessment of the handling of other types of vehicles.

(11) Gullstrand,R (SAAB Scania 1989) \ "Prometheus" 12th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1989.

Dr Gullstrand describes the European PROMETHEUS project which was initiated by 13 European car manufacturers. In brief, the project involves the application of advanced electronics to increase road safety, increase travel efficiency and reduce pollution.

(12) Institution of Mechanical Engineers (1985) \ "Anti-lock braking systems for road vehicles", Conference papers 1985-8.

The IMechE sponsored a conference on anti-skid braking systems in 1985. Most papers cover the technical aspects of anti-skid brakes on cars and commercial vehicles. A paper by A.Grimm describes the development of British anti-skid regulations and a paper by P.Oppenheimer describes international regulations, including the notorious FMVSS 121.

(13) Itoh, Ono & Yasuhiko (Japan, 1987) \ "In-depth Study of Motor Vehicle Accidents in Japan", 11th Inter. technical Conference on Experimental Safety Vehicles, NHTSA 1987.

This paper describes accident investigation methodology in Japan. Each year approximately 100 in-depth studies are conducted and a further 4,500 cases are subjected to detailed statistical analysis. In-depth studies include examination of the road environment and the involved vehicles. The results presented in the paper primarily concern direction of impact and collision damage but it is evident that data relevant to crash-avoidance is contained in the database.

(14) Koornstra,M (1989) \ "Road Safety and Daytime Running Lights", SWOV Institute for Road Safety Research, The Netherlands, R-89-4.

This paper reviews previous studies in this field and presents the results of recent research. Criticisms of these studies are addressed. Reductions in multiple-vehicle daytime accidents range from 7% to 40%. The studies ranged from fleet experience in the USA and Canada to monitoring the introduction of daylight running lights in some European countries. A Swedish study found no marked change during Summer - an indication that the system has benefits over a wide range of lighting conditions. Major reductions (around 45%) in pedestrian and pedal cyclist accidents were noted in Norway and Sweden.

It is concluded that daytime running lights will reduce multiple-vehicle daytime accidents by between 10% and 25% and the total number of accidents will reduce by at least 5%. Costs are estimated at less than Hfl30 per car per year. A further extensive study is planned.

(15) McLean,AJ (1979) \ "Adelaide in-depth accident study: Part 6 - car accidents", University of Adelaide, 1979.

A multi-disciplinary team investigated a total of 262 passenger car accidents in the Adelaide metropolitan area in 1976/77. The contribution of vehicle factors (design and maintenance) to the cause of these accidents and severity of injuries was assessed. One objective was to determine the effectiveness of Australian Design Rules for Motor Vehicle Safety in force at the time. The team generally arrived at the scene of an accident at the same time an ambulance and therefore had very good knowledge of the circumstances of the accident. Most vehicles were subsequently examined in detail although no attempt was made to dismantle components. Comments about ADRs were confined to secondary safety items, however the detailed description of accidents in which vehicle defects were considered to be a contributing factor does give an indication of the importance of vehicle design factors such as driver visibility, directional stability under heavy braking etc.

(16) Robinson,B (TRRL, 1989) \ "Braking and Stability Performance of Cars Fitted with Anti-Lock Braking Systems", 11th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1987.

This paper presents the results of an extensive test program on four cars fitted with anti-skid braking systems. Significant accident avoidance potential is achieved, even with a simple, cheap mechanical system.

(17) Rumar, K (Sweden,1987) \ "Vehicle Conspicuity", 11th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1987.

General vehicle conspicuity issues are discussed and then the paper concentrates on daytime running lights. The importance of light intensity for peripheral vision (compared with central vision) and doubt is raised about the conclusions reached by Attwood and others because intensities similar to that of headlights are needed for improved peripheral vision conspicuity under bright daylight conditions (Attwood considers that ordinary headlights are too bright for use as daytime running lights).

An additional advantage of daytime running lights is that they make it easier for other drivers to judge the distance and speed of the vehicle.

(18) SAE \ "ABS Traction Control", Extract from the proceedings of the 1988 SAE World Congress, SP 744.

This collection of papers related to anti-skid braking systems covers most technical aspects of such systems.

(19) Shladover, Steven (1989) \ "Research needs in roadway automation technology", SAE Paper 891725, SP 791.

This paper examines the (daunting) information engineering challenges for intelligent vehicle/highway systems. The following functions are assessed: intelligent traffic signalling, traffic information systems, driver warning and assistance, automatic steering control, automatic spacing (headway) control, obstacle avoidance, automatic trip routing/scheduling, control of merging traffic streams and transition form automatic to manual control. In the case of automatic spacing control it is pointed out that the main advantages are derived if the on-board system is able to obtain information about several preceding vehicles so that appropriate adjustments can be made. This is, however, no easy task and the simplest approach might be to use roadside computer systems to process such information and pass it on to individual vehicles. In the case of obstacle avoidance, sophisticated systems will be needed to distinguish between important objects (pedestrians & dogs!) and inconsequential objects (squirrels!). Transition systems will need to check that a vehicle is in satisfactory condition (electronics, fuel, brakes?) before allowing it to join an automated traffic stream and they will need to check the driver's alertness when leaving an automated system (is the driver still awake?).

(20) Stein, H (1985) \ "Fleet Experience with Daytime Running Lights in the United States", SAE Paper 851239.

This paper presents the results of a study of 2000 fleet vehicles fitted with daytime running lights. A 7% reduction in daytime multiple-vehicle crashes were reported.

(21) Teramoto, Fujimura & Fujita (Toyota/Fujitsu, 1989) \ "Study of Laser Radar" 12th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1989.

This paper describes the development of a prototype headway control radar which uses a pulsed laser. The system was found to be feasible but problems with non-detection of some objects were noted.

(22) Vostrez, John (1989) "Vehicle/Highway Automation:Policy issues and strategies in California", SAE Paper 891721, SP 791.

Opportunities for introducing intelligent vehicle/highway systems in California are discussed. The main benefits concern network efficiency (increased capacity, narrower lanes etc) but some safety benefits are discussed. Firstly, it should be possible to virtually eliminate the delays due to driver reaction time through the use of radar warning systems. Secondly, the shock-wave effect of a disturbance in traffic flow, which often results in stop/start traffic downstream of the disturbance, can be eliminated (the shock-wave is built up by successive driver over-reaction). Thirdly, control of platoons of cars can be achieved to provide for safer merging of traffic (a space opens up for the merging car). The paper then discusses the various obstacles to implementing an integrated system.

(23) Viel,A (Quebec, 1989) \ "Police Reports: First Step Towards Investigation", 12th Inter. Technical Conference on Experimental Safety Vehicles, NHTSA 1989.

This paper deals with the reporting of accidents by Police. It covers under-reporting, improvements in data collection and usefulness of the data. Cross checks were made against coronial reports (fatal accidents), hospital records (serious injury accidents) and insurance records to determine the reliability of the data. Under-reporting of hospital admissions ranged form 12% to 20%. It was found that police-reported fatalities *exceeded* coronial reports by 10%. Detailed audit of some police reports revealed a wide range of errors and omissions (min 0 to 10% max 29 to 40%) for "witness" items (vehicle movements, seat belt use etc).

(24) Kahane, C J (Washington,1989) \ "An evaluation of center high mounted stop lamps based on 1987 data", NHTSA report DOT HS 807 442, July 1989.

The author reports the results of an extensive evaluation of the crash experience of vehicles with and without high-mounted stop lights. It was found that cars equipped with high mounted stop lights were 17%(+/-4%) less likley to be struck in the rear while braking.

(25) Federal Office of Road Safety (Canberra,1990) \ "The effects of daylight running lights on motorcycle safety", Aust Dept of Transport & Communications.

This paper examines general issues related to the use of daylight running lights or daytime use of headlights on motorcycles. It is concluded that there is a very high benefit /cost ratio.

(26) Zeidman, Berger & Smith (Santa Monica, 1990) \ "Evaluation of the conspicuity of daytime running lights", NHTSA report DOT HS 807 609.

This reports reviews several overseas studies concerning the effectiveness of daytime running lights. It then examines in detail the issue of detection with peripheral vision. A minimum intensity of 1600 Candela is recommended for these lights.