REVIEW OF THE WA STATE BLACK SPOT PROGRAM: A LITERATURE REVIEW OF AUSTRALIAN AND INTERNATIONAL BLACK SPOT PROGRAMS

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Title

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Abstract

This report reviewed black spot programs conducted in Australia and around the world in terms of funding allocations, black spot identification methods and crash criteria and compared them to the methods used by the WA State Black Spot Program. To ensure the WA State Black Spot Program continues to produce maximum benefits, its procedures and methods need to be constantly reviewed and compared to other programs so that possible modifications and improvements can be made.

Keywords

Black spot treatment, qualitative interviews

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EXECUTIVE SUMMARY

This report, which is part of a systematic review of the WA Black Spot Program, examined black spot programs currently undertaken in Australia and worldwide in terms of funding allocations, black spot identification methods and crash criteria and compared them to the methods used by the WA State Black Spot Program. To ensure the WA State Black Spot Program continues to produce maximum benefits, its procedures and methods need to be constantly reviewed and compared to other programs so that possible modifications and improvements can be made.

The WA State Black Spot Program

WA operates the State Black Spot Program complementary to AusLink's federally funded Black Spot Program. The State Black Spot Programs stipulates that approximately 50% of funding is to be spent on non-metropolitan roads and 50% on metropolitan roads. In addition, 50% of funding must be spent on State roads and 50% on local roads with these projects being funded by a joint contribution of two dollars from the State Black Spot Program and one dollar from the local government. Up to 100% of total State Program funding can be provided to potentially hazardous locations identified through a road safety audit (RSA) if needed.

Black spot or black length projects can be identified on the basis of their crash history or through a RSA. The WA State Black Spot Program uses a non-model based 'crash number' and 'crash frequency' (crashes per km) identification method to establish the eligibility of projects nominated on the basis of crash criteria. Different crash criteria are set for State, local, metropolitan and non-metropolitan roads, reflecting different road volumes. Property damage only (PDO) crashes are included in the selection process as well as casualty crashes. A benefit cost ratio (BCR) is calculated for all nominated projects that meet the crash criteria to measure the cost-effectiveness of the proposed treatment. The WA Program stipulates that projects must have a BCR of one to be eligible. Potentially hazardous locations nominated on the basis of a road safety audit are prioritised with a Risk Cost Ratio. The maximum cost of an individual project for the WA State Black Spot program is $1 million.

Black Spot Programs around Australia

Within Australia, WA, South Australia (SA), Tasmania and Victoria run specific State Black Spot Programs and the other states undertake black spot treatments as part of broader road safety programs.

WA also receives around $5 million funding per annum from the federal, Australia-wide AusLink Black Spot Program. Like the State Program, this Program requires 50% of funding to be spent on metropolitan roads and 50% on non-metropolitan roads. Division of funding between State and local roads is not specified and only up to 20% of funding is allocated to potentially hazardous locations identified through a RSA. The AusLink Program only includes casualty crashes in its analysis. BCRs are used to prioritise projects nominated on the basis of crash data and projects must have a BCR of two to be eligible. The cost of an individual project nominated for AusLink funding can not be more than $750 000.

In relation to funding allocations, SA designates 60% of funding to non-metropolitan roads where 61% of road fatalities occur and Tasmania does not specify allocations. SA allocates two thirds of funding to State roads with only one third to local roads. Tasmania's State Black Spot Program, on the other hand funds only local roads. In contrast to WA, the SA Program only allocates up to 30% of funding for potentially hazardous locations identified through an RSA and under the Tasmanian program, such sites are not eligible at all. In addition, SA specifically directs 10% of total funding to cycling-related improvements. Like WA, SA sets the project cost limit at $1 million and Tasmania at $250 000.

All the programs within Australia use non-model based black spot identification methods including 'crash number' and 'crash frequency' (crashes per km) to establish the eligibility of projects nominated on the basis of crash criteria. However, WA's program is the only one to set different crash criteria for State, local, metropolitan and non-metropolitan roads.

In the past, Victoria allocated large amounts of funding to eliminating black spots. Due to the success of these programs, Victoria now addresses black spots through the Safer Roads Infrastructure Program aimed at reducing run off road and intersection crashes with a special focus on rural and outer metropolitan areas. Sites are identified and prioritised on the basis of their crash history and potential crash risk. This program does not invite nominations from the public and does not set a project cost limit. Victoria also funds a Grey Spot Program aiming to improve road safety at potentially hazardous locations particularly outer-metropolitan and rural intersections that do not meet traditional crash-based black spot criteria. These projects are identified through RSAs and there is no project maximum cost imposed. In addition, Victoria has initiated the world's first Motorcycle Black Spot Program. These projects are identified on the basis of 'crash number' and 'crash frequency'.

Queensland addresses black spots within the broader 'Safer Roads Sooner' program that focuses on high-benefit, low-cost road safety measures targeting high fatality and serious injury crash locations on State roads only. Queensland also undertakes network level risk assessments of their roads to identify and treat potentially hazardous locations. The Safer Roads Sooner Project has no maximum funding limit for projects and one project can take place over several locations. This allows the funding of mass action projects, over longer time periods and road lengths. New South Wales (NSW), the Australian Capital Territory (ACT) and the Northern Territory (NT) also treat black spots within their broader road safety programs.

International Black Spot Programs

Black Spot Programs have been used at some stage by all leading road safety countries of the world including Canada, the USA, New Zealand and much of Europe but due to their success, the majority no longer implement large scale black spot programs. Instead, most black spot work is conducted by regional or local authorities who determine their own identification methods and eligibility criteria.

The majority of countries reviewed, use a non-model based black spot identification methods, the most common being 'crash number' and 'crash frequency'. However, several programs including those in Canada, Texas, Austria and the UK use the 'crash rate' method (crashes per vehicle km) which is considered better practice. Only three programs identified the use of model-based methods of identification including 'category analysis' in Kentucky, USA, the Poisson statistical method in Denmark and the Empirical Bayes approach in Portugal. All three of these programs use these methods in combination with the non-model based 'crash number' method. Several countries also identify black spots by examining specific 'crash types' (specific road users) or 'crash themes' (eg. run off road crashes). RSAs are common practice in all countries reviewed except the USA but are not used as part of specific black spot programs.

Discussion

In WA, 56% of road fatalities occur on non-metropolitan roads despite only a quarter of the population living in regional areas. Currently there is debate whether 50% of funding is adequate to meet the needs of non-metropolitan areas or if they should receive a larger portion. In WA, locally owned roads make up 88% of the road network and 65% of serious crashes occur on these roads. It is possible when considering local government financial contributions to black spot projects, the lower volume of traffic and the overall lower cost of treatments on local roads, that 50% of Black Spot funding is adequate. However, this should be investigated.

The European Commission recently funded a report on state-of-the-art black spot approaches. When identifying black spots based on crash criteria, the report rated model-based methods as best practice with the Empirical Bayes method considered best, followed by a traditional model (including the Poisson method), then category analysis. Model based methods however, require comprehensive and connected crash, road and traffic data and may be currently unrealistic for WA with its vast road network. If such traffic data is not available, the European Commission Report recommends the use of non-model based techniques with the 'frequency rate' method

ranked as best, followed by ‘crash rate’, then ‘crash frequency’ and ‘crash number’. It is possible that WA could work towards collecting enough traffic data to use ‘crash rate’ or ‘frequency-rate’ methods and eventually implement the model-based state-of-the-art Empirical Bayes method of identification.

The actual crash criteria used to identify black spots varies widely from program to program and there are no correct or incorrect criteria. The WA State Program has devised different crash criteria for State, Local, Metropolitan and non-metropolitan roads that take into account road volumes and total funding available. However, these criteria do not account for variations in traffic volume within regions. The WA Program only weights crashes by crash type cost when calculating the BCR rather than by crash severity but based on findings by the European Commission Report, it would be worthwhile to investigate the value of using crash severity weightings to identify black lengths and in all BCR calculations. BCRs are commonly used throughout the world to rank and prioritise black spot projects. The BCR of one is appropriate for WA and allows a greater scope of projects.

Using crash data from the previous five years to determine project eligibility in WA provides statistical reliability and this five-year period should be maintained. It is also positive that the WA Program includes PDO crashes in the criteria because ignoring these crashes may give a misleading picture of the nature of problems at a black spot.

Interestingly, Australia is the only country reviewed that addresses potentially hazardous locations identified through a RSA within its black spot programs. This method of identification is highly relevant to WA due to its large area and long stretches of remote roads. RSAs are emerging as an effective tool for identifying safety issues on roads and currently, they are the best tool available for identifying potentially hazardous locations. The WA State Black Spot Program’s use of RSAs to identify potentially hazardous locations and the flexible funding allocations to these proactive projects is positive.

Black spot programs targeting specific, vulnerable road users have being initiated in Australia and around the world. It should be investigated if it would be feasible and cost effective to introduce targeted Black Spot Programs in WA, particularly for motorcyclists who are at particular risk of fatal crashes.

Under the WA State Black Spot program, projects are required to have a total cost under $1 million. However, WA is experiencing the highest rate of construction cost inflation in Australia in recent years meaning some treatments are in danger of becoming ineligible because they exceed this funding threshold. The threshold should be increased to reflect construction cost inflation in the State.

Strengths of the WA State Black Spot Program

Strengths of the WA State Black Spot Program identified in this review include the public nomination process, specific funding allocations to metropolitan/ non-metropolitan and local/ State roads, inclusion of both projects based on crash data and potentially hazardous locations based on RSAs, allowing 100% of funding to be used on potentially hazardous locations if needed, different crash criteria for different WA roads, the use of five years worth of crash data, inclusion of PDO crashes in the analysis and use of the BCR to prioritise projects.

Areas for further consideration

Areas for further consideration and possible modification include the distribution of funding to metropolitan/ non-metropolitan and local/ state roads, changing to 'crash rate' or 'frequency rate' methods of black spot identification with the view to eventually utilise the model based Empirical Bayes approach, inclusion of crash severity ratings in BCR calculations and black length identification, the use of Geographic Information Systems to record crashes, directing black spot funding to specific road user groups and remaining up to date with new instruments for identifying potentially hazardous locations.

Conclusion and Future Directions

As leading countries in road safety have begun to eliminate the majority of their black spots, they have decided it is more cost effective to gradually move the emphasis towards the 'safer systems' approach to road safety. WA's vast road network and comparatively low population may mean dangerous sections of road remain, making the continued treatment of black spots still important and beneficial. The Program's guidelines and procedures need to be constantly reviewed and updated to ensure maximum benefits. As time progresses, the benefits of treating remaining black spots in WA will eventually reduce so ongoing evaluations are required to determine when the Program is no longer useful.

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1. INTRODUCTION

The State Black Spot Program was first introduced in Western Australia in 2000. Black spots are locations noted for a high incidence of crashes involving death and injury (Australian National Audit Office (ANAO) 2007). Most black spot treatments are relatively low cost compared with benefits that accrue over time and therefore provide substantial economic returns (Australian Transport Safety Bureau, 2004). A recent evaluation of projects treated between 2000 and 2002 in WA showed that the program has been effective overall, reducing all reported crash frequencies by 20% and casualty crash frequencies by 36% (Meuleners et al. 2008). In Australia, AusLink runs a Federal Black Spot Program, WA, SA, Tasmania and Victoria run specific State Black Spot Programs and the other states undertake black spot treatments as part of broader road safety programs. Black spot-style programs have been used at some stage by all leading road safety countries but due to their success, many of these countries have moved their focus from treating spots to mass action, area-wide or network treatments or adopted the 'safe systems' approach to road safety. To ensure the WA State Black Spot Program continues to produce maximum benefits, its procedures and methods need to be constantly reviewed and compared to other programs. Specifically, this report will review the funding allocations, black spot identification methods and crash criteria of programs conducted within Australia and worldwide

1.1 Aim

The aim of this study is to conduct a review of black spot programs undertaken in Australia and worldwide in terms of funding allocation, black spot identification methods and crash criteria and compare them to the methods used by the WA State Black Spot Program. Strengths of the Program and areas for further considerations will be identified.

1.2 Significance

The results of this review will provide Main Roads WA and other responsible agencies with comprehensive information about Australian and international black spot

practices. Such information is essential to ensure that the Program meets best practices in funding allocation, black spot identification and crash criteria now and into the future.

2. METHODS

The Medline and ScienceDirect databases were searched for Australian and international publications on black spot programs using the keywords ‘road’ in combination with ‘black spot’, ‘hot spot’, ‘cluster site’ or ‘hazard elimination’. Publication reference lists were also scanned for relevant articles. In addition, each Australian State road authority’s website was searched for information as well as the websites of various Transport Authorities in other countries including those in North America, Europe and New Zealand.

3. RESULTS

3.1 The WA State Black Spot Program

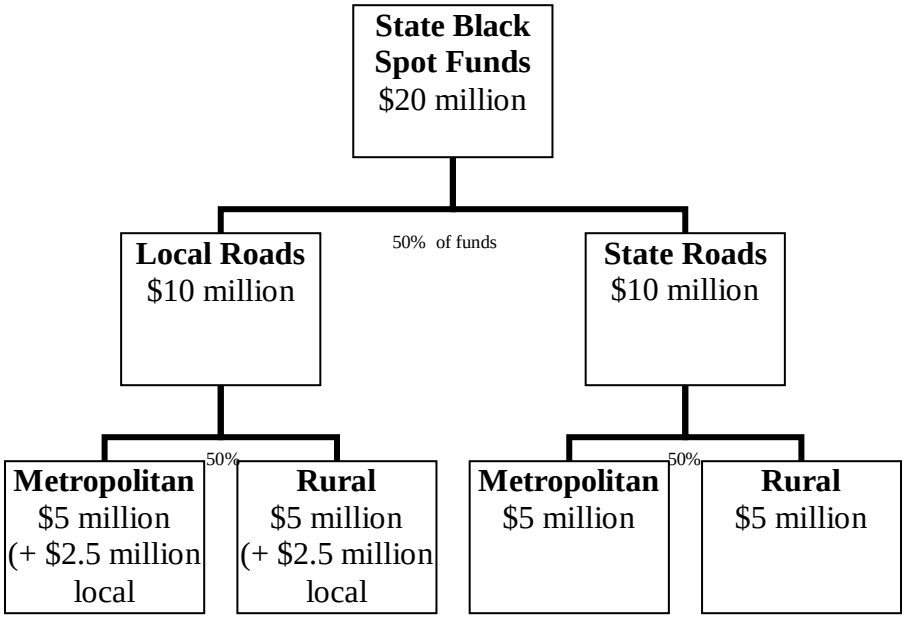
WA has operated the State Black Spot Program since 2000, complementary to AusLink's Federally funded Black Spot Program commencing in 1990 (Department of Transport and Regional Services (DOTARS) 2006). The WA State Black Spot Program's objective is to further improve road safety across Western Australia thereby reducing the significant trauma and suffering by crash victims, family and friends and $20 million was allocated in 2006/ 07 (Main Roads/ WALGA 2004).

3.1.1 Funding Allocations

Under the State Program, all road classifications are eligible, including State roads, local roads and national highways. The guidelines stipulate that approximately 50% of funding is to be spent on metropolitan roads and 50% on non-metropolitan roads. In addition, 50% of funding must be spent on local roads with these projects being funded by a joint contribution of two dollars from the State Black Spot Program and one dollar from the local government in which the project resides.

Up to 50% of total program funding can be provided to potentially hazardous locations but this proportion may be increased up to 100% to suit need. Figure 1 illustrates the State Black Spot Program funding allocations (Main Roads/ WALGA 2004).

Figure 3.1: WA State Black Spot Program Funding Allocations



3.1.2 Nomination Process

Nominations for projects are invited from State and Local governments, community groups, transport industry groups, road user groups and individuals. The WA Black Spot Program places an emphasis on direct input from the community. Main Roads WA is responsible for the overall administration of the Program. Proposals for treatments on national highways, State highways and roads under the care of Main Roads are evaluated and managed by Main Roads. Proposals for local roads under the care of local government are evaluated through Regional Road Groups and managed by the State Road Funds to Local Government Advisory Committee through those groups. After approval, Main Roads and local governments are then responsible for managing and delivering the projects (Main Roads/ WALGA 2004).

3.1.3 Eligibility for Black Spot Programs

The State Program has two ways projects can meet eligibility criteria for funding. Black spots or black lengths can be eligible on the basis of their crash history and potentially hazardous locations can be identified and made eligible on the basis of a RSA.

WA's Program uses particular crash criteria for eligibility as it intends to enable application of funds to a wider range of projects than the AusLink Program. The State Program's crash criteria vary according to whether the road is a State or a local road and whether it is in a metropolitan or non-metropolitan area. This takes into account the lower traffic volumes on non-metropolitan and local roads with a lower number of crashes being required for eligibility in non-metropolitan than in metropolitan areas and on local roads than State roads. Table 1 details the crash criteria for the State Black Spot Program. Road Safety Design Audits are required to accompany crash data nominated projects where the cost exceeds $150 000 and when project treatments are complex (Main Roads/ WALGA 2004).

Table 3.1: Crash criteria for the State Black Spot Program

Crash Criteria	**Highways and Main Roads**		**Local Roads**	
	Metro	**Rural**	**Metro**	**Rural**
Intersection or Mid-block or Short road section (< 3 km)	10 crashes over 5 years	3 crashes over 5 years	5 crashes over 5 years	3 crashes over 5 years
Road length (≥ 3km)	Average of 3 Crashes per km over 5 years	Average of 1 crash per km over 5 years	Average of 2 Crashes per km over 5 years	Average of 1 crash per km over 5 years
Benefit-cost ratio (BCR)	1			

(Main Roads/ WALGA 2004)

PDO crashes as well as casualty crashes (crashes where someone is injured or killed) are included in the analysis for WA State Black Spot projects. Including PDO crashes means warning signs for potential casualty crashes are not ignored and a wider scope of projects can be funded. In WA, it is mandatory to report a crash to the police if a person is injured or if property damage exceeds $1,000. Crash data can be analysed on the Main Roads CRASHtool System, which is updated annually (Main Roads/ WALGA 2004).

3.1.4 Prioritisation of Projects Nominated on Crash Data

A BCR is calculated for all nominated projects that meet the above crash criteria. This is the measure of the cost-effectiveness of the proposed treatment and ensures that the black spot exhibits a significant number of crashes that are correctable by infrastructure treatment. Figure 2 presents the formula for calculation of BCR. In WA, these can either be calculated manually or by using the Main Roads CRASHtool System that allows up to four countermeasures to be considered simultaneously. This measure allows projects to be prioritised for funding and projects with the highest BCRs are considered first. The WA State Program aims to include a wide range of projects so only requires a BCR ≥1 for eligibility (Main Roads/ WALGA 2004).

Figure 3.2: Formula for Calculating BCR

$$\text{Benefit Cost Ratio} = \frac{\text{Present value of estimated benefits (the annual crash rate x accident reduction factor x average cost of a prevented crash discount factor determined by the life of the treatment and the applied discount rate)}}{\text{Estimated cost of project}}$$

(ANAO 2007)

3.1.5 Eligibility of potentially hazardous locations

Potentially hazardous locations that do not satisfy the crash criteria can also be eligible for funding if they are recommended for treatment by an official RSA that assesses the site as hazardous. This allows proactive safety works to be conducted before crashes occur.

A RSA is a formal examination of an existing road, in which an independent, qualified team reports on crash potential and safety performance. RSAs can identify problems at potentially hazardous locations and assist in identifying the most appropriate solution (Austroads 2001). For potentially hazardous locations, the State Program requires use of an RSA for each site where the estimated cost is greater than $40 000 and if the nature of works will significantly alter traffic patterns (Main Roads/ WALGA 2004).

3.1.6 Prioritisation of Potentially Hazardous Locations

Potentially hazardous locations can be assessed and prioritised with a Risk Cost Ratio and can be calculated through the use of the Road Safety Risk Manager Software developed by ARRB and AusLink (Main Roads/ WALGA 2004).

3.1.7 Maximum Project Cost

The maximum cost of an individual project for the WA State Black Spot Program is $1 million and must cost at least $2000. The Program limits the payment for each project to the allocated Total Estimated Cost amount for each. However, variation in scope or expenditure on a project is possible but must be approved by Main Roads. In addition, a revised project BCR must be considered as part of the approval to variations for applications based on crash criteria (Main Roads/ WALGA 2004).

3.1.8 Timeframe of Project Delivery

The WA State Black Spot Program Guidelines state that projects must make every endeavour to expend the funds in the year of allocation. Under exceptional circumstances, extension of projects may be considered by the managing authority. However, complex projects that cannot be completed in one year may be stage constructed but this must be clearly indicated at the time of nomination (Main Roads/ WALGA 2004).

3.1.9 Other Road Safety Infrastructure Programs in WA

While the WA State Black Spot program aims to deliver low cost treatments to identified problem areas, the five-year $103 million state funded Safer Roads Program allows mass action with higher cost infrastructure projects to be undertaken on State or Main Roads WA managed roads. This program aims to create more forgiving roads and roadsides, targeting single vehicle run off road crashes in rural areas and major intersection crashes in urban areas with no specified project maximum costs. Treatments include road widening, building passing lanes and road realignments. (Main Roads 2007).

3.2 Black Spot Programs in Australia

Each state in Australia receives funding from the AusLink Black Spot Program and while WA, SA, Tasmania and Victoria run specific State Black Spot Programs, the other states undertake black spot treatments as part of broader road safety programs.

3.2.1 AusLink Black Spot Program

WA also receives around $5 million funding per annum from the federal, Australia-wide AusLink Black Spot Program. The objective of this Program is to reduce the social and economic costs of road trauma by improving the physical condition and management of black spots. Like the State Program, this Program requires 50% of funding to be spent on metropolitan roads and 50% on non-metropolitan roads (except in Tasmania, ACT and NT). Division of funding between State and local roads is not specified. Only up to 20% of funding is allocated to potentially hazardous locations identified through a RSA (Department of Transport and Regional Services (DOTARS) 2006).

The nomination process for the AusLink Program is the same as the for the WA State Black Spot Program but final nominations must be approved by DOTARS and the Federal Minister (DOTARS 2006).

The AusLink Program only includes casualty crashes in its analysis and sets the criteria of 3 casualty crashes over a 5 year period for intersections, mid-blocks or sections of road shorter than 3km (black spots). For lengths of road 3km or longer (black lengths), the criteria is 0.2 casualty crashes per kilometre per annum over a 5 year period or the road length must be among the top 10% of sites which have a demonstrably higher crash rate than other roads in a region. BCRs are used to prioritise projects nominated on the basis of crash data and projects must have a BCR of ≥ 2 to be eligible (table 4) (DOTARS 2006).

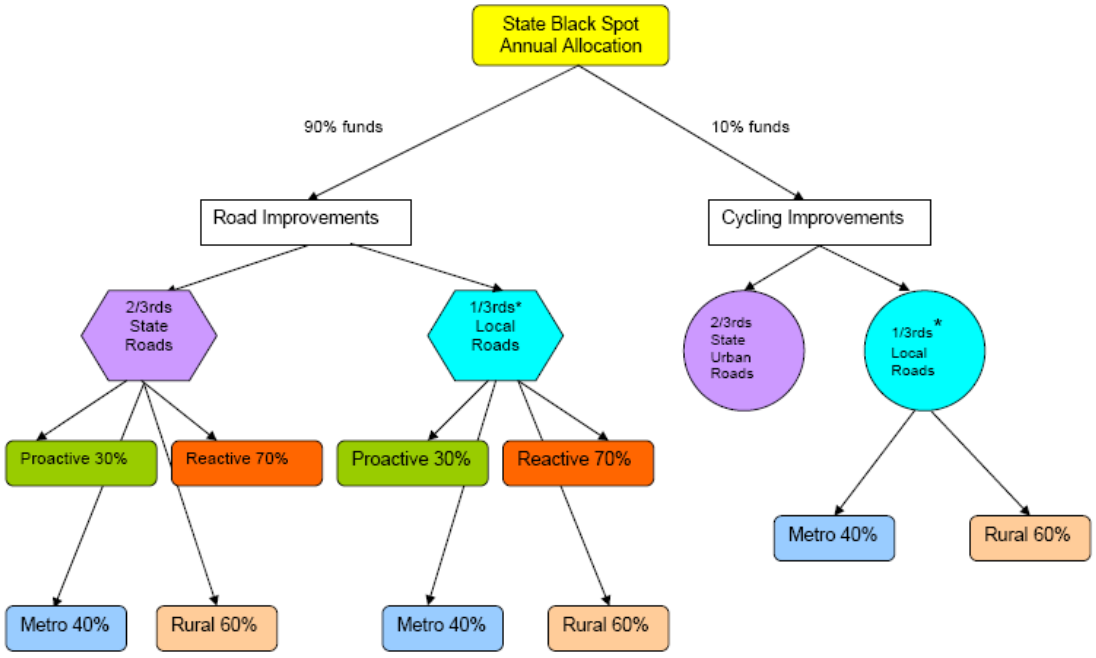
The cost of an individual project nominated for AusLink funding must be equal to or greater than $2000 but not more than $750 000. Projects should be completed within 12 months of funding approval and explanations are required if this is not the case.

3.2.2 South Australia

The aim of the SA State Black Spot Program is to bring about significant reductions in crashes and fatalities by the identification and treatment of locations and sections of road that have a poor casualty crash record or that have a significant crash potential identified by safety audits. Nominations are invited from the public including local governments, the Department for Transport, Energy and Infrastructure (DTEI) regions, other organisations and individuals. These nominations are received by the DTEI who assess eligibility, approve and prioritise them (DTEI 2007a).

SA's current State Black Spot Program commenced in 2002/03 and has an allocation of $7.2 million for 2007/08. SA specifically directs 10% of all funding to cycling-related improvements. Funding is also divided two thirds to state roads and one third to local roads with local councils being required to contribute a third of the cost to the project and being encouraged to contribute half. Funding is further divided 60% to non-metropolitan roads and 40% to metropolitan roads. This split is based on the relative percentage of fatalities that occur each year on each of these roads. The Program only allocates 30% of funding to proactive projects identified through an RSA with 70% going to reactive projects based on crash data (DTEI 2007a). Figure 3 illustrates the distribution of State Black Spot funding in SA.

Figure 3.3: Distribution of State Black Spot Funding in South Australia



(DTEI 2007a)

All roads are eligible for funding under the Program. For projects nominated based on crash data, the criteria for eligibility is identical to the AusLink Black Spot Program criteria in Table 1. However, State projects are now eligible if they have a BCR ≥ 1 rather than ≥ 2 as for the AusLink Program. The project cost limit has been raised from $750 000 to $1 million for 2008/09. In addition, complex projects can be submitted on the basis of being delivered over two years. Potentially hazardous locations, nominated on the basis of an official RSA are ranked and prioritised with a Risk Reduction Cost Ratio calculated from ARRB's Road Safety Risk Manager (DTEI 2007a).

3.2.3 Tasmania

Two black spot programs operate in Tasmania. The Motor Accidents Insurance Board (MAIB) funds a program for State and local roads and selects projects purely on the basis of crash history. MAIB has allocated $3 million over the 3 years from 2006/07 – 2008/09 (MAIB 2007). The State-funded Black Spot Program in Tasmania has been allocated $2 million, specifically for black spots on local roads for the years 20006/07-2009/10. The objective of this Program is to reduce the social and economic cost of

road trauma by identifying and effectively treating locations with a high incidence of crashes (TEB 2007).

To identify potential projects for the State Program the Traffic Engineering Branch (TEB) of the Department of Infrastructure, Energy and Resources use the Crash Data Manager computer system to identify high crash locations in each municipality. The TEB also formally writes to Local Councils formally inviting them to nominate black spots for consideration and the nominations are assessed and approved by the TEB (TEB 2007). Local Councils are encouraged to jointly fund projects. There is no specific allocation for metropolitan and non-metropolitan local roads (TEB 2007).

Project eligibility for the State Program is based only on crash data as funds are not allocated to potentially hazardous locations. The required crash number for intersections and sections of road less than 3km long is three reported crashes within the last five years. For sections of road more than three km long the criteria is at least one reported crash per kilometre within the last five years. The criteria are the same for both metropolitan and non-metropolitan roads and the Program includes PDO crashes when assessing nominations. The cost of a project must be between $10 000 and $250 000 as the program focuses on low cost, high return schemes. Projects are also prioritised using BCRs but no minimum BCR for eligibility is stated in the Notes on Administration (TEB 2007).

3.2.4 Queensland

Queensland addresses the issue of black spots within the broader ‘Safer Roads Sooner’ program that aims to reduce road trauma on Queensland roads and its social consequences, by targeting road safety improvements and locations with a severe accident history. It focuses on high-benefit, low-cost road safety measures targeting high fatality and serious injury crash locations. From 2007-08 the Queensland Government will contribute $47 million per annum to this program contributing $235 million over five years (Department of Main Roads 2007).

The Safer Roads Sooner Program funding covers State roads but not local roads. Local roads are funded through local governments who apply for subsidies for works on local roads under the Transport Infrastructure Development Scheme. The Safer Roads Sooner Program includes both the reactive component, targeting high crash locations from data from the Queensland Road Crash Database and a proactive component, addressing potentially hazardous locations. All reactive and proactive projects are selected by the multi-sectorial Safer Roads Sooner Advisory Committee and a list recommended to the Minister. Nominations from the public or organisations are not called for. Queensland undertakes network level risk assessments of their roads to identify potentially hazardous locations and uses the Road Safety Risk Manager to prioritise projects. Although there is no proportion of funding specifically dedicated to reactive and proactive projects Queensland does undertake several proactive projects, with many being implemented on high risk, low volume/ low crash rate non-metropolitan roads (Department of Main Roads 2007).

The Safer Roads Sooner Project has no maximum funding limit for projects and one project can take place over several locations. This allows the funding of mass action projects, over longer time periods and road lengths, often costing several million dollars such as fatigue counter-measures on isolated roads and audio-tactile marking of 1000 kilometres of State roads (Department of Main Roads 2007).

3.2.5 Victoria

Victoria has been among the most successful jurisdictions in reducing road trauma (Johnston 2006). In the past, Victoria allocated large amounts of funding to eliminating black spots. Due to the success of these programs, Victoria now spends much less State funding treating black spots and focuses on more proactive measures including creating ‘safe systems’, a concept developed in Europe, that reduce the likelihood of fatality and injury crashes.

3.2.5.1 Previous $240 million State Black Spot Program

For four years until 2003–04, Victoria had a State Black Spot Program funded from a special dividend of $240 million from the Transport Accident Commission (TAC) and a total of 1 098 projects were completed across the state. This was the largest road safety blitz conducted by any government in Australia. The public including organisations and individuals were invited to nominate projects and an independent program advisory committee considered the nominations and made recommendations to the Victorian Government.

3.2.5.2 The Grey Spot Program

Victoria currently funds a $15 million Grey Spot Program to be spent in 07/08 and 08/09 funded by the TAC aiming to improve road safety at potentially hazardous locations that do not meet traditional crash-based black spot criteria. This program particularly targets outer-metropolitan and rural intersections. These projects are identified through RSAs and there is no project maximum cost imposed. (VicRoads 2007)

3.2.5.3 Motorcycle Black Spot Program

Victoria also initiated the world's first Motorcycle Black Spot Program which is funded through the Motorcycle Safety Levy introduced to Victoria in 2002. To date, the 112 projects in the program have a value of $11.6 million and an evaluation of 51 sites showed an approximate 38% reduction in casualty crashes. This program targets locations with a history of motorcycle crashes and develops treatments that specifically address the factors contributing to these. The three components of the Motorcycle Black Spot Program are loss of control black spots/ black lengths, long route treatments and intersection black spot projects. Funding bids are developed by engineers in the VicRoads regional offices, BCRs calculated and projects submitted to the Victorian Motorcycle Advisory Council for consideration (Brennnan & Beer 2006). The specific crash criteria for each component are detailed in Table 2.

Table 3.2: Crash Criteria for Funding Under the Victorian Motorcycle Black Spot Program

Type of crash	Loss of control sites*			Intersection sites	Long routes
	Metropolitan black lengths	**Rural black lengths**	**Black spots (metropolitan and rural)**		
Crash criteria	at least 3 *loss-of-control* motorcycle casualty crashes and a rate of 2 casualty crashes per kilometre over the last 5 years.	at least 3 *loss-of-control* motorcycle casualty crashes and a minimum rate of 0.5 casualty crashes per kilometre over the last 5 years.	a minimum of 3 *loss-of-control* motorcycle casualty crashes over the last 5 years.	A minimum of 3 motorcycle casualty crashes over the last 5 years.	Routes for which the proportion of motorcycle causality crashes exceeds 11% of all casualty crashes.

**Loss-of-control black spots include intersections and lengths of road less than approx. 500 metres. (Brennan & Beer 2006)*

3.2.5.4 Safer Roads Infrastructure Program

Since the Black Spot Program, Victoria has allocated large amounts of funding to its Safer Roads Infrastructure Program. A total of $240 million was allocated over 2006-07 to 370 projects aimed at reducing run off road crashes and intersection crashes with a special focus on rural and outer metropolitan areas. Sites are identified and prioritised on the basis of their crash history and potential crash risk. This program does not invite nominations from the public and does not have a project maximum cost with several projects being implemented costing several million dollars (VicRoads 2007)

3.2.6 New South Wales, the Australian Capital Territory and the Northern Territory

NSW, ACT and the NT treat black spots within their broader road safety programs. The Roads and Traffic Authority in NSW still spends considerable funds treating black spots and NSW also offers funding programs for local councils to assist them with road safety including black spot treatment (Roads and Traffic Authority 2000). However, like Victoria, NSW and the ACT are both moving towards the 'safe systems' approach to road safety and NSW has already successfully applied these principles to safety upgrades on major corridors, the Pacific and Princes Highways.

3.2.7 A Comparison of Black Spot Funding Criteria and Programs Among the States

In summary, the WA Black Spot Program stipulates that approximately 50% of funding is spent on non-metropolitan roads and 50% on metropolitan roads (see table 3). WA designates 50% of State Black Spot funding to non-metropolitan roads to ensure they are not overlooked, as does the AusLink Program. However, in SA where 61% of road fatalities occurred on non-metropolitan roads in 2007 (DTEI 2007b), they designate 60% of State funding.

Table 3.3: Black Spot Funding Allocation in Australia

	AusLink Black Spot Program	**WA Black Spot Program**	**SA Black Spot Program**	**TAS Black Spot Program**
% funding to metro and non-metro roads	50% metro roads 50% non-metro roads	50% metro roads 50% non-metro roads	40% metro roads 60% non-metro roads	Not specified
% funding to state and local roads	Not specified	50% state roads 50% local roads	2/3 state roads 1/3 local roads	100% local roads
% proactive and reactive projects	Up to 20% proactive	50% proactive projects but this can be increased to 100% to suit need	30% proactive 70% reactive	100% reactive

The WA Black Spot Program as well as the AusLink, SA and TAS programs all use non-model based 'crash number' and 'crash frequency' (crashes per km) identification methods to establish the eligibility of projects on road sections < 3km or road lengths ≥ 3km. However, WA's program is the only one to set different crash criteria for state, local, metropolitan or non-metropolitan roads, reflecting different road volumes (see table 4). However, these criteria do not account for intra-regional variation. The number and frequency of crashes required for eligibility is higher in WA than other programs because police reported PDO crashes are included as well as casualty crashes.

Table 3.4: Crash Criteria for WA and other Australian Black Spot Programs

	WA Black Spot Program				Federal Black Spot Program	SA Black Spot Program	TAS Black Spot Program
Crash criteria for intersection or mid-block or short road section (< 3 km)	**State metro roads** 10 crashes over 5 years	**State rural roads** 3 crashes over 5 years	**Local metro roads** 5 crashes over 5 years	**Local rural roads** 3 crashes over 5 years	3 casualty crashes over a five-year period	3 casualty crashes over a five-year period	3 casualty crashes over a five-year period
Crash criteria for road length (≥ 3km)	Average of 3 crashes per km over 5 years	Average of 1 crash per km over 5 years	Average of 2 crashes per km over 5 years	Average of 1 crash per km over 5 years	An average of 0.2 casualty crashes per km per annum over a 5 year period or top 10% of sites which have a demonstrably higher crash rate than other roads in a region	An average of 0.2 casualty crashes per km per annum over a 5 year period. Or top 10% of sites which have a demonstrably higher crash rate than other roads in a region	At least 1 reported crash per km within the last 5 years
BCR	≥ 1				≥ 2	≥ 1	Not stated
Maximum project cost	$1000 000				$750 000	$1000 000	$250 000

3.3 International Black Spot Programs

Black spot programs have been used at some stage by all leading road safety countries of the world to effectively reduce serious road crashes. Internationally, they go by different names including 'hotspots', 'cluster sites' and 'hazard elimination'. Due to the success of black spot programs, some of these countries have moved their focus from treating 'spots' to mass action, area-wide or network treatments or adopted the 'safe systems' approach to road safety.

3.3.1 Canada

In Canada, Black Spot Programs are administered by the provincial governments. Alberta's Mission Possible Traffic Safety Initiative and Black Spot Program for example, identify projects through the non-model based 'crash rate' method (crashes per vehicle kilometre) as well as the specific 'crash type' method that involves examining patterns of particular road user crashes including those involving pedestrians and cyclists. However, only smaller projects such as signage, road markings and lighting can be funded through the Black Spot Program and larger infrastructure changes are funded through the regular capital program (Alberta Infrastructure and Transportation Driver Safety Research and TSI 2006). RSAs of existing roads are common in Canada and Transport Canada is currently developing national guidelines for RSAs (Transport Canada 2001).

3.3.2 United States of America (USA)

The USA has a Federal Black Spot or 'Hot Spot' Program run by the Federal Highway Administration called the Highway Safety Improvement Program (HSIP). Funding is allocated to each state based on the following factors:

- $33^1/_3$ % of funding based on lane miles of Federal-aid highways
- $33^1/_3$ % of funding based on vehicle miles traveled on lanes on Federal-aid highways
- $33^1/_3$ % of funding based number of fatalities on the Federal-aid system

It is then the state's responsibility to establish their own 'hot spot' identification process, eligibility criteria and project cost limits. The HSIP provides up to 90% of the

project funding with state or local governments providing the rest (Colorado Department of Transportation 2007).

3.3.2.1 Kentucky

In Kentucky for example, nominations for HSIP funding are invited from state and local agencies and individuals. Kentucky use non-model identification methods to set a minimum 'crash number' of 14 crashes over three years in urban areas and five crashes over three years in rural areas. In addition, model-based analysis is used to calculate a critical rate factor. This is calculated by dividing the actual crash rate by the average statewide crash rate for that particular type of road or intersection and the vehicle exposure and the location must have a critical rate factor of one or more to qualify. Projects are then prioritised according to BCR (Green & Agent 2003).

3.3.2.2 Colorado

The state of Colorado uses non-model based methods to set a minimum 'crash number' for funding of seven PDO or casualty crashes or three fatal crashes within three years. This is used in combination with model-based identification methods. To be eligible, a site must have a weighted hazard index ≥ 0. This statistic considers crash frequency, severity, traffic volume and statewide weighted crash averages for the particular class of road or intersection. Resulting positive values of the weighted hazard index indicate highway sections which have an accident frequency/severity history higher than the statewide average. A binomial probability of $\geq 90\%$ is then required. This measure calculates whether there is a crash pattern in terms of crash types or characteristics and susceptibility to correction (Colorado Department of Transportation 2007).

3.3.2.3 Texas

Several smaller Black Spot Programs are also run within the states of the USA, for example the Houston-Galveston Area Council (H-GAC) Traffic Safety Program in Texas (Levine 2006). The H-GAC uses Geographic Information Systems (GIS) to spatially analyse serious crash locations including injuries, fatalities and property damage where at least one vehicle is towed. This is one of the few GIS based crash

information systems in the US. Projects are selected by the H-GAC according to the 'crash rate' method (crashes per 100 million vehicle miles traveled). There is no set maximum cost for projects and costs are split with local governments but in no particular proportion. H-GAC also conducts crash analyses for specific crash 'themes' and 'types' including bicyclists and pedestrians. Road safety audits of existing roads are not very common in the US and only a few states actively use them. However, the H-GAC actively conducts safety analyses on road corridors in Texas (Levine 2006).

3.3.3 New Zealand

New Zealand have run a Federal Black Spot or 'Cluster Site' Program called the Crash Reduction Study Programme since 1985 and in many areas, most 'cluster sites' have been treated and few remain. Therefore, emphasis has shifted to projects over whole routes, corridors, networks or preventing particular crash types (Land Transport New Zealand (LTNZ) 2004). However, Road Controlling Authorities (RCAs) can still obtain funding from LTNZ to treat black spots and implement mass action projects. LTNZ has a Crash Analysis System containing details of all fatal, injury and PDO crashes reported to police that can be used to identify project sites on state and local roads. While RCAs can determine their own identification procedure and eligibility criteria, LTNZ suggest a 'crash number' threshold of 3-5 crashes over 5 years (LTNZ 2004). Proactive RSAs also form a key element of NZ's road safety programs, although are not covered under the Crash Reduction Study Programme.

3.3.4 Austria

Austria conducts black spot treatments as part of their Road Safety Programme. They use the non-model based 'crash rate' (crashes per vehicle kilometre) identification method to identify black spots and also conduct specific analyses on different subsets of crash 'types' and 'themes' to identify further black spots (Sorensen 2007).

3.3.5 Belgium

Black spot programs are currently undertaken in all regions of Belgium. For example, in Flanders approximately 800 sites were considered dangerous and 100 million euros invested from 2003- 2007 to tackle these. GIS technology and the 'crash number'

method is used to identify black spots. The minimum crash criteria is three or more fatal or injury crashes over 3 years at an intersection or 100m road segment. In addition, injury weighting values are used and a priority value (P) of ≥ 15 is required for eligibility (see figure 4) (Geurts 2006).

Figure 3.4: Formula for Calculating a Site's Priority Value (P) in Belgium

P = 1L + 3S + 5D	L – lightly injured persons S – severely injured persons D – deadly injured persons

Road safety audits of existing roads, commonly called Road Safety Inspections are also commonly conducted in Belgium but separately to the Black Spot Programs.

3.3.6 Denmark

In Denmark, black spot or 'hot spot' work is undertaken by the Road Directorate, regional authorities and some local authorities on each of their respective roads. They use a model-based identification principle to identify 'hot spots', specifically a Poisson statistical method where the normal expected number of crashes is estimated through regression analysis under the assumption that crashes follow a Poisson binomial distribution. This method is used in combination with the non-model based 'crash number' method to establish a minimum threshold of four crashes in 5 years (Sorensen 2007).

3.3.7 Germany

In Germany, it is the responsibility of Local Accident Commissions to identify, investigate and solve black spots within their jurisdiction. Although these Commissions determine their own black spot identification methods, suggested 'crash number' criteria include three fatality or serious injury crashes in the past three years or five injury crashes in the past three years. Use of the specific crash 'type' method targeting

locations with five or more similar crashes in one year is also suggested (Sorensen 2007). Road Safety Inspections are conducted regularly on a 2 or 4 year basis, depending on road type in Germany.

3.3.8 Portugal

Black spot programs in Portugal use the model-based Empirical Bayes statistical method to identify black spots, considered to be state-of-the-art. For this approach, the local expected number of crashes is estimated by weighting the registered and the model estimated number of crashes. The non-model based 'crash number' method is used in conjunction with this to set a minimum number of crashes for eligibility (Sorensen 2007).

3.3.9 United Kingdom (UK)

In the UK, the approach to road safety planning is now moving towards whole route and area treatments as the majority of black spots have been eliminated. In Scotland however, the Moving Cursor Programme still identifies and treats 'accident cluster sites' which meet or exceed the 'crash number' criteria of three casualty crashes within three years in a 100m radius (Transport Scotland 2007). In England, local authorities now receive a single block allocation for road safety schemes that can be used according to locally determined priorities. These authorities are responsible for the identification of remaining black spots within their jurisdictions. While they establish their own eligibility criteria, The Department for Transport recommends they use non-model methods of both 'crash rate' and 'crash number' as well as examining specific 'types' of road user crashes (Department for Transport 2000). The concept of RSAs originated in England in the 1980s (van der Kooi 1999) and although they are not used in specific black spot programs, they have now become a well-accepted, widespread practice in reviewing the road network in the UK by all levels of government.

3.3.10 Sweden and Norway

Sweden and Norway's international road safety position has always been at the forefront and they no longer undertake large scale black spot programs because they have been largely eliminated through past initiatives. Currently, The Public Roads

Administration in Norway has set up accident analysis groups in several counties to analyse and treat specific crashes including fatal, heavy vehicle and pedestrian crashes. These groups decide project 'crash number' criteria (Ministry of Transport and Communications 2002).

In 1997, Sweden adopted the systematic, proactive 'safe systems' approach to road safety and initiated the somewhat controversial vision 'Vision Zero'. They were followed by Norway in 2000. 'Vision Zero' is the vision that that eventually, no-one will be killed or seriously injured within the road transport system. The 'safe systems' approach theorises that humans are fallible and bound to make mistakes and road design should be 'forgiving' to this. Responsibility for road crashes is ascribed to road authorities as well as road users (Elvebakk 2007).

The principles underlying Vision Zero include:

- the designers of the system are always ultimately responsible for the design, operations and use of the road transport system, and are thereby responsible for the level of safety within the entire system
- Road users are responsible for following the rules for using the road transport system set by the system designers
- If road users fail to obey these rules due to lack of knowledge, acceptance or ability, or if injuries do occur, the system designers and required to take the necessary further steps to counteract people being killed or seriously injured
  (Commuter Security Group 2006)

Sweden and Norway are designing all new and existing road construction so that incidents causing fatality or serious injury are 'impossible' through physical barriers such as guard rails or subways. Roads that are not currently constructed according to these principles should have sufficiently low speed limits to avoid death or serious injury. The goal is that eventually the entire road system should meet the requirements of Vision Zero (Commuter Security Group 2006).

3.3.11 The Netherlands

The Netherlands, another world leader in road safety, began black spot or 'road crash concentration' identification and treatment in the 1970s. The focus then moved to treating 'dangerous situations' including routes, areas and specific crash types. Today, in the Netherlands it is considered that a black spot approach can no longer make a substantial contribution to further road safety improvement. This is because there are ever fewer black spots and ever fewer casualties at these locations. However, on a smaller level, Provincial Road Administrators do still use the black spot approach as required and set their own 'crash number' thresholds. Like Sweden and Norway, the Netherlands has also adopted the proactive 'safe systems' approach to road safety through their 'Sustainable Safety' vision (Traffic Research System 2000).

Interestingly, the Netherlands have not been common users of road safety audits but with the introduction of 'Sustainable Safety' they have developed the Sustainable Safety Indicator (DV-meter). This indicator uses quantitative scores to indicate the extent to which the characteristics of the road design correspond with the 'safe systems' requirements (Institute for Road Safety Research 2007).

3.3.12 Summary

Table 3.5 provides a summary of the various black spot identification principles and criteria used by the above mentioned countries.

Table 3.5: Crash Based Identification Methods and Criteria Around the World

Country	Identification Principle*	Method*	Minimum crash criteria
Australia (Federal and state programs)	• specific (SA and VIC) • non-model based	• crash type • crash number • crash frequency	• see table 4
Canada	Combined principles • specific • non-model based	• crash type • crash rate	• Not available
USA Kentucky	Combined • non-model based • model based	• crash number • category analysis	• Urban: 14 crashes over 3 years, Rural: 5 crashes Over 3 years • Critical rate factor > 1
Colorado	Combined • non-model based • model based	• crash number • traditional approach	• 7 PDO or casualty crashes or 3 fatal crashes over 3 years • Weighted hazard index ≥ 0 • Binomial probability of ≥ 90%
Texas	Combined • specific • non-model based	• crash type • crash theme • crash rate	• Not available
New Zealand	• non-model based	• crash number	• determined by Road Controlling Authority. LTNZ recommends 3-5 crashes over 5 years
Austria	Combined • specific • non-model based	• crash type • crash theme • crash rate	• Not available
Flanders (Belgium)	• non-model based	• crash number	• 3 or more casualty crashes over 3 years per intersection or 100m road segment
Denmark	Combined • model based • non-model based	• traditional approach (Poisson) • crash number	• 4 crashes over 5 years
Germany	Combined • specific	• crash theme	Recommended criteria: • 5 similar crashes at a

	• non-model based	• crash number	location in the past year • 3 fatal or serious injury crashes in the past 5 years or: • 5 injury crashes over the past 3 years
Portugal	Combined • model based • non-model based	• modern approach (Empirical Bayes) • crash number	• Not available
UK Scotland England	• non-model based Combined • specific • non-model based	• crash number • crash type • crash number • crash rate	• 3 casualty crashes over 3 years in a 100m radius • determined by local authorities.
Sweden	No longer conducts black spot programs		
Norway	• non-model based (followed by a model based ranking)	• crash number	• determined by accident analysis groups
Nether-lands	• non-model based	• crash number	• determined by provincial road administrators

* Identification principles and methods are defined in table 6

3.4 Identification of Black Spots and Crash Criteria-Best Practice Guidelines

3.4.1 European Commission Report

The European Commission has funded a project named 'Black Spot Management and Safety Analysis of Road Networks- Best Practice Guidelines and Implementation Steps' (Sorensen 2007). Current approaches to black spot treatments differ from country to country and lack standardised definitions and methods. The above report takes into consideration the black spot approaches considered state-of-the-art from a theoretical point of view, evaluates how practical these are in terms of resources available and recommends currently more realistic best practices. The report describes best practices for both black spot and network management and differentiates between these based on road length. WA and Federal programs combine these principles by targeting black spots and black lengths within the same Programs.

3.4.2 Identification Principles for Black Spots

Sorensen (2007) reviews several methods for identifying black spots using crash based principles (see Table 6).

Table 3.6: Black Spot Identification Principles (Sorensen 2007)

<table>
<tr><th colspan="3">Crash based principles</th><th rowspan="2">Not crash based principles</th><th rowspan="2">Combination</th></tr>
<tr><th>Non-model based</th><th>Model based</th><th>Specific</th></tr>
<tr><td><u>Crash Number</u>
The absolute number of crashes for road elements with the same length</td><td><u>Category analysis</u>
The actual number of crashes divided by the average number of crashes in a predefined category</td><td><u>Theme</u>
Eg
- Head on crashes
- Run off road crashes</td><td><u>Road Information</u>
Eg.
- Road geometry
- Sight distance
- Friction
- Fixed obstacles
- Guardrails</td><td>Combination of methods from the same principle</td></tr>
<tr><td><u>Crash Frequency</u>
Crashes per km</td><td><u>Traditional approach</u>
The normal expected number of crashes is estimated through regression analysis done under the assumption that crashes follow a Poisson or negative binomial distributon</td><td><u>Type</u>
Eg
- Pedestrian
- Bicyclist
- Motorcyclist</td><td><u>Traffic Information</u>
Eg.
- Speed limit
- Variation and changes in speed
- Traffic volume
- Distribution and distances between vehicles
- Near misses</td><td rowspan="4">Combination of methods from different principles</td></tr>
<tr><td><u>Crash Rate</u>
Crashes per vehicle km</td><td rowspan="3"><u>Modern (Empirical Bayes) approach</u>
Local expected amount of crashes are estimated by weighting the registered and the model estimated number of crashes</td><td rowspan="3"><u>Severity</u>
Eg
- Fatalities
- Injury crashes</td><td rowspan="3"><u>Driver Information</u>
Eg.
- Cognitive capacity
- Driver expectations</td></tr>
<tr><td><u>Crash Frequency-rate</u></td></tr>
<tr><td><u>Change</u>
Change in frequency, rate or number of crashes</td></tr>
<tr><td><u>Combination</u>
Combination of the above methods</td><td></td><td></td><td></td><td></td></tr>
</table>

Reactive crash analysis is still considered the best indicator of black spots because proactive methods have not yet been extensively researched and developed.

Model-based methods are rated as best practice for black spot identification by Sorensen (2007) because they use statistical techniques that take into account systematic variation determined by general road design and traffic volume as well as random variation. Model-based methods considered best from are theoretical point of view are as follows:

1. The Empirical Bayes technique (for more information on this technique see Congdon, 2007)
2. Traditional approaches including the Poisson or Negative Binomial Distribution
3. Category analysis

A weakness of these model based methods however, is that they require comprehensive and connected crash, road and traffic data. If such extensive data is not available, the report recommends using non-model based methods of identification.

The best non-model based black spot identification methods are ranked by Sorensen (2007) as follows:

1. Crash frequency-rate
2. Crash rate
3. Crash frequency
4. Crash number

4. DISCUSSION

The significant findings from the review are discussed below.

4.1 Black Spot Nomination Process

The State Black Spot Program in WA and the AusLink Program receive nominations from local government and the community to identify black spots for funding. While some states in Australia also involve the community in this process, around the world, black spots are more commonly identified solely by the government. The Hitari-Hatto method initiated in Japan, views this involvement of road users and their personal experiences in traffic safety programs as positive (Fukuda et al 2005).

4.2 Division of Funding

4.2.1 Metropolitan and Non-metropolitan Roads

Some rural groups in Australia consider that the crash criteria for black spot programs have a built-in bias against non-metropolitan projects due to their low traffic volume and concentration of crashes, despite these roads having a more hazardous environment (Road Safety Committee (RSC) 2002). In 2005 in WA, 56% of road fatalities occurred on non-metropolitan roads despite only a quarter of the population living in regional areas (Hill et al. 2007). WA designates 50% of State Black Spot funding to non-metropolitan roads to ensure they are not overlooked, as does the AusLink Program. However, in SA where 61% of road fatalities occurred on non-metropolitan roads in 2007 (DTEI 2007b), they designate 60% of State funding.

Currently there is debate in WA whether 50% of funding is adequate to meet the needs of non-metropolitan roads or if they should receive a larger portion of the funding. Therefore, the distribution of Black Spot Program funding to metropolitan and non-metropolitan areas of WA should be reviewed. Investigation into current crash patterns and crash severity in both of these areas is required to determine how funding should be distributed to produce optimum safety benefits.

4.2.2 Local and State Roads

In WA, local government managed roads make up 88% of the road network and 65% of serious crashes occur on these roads (Road Safety Council 2004). WA's State Black Spot program allocates 50% of funding to local roads. Other states allocate funding very differently. SA for example, only designates one third of its black spot funding to local roads though they make up 75% of their road network. Tasmania, on the other hand allocates its whole State Black Spot funding to local roads which make up 80% of their network. It is possible when considering local government financial contributions to black spot projects, the lower volume of traffic and the overall lower cost of treatments on local roads, that 50% of Black Spot funding is adequate. However, further investigation into crash patterns and severity is again required to determine how to best distribute funding.

4.3 Best Practice: Model Based Methods of Identification

The WA and Australian programs use non-model 'crash number' and 'crash frequency' (crashes per kilometre) methods as criteria for funding. Disadvantages of these methods are that they tend to detect more sites with higher traffic volumes (Geurts et al. 2006) and do not take into account systematic and random variation, potentially producing high numbers of false positives and false negatives (Sorensen 2007, Cheng & Washington 2005). However, a strength of these non-model based methods is that they are easy to use and understand which is important for WA's program that receives nominations from local governments and the public. The adoption of complex models for Black Spot identification could make local government and community participation difficult. The amount of integrated crash, road and traffic data required to implement an Empirical Bayes method means this is highly resource intensive and may be currently unrealistic for WA and its vast road network. WA's program is unique in that it specifies different crash criteria for state, local, metropolitan and non-metropolitan roads which is very positive in reducing some of the possible bias against lower volume road black spots. However, these criteria do not take intra-regional road volume variation into account. Several countries including Canada, USA, Austria and

the UK use a ‘crash rate’ method (crashes per vehicle kilometres) which is considered better practice than ‘crash number’ or ‘crash frequency’ to identify black spots (Sorensen 2007).

It is possible that WA could work towards collecting enough traffic data to use ‘crash rate’ or ‘frequency-rate’ methods and eventually implement the model-based state-of-the-art Empirical Bayes method of identification.

4.3.1 Crash Criteria

The majority of black spot programs reviewed set specific ‘crash number’ criteria for funding. Colorado, Denmark and Portugal, who use model based methods also additionally set a minimum ‘crash number’ criteria. Using a combination of principles such as this is considered positive as it makes use of the different methods’ advantages and compensates for their disadvantages (Sorensen 2007). The literature indicates that actual crash criteria used should depend on the type of road, traffic volume, general traffic safety level and funding available for black spot treatment (Sorensen 2007). The actual crash criteria vary widely from program to program and there are no correct or incorrect criteria. The WA state program has taken these factors into account in that it has devised different criteria for different roads. Again however, these criteria do not take into account variations in traffic volume within regions.

4.3.2 Crash Severity

Some of the black spot programs reviewed include measures of crash severity to determine project eligibility including Colorado and Flanders, Belgium. Sorensen (2007) states that it is best practice to include crash severity in network assessment (black lengths) but not in spot identification because longer sections of road with a higher number of crashes permit a more meaningful consideration of crash severity. Severity should also be considered when prioritising black spots and black lengths, ie in the BCR calculation. The WA Program only weights crashes by crash type cost when calculating the BCR rather than by severity, eg. head on or rear end crashes and it

would be worthwhile to investigate the value of using crash severity weightings in black length identification and all BCR calculations.

4.4 Prioritisation of Projects Nominated on Crash Data

BCRs have been used throughout Australia and the world to rank and prioritise Black Spot projects. This formula identifies whether the site is amenable to treatment and if the location exhibits significant correctable crashes for the treatment and cost to be worthwhile (ANAO 2007). BCR's are a useful tool if managed correctly. An audit of the AusLink Black Spot Program highlighted the importance of including the whole project cost in the BCR calculation as well as only including types of crashes that the proposed treatment would address so that an accurate reflection of the treatment's effect could be achieved. The audit also indicated that WA calculated BCRs correctly (ANAO 2007). The State Black Spot Program's BCR requirement of ≥ 1 allows greater scope of projects than the AusLink Programs' requirement of ≥ 2.

4.5 Crash Data and Crash Recording Systems

WA, like the other states has a detailed crash data recording system, called the Integrated Road Information System (IRIS). However, an audit of the AusLink Program identified inaccurate recording of location of road crashes as an ongoing issue common to all states (ANAO 2007). Internationally, including in Texas and Belgium, Geographic Information Systems (GIS) are being used to identify black spots and spatially analyse crash locations. GIS technology can provide mapping and visualisations, show interactions between several roads and analyse crash risk (Levine 2006). Although GIS methods are not reviewed in Sorensen (2007), GIS appears to have many advantages over other crash recording methods.

The State Program crash criteria requires crash data for the previous five years. While many international programs only use three years of data, a five year period provides statistical reliability and should be maintained (ANAO 2007). WA also includes PDO crashes in its analysis. This data is available due to the mandatory reporting of crashes to police if property damage exceeds $1000 in WA. Due to variations in mandatory

reporting laws around Australia and the world, only some black spot programs, such as Tasmania's, include PDO data. Previous research has found that whether a crash causes a casualty or not is, in some instances, a question of chance (RSC 2002). Therefore ignoring PDO crashes may give a misleading picture of the nature of crash problems at a black spot (ANAO 2007). With the recent increase in vehicle safety protection, a crash that might previously have resulted in injury, now may result only in property damage (RSC 2002). It is therefore positive that WA includes PDO crashes in its criteria so that warning signs for potential casualty crashes are not missed and a wider scope of projects can be funded than with the AusLink Program.

4.6 Black Spot Programs Targeting Specific Road Users

Black spot programs targeting specific, vulnerable road users are being initiated in Australia and around the world. For example, South Australia dedicates 10% of its State Black Spot funding to cycling black spots and Victoria has initiated the Motorcycle Black Spot Program. Such road users are often overrepresented in serious crash statistics but experience too few crashes to be ranked as a priority for funding. In WA, motorcyclists for example, are 29 times more likely to be fatally injured than operators of other vehicles traveling the same distances and bicyclists, are 5.6 times more likely to be injured in police reported crashes (Hill et al. 2007). Sorensen (2007) does not recommend these specific methods as best practice in Europe as they are resource intensive, and may result in the failure to identify other safety problems at a location. However, WA should investigate if it would be feasible and cost effective to introduce targeted Black Spot Programs particularly for motorcyclists.

4.7 Potentially Hazardous Locations

While all leaders in road safety conduct proactive infrastructure safety projects, Australia is the only country reviewed that addresses potentially hazardous locations identified through a RSA within its black spot programs. While the AusLink and SA State Black Spot Programs only allocate 20% to 30% of their budgets to proactive projects, WA can allocate up to 100%. This method of identification is highly relevant to WA due to its large area and long stretches of remote roads. These allocations are

very positive in balancing the bias inherent in black spot crash frequency criteria against low volume rural and local roads where crashes are more dispersed.

In WA, over 45 per cent of all fatal crashes are single vehicle run off the road crashes on non-metropolitan roads (Office of Road Safety 2007). Due to the nature of these crashes and the fact they are often influenced by fatigue, they are usually dispersed over a long stretch of road rather than clustered. Although this type of crash is targeted by WA's Safer Roads Program, the proactive component of the State Black Spot Program allows particularly dangerous roads that do not meet crash criteria to be identified and prioritised for more urgent funding and treatment.

4.8 Use of Road Safety Audits

The RSA was first used in England in the 1980s and RSAs of existing roads have been widely used in Australia, New Zealand and much of Europe since then (Van der Kooi 1999). In the past, US highway agencies have been skeptical about their value, possibly due their relatively time-consuming, resource-intensive nature and their vast road network spanning nearly 6.5 million km, however their use is increasing. Sorensen (2007) indicates that proactive methods of identification such as RSA should be further explored and are particularly important for identifying hazards on road networks or black lengths.

Road safety design audits, conducted at various stages of a construction project have shown to cost only a small fraction of the entire project and be highly cost-effective (Austroads 2001). For RSAs on existing roads, a leading traffic safety consultancy estimated that 30% of hazards identified during a road safety audit will lead to a crash within 5 years unless they are conclusively eradicated (European Union Road Federation 2005). Various organisations around the world are working to modify and improve RSAs. In Australia, the ARRB Group, in collaboration with the Queensland Roads Alliance have developed a network assessment process called NetRisk that uses a set of trigger points to prompt investigation of the most hazardous road sites. In addition, the Road Safety Risk Manager can assess and prioritise RSA

recommendations and over 60 treatment options. The South Coast Hinterland District in Queensland assessed hundreds of kilometers of roads and 84 intersections using this instrument and found that several sections with higher risk scores were located on low volume roads with low crash rates prone to be overlooked in more common reactive road safety treatment assessments (Grant et al. 2006).

RSAs are emerging as an effective tool for identifying safety issues on existing roads and currently, they are the best tool available for identifying potentially hazardous locations. With the gradual adoption of the 'safe systems' approach in WA, RSA instruments that measure the extent to which the characteristics of the road design correspond with 'safe systems' requirements will need to be developed. The Netherlands have developed one such instrument called the Sustainable Safety Indicator (DV-meter) (Institute for Road Safety Research 2007).

4.9 Project Funding Thresholds

Under the WA State Black Spot program, projects are required to have a total cost under $1 million dollars, more than the $750 000 limit of the AusLink Program. Although the State Black Spot Program aims to deliver low cost, highly effective treatments, it is likely that the $1 million threshold will become restrictive. WA has experienced the highest rate of construction cost inflation in Australia with costs increasing at a rate of at least 13% per annum in previous years and they are set to increase even further with rising oil prices and labour costs (Macromonitor 2008). Some of the most expensive black spot projects include installation of traffic lights and roundabouts and constructing extra lanes or overtaking lanes. If a project treatment requires a combination of treatments, they could exceed the one million dollar threshold.

In addition, a particular problem area for WA is run off road crashes in rural areas. Typical treatments for these crashes often need to be applied over long stretches of roads such as improving road alignment, shoulder sealing, anti-skid treatments and removing roadside obstacles (Johnston et al. 2006) and depending on the required

distance, could cost over one million dollars. Although most mass-action treatments are delivered through WA's Safer Roads Program, the cost threshold could prevent these particular potentially hazardous locations from being eligible under the Black Spot Program.

The audit of the AusLink Black Spot Program revealed that there were many instances where completed costs were significantly higher than the approved cost, possibly making the project BCR ineligible or uncompetitive (ANAO 2007). These problems also affect the WA Program. While construction work is by nature, subject to variation from estimate to actual cost, the increasing cost of construction and delays due to labour shortage would have contributed to these higher costs. It is also possible that the BCRs provided by Main Roads' CRASHtool may be outdated.

4.10 Strengths of the WA State Black Spot Program

This review of the WA State Black Spot Program and comparison with Australian and International black spot programs revealed several positive features of the WA Program. These include:

- A public nomination process.
- The allocation of specific proportions of Program funding to metropolitan, non-metropolitan, local and State roads.
- Inclusion of both reactive projects identified on the basis of crash data and potentially hazardous locations identified on the basis of RSAs in the Program.
- Flexibility of the Program guidelines to allow up to 100% of funding to be allocated to potentially hazardous locations identified on the basis of a RSA if this suits need.
- Different crash criteria for funding eligibility for different types of roads in WA including metropolitan, non-metropolitan, local and State roads.
- Use of crash data from the previous five years provides statistical reliability and should be maintained.

- Inclusion of PDO crashes as well as casualty crashes in the crash criteria.
- Use of the BCR to prioritise projects nominated on the basis of crash data.

4.11 Areas for Further Consideration

This review and comparison with world-wide black spot programs has also uncovered several areas, procedures or methods worthy of further investigation. If more effective methods of distributing funding or identifying black spots are deemed feasible for the WA Program, modifications could be made. These include:

- The distribution of State Black Spot Program funding to metropolitan and non-metropolitan areas of WA should be reviewed. Investigation into current crash patterns and crash severity in both of these areas is required to determine how funding should be distributed to produce optimum safety benefits.
- The distribution of State Black Spot Program funding to State and Local roads should be reviewed and requires investigation into crash patterns and severity on these roads.
- WA should investigate the feasibility of using better non-model based techniques to identify black spots including 'crash rate' (crashes per vehicle kilometre) or 'frequency-rate' and eventually work towards collecting enough traffic data to implement the model based state-of-the-art Empirical Bayes method of identification.
- It would be worthwhile to include crash severity weightings in BCR calculations for *prioritising* projects on both black spots and black lengths. Severity should be divided into three categories; fatal and serious injuries, slight injuries and PDO crashes. Crash severity weightings should also be used to *identify* black lengths but not spots.
- Geographic Information Systems appear to have many advantages over other crash recording systems and this option should be investigated.
- The feasibility and cost effectiveness of targeting black spot funding to specific road user groups such as cyclists, pedestrians or motorcyclists should be investigated. This may be particularly relevant for motorcyclists.

- While RSAs are currently the best tool available for identifying potentially hazardous locations, the WA Program should remain aware of new instruments being developed that incorporate the ‘safe systems’ requirements.

5. CONCLUSION AND FUTURE DIRECTIONS

As leading countries in road safety have begun to eliminate the majority of their black spots, they have decided it is more cost effective to gradually move the emphasis to mass action, route, area or network infrastructure treatments. Sweden, Norway and the Netherlands have all adopted the 'safer systems' approach to road safety. WA, along with Victoria and NSW are all looking to adopt the 'safe system' approach and WA's new 2008-2012 strategy aims to begin 'safe system' transformation of metropolitan intersections and routes radiating from Perth and key rural centres. These projects will be funded, complementary to the current State and AusLink Black Spot Programs and Safer Roads Program (Corben et al. 2007).

While some European countries have been able to eliminate their large-scale black spot programs, WA's vast road network and comparatively low population may mean that several black spots remain, making the continued treatment of black spots still important and beneficial. The State Black Spot Program remains vital, alongside mass action and 'safe systems' approaches to reduce casualty crashes in WA. However, the Program's guidelines and procedures need to be constantly reviewed and updated to ensure maximum benefits. As time progresses, the benefits of treating remaining black spots will reduce so ongoing evaluations are required to determine when the Program is no longer useful.

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