HEAVY VEHICLE OBJECT DETECTION SYSTEMS

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for

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Executive Summary

Most heavy vehicles have significant blind zones where the driver cannot see other road users such as vehicles and pedestrians. This contributes to some road crashes where the driver fails to detect the other road users, typically during cornering, lane change or reversing manoeuvres.

In the USA, collisions during lane change or turning manoeuvres account for about 16% of interstate truck crashes and 6% of urban bus crashes. There is insufficient information to determine the equivalent numbers in Australia but it is unlikely that either trucks or buses in Australia would be greater than 6%. Using NHTSA's estimate that an effective countermeasure could prevent about half of these crashes then the potential savings in Australia would be a few percent.

A range of visual aids (video systems and mirrors) and electronic proximity sensors are now available for heavy vehicles. Without some form of built-in "intelligence", however, it is possible that drivers would be overloaded with information.

The Eaton Vorad Collision Warning System has been in use on trucks in the USA for nearly ten years. Some 40,000 trucks are now fitted with the system and fleets report favourable results. However, claims of remarkable reductions in accidents should be treated with caution due to confounding factors (other fleet safety initiatives and the inclusion of forward collision warning in most of the systems).

In the USA the National Highway Traffic Safety Administration (NHTSA) and the Federal Transit Authority (FTA) are currently undertaking trials of commercial and prototype collision warning systems. The FTA has found that available systems are inadequate for the urban bus environment. A specialist in robotics and artificial intelligence is heading FTA research in this field and it is considered that this is a realistic approach to the development of an effective side collision warning system.

A trial of a commercial (US) collision warning system is about to start in Australia and other trials may soon start. These are privately operated and the results are unlikely to be made public. However, the radar frequencies of US-derived equipment may not be able to be legally used in Australia without approval of the Australian Communications Authority.

Subject to the radio licensing issues, it would be possible to assess the blindspot warning functions of systems available in Australia. The intention would be to map the detection area of the sensors of commercial (or prototype) systems by parking the vehicle in a open area and having a pedestrian walk slowly along set paths on either side of the vehicle. This could be based on the ISO wording set out in Appendix B but modified to address shortcomings.

In view of the ongoing work that is being performed by NHTSA, FTA and the ISO Working Group, it is recommended that no formal trials be undertaken by Vicroads at this stage. Contact should be maintained with overseas researchers and local distributors of collision warning systems and the situation should be reviewed if promising systems become available.

Introduction

Most heavy vehicles have significant blind zones where the driver cannot see other road users such as vehicles and pedestrians. This contributes to some road crashes where the driver fails to detect the other road users, typically during cornering, lane change or reversing manoeuvres.

A range of visual aids (video systems and mirrors) and electronic proximity sensors are now available for heavy vehicles. Without some form of built-in "intelligence", however, it is possible that drivers would be overloaded with information. Intelligent object detection systems are being developed (mostly for non-transport uses) and these may have an application to heavy vehicles. The intention is that these would filter out trivial information and only alert the driver if there was a significant possibility of a collision. Intelligent Transport System (ITS) technologies have the most promise for this purpose.

The main aim of the project was to survey the available technologies in this field and to develop a methodology to assess potential systems. This was primarily an information gathering and evaluation project. It was not intended that equipment would be acquired or tested. It was also not intended that travel would be involved. Fortuitously, however, the author had a trip to Japan for another purpose and was able to meet with a Japanese expert on collision avoidance systems.

Literature review and advice from experts

Government projects

NHTSA (USA)

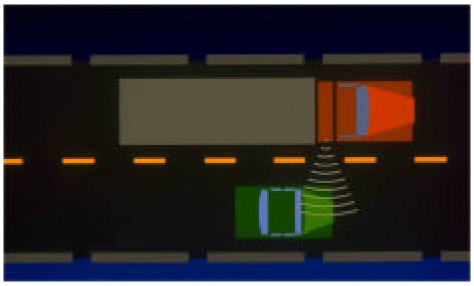
Numerous reports on collision warnings systems are available from the ITS website of the US National Highway Traffic Safety Administration (NHTSA). Key reports that are relevant to this project are:

"Development of performance specifications for collision avoidance for lane change, merging and backing" (Eberhard and others 1995) - a series of reports covering functional goals, draft performance specifications and hardware evaluation. The main recommendations for a lane change system were:

- The system should provide both visual and audible warning to the driver and be very simple to use.
- Normally the audible warning should only sound if the turn indicator is on (ie the driver intends to change lane or turn). However, detection of steering manoeuvres may be a desirable alternative.

- The visual indicator should be in the same line of sight as the appropriate rear view mirror.
- A red light should indicate that an object has been detected.
- An orange light should indicate that the system is working but no object has been detected.
- Adjustable volume for the audio warning.
- Adjustable (or automatic) brightness of visual signal.
- A detection probability of at least 99% is specified.
- Probability of false alarm (nothing there) < 10^{-6}
- Probability of nuisance alarm (object present but not a concern - maybe out of zone of interest) < 10^{-3}
- Detection zone (minimal system): 3.7m on either side of the vehicle, for the entire length of the vehicle and a height between 0.3m and 3m.
- Objects detected: all road vehicles, from bicycles to trucks, travelling at between zero and 105km/h.
- Distance accuracy: 0.6m
- Measurement latency (delay): no more than 0.5s
- Extra requirements for a system to detect fast-approaching vehicles: longitudinal detection zone extends 24m fore and aft of the vehicle; longitudinal relative velocity calculated and taken into account.
- Extra requirement for a system to detect whether another vehicle, two lanes away, is moving into the adjacent lane at the same time as the truck: same as previous plus 3m transverse detection and (unspecified) transverse relative velocity calculation.

Driving simulators were used to determine the likely performance of "virtual" systems and the impressions of drivers.



Advice from Mr Mike Perel from NHTSA is that they have an ongoing field test of collision avoidance systems but no results have been published at this stage.

Federal Transit Administration (FTA)

The FTA is a division of the US Department of Transportation. Mr Brian Cronin from FTA provided advice about a project to develop a side (lane change) collision warning system for transit buses in the USA. A preliminary benefit/cost analysis suggest that a 26% or greater reduction in accident costs would produce a positive benefit. The report points out that most collision warning systems that have been developed for trucks are not suitable for transit buses. This is because the buses operate in much more crowded environments than (interstate) trucks and a preliminary trial showed that these systems generate an extremely high number of false alarms.

Analysis of US bus accident data found that lane change/merge accidents account for only about 6% of bus accidents (compared with about 16% for trucks, according to Eaton - see below). This low proportion appears to make it impossible to reach a positive benefit/cost ratio but this does not appear to have hindered development of a specification for a side collision warning system (SCWS).

The specification appears to be quite ambitious in that the SCWS will need to discriminate between different types of objects that pose different hazards: pedestrians, vehicles and other moving objects such as bicycles and non-mobile objects such as lamp posts. It will need to calculate relative velocities and, perhaps, potential change in velocity. Key requirements are:

- Detection zone for *stationary* objects: 2m on either side of the bus, for the entire length of the bus and 1m ahead of the bus.
- Detection zone for *moving* objects: 3m on either side of the bus, for the entire length of the bus and 1.5m ahead of the bus.
- Distance accuracy: the greater of 100mm and 10% for longitudinal and the greater of 50mm and 5% for lateral.
- 95% reliability in detecting pedestrians, vehicles and other moving objects
- Detects pedestrians who have fallen partially under the bus ahead of the wheels.
- Calculates speed and direction and, optionally, yaw rate.
- Calculates probability of collision and gives a warning based on time to collision and type of object.

The project is also looking at rear collision warning systems that detect when another vehicle is likely to strike the back of the bus. The intention is to provide a visual and audible warning to the other driver (since there is not much the bus driver can do).

Dr Chuck Thorpe, Director, The Robotics Institute, Carnegie Mellon University, is undertaking the project for the FTA. He advises that a further project report is due out shortly. This work involves advanced robotics, as described the Institute's web page: http://www.ri.cmu.edu/projects/project_498.html

Europe

ERTICO is a European partnership of government and industry that is co-ordinating the implementation of ITS. A review of ERTICO projects reveals that they are mainly concerned with transport efficiency. No references could be found to collision avoidance systems.

eSafety is another European partnership that is focusing on road safety benefits of ITS. However the "Final report of the eSafety Working Group on Road Safety" deals more with sensor technology than complete systems. They are part of a group seeking a dedicated radio frequency (24 GHz) for radar sensor to be used on vehicles. SARA (Short range Automotive Radar frequency Allocation) has been lobbying through the USA, Europe and Japan on this issue.

An eSafety research report issued in September 2002 indicates that a wide range of collision avoidance projects are underway. However, some of these involve developing technology and have quite ambitious goals. The main effort seems to be directed at heavy vehicle *forward* collision avoidance.

ISO (International Standards Organisation) and Japan

During a visit to Japan in February 2003 I met with Dr Kiichi Yamada from the Japanese Automobile Research Institute (JARI). Dr Yamada is convenor of ISO Working Group 14 of Technical Committee TC204. The Working Group is responsible for "Vehicle/roadway warning and control systems". Dr Yamada outlined the Group's work that was relevant to heavy vehicle collision avoidance and he gave me a copy of the Standardised Working Draft for PW114.5 - Side Obstacle Warning Systems. This sets out proposed performance requirements for such systems. The standard is intended for rigid vehicles only and does not cover truck/trailer combinations and articulated vehicles.

The Type III system provides coverage for lane-change warning. In brief it requires:

- Blind spot warning for adjacent lanes (3m) on either side of the vehicle, extending from the driver's eye position to a plane 3m rearward of the back of the vehicle.
- Blind spot warning must not be activated if there is no target within 6m of either side of the vehicle and within 30m of the rear of the vehicle.
- Closing vehicle warning if a target vehicle is at least 3m to the rear of the vehicle, within an adjacent lane (3m) and the estimated time to collision is XX seconds.
- The time to collision (for a closing vehicle warning) requires the sensing of the relative speeds and has yet to be determined. A value of 1.2s is mentioned but appears to be highly optimistic. No warning is necessary if the time to collision is 7.5s or more.
- Response time (from time when target is in a defined zone to the activation of the warning) not more than 300ms.

A static test of vehicle blind spots, using a motorcycle with rider, had been proposed but was rejected by one of the delegates (see Appendix B). Dynamic tests are currently being developed. The Japanese delegation has proposed that the standard allows for closing vehicle warning without blind spot functionality.

It is noted that the draft standard only appears to address vehicles moving in a straight line. The detection zone for "closing vehicle warning" is intended to cover the case of both vehicles moving on a radius of 125m but there does not appear to be an attempt to determine the trajectory of both vehicles. US systems already in use on thousands of trucks are able to evaluate yaw rates in order to eliminate some false warnings.

Another concern with the Working Draft is that the coverage on the nearside only extends as far forward as the driver's eye position. With large trucks it is possible for a blind spot to extend to the front of the vehicle because the door and bodywork of the truck obscure the view of this region.

In Japan there is on-going research into driver behaviour during lane changes and some experimental evaluation of Side Obstacle Warning Systems (SOWS). No in-service trials with trucks appear to be underway in Japan.

ESV 2003

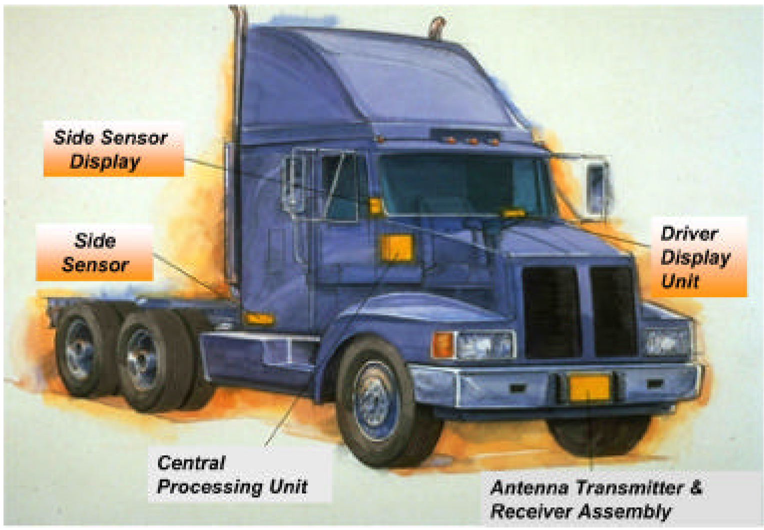
The 18th International Conference on the Enhanced Safety of Vehicles (ESV) was held in Japan during May 2003. The author attended the conference and discussed object detection systems with several experts. In brief, most work is still at the experimental stage and most research is looking at forward collision warning system, that are inherently simpler than side collision warning systems. Papers published in the conference proceedings were reviewed and relevant findings are set out below.

- Alix (France) described research with monocular and binocular camera systems for object detection and ranging. Sensors were criticised as being "unable to make a distinction between and bridge and a car". Similar work on visual perception is being conducted by Ieng and others.
- Ishida (Japan) described Japanese research on Advanced Safety Vehicle (ASV) technologies. The design principles are: 1 - ASV should understand the driver's wills (wishes) and support their safe driving based on the concept of driver responsibility. 2 - ASV technologies should be easy to use and be trusted by drivers. 3- ASV vehicles must operate (safely) with un-equipped vehicles and pedestrians.
- Noy and others describe the work of the International Harmonised Research Activities (IHRA) ITS working group. There is concern about overloading the driver with information and guidelines for assessing in-vehicle information systems are being developed. Speech user interfaces are being evaluated but the "safety of speech (systems) remains to be proven". Gelau and others examine driver task demands in more detail.
- Yamada describes research on forward obstacle collision avoidance. Sultan and others assess the safety benefits of such systems with a range of time-to-collision settings. Kodaka describes Honda research on forward collision avoidance. Their research indicates that "momentary inattention of about 1-2 seconds in duration occurs even during ordinary operations such as operating the stereo or instrument check". Suzuki describes JARI research into the timing of forward collision warning systems and recommends a time-to-collision of not more than 1.7s to "minimize over-dependence on the system".

Suppliers of collision avoidance systems

Eaton Vorad Collision Avoidance System

The Eaton Vorad EVT-200 Collision Warning System was introduced in 1994. The latest model - the EVT-300 - has forward and side collision warning functions. It is intended mainly for large trucks. The system takes into account any turning (yaw) motion of the truck when determining the probability of a collision. Generally the system appears to meet the requirements of the NHTSA draft performance specifications. It uses radar sensors operating at 24.725 GHz.



Eaton collision warnings systems are now fitted to more than 40,000 trucks in the USA and operators are reporting excellent reductions in accidents, with accidents per million miles dropping from 1 to 0.3. In a Powerpoint presentation prepared in 2001, Eaton quote NHTSA data that shows that rear-end crashes (truck running into another vehicle) account for 25% of all truck accident and lane-change/merge crashes account for 16%. Based on NHTSA data, Eaton claim that collision warning systems can eliminate 51% of rear-end crashes and 47% of lane-change/merging accidents (based on NHTSA 1996). Hence it was estimated that a forward collision warning system could prevent 13% of all truck crashes and a side collision warning system could prevent 8% of all truck crashes. The combined value of 21% is substantially less than the reduction of about 73% claimed for fleets with the Eaton system and it is considered that the latter should be treated with caution as there may be confounding factors such as associated fleet safety programs. On the other hand, the NHTSA estimate of potential savings may have been too conservative.

An Iowa State University study quoted by Eaton suggests that the costs of rear-end and lane-change merging accidents are higher than most other types of crashes. In that study forward crashes (that may include some run off the road crashes) account for 57% of costs and lane-change/merging account for 37%.

Mr Tom Maddox from Eaton in the USA advises that the basic system sells for US$2,000 and takes about 5 hours to install.

Mr Graeme Beynon from Eaton Australia advise that they have trialled a few EVT-300 systems in Australia but found that there were radar frequency conflicts. Once these have been resolved Eaton will look at marketing the systems in Australia. He was unable to give an indication of the possible price in Australia.

Preco PreView Object Detection System

The Preview Object Detection System uses radar sensor units to detect forward, side and rearward obstacles. Unlike some radar units, it is designed to detect both stationary and moving objects (radar systems are inherently better at detecting relative movement).

Four detection ranges are available: 3, 5, 6 and 8m.

Mr Russ Fulcher from Preco in the USA did not provide information about the number of US trucks fitted with the PreView system and it may be quite new to the market. He put me in contact with Mr Paul Griffiths, National Sales Manager for NARVA Automotive and Electrical, Melbourne. Mr Griffiths advised that one PreView unit was currently being fitted to a B-Double truck for evaluation purposes in Victoria. A single sensor system was being used specifically to evaluate the blind spot during left turns. It cost $1800 for supply. No other units were installed in Australia at this stage.

Other US suppliers

The website www.etrucker.com lists 18 suppliers of "collision avoidance systems" including the two listed above. However, it appears that no other US companies market side collision warning systems (most of the 18 provide backing aids or video systems).

Valeo Raytheon Systems Inc. have recently developed a "blind spot detection system" for cars. This was featured in the May 2003 issue of Automotive Engineering International (p74).

Canesta Design Systems has demonstrated a prototype infra-red 3D mapping device for personal computers. May (2003) reports that the company is negotiating with vehicle manufacturers over the use of the sensing device for "detecting objects around vehicles", and whether passenger seats are occupied. This technology has promise but it could be several years before it is widely introduced.

Japanese and European suppliers

There do not appear to be any Japanese or European suppliers of complete systems that are suitable for trucks. The following companies have related products or research:

- Toyota - reversing sensor and video system
- Denso - radar and ultrasonic sensors
- Matsushita - ultrasonic sensors
- Mitsubishi - 76.5GHz radar, video systems and ultrasonic sensors.
- Fujitsu Ten - 76.5GHz radar, stereo camera
- Omron - 76.5GHz radar

- Bosch (Germany) - 24GHz radar , smart video systems (eg lane edge detection, stereo imaging), Adaptive Cruise Control (maintains headway)

Application of research to Australia

Influence on crashes

It is evident that there is a wide range in expected benefits from collision warning systems in the USA, depending on the nature of the vehicle operations. Trucks operating on interstate highways benefit most from frontal and side (lane change) collision warning systems (potentially influencing 25% and 16% of all crashes respectively). However, for buses operating in urban areas, *side* collision warning systems could potentially influence only 6% of all crashes - less than half of that for interstate trucks. In addition US experience suggests that the effectiveness of the current generation of side collision warning systems is markedly reduced in cluttered urban road situations.

A 1990 study of 83 heavy vehicle crashes on two NSW highways (Sweatman and others 1990) estimated that "radar braking" (ie forward collision warning systems) could have potentially influenced 7% of the crashes. "Improved truck driver visibility" (possibly side collision warning systems) could have potentially influenced only 2% of the crashes.

A 1995 study of 88 "urban" heavy vehicle crashes (Sweatman and others 1995) found that 50 to 75% of serious rigid truck crashes and 25 to 50% of serious articulated vehicle crashes occurred in urban areas. "Drivers field of view" was a factor in 13% of these crashes (but may have been the other driver in some cases).

Provisional (unpublished) analysis of 900 heavy vehicle crashes from the NSW Crashed Vehicles Study (1995-1998) found that about half of all fatal/serious crashes occurred in urban areas whereas about 40% of all crashes occurred in urban areas (that is, rural crashes tend to be more severe). Due to the sketchy data available, the potential for vehicle-countermeasures was likely to be an underestimate. Subject to this caution, "driver alertness" was considered a factor in 3% of the crashes and "improved signals" (mostly left turns across the inside lane) was considered a factor in less than 1%.

With the scant information available it is not possible to provide a reliable estimate of the potential reduction in accidents due to the use of collision warning systems on trucks in Australia. At best it would be a few percent of all truck crashes, assuming that forward and side collision warning is provided on all heavy trucks.

Caution should be exercised in applying the remarkable fleet accident reductions that have been claimed in the USA. It is suspected that there are confounding factors contributing to the statistics.

Application of technology

The main issue with the use of the technology in Australia is the operating frequency of the radar sensors. Preliminary trials of the EVT-300 system in Australia revealed that there was interference at the frequencies currently used in the USA. It will therefore be necessary for an alternative frequency to be used in Australia.

In 2001 the Australian Communications Authority issued a report "A review of automotive radar systems - devices and regulatory frameworks". It discussed favourably the use of the 76-77Ghz band for automotive radar applications. It did not discuss the 24GHz band currently being promoted by the SARA consortium, and used in the Eaton Vorad system. The report made the point that low power radio emissions typical of automotive radar had a short range (up to a few hundred metres) and were blocked by objects so that interference problems should be minimal. It was noted that several models of imported luxury sedans were already fitted with 77GHz radar systems and were in use in Australia.

The Australian Radio Frequency Spectrum Plan issued by ACA in January 2002 indicates that the 24GHZ band is allocated for several users, including Earth to satellite communications. Advice from ACA Senior Engineer, Mr Steven Forst, is that a Low Interference Potential Device (LIPD) class licence applies for low wattage transmitters in the band 24.000 to 24.250GHz. However, the frequency 24.75GHz, as used by Eaton Vorad, is not currently licensed for this purpose in Australia. Mr Forst suggests that ACA would give consideration to including that frequency in the LIPD class licence if it was requested by a peak industry body. However the frequency is of interest to radio astronomers in Australia and other users. Their needs would need to be taken into consideration.

Overseas performance specifications

The three performance specifications that have been reviewed are in draft form and it could be at least a year before each is finalised. Each of them is considered to have limitations that make them unsuitable for direct application in Australia but the ISO specification is considered to be the most appropriate.

In addition to technical performance requirements, it would be advisable to develop a methodology to assess any on-road trials. Several trials are currently underway in the USA and it may be best to await the results of these trials before commencing extensive trials in Australia.

Functional requirements

It is useful to look at the tasks of the driver during a lane change or turning manoeuvre so that the functions of a collision warning system can be associated with these tasks. Appendix A contains flowcharts showing the steps and decisions that would normally be taken by a driver during a manoeuvre.

From this chart it is evident that two functions are amenable to ITS technology:

- A Blind Spot Warning System (BSWS) that simply indicates that an object is within a defined “blind spot” beside the vehicle. Primarily this covers the case of a vehicle in an adjacent lane that is travelling at the same speed as the subject vehicle. The driver would use the BSWS visual indicator in conjunction with the mirrors in order to decide whether to initiate a turn. An audible alarm is not appropriate because it would be subject to frequent false alarms.

- A Side Collision Warning System (SCWS) that has sophisticated electronics to determine whether a collision is likely to occur (within a reasonable time) if evasive action is not taken by the driver of the subject vehicle. If a collision is imminent then an audible alarm would sound. The driver of the subject vehicle would then need to decide whether to act on the alarm or treat it as a false alarm and continue with the vehicle manoeuvre.

Ideally, the BSWS assists the driver in making a decision whether to commence a manoeuvre whereas an SCWS monitors conditions once a manoeuvre starts and alerts the driver if a collision is imminent. These functions match those identified by the ISO Working Group and in NHTSA reports.

Functions of Blind Spot Warning System (BSWS)

The function of a BSWS is relatively simple. Critical zones on either side of the vehicle need to be identified so that potential blind spots are covered. Then sensors or other object detection devices would need to be fitted to the vehicle so that their combined detection zone matches the critical zones as closely as possible. Key requirements are:

- The detected zones should not extend excessively beyond the critical zone, otherwise too many false indications will occur.
- Equally, the detected zone should not fall excessively short of the critical zones, otherwise hazardous situations may not be evident to the driver.
- The sensors need to be able to detect a wide range of objects, from pedestrians to trucks.

Functions of Side Collision Warning System (SCWS)

The function of an SCWS is to determine whether there is likely to be a collision between a detected object and the subject vehicle. This will require sensors with a much longer range than those needed for a BSWS. In addition an SWOS will need to have information about the likely path of the subject vehicle. It will need to combined the data in order to estimate closing speed and angle and, from these, the time to collision (TTC). If the TTC is less than a certain amount then an alarm of appropriate priority should be sounded. Some of the difficulties that may be encountered in meeting these functions are:

- The driver’s intended action will not be known to the system. The only practical indications would be activation of the turn signal indicator and turning of the steering wheel. To avoid false alarms, it is advisable that an SCWS only be becomes active when the turn signal is activated by the driver.
- A long detection range is needed to cater for vehicles overtaking at high relative speeds. In particular, curved paths of both vehicles become difficult to deal with at long ranges.

- It may not be feasible to continue the detection function once the manoeuvre is nearing completion. This is because the system will not know when the driver intends to straighten the rig, and therefore alter the collision parameters (a lack of anticipation). An example is where there are three lanes and the subject vehicle moves from the kerb lane to the middle lane. If a vehicle is in the outside lane then, near the end of the lane change manoeuvre, the SCWS will determine that a collision is likely, until the driver straightens the rig and the closing speed is no longer critical. A key problem is how will the SCWS know that a manoeuvre has started and when it is about to end?
- Inevitably there will be false alarms. If there are too many this will desensitise the driver, who might no longer respond appropriately. How will drivers recognise situations (like that described above) where an alarm should be ignored?

Practicalities of assessing functional requirements

The essential functions of a BSWS can be assessed by determining the performance of the sensors. The ISO Working Group had initially considered a static test of BSWS and the Working Draft was worded accordingly. Last year, however, the German delegation requested that a dynamic test be used. Details of the German proposal, and the reasons for rejecting a static test are not available. A static test would be much simpler to conduct and it is proposed that any tests of BSWS in Australia be based on a static test at this stage.

The functions of a SCWS are significantly more difficult to assess. This is because the "smartness" of the whole system will need to be evaluated under a wide range of conditions encountered on the road. It is evident from the ISO Working Draft that the experts are far from agreeing on test methods and performance criteria for SCWS. The FTA are considered to be the most advanced in the development of SCWS specifications but they appear to be still at the experimental stage.

The Eaton Vorad EVT300 system fulfils some elements of both functions. To date it appears that only field trials of this system have been conducted, rather than tests under controlled conditions. Some of these trials have attempted to assess false-positives and false negatives by, for example, analysis of video taken during a truck journey (Talmadge and others 1995). This analysis is very tedious. Other trials have been more subjective and have depended on driver or observer reports. For example the FTA trials on buses in urban areas found that systems such as the EVT-300 produced too many false alarms.

In view of the work that is being undertaken by the ISO Working Group and the US Federal Transit Authority, there appears to be little point in developing an assessment methodology for SCWS in Australia. It is apparent that a considerable amount of further research is needed to develop a suitable assessment protocol.

A static test of Blind Spot Warning Systems could be developed, based on a section of the ISO Working Draft that is scheduled for deletion (copy provided in Appendix B for future reference). However, the ISO test does not assess false alarms, (such as a vehicle much further than 3m from the side or rear of the subject vehicle). Also the test may not adequately provide for vulnerable road users such as pedestrians or pedal cyclists.

Based on the author's work with reversing proximity sensors (Paine and Henderson 2001), a simpler and more appropriate test might be to have a pedestrian slowly walk along specified paths next to the stationary vehicle (for example, walking along the length of line FF, from 6m behind the vehicle to the front of the vehicle) and record when the BSWS detects the person. This would produce a map of the sensor detection zones that could then be compared with the desired requirements.

Despite the lack of formal performance requirements, the Eaton Vorad system is now widely in used in the USA. It appears that fleets have decided to equip their vehicles after limited on-road trials. Presumably drivers would have raised concerns if there were serious problems in the trials, such as false alarms or too many collisions or near misses. Also it should be noted that most of the Eaton systems incorporate forward collision warning and this might be the most attractive feature for fleets.

Conclusions

In the USA, collisions during lane change or turning manoeuvres account for about 16% of interstate truck crashes and 6% of urban bus crashes. There is insufficient information to determine the equivalent numbers in Australia but it is unlikely that either trucks or buses in Australia would be greater than 6%. Using NHTSA's estimate that an effective countermeasure could prevent about half of these crashes then the potential savings would be a few percent.

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In view of the ongoing work that is being performed by NHTSA, FTA and the ISO Working Group, it is recommended that no formal trials be undertaken by Vicroads at this stage. Contact should be maintained with overseas researchers and local distributors of collision warning systems and the situation should be reviewed if promising systems become available.

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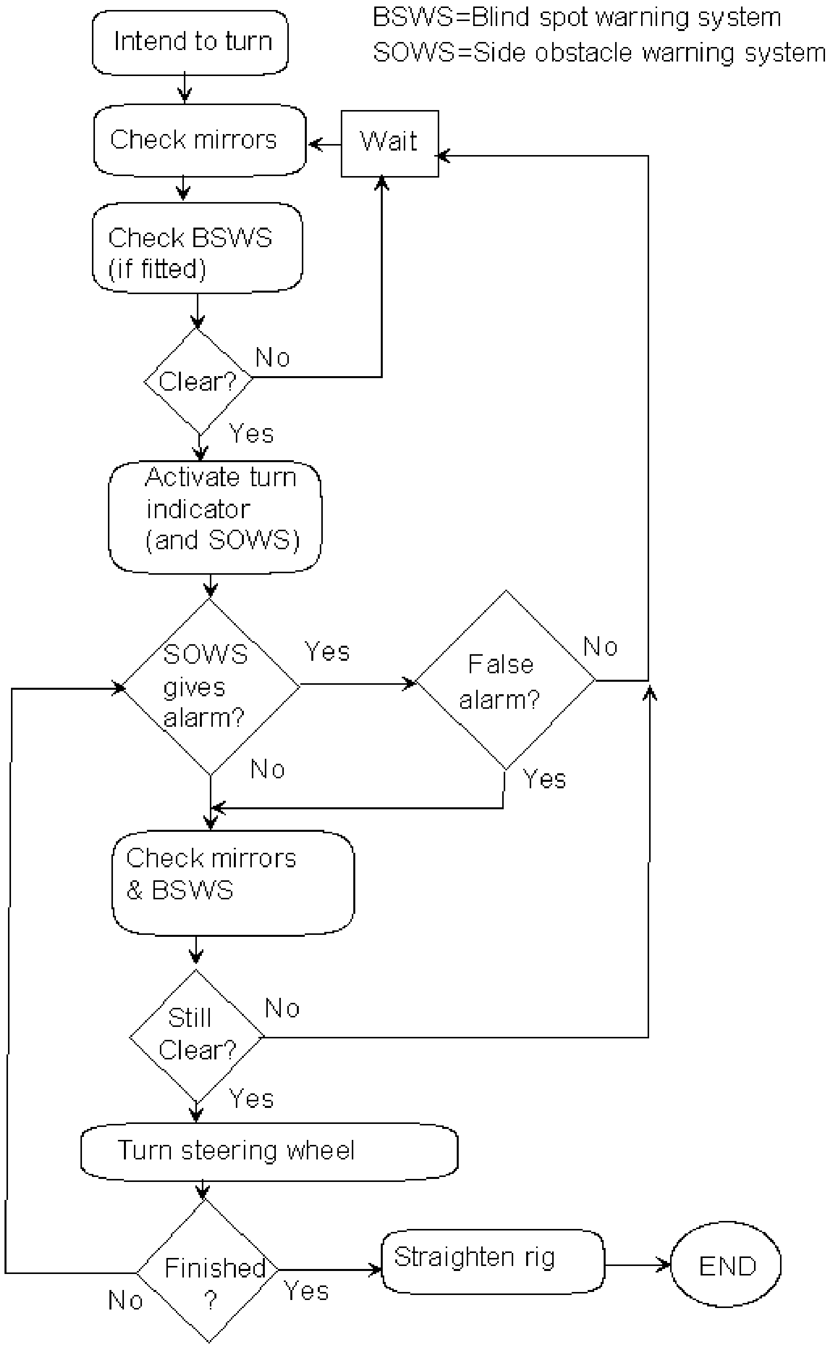
Appendix A – Decision flowcharts

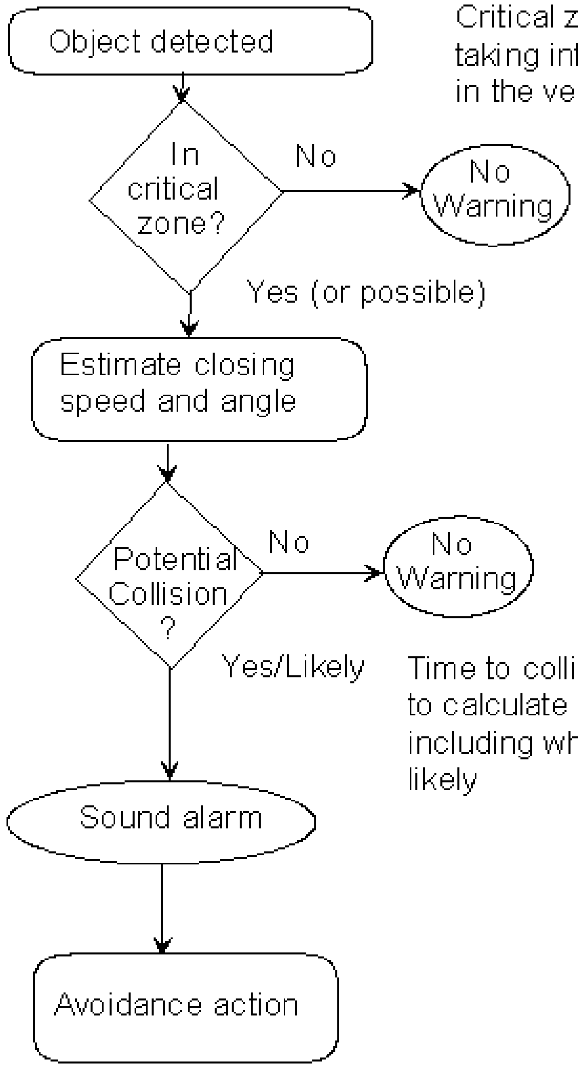
Driver decision chart for lane change or left turn

Task: To avoid a collision with another road user while changing lanes or turning left in a heavy vehicle.



Determination of potential collision

Task (of driver and/or SOWS): Determine whether there is likely to be a collision with another road user if the two bodies continue on their same path.



Critical zone is in adjacent lanes, taking into account any curvature in the vehicle path.

Time to collision can be used to calculate the alarm priority, including whether a collision is likely

Appendix B - Extract from ISO Working Draft N40.19

Note that this section is marked for deletion in the ISO document, pending the development of a dynamic test. It is included here for reference.

Blind Spot Warning Test Requirements

The sections below describe the minimum test requirements for a Blind Spot Warning (SOW Type I) system.

Test Object

For each of the following tests, the test object shall be a motorcycle with a rider. The length of the motorcycle shall be between 2.0 meters and 2.5 meters. The width of the motorcycle at its widest point (not including the side mirrors) shall be between 0.7 meter and 0.9 meter. The height of the motorcycle (not including the windscreen) shall be between 1.1 meters and 1.5 meters.

Environmental Conditions

The test location shall be on a flat, dry asphalt or concrete surface. The ambient temperature during testing shall be within the range of 10 degrees C +/-30 degrees C. The horizontal visibility range shall be greater than 1 km.

Static Tests

The subject vehicle shall be parked on a flat surface. Lines B, C, F, G, K and L shall be marked according to the measurements given in section 5.2.2.1.

[Lines FF and KK are 0.5m transverse distance from the extreme width of the vehicle.

Lines GG and LL are 3m transverse distance from the extreme width of the vehicle.

Line CC is in line with the eyes of the driver (95%)

Line BB is 3m rearward of the rearmost point of the vehicle.]

The test object shall be placed in various positions as shown in figure 9 and described in the following sections.

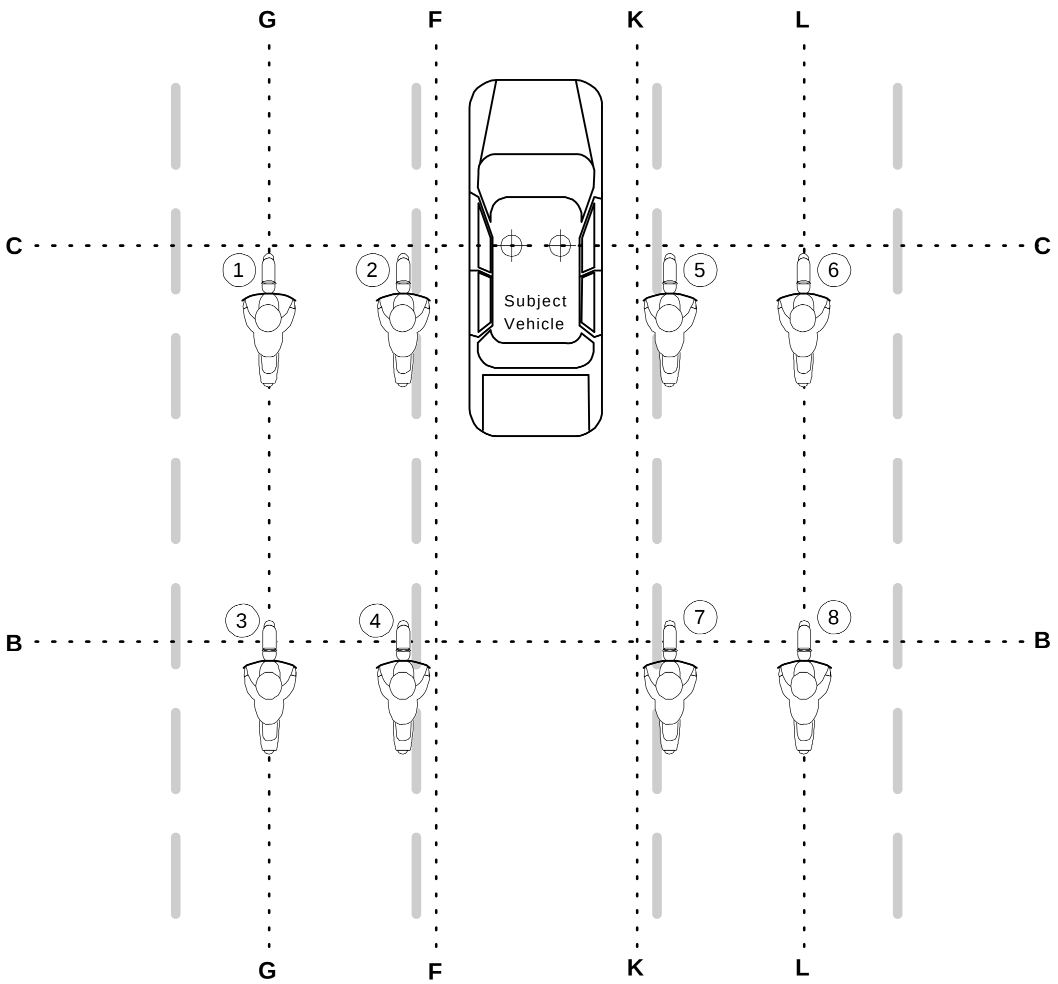


Figure 9: Blind Spot Static Test Positions

Position 1

The test object shall be placed such that it is no more than 0.05 meters behind line C, and its wheels rest on line G. With the test object in this position, the Blind Spot Warning system shall give a left blind spot warning.

Position 2

The test object shall be placed such that it is no more than 0.05 meters behind line C, and no more than 0.05 meters to the left of line F. With the test object in this position, the Blind Spot Warning system shall give a left blind spot warning.

Position 3

The test object shall be placed such that its front wheel rests upon the intersection of lines B and G, and its rear wheel rests upon line G. With the test object in this position, the Blind Spot Warning system shall give a left blind spot warning.

Position 4

The test object shall be placed such that it is no more than 0.05 meters to the left of line F, and its front wheel rests upon line B. With the test object in this position, the Blind Spot Warning system shall give a left blind spot warning.

Position 5

The test object shall be placed such that it is no more than 0.05 meters behind line C, and no more than 0.05 meters to the right of line K. With the test object in this position, the Blind Spot Warning system shall give a right blind spot warning.

Position 6

The test object shall be placed such that it is no more than 0.05 meters behind line C, and its wheels rest on line L. With the test object in this position, the Blind Spot Warning system shall give a right blind spot warning.

Position 7

The test object shall be placed such that it is no more than 0.05 meters to the right of line K, and its front wheel rests upon line B. With the test object in this position, the Blind Spot Warning system shall give a right blind spot warning.

Position 8

The test object shall be placed such that its front wheel rests upon the intersection of lines B and L, and its rear wheel rests upon line L. With the test object in this position, the Blind Spot Warning system shall give a right blind spot warning.