iRAP Cayman Islands

Technical Report

About iRAP

The International Road Assessment Programme (iRAP) is a registered charity dedicated to saving lives through safer roads.

iRAP works in partnership with government and non-government organisations to:

- inspect high-risk roads and develop Star Ratings and Safer Roads Investment Plans,
- provide training, technology and support that will build and sustain national, regional and local capability, and
- track road safety performance so that funding agencies can assess the benefits of their investments.

The programme is the umbrella organisation for EuroRAP, AusRAP, usRAP and KiwiRAP. Road Assessment Programmes (RAP) are now active in more than 70 countries throughout Europe, Asia Pacific, North, Central and South America and Africa.

iRAP is financially supported by the FIA Foundation for the Automobile and Society and the Road Safety Fund. Projects receive support from the Global Road Safety Facility, automobile associations, regional development banks and donors.

National governments, automobile clubs and associations, charities, the motor industry and institutions such as the European Commission also support RAPs in the developed world and encourage the transfer of research and technology to iRAP. In addition, many individuals donate their time and expertise to support iRAP.

For more information

This report was written by:

Morgan Fletcher, Senior Road Safety Engineer, iRAP (morgan.fletcher@irap.org)

Julio Urzua, Regional Director Latin America and the Caribbean, iRAP (julio.urzua@irap.org)

For general enquiries, contact us at:
International Road Assessment Programme (iRAP)
Worting House, Basingstoke
Hampshire, UK, RG23 8PX
Telephone: +44 (0) 1256 345598
Email: icanhelp@irap.org

To find out more about the programme, visit www.irap.org.

You can also subscribe to 'WrapUp', the iRAP e-newsletter, by sending a message to icanhelp@irap.org.

iRAP is registered in England & Wales under company number 05476000.
Registered Office: 60 Trafalgar Square, London, WC2N 5DS.

iRAP503.20.3 September 2014

Document Version History

Version	Date	Description
iRAP503.20.1	18-07-2014	
iRAP503.20.2	08-09-2014	
iRAP503.20.3	15-09-2014	iRAP Cayman Islands Technical Report

1 Executive Summary

As part of efforts to curb road deaths and serious injuries, the Cayman Islands National Road Authority (NRA) invited the International Road Assessment Programme (iRAP) to assess the safety of Cayman Islands roads. During this first assessment of Cayman Islands roads, over 200km of roads were assessed, comprising the entire arterial and collector road networks, some local roads in addition to one new road design. This technical report describes the road assessment project in the Cayman Islands and includes details on data collection, the methodology used and a summary of the results.

The infrastructure-related risk assessment involved detailed surveys and coding of 50 road attributes at 100 metre intervals along the network and creation of Star Ratings, which provide a simple and objective measure showing the level of risk on the road network. The star ratings show that 11% of road length is rated as 5-star, 30% is rated as 4-star, 38% is rated as 3-star, and the remaining 22% is rated as 2-star and below for vehicle occupants. For motorcyclists, 8% of road length is rated as 5-star, 15% is rated as 4-star, 50% is rated as 3-star, and the remaining 27% is rated 2-star and below. For pedestrians 1% of road length is rated as 5-star, 5% is rated as 4-star, 21% is rated as 3-star and 27% is rated 2-star and below, while 46% of the network is not expected to receive significant pedestrian flow on a regular basis. For cyclists 17% of road length is rated as 5-star, 15% is rated as 4-star, 34% is rated as 3-star and 22% is rated 2-star and below, while 13% of the network is not expected to receive significant bicyclist flow on a regular basis.

Table 1 Star Ratings, Cayman Islands

	Vehicle Occupant		Motorcycle		Pedestrian		Bicycle	
Star Ratings	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
5 Stars	22.4	11%	15.4	8%	1.1	1%	34.0	17%
4 Stars	61.1	30%	30.6	15%	10.7	5%	30.2	15%
3 Stars	77.9	38%	102.7	50%	44.0	21%	70.0	34%
2 Stars	38.0	19%	45.4	22%	36.8	18%	41.1	20%
1 Star	5.8	3%	11.1	5%	18.7	9%	4.2	2%
Not applicable	0.0	0%	0.0	0%	93.9	46%	25.7	13%
Totals	205.2	100%	205.2	100%	205.2	100%	205.2	100%

Note: the table shows 'smoothed' Star Ratings.

The road attribute data show that the majority of the survey was conducted along the single carriageway network, with physical separation between opposing flows only present on a number of key routes. Roadside hazards are numerous, with approximately 90% of the survey length having hazardous objects within 5m of the running lane and limited road side protection (such as safety barriers). However, the road authority has recognised these deficiencies when setting the posted speed limits, which, combined with operating speeds not greatly exceeding the posted speed limits, has resulted in more than three- quarters of the network achieving a 3 star rating or better for vehicle occupants.

Provision for vulnerable road users, however, is poor on many roads, with limited and often discontinuous sidewalks and crossing facilities where pedestrian numbers are high.

The project also involved the creation of Safer Roads Investment Plans, which draws on more than 90 proven road safety treatments, ranging from low cost road markings and pedestrian refuges to higher cost intersection upgrades and full highway duplication.

The two Safer Roads Investment Plan options in this report prioritise countermeasure options that could maximise the prevention of deaths and serious injuries within the available budget. The plans largely focus on:

- reducing the risk associated with run-off road crashes by improving shoulders and reducing the severity of roadsides
- reducing the risk associated with head-on crashes by reducing the opportunity for vehicles to cross into the path of oncoming vehicles
- improving safety for all road users at intersections
- providing facilities for pedestrians and bicyclists.

Table 2 below shows that for the most comprehensive SRIP (Plan 1), an investment of $114 million KYD could reduce the number of deaths and serious injuries on the road by 35%, preventing approximately 530 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 3:1. Plan 2 shows that, by investing $51 million KYD, the number of deaths and serious injuries on the road could be reduced by 29%, equivalent to a reduction of approximately 430 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 6:1.

Table 2 Investment Plan options (20 year analysis)

	Plan 1	Plan 2
Present value of investment	$114 million KYD	$51 million KYD
	US$139 million	US$62 million
Deaths and serious injuries prevented	530	440
Present value of safety benefits	$384 million KYD	$316 million KYD
	US$468 million	US$385 million
Cost per death and serious injury prevented	$ 212,069 KYD	$ 115,338 KYD
	US$258,621	US$ 140,656
Benefit cost ratio (BCR)	3	6
Reduction in death and serious injuries	35%	29%

Exchange rate: $0.82 KYD = US$1 (as at February 1, 2014)

The selection of an appropriate level of investment is open for decision by the NRA and the Cayman Islands Government. Final implementation of the plan will preferably include the following steps:

- local examination of proposed countermeasures (including a 'value engineering' type workshop including all relevant stakeholders),
- detailed analysis of traffic survey and crash data (if available),
- preliminary scheme investigation studies, including site surveys and preliminary design,
- detailed design, star ratings of the designs, road safety audit, detailed costing and procurement, final evaluation and construction, and
- post-construction evaluation and road safety audit, including Star Ratings for the upgraded road and analysis of crash data (if it is available).

The detailed results of the project and online software that enabled the iRAP analyses to be undertaken are available to stakeholders for further exploration and use.

However, in order to achieve the best road safety gains on the network, efforts that go beyond the engineering improvements discussed in this report will be necessary. Significant benefits could be realised through the coordinated improvement of road user behaviour (such as speeding, seat belt and helmet wearing and driving under the influence of alcohol or drugs) and vehicles, as well as road infrastructure. The Road Safety Toolkit (http://toolkit.irap.org) and United Nations Road Safety Collaboration Good Practice Manuals provide further information on these issues.

Acknowledgments

The iRAP Cayman Islands project would not have been possible without the support of numerous people and organisations. These include:

- National Roads Authority, Cayman Islands
- Servicios Mexicanos de Ingenieria Civil (SEMIC)
- Marion Pandohie, Transportation Planner, NRA
- Edward Howard, Deputy Managing Director, NRA
- Royal Cayman Islands Police Service (RCIPS)
- Hon. D. Kurt Tibbetts, Ministry of Planning, Lands, Agriculture, Housing & Infrastructure

Contents

2 Introduction

Around the world 1.24 million people die as a result of road traffic crashes each year, that's 3,400 deaths per day, or one every 25 seconds.[1] Although many countries are reducing the number of deaths on their roads, others are experiencing an increase in the numbers of fatal and serious injuries.

With road traffic fatalities now the leading cause of death for young people aged 15 to 29 worldwide, key partners in global road safety have come together in an attempt to tackle this rapidly worsening public health crisis through accelerated investment in road safety and by fundamentally changing the way we design, build and maintain our road infrastructure networks around the world. As such, the United Nations has declared 2011-2020 the Decade of Action for Road Safety. It is expected that during the decade, significant efforts will be made to stabilise and then reduce the death toll through systematic improvements in road infrastructure, road user behaviour and vehicle safety.

2.1 Road Safety in the Cayman Islands

Road crashes cause enormous grief to victims, their families and friends. They are also often a factor responsible for tipping a household into financial distress. The loss of a wage-earner due to death or disability can be disastrous, leading a family into lower living standards and poverty. In the Cayman Islands, an average of 8 fatalities occurred per year between 2007 and 2012[2], equivalent to 14 per 100,000 population. This is in excess of the WHO's 2013 figure of 8.7 traffic deaths per 100,000 inhabitants in high income countries[3] and, as such, the impact of road trauma is very severe in the Cayman Islands.

In an attempt to reduce this figure, the Department of Vehicle and Drivers' Licensing (DVDL), the NRA, the RCIPS, Public Works Department (PWD), and Government Information Services (GIS) joined together to launch the Streetskills initiative. This initiative focused on improving driver behaviour through targeted road safety campaigns. The campaign appears to be working, with a downward trend in fatalities starting to develop in the Cayman Islands over the last 2 years, however more can be done to ensure this trend continues.

2.2 The iRAP Cayman Islands Project

To supplement the Streetskills initiative, the International Road Assessment Programme (iRAP) was contracted by the NRA in 2013 to carry out an assessment of the Grand Cayman Island road network.

The project was designed to assist the NRA assess road infrastructure-related risk on 199 km (124 miles) of roads and identify economically viable road safety countermeasures for implementation.

Also included within the scope of this project was the assessment of the proposed 3 km (2 mile) dual carriageway Airport Connector Road bringing the total length of the study to 205 km (127 miles).

[1] WHO Global status report on road safety (2013)

[2] Cayman Islands Economics and Statistics Office http://www.eso.ky/2012compendiumofstatistics.html#4

3 WHO (2013) Global Status Report on Road Safety (http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/index.html)

The project included assessments of the following roads:

Table 3 Cayman Islands surveyed road network

Road ID	Road Name	Direction	Length (Km)	Road ID	Road Name	Direction	Length (Km)
KY001	North Sound Rd	Eastbound	2.1	KY074	Bodden Rd	Eastbound	0.4
KY004	Thomas Russell Ave	Northbound	0.2	KY075	West Bay Rd	Northbound	8.4
KY006	Elgin Ave	Eastbound	0.8	KY076	Willie Farrington Dr	Northbound	0.9
KY010	Fern Cir	Clockwise	0.7	KY077	Mount Pleasant Rd	Northbound	1.1
KY011	Fairbanks Rd	Westbound	1.3	KY078	Capt Reginald Parsons Dr	Northbound	1.0
KY012	Aspiration Dr	Westbound	0.5	KY082	Church St	Northbound	0.7
KY013	Academy Way	Westbound	0.3	KY083	Stadium Dr	Northbound	0.3
KY018	Bobby Thompson Way T1	Northbound	0.1	KY086	Powell Smith Rd	Northbound	0.8
KY019	Bobby Thompson Way T2	Northbound	0.4	KY087	Birch Tree Hill Rd	Northbound	1.5
KY020	Huldah Ave	Northbound	0.3	KY088	Conch Point Rd	Eastbound	1.5
KY022	Agnes Way	Northbound	0.3	KY092	Town Hall Rd	Northbound	1.3
KY023	Lyndhurst Ave	Westbound	0.2	KY093	Fountain Rd	Northbound	0.7
KY025	Smith Rd	Westbound	1.2	KY096	North West Point Rd	Northbound	3.1
KY027	Hospital Rd	Northbound	0.2	KY097	Boatswain Bay Rd	Eastbound	0.7
KY029	Goring Ave	Northbound	0.2	KY098	Finch Dr	Eastbound	0.6
KY031	Walkers Rd	Southbound	2.9	KY102	Watercourse Rd	Northbound	1.4
KY033	South Sound Rd	Westbound	4.5	KY104	Hell Rd	Eastbound	0.7
KY035	Boilers Rd	Northbound	0.3	KY105	Rev Blackman Rd	Eastbound	0.6
KY038	South Church St	Northbound	3.2	KY106	West Church St	Eastbound	0.4
KY039	Louise Llewelly Way	Eastbound	0.1	KY107	Batabano Rd	Eastbound	1.4
KY042	Shedden Rd	Westbound	1.7	KY113	Lawrence Blvd	Eastbound	0.4
KY043	Harbour Dr	Northbound	0.2	KY114	Lawrence Blvd	Westbound	0.4
KY045	Cardinall Ave	Eastbound	0.1	KY115	Gecko Link	Eastbound	0.0
KY047	Fort St	Eastbound	0.2	KY117	Canal Point Dr	Eastbound	0.2
KY049	Albert Panton St	Southbound	0.1	KY118	Canal Point Dr	Westbound	1.3
KY052	Edward St	Northbound	0.2	KY119	Snug Harbour Dr	Eastbound	0.1
KY053	Dr Roys Dr	Eastbound	0.3	KY120	S/N 3	Eastbound	0.0
KY055	Main St	Eastbound	0.1	KY122	Jennifer Dr	Eastbound	1.1
KY058	North Church St	Northbound	1.1	KY123	S/N 5	Southbound	0.0
KY060	Mary St	Eastbound	0.5	KY124	Andrew Dr	Westbound	1.1
KY061	Eastern Ave	Northbound	1.5	KY125	S/N 4	Northbound	0.0
KY063	Mcfield Ln	Northbound	0.1	KY126	Lime Tree Bay Ave	Eastbound	0.2
KY065	Gresscott Ln	Northbound	0.1	KY127	Lime Tree Bay Ave	Westbound	0.2
KY068	School Rd	Eastbound	0.6	KY128	Esterley Tibbetts Hwy	Northbound	9.4
KY070	Rock Hole Rd	Eastbound	0.4	KY129	Esterley Tibbetts Hwy	Southbound	6.9
KY072	Godfrey Nixon Way	Westbound	0.4	KY130	Dorcy Dr	Southbound	1.2

Road ID	Road Name	Direction	Length (Km)
KY131	Crewe Rd T1	Eastbound	2.6
KY132	Crewe Rd T2	Southbound	0.6
KY133	Crewe Rd T2	Northbound	0.6
KY136	Owen Roberts Dr	Eastbound	1.1
KY138	Tropical Gardens Rd	Eastbound	0.6
KY141	Linford Pierson Hwy	Eastbound	2.3
KY142	Old Crewe Rd	Southbound	0.6
KY144	Shamrock Rd T1	Eastbound	1.7
KY145	Shamrock Rd T2	Eastbound	8.8
KY147	Shamrock Rd T1	Westbound	0.5
KY148	Selkirk Dr	Northbound	1.6
KY150	East-West Arterial Rd	Eastbound	5.1
KY151	East-West Arterial Rd	Westbound	5.1
KY153	S/N 1	Northbound	0.0
KY154	Victory Ave	Northbound	0.9
KY156	Prospect Dr	Northbound	1.9
KY158	Marina Dr	Northbound	1.8
KY160	Mahogany Way	Northbound	1.0
KY162	Mangrove Ave	Northbound	1.1
KY164	Poindexter Rd	Northbound	1.6
KY166	Spotts Newlands Rd	Northbound	0.5
KY167	Chime St	Northbound	0.3
KY170	Hirst Rd	Northbound	3.4
KY172	Rackley Blvd	Northbound	0.5
KY174	Farrell Rd	Eastbound	0.4

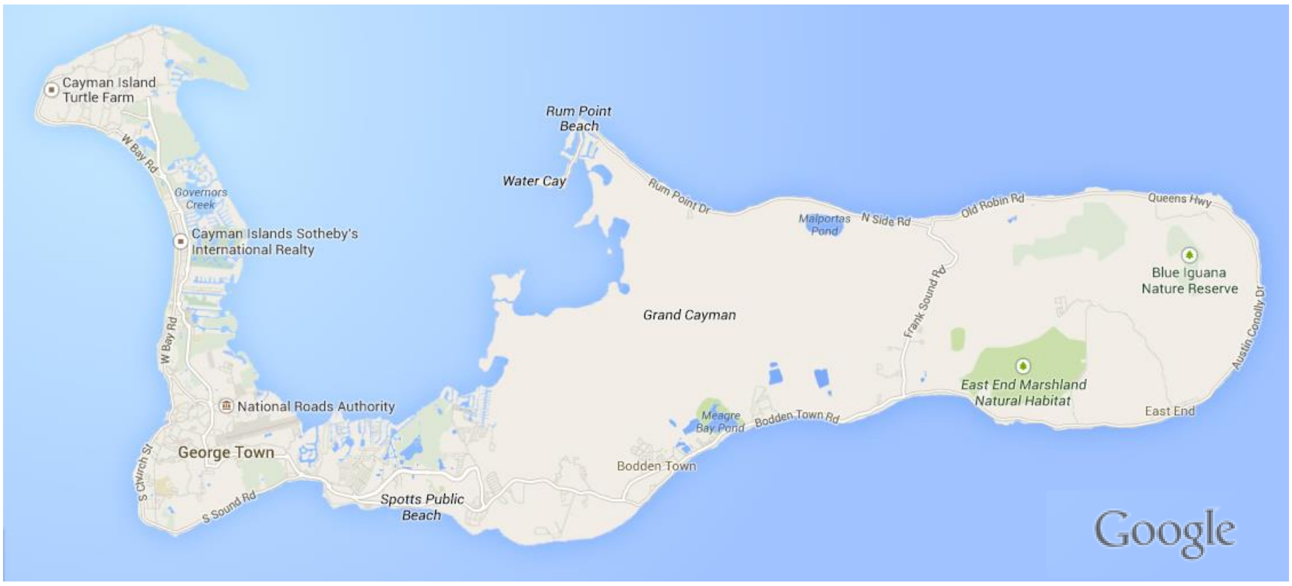
Road ID	Road Name	Direction	Length (Km)
KY176	Southward Dr	Eastbound	0.4
KY178	Leeward Dr	Northbound	1.1
KY180	Windward Rd	Northbound	1.0
KY182	Will T Rd	Northbound	1.4
KY184	Starapple Rd	Northbound	0.3
KY185	Burgundy Way	Northbound	0.0
KY188	Beach Bay Rd	Southbound	1.3
KY190	Northward Rd	Northbound	1.8
KY192	Condor Rd	Eastbound	0.4
KY193	Anton Bodden Dr	Eastbound	1.4
KY196	Bodden Town Rd	Eastbound	8.6
KY197	Frank Sound Rd	Northbound	5.7
KY199	Sea View Rd	Eastbound	8.9
KY201	John Mclean Dr	Westbound	0.3
KY203	East End Rd	Eastbound	1.5
KY204	Eastland Dr	Northbound	0.6
KY206	Austin Conolly Dr	Northbound	5.3
KY207	Queens Hwy	Westbound	4.7
KY208	Old Robin Rd	Westbound	5.1
KY209	North Side Rd	Westbound	3.9
KY210	Hutland Rd	Southbound	2.2
KY212	Rum Point Dr	Westbound	6.9
KY213	Water Cay Rd	Southbound	2.3
KY999	Airport Connector Design	NB/SB	6.4

This report provides the technical details for the assessment in the Cayman Islands including details on data collection and the methodology used along with a summary of results. The Star Rating results and Safer Roads Investment Plans shown here will assist both the NRA and design consultants in ensuring the safety of all road users is adequately addressed within the designs for the rehabilitation of these roads.

2.3 Cayman Islands

The Cayman Islands are a British Overseas Territory in the western Caribbean Sea. The territory comprises the three islands of Grand Cayman, Cayman Brac and Little Cayman, south of Cuba and northwest of Jamaica. Of the three islands, Grand Cayman contains approximately 95% of the territory's entire population and encompasses 76% of the territory's land mass. The iRAP study was limited to Grand Cayman Island.

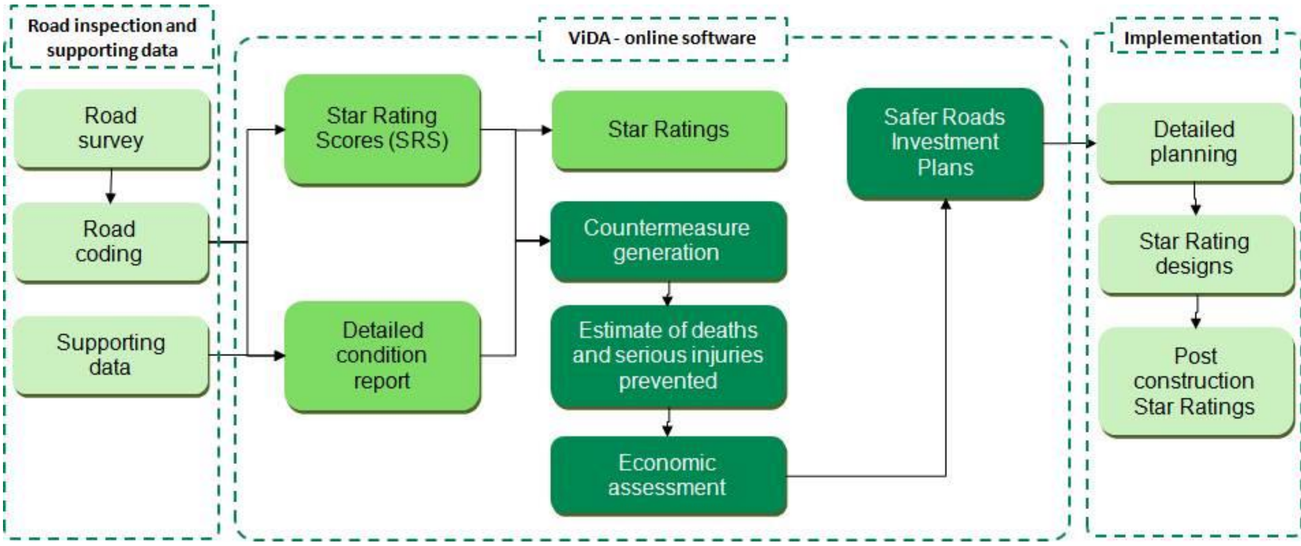
Figure 1 Grand Cayman Island



2.4 Methodology

The production of Star Ratings and Safer Road Investment Plans involve a number of data collection, survey and analysis processes, as illustrated in Figure 2. The iRAP assessments make use of road attribute data for more than 50 variables at 100 metre intervals along a road. Thus, the data collection task is large; in this project in the Cayman Islands for example, a total of 160,056 data points were recorded. These data were compiled through road surveys that collect digital images of the road using multi-view high-resolution cameras. After the images were collected, they were viewed by coders using specialised software to record the road attributes.

Figure 2 The iRAP road survey, coding, Star Rating and Safer Roads Investment Plan process



iRAP uses globally consistent models to produce vehicle occupant, motorcyclist, pedestrian and bicyclist Star Ratings and Safer Road Investment Plans. The methodology for each of these is described in:

- Star Rating Roads for Safety: The iRAP Methodology, and
- Safer Roads Investment Plans: The iRAP Methodology.

These reports are available for download at: http://irap.org/about-irap-3/methodology.

Other iRAP reference documents used in this project include:

- *The True Cost of Road Crashes – Valuing life and the cost of a serious injury,*
- *Vehicle Speeds and the iRAP Protocols,*
- *iRAP Star Rating Coding Manual v3, and*
- *Road Coding Quality Assurance Guide.*

2.5 Online Results

This report provides details of the methodology used and summarises the results produced in the Cayman Islands project. Full results, including data tables and charts, interactive maps and download files, as well as data underpinning the analyses, are available in the iRAP online software at http://vida.irap.org.

The Star Ratings and Safer Road Investment Plans shown in this report can be accessed through ViDA – the Road Assessment Programme's online analysis software. A guide to using ViDA to access the full results, plus details on how to request a User Account is available at http://downloads.irap.org/docs/ViDA_tour.pdf. The guidance document shows how the maps, charts, tables, economic analysis and download files can help to improve safe road design by improving understanding of the role that road infrastructure plays in influencing the likelihood and severity of common crash types and identifying countermeasures that will reduce risk.

Access to the iRAP online software is password protected. Usernames and passwords can be allocated to project stakeholders. For further information about accessing the results for the Cayman Islands project, contact Marion Pandohie at marion.pandohie@nra.ky.

Figure 3 ViDA login page

3 iRAP and the Safe System Approach

Road deaths and injuries are the result of a complex interaction between the way people behave on the roads, the types of vehicles in use and the speed they are travelling, and the design of the roads themselves. Despite this complexity, the process of creating a road system that is genuinely safe is now well understood. Experience in implementing the well-established 'safe system' approach, which recognises the mutual importance of safe road users, safe vehicles and safe roads, shows how death and serious injury can be prevented on a large scale.[4] The following principles broadly underline the safe system approach and inform the iRAP process:

- mistakes, errors of judgment and poor driving decisions are intrinsic to humans. The road safety system needs to be designed and operated to account for this,
- humans are fragile. Unprotected, we cannot survive impacts that occur at even moderate speeds,
- people who behave with criminal disregard for the safety of themselves and others should expect tough policing and tough penalties,
- safety can be built into the road system in a comprehensive and systematic fashion, not just targeting the apparent problem areas, and
- the 'engineered' elements of the system - vehicles and roads - can be designed to be compatible with the human element, perhaps taking lessons from motor racing that, while crashes will occur, the total system is designed to minimise harm.

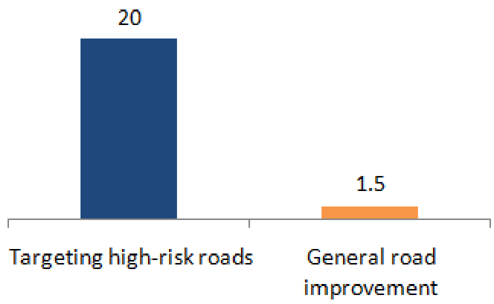
The role of iRAP is to focus specifically on the 'safe roads' element of the safety equation, in the context of safer road users, safer vehicles and safer roads. iRAP builds on the experience of developed countries that have a proven track record in infrastructure safety and, with the support of local engineers and researchers, applies knowledge and technical processes that are applicable for low and middle-income countries.

A safe road will recognise and make provision for the limitations of humans within the transport system. The network should be designed to limit the probability of crashes occurring and minimise the severity of those crashes that do occur.

Evidence shows that affordable, safe road infrastructure can cut vehicle occupant, motorcyclist, pedestrian and bicyclist deaths dramatically. Few infrastructure investments can match the economic benefits of those generated by targeted road safety measures (see Figure 4 below). Research from Australia, the United States, the United Kingdom, France, Canada, Netherlands, the Nordic Countries and New Zealand shows that targeted road safety projects generated crash cost savings of up to 60 times the cost of construction.[5] That is, for each $1 invested, there was a return of up to $60 in terms of crash costs avoided. Other research has shown that low-cost improvements at specific high-risk sites have first year rates of return of 300%.[6] With adequate maintenance, road infrastructure investment can last decades, so the safe roads built today will continue saving lives and preventing injuries long into the future.

[4] See for example www.who.int/violence_injury_prevention/road_traffic/strategies/en/index.html and www.ors.wa.gov.au/.
[5] OECD (2008) Towards Zero – Ambitious road safety targets and the safe systems approach -- page 96, section 4.2 "The road safety management system".
[6] Road Safety Foundation (2008).

Figure 4 Number of lives saved for each $100m invested [7]



Engineering solutions exist for all of the primary crash types that kill road users, Table 4 below shows a summary of each of the common crash types with details of the engineering solutions that are proven to reduce risk, further information on these treatments can be found in the iRAP Road Safety Toolkit (http://toolkit.irap.org).

Table 4 Primary causes of road death and engineering solutions that save lives

Crash Type / Mechanism	Engineering Solutions	Examples
Hit Pedestrian Crash Pedestrians are killed walking along the road and trying to cross the road.	Solutions include: Footpaths, pedestrian fencing, speed management and traffic calming, safe crossing points.	
Head-on Crash Oncoming traffic collides at high speed (while overtaking or when momentarily crossing into the opposing lane).	Solutions include: Provision of overtaking lanes, median barriers or separation, flexible posts, central hatching.	
Run-off Road Crash Vehicle leaves the road and strikes a fixed object (tree, pole, structure) or steep embankment.	Solutions include: Shielding the hazard with barriers, removing the hazard, providing safe run-off area.	

[7] Vulcan, P. and Corben, B. (1998) Prediction of Australian Road Fatalities for the Year 2010, Monash University Accident Research Centre (MUARC), Melbourne.

Crash Type / Mechanism	Engineering Solutions	Examples
Intersection Crash High speed frontal or side impact, rear-end crash with non-compatible vehicles.	Solutions include: Grade separation, speed management, roundabouts, signalisation, turning lanes.	
Hit Bicyclist Crash Bicyclists are killed cycling along the road and in trying to cross the road.	Solutions include: On-road and off-road, cycle paths, speed management and traffic calming, safe crossing points.	

An important principle for iRAP is the application of countermeasures on a large scale. Experience from the health sector has taught us that large-scale application of proven treatments is essential in eradicating wide-spread epidemics. Operation Smallpox Zero for example, was responsible for eradicating this deadly disease in just ten years. The programme of Smallpox vaccinations was described as a triumph of World Health Organization management, not of medicine. Likewise the systematic safety upgrading of the Cayman Islands road network over the Decade of Action can make a significant contribution to the eradication of road traffic death and injury in the country.

4 Road Surveys and Coding

Using a specially equipped vehicle the road network was surveyed, recording digital images at 20m intervals to enable the coding of more than 50 road attributes relating to the likelihood and severity of a crash.

4.1 Road Surveys

The surveys were undertaken by Servicios Mexicanos de Ingenieria Civil (SEMIC) during January 2013 using a proprietary digital imaging system that was mounted to a NRA vehicle. The features of the inspection system were:

- use of four high-resolution digital cameras (1624 x 1224 pixels).
- digital images collected with more than a 180 degree field of view at 20m intervals.
- geo-reference data collected for each digital image, including distance along road (from an established start point) plus latitude and longitude coordinates.
- image calibration to enable detailed measurements of the road features.
- Ability to provide automated measurements of radius of curvature for horizontal curves, gradient for vertical alignment and vehicle travel speeds.

Figure 5 Photograph of the NRA provided vehicle mounted with SEMIC survey equipment

4.2 iRAP Coding

Upon completion of the surveys, trained and experienced SEMIC coders recorded road attributes from digital images using the proprietary SEMIC VISOR Processing Toolkit software, in accordance with the iRAP Star Rating Coding Manual v3. The coded data were subject to quality assurance checks in accordance with the *iRAP Road Coding Quality Assurance Guide,* to ensure the highest standards of quality and consistency during the road coding process and subsequent quality reviews prior to data processing.

4.3 Road Attributes

The following table summarises the road attributes recorded at the completion of the survey (January 2014) and helps to illustrate the relationship between road infrastructure attributes and road user risk. A full data set of the coded attributes is also available as a downloadable file from http://vida.irap.org.

Table 5 Recorded road attributes (survey length: 205.2km)

Road attribute	Category	Details / key findings				
Traffic flow (AADT in vehicles)	0 - 1000	4%				
	1000 - 5000	48%				
	5000 - 10000	21%				
	10000 - 15000	10%				
	15000 - 20000	12%				
	20000 - 40000	6%				
Operating Speed (85th percentile) see next section on the importance of operating speed in relation to the iRAP model	<24mph	6%				
	25mph	12%				
	30mph	26%				
	35mph	17%				
	40mph	1%				
	45mph	24%				
	55mph	15%				
Number of lanes (per direction)	One	83%				
	Two	15%				
	Three	<1%				
	Two and one	2%				
			Road User Risk*			
			V	**MC**	**P**	**B**
Lane width	Wide	95%	✓	✓		✓
	Medium	3%				
	Narrow	2%				
Paved shoulder - passenger-side	Wide	12%	✓	✓	✓	✓
	Medium	6%				
	narrow	30%				
	None	52%				
Curvature	straight or gently curving	63%	✓	✓		✓
	moderate	28%				
	Sharp	10%				
Quality of curve	adequate	37%	✓	✓		✓
	Poor	1%				
	not applicable	63%				

Road attribute	Category	Details / key findings				
Delineation	adequate	42%	✓	✓		✓
	poor	58%				
Shoulder rumble strips (raised profile edge lines)	present	0%	✓	✓		
	not present	100%				
Road surface condition	Good	91%	✓	✓		✓
	medium	7%				
	Poor	1%				
Roadside severity - driver-side object	Safety barrier - metal	<1%	✓	✓		✓
	Safety barrier - concrete	<1%				
	Upwards slope - rollover gradient	<1%				
	Upwards slope - no rollover gradient	<1%				
	Downwards slope	1%				
	Tree >=10cm dia.	29%				
	Sign, post or pole >= 10cm dia.	40%				
	Non-frangible structure/bridge or building	12%				
	Frangible structure or building	13%				
	Large boulders >=20cm high	1%				
	Unprotected safety barrier end	1%				
	None	4%				
Roadside severity - driver-side distance	0 to <1m	21%	✓	✓		✓
	1 to <5m	69%				
	5 to <10m	4%				
	>= 10m	6%				
Roadside severity - passenger-side object	Safety barrier - metal	2%	✓	✓		✓
	Safety barrier - concrete	<1%				
	Upwards slope - rollover gradient	<1%				
	Upwards slope - no rollover gradient	<1%				
	Downwards slope	1%				
	Tree >= 10cm dia.	34%				
	Sign, post or pole >=10cm dia.	45%				
	Non-frangible structure/bridge or building	13%				
	Frangible structure or building	2%				
	Unprotected safety barrier end	<1%				

Road attribute	Category	Details / key findings				
	Large boulders >=20cm high	1%				
	None	6%				
Roadside severity – passenger-side distance	0 to <1m	28%	✓	✓		✓
	1 to <5m	61%				
	5 to <10m	9%				
	>=10m	1%				
Median type	Safety barrier - metal		✓	✓	✓	✓
	Safety barrier - concrete					
	Physical median width >= 10.0m to < 20.0m	4%				
	Physical median width >= 5.0m to < 10.0m	1%				
	Physical median width >= 1.0m to < 5.0m	10%				
	Physical median width >= 0m to < 1.0m	2%				
	Continuous central turning lane	4%				
	Central hatching (>1m)	1%				
	Centre line	76%				
	Wide centre line (0.3m to 1m)	1%				
Intersections	Merge lane	22 sites	✓	✓		✓
	Roundabout	42 sites				
	3-leg (unsignalised) with protected turn lane	27 sites				
	3-leg (unsignalised) with no protected turn lane	315 sites				
	3-leg (signalised) with protected turn lane	6 sites				
	3-leg (signalised) with no protected turn lane	1 site				
	4-leg (unsignalised) with protected turn lane	13 sites				
	4-leg (unsignalised) with no protected turn lane	27 sites				
	Median crossing point – informal	9 sites				
	Median crossing point – formal	20 sites				
	Mini roundabout	6 sites				
Intersection quality	Adequate	13%	✓	✓		✓
	Poor	11%				
	Not applicable	76%				
Sidewalk - driver-side	Non-physical separation >= 3.0m	0%			✓	

Road attribute	Category	Details / key findings				
	Non-physical separation 1.0m to <3.0m	1%				
	Non-physical separation 0m to <1.0m	11%				
	None	85%				
	Informal path >= 1.0m	<1%				
	Informal path 0m to <1.0m	2%				
Sidewalk - passenger-side	Non-physical separation >= 3.0m	0%			✓	
	Non-physical separation 1.0m to <3.0m	2%				
	Non-physical separation 0m to <1.0m	15%				
	None	81%				
	Informal path >= 1.0m	<1%				
	Informal path 0m to <1.0m	2%				
Pedestrian crossing facilities	Signalised with refuge	2 sites			✓	✓
	Signalised without refuge	9 sites				
	Unsignalised marked crossing with refuge	16 sites				
	Unsignalised marked crossing without a refuge	38 sites				
	Refuge only	7 sites				
	No facility	1980 sites				
Pedestrian fencing	Not present	100%			✓	
Street lighting	Not present	91%			✓	✓
	Present	9%				
Traffic calming	Present	102 sites	✓	✓	✓	✓
Bicycle lane	Present	16.7km				✓

*VO - vehicle occupants, MC motorcyclists, P - pedestrians, BC - bicyclists

The Detailed Road Condition tables within ViDA provide the length and percentage of the filtered network for each category of recorded road attribute. They can be used to compare the infrastructure attributes of different roads or road sections and can help to provide an understanding of the Star Ratings of a given road section and the proposed countermeasures that will potentially alter the road attributes and reduce risk.

5 Supporting Data

Although the iRAP Star Ratings and Safer Roads Investment Plans use a standardised global methodology, the models are calibrated with local data to ensure that the results reflect local conditions. The following section outlines the supporting data and how it was used in the iRAP analysis.

5.1 The Role of Speed

The issue of speed management is of paramount importance in road safety and in-turn traffic speeds have a significant bearing on the iRAP Star Ratings.

The risk of death or serious injury is minimised in any crash, where:

- vulnerable road users (e.g. motorcyclists, bicyclists and pedestrians) are physically separated from cars and heavier vehicles, or traffic speeds are 25mph or less,
- opposing traffic is physically separated and roadside hazards such as trees and other fixed objects (including concrete guard posts) are well managed, and
- traffic speeds are restricted to 45mph or less on roads where opposing traffic flows are not physically separated, or where roadside hazards exist.

The safety of infrastructure is heavily influenced by the speed of traffic, and without an understanding of the operating speeds it is difficult to assess the safety performance of infrastructure at a given location. All iRAP assessments are based on vehicle operating speeds to ensure that the Star Rating evaluates how the road is actively functioning, which in some cases can be above the posted speed limit. For further details of the iRAP specifications in relation to vehicle speeds see *Vehicle Speeds and the iRAP Protocols*, which can be found on the iRAP website http://irap.org/about-irap-3/research-and-technical-papers.

In many countries there can be a marked difference between the posted speed limit and the actual speed of vehicles using the road. This is a function of local behaviour, local enforcement practice and whether the engineering features of the road are designed in accordance with the speed limit, for example the use of traffic calming measures to help manage speeds.

5.2 Speed Data

The NRA provided comprehensive speed data across the network for posted, 85th percentile and median operating speeds. These data, in conjunction with advice from the NRA and RCIPS were used to estimate the operating speeds across the network.

Generally, 85th percentile operating speeds were 5-10 mph above the posted speeds. However, data from the speed surveys showed that on several roads sections, particularly in Georgetown, congestion during morning and afternoon peaks resulted in speeds significantly below the posted speed.

5.3 Traffic Volumes

Total traffic flow (or volume) for all motorised vehicles is required for each road section and is used in the estimation of the distribution of the numbers of deaths and serious injuries that could be prevented on the network. The data are required to be in Annual Average Daily Traffic (AADT) format and should not be adjusted to passenger car equivalent (PCU) volumes.

The AADT flows for the road sections within this assessment were obtained from the NRA. However, data were not provided for all road sections within this assessment, therefore, where data have not been supplied estimates have been made based on:

- observations made during the detailed road survey and coding phase, and
- local knowledge from the NRA.

5.4 Motorcycle Volumes

Detailed data on motorcycle traffic are not collected in the Cayman Islands. Based on advice from the NRA, the percentage of motorcycles was assumed to be between 1% and 5% for all roads surveyed.

5.5 Pedestrian and Bicycle Flows

Pedestrian and bicycle flows were recorded during the coding process. It is possible to rely solely on this data for processing, though it is not recommended. This is because pedestrian and bicycle flows can be transitory and a one-off visual inspection is unlikely to provide a strong basis for determining overall flows. In this project, pedestrian and bicyclist flows were estimated based on observed flows and the surrounding land use and road attributes. See *iRAP 310: A Guide to Producing iRAP Star Ratings and Safer Roads Investment Plans* for further information on estimating flows based on adjacent land use.

5.6 Number of Deaths and Serious Injuries

As part of the iRAP model calibration, an estimate of the number of deaths and serious injuries that occur on the road was required. In order to allocate deaths and serious injuries to the network, the iRAP model requires an estimate of the distribution of deaths by road user type.

The RCIPS provided road trauma fatality data for the years 2013, 2011 and 2010 for all road sections included within this analysis with fatalities on all sections shown in the link below. These data were used to determine a yearly average fatality rate on the network.

The number of serious injuries was estimated using the standard iRAP assumption that for each death, 10 serious injuries occur.[8]

Table 6 Crash data supplied by RCPIS

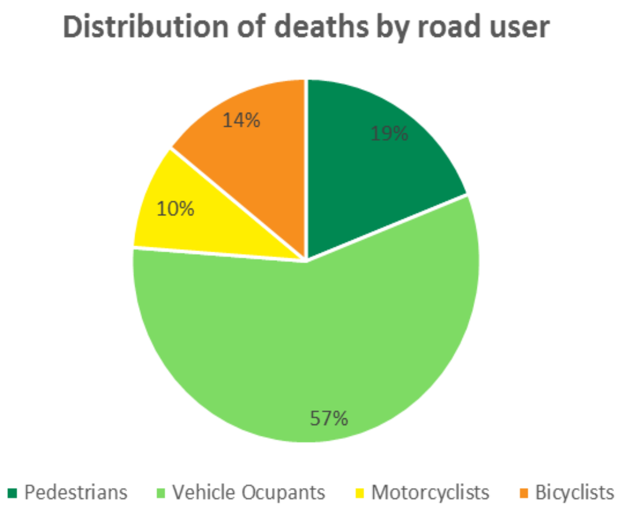
Date	Location	Victim	Main Cause Of Accident
17/11/2013	Old Robin Road	Passenger	Speeding
10/08/2013	Seaview Road	Passenger	Speeding

[8] K. McMahon and S. Dahdah, *The True Cost of Road Crashes: Valuing life and the cost of a serious injury*, iRAP, 2008. http://irap.org/library.aspx.

7/07/2013	Hell Road vicinity of Memory Lane Club	Bicycle	Hit From Bicycle
18/05/2013	South Church Street	Driver	DUI
27/02/2013	Mount Pleasant Road vicinity of #329	Driver	
8/02/2013	West Bay Road of Lone Star	Pedestrian	
28/12/2011	Linford Pierson Highway	Driver	
23/12/2011	Shamrock Road vicinity of Midway Close	Driver	Speeding
30/11/2011	Esterley Tibbetts Highway vicinity of Lakeside Villas	Driver	
14/07/2011	Seaview Road vicinity of Halfmoon Bay	Passenger	Speeding
26/06/2011	Town Hall Road vicinity of Captain Curry's Road	Rider	Speeding
1/06/2011	Esterley Tibbetts Highway	Driver	Speeding
10/05/2011	Batabano Road vicinity of Jubilee Lane	Passenger	Incorrect Side Of Road
21/04/2011	North Side Road	Cyclist	
18/12/2010	West Bay Road vicinity of Jet Night Club	Pedestrian	DUI
12/11/2010	Crewe Road vicinity of Mango Tree Restaurant	Pedestrian	Hit & Run
3/08/2010	Esterley Tibbetts Highway	Passenger	DUI
27/06/2010	Eastern Avenue vicinity of Cayman Shoe Shop	Cyclist	Hit & Run
14/06/2010	Linford Pierson Highway vic. of Randyke Gardens	Rider	Speeding
19/04/2010	West Bay Road	Pedestrian	Speeding
15/01/2010	Shamrock Road vicinity of Will T Drive	Passenger	Speeding

The distribution of deaths by road user category was determined using the data contained in table 6 above.

Figure 6 Road deaths by user type



5.7 The Economic Cost of a Death and Serious Injury

The document *Safer Roads Investment Plans: The iRAP Methodology* describes the process used to estimate the economic cost of a road death and a serious injury for iRAP projects. This approach is applied globally by iRAP and is based on research undertaken by McMahon and Dahdah (2008).

The key equations used are:

- the economic cost of a death is estimated to be: 70 x Gross Domestic Product (GDP) per capita (current prices)
- the economic cost of a serious injury is estimated to be: 0.25 x economic cost of a death.

On this basis:

- the economic cost of a death is estimated to be 70 x $ 47,240 KYD[9] = $ 3,306,814 KYD (US$4,032,700)[10]
- the economic cost of a serious injury is estimated to be: ¼ x $ 3,306,814 KYD = $ 826,704 KYD (US$1,008,175).

Based on the recorded road fatalities and assuming a ratio of 10 serious injuries to every death, the economic cost of road trauma in the Cayman Islands alone is in excessive of US$100 million per year.

To calculate Net Present Costs and Benefits, a discount rate of 4% was used.

5.8 Countermeasure Costs

The iRAP model requires the input of local construction and maintenance costs for each of the 93 countermeasures that are considered in the development of the Safer Roads Investment Plans. The estimated costs are categorised by area type (urban and rural) and upper and lower costs (low, medium and high), based on the extent to which the surrounding land use and physical environment impacts upon the construction cost of major works.

The countermeasure costs used in this study were based on estimates calculated by iRAP and reviewed by the NRA. The full data set for each study is provided in Appendix A.

---

[9] The United Nations Statistics Division data service (https://data.un.org/)

[10] Exchange rate: $0.82 KYD = US$1 (as at February 1, 2014)

6 Star Ratings

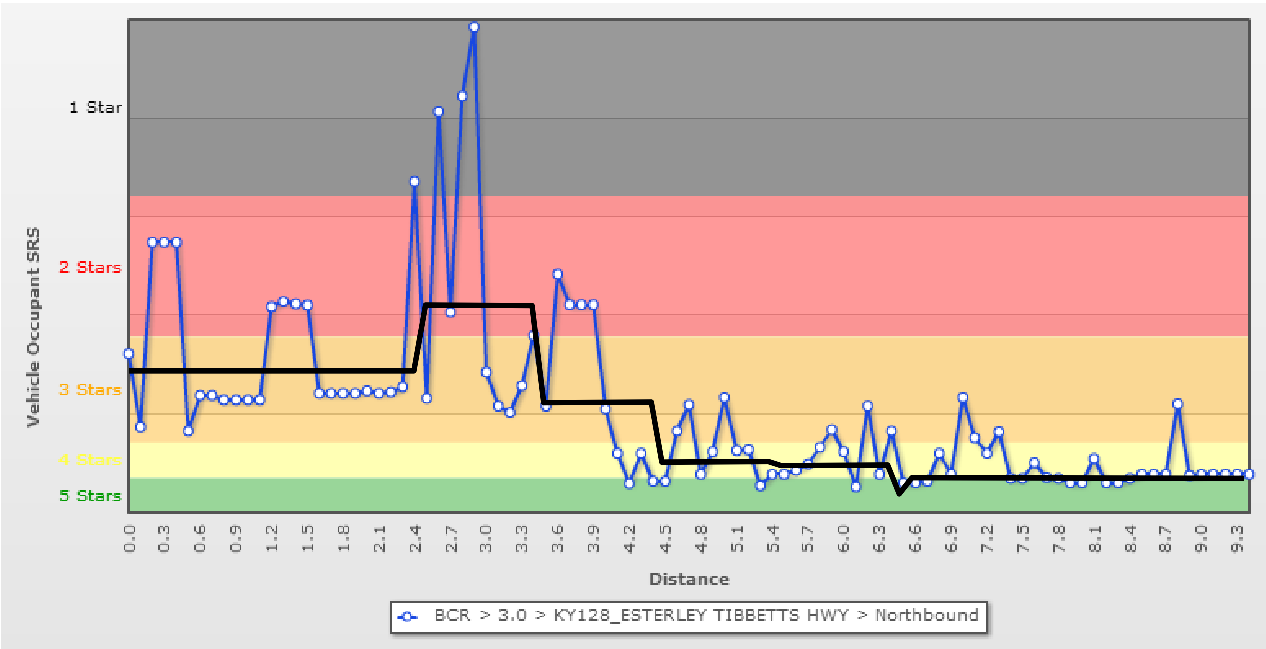
iRAP Star Ratings are based on road infrastructure features and the degree to which they impact the likelihood and severity of road crashes. The focus is on the features which influence the most common and severe types of crash on roads for motor vehicles, motorcyclists, pedestrians and bicyclists. They provide a simple and objective measure of the relative level of risk associated with road infrastructure for an individual road user. 5-star (green) roads are the safest, while 1-star (black) roads are the least safe. Star Ratings were not assigned to roads where there was very low use by that type of road user. For example, if no bicyclists use a section of road, then a bicyclist Star Rating is not assigned to it.

The Star Ratings are based on Star Rating Scores (SRS). The iRAP models calculate an SRS at 100 metre intervals for each of the four road user types, based on relative risk factors for each of the road attributes. The scores are developed by combining relative risk factors using a multiplicative model. More information on the risk factors used within the model can be found at http://irap.org/about-irap-3/methodology.

6.1 Smoothed Star Ratings

A Star Rating Score (SRS) is calculated for each 100 metre segment of road for vehicles occupants, motorcyclists, pedestrians and bicyclists. These scores are then allocated to Star Rating bands to determine the Star Rating for each 100 metre of road. However, for the purposes of producing a network level map showing Star Ratings, 100 metres is too much detail. Hence, Star Ratings are smoothed (or averaged) over longer lengths in order to produce more meaningful results. The effect of smoothing is illustrated in the chart below, which shows unsmoothed (raw) Star Rating Scores (SRS) in blue and smoothed SRS in black for the northbound carriageway of the Esterley Tibbetts Hwy.

Figure 7 Raw Star Rating Scores (blue) and smoothed SRS (black) for the northbound carriageway of the Esterley Tibbetts Hwy



6.2 The Star Rating Results

The combined Star Rating results for all road sections surveyed within the Cayman Islands project demonstrate that there is potential to improve the safety of road infrastructure for all users, but particularly for vulnerable road users.

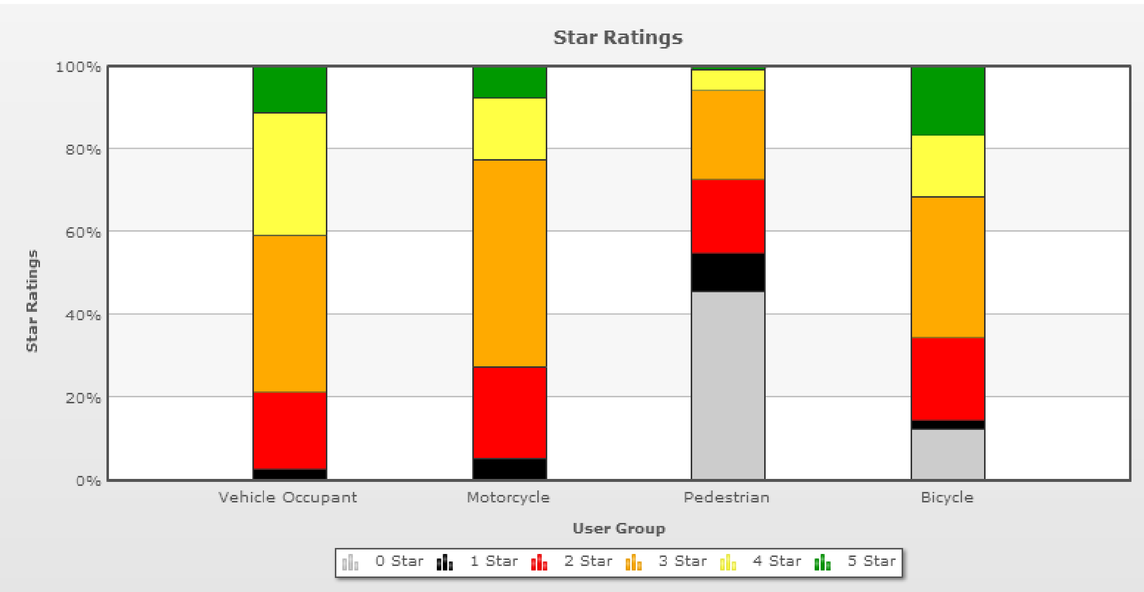
The star ratings show that 11% of road length is rated as 5-star, 30% is rated as 4-star, 38% is rated as 3-star, and the remaining 22% is rated as 2-star and below for vehicle occupants. For motorcyclists, 8% of road length is rated as 5-star, 15% is rated as 4-star, 50% is rated as 3-star, and the remaining 27% is rated 2-star and below. For pedestrians 1% of road length is rated as 5-star, 5% is rated as 4-star, 21% is rated as 3-star and 27% is rated 2-star and below, while 46% of the network is not expected to receive significant pedestrian flow on a regular basis. For cyclists 17% of road length is rated as 5-star, 15% is rated as 4-star, 34% is rated as 3-star and 22% is rated 2-star and below, while 13% of the network is not expected to receive significant bicyclist flow on a regular basis.

Table 7 Star Ratings table, Cayman Islands

	Vehicle Occupant		Motorcycle		Pedestrian		Bicycle	
Star Ratings	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
5 Stars	22.4	11%	15.4	8%	1.1	1%	34.0	17%
4 Stars	61.1	30%	30.6	15%	10.7	5%	30.2	15%
3 Stars	77.9	38%	102.7	50%	44.0	21%	70.0	34%
2 Stars	38.0	19%	45.4	22%	36.8	18%	41.1	20%
1 Star	5.8	3%	11.1	5%	18.7	9%	4.2	2%
Not applicable	0.0	0%	0.0	0%	93.9	46%	25.7	13%
Totals	205.2	100%	205.2	100%	205.2	100%	205.2	100%

Note: the table shows 'smoothed' Star Ratings.

Figure 8 Star Ratings table, Cayman Islands

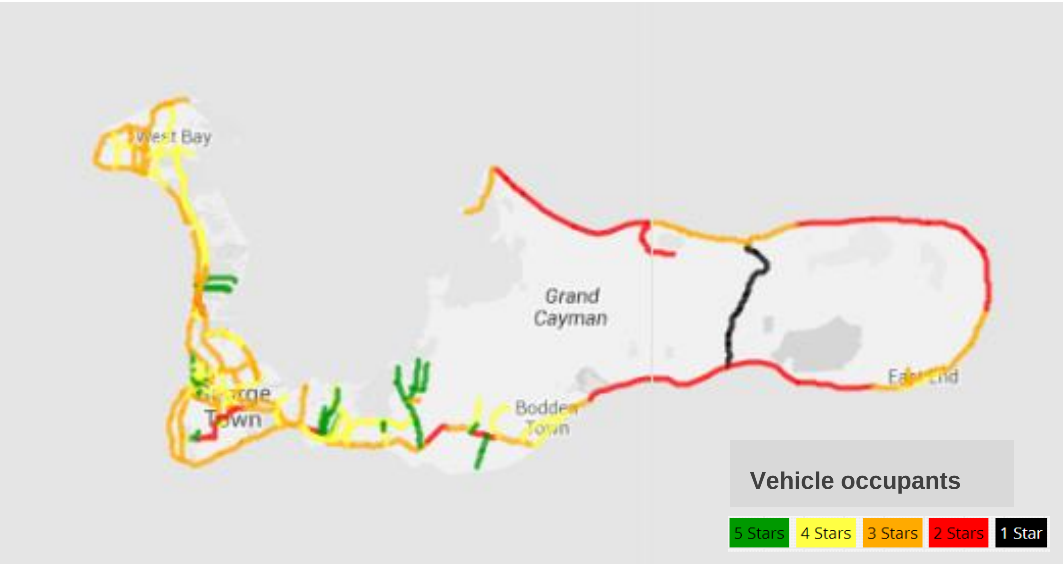


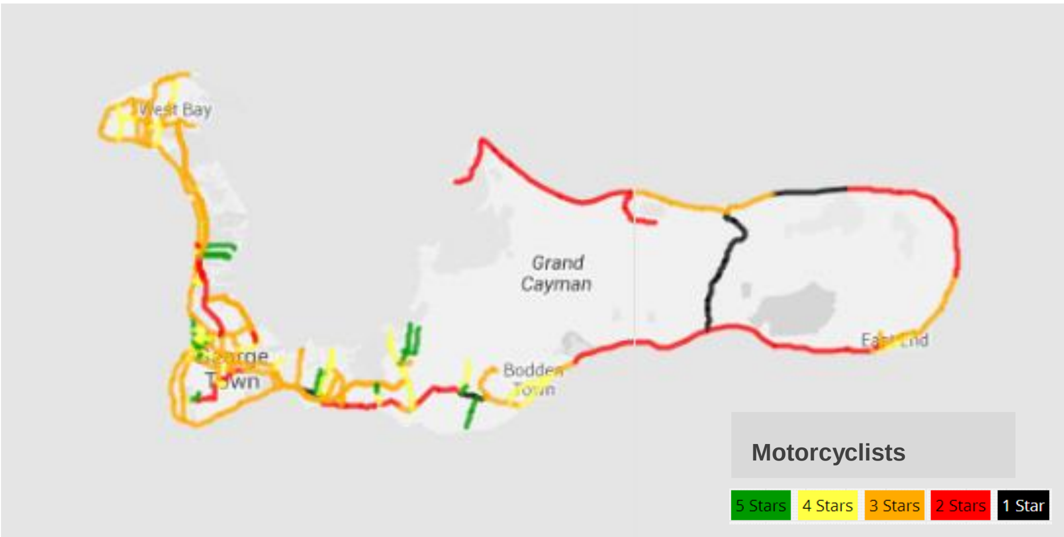
Note: the chart shows 'smoothed' Star Ratings.

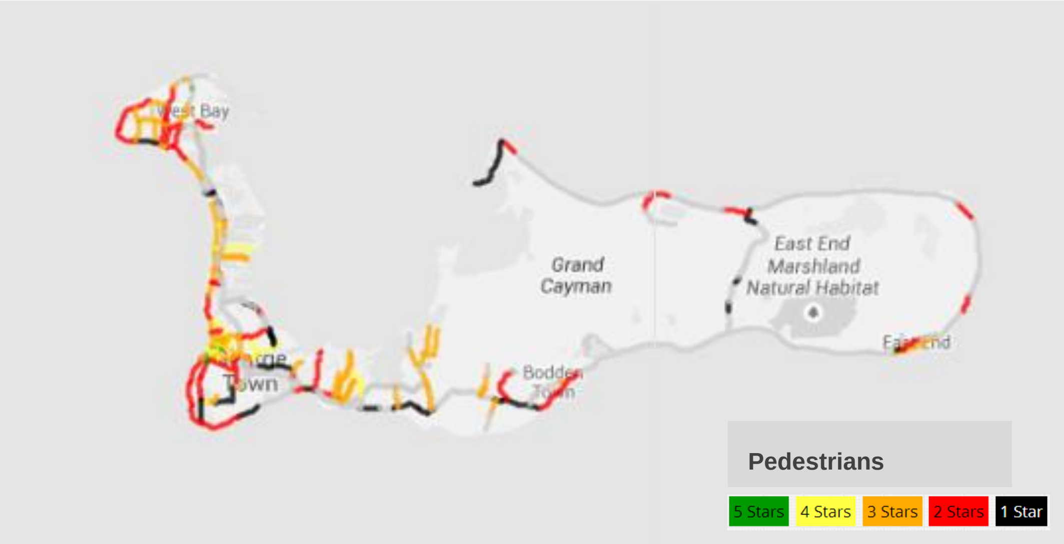
6.3 Star Rating Maps

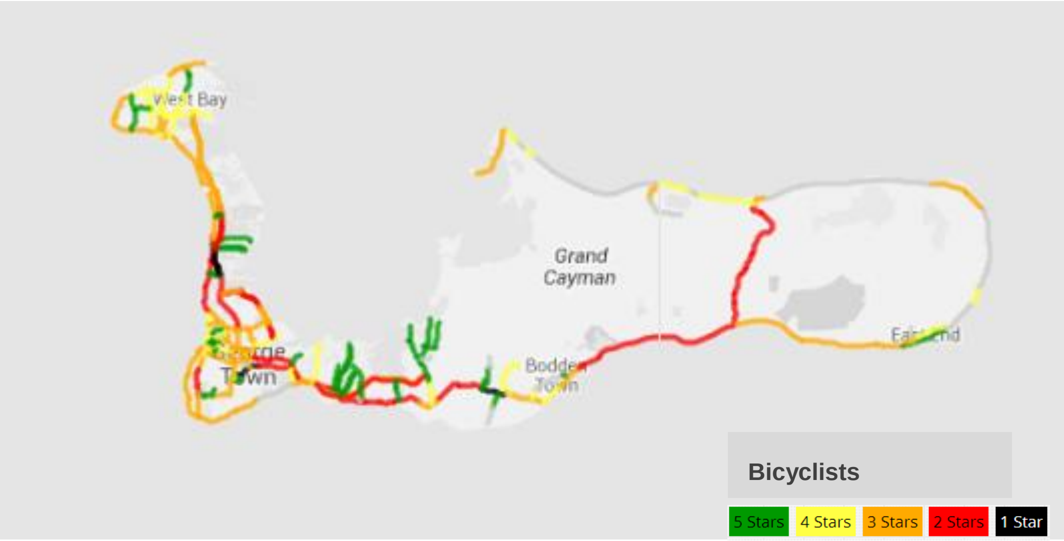
The following images show the Star Rating maps for vehicle occupants, motorcyclists, pedestrians and bicyclists. Green represents 5-star road sections, yellow represents 4-star road sections, orange represents 3-star road sections, red represents 2-star road sections and black represents 1-star road sections.

Figure 9 Star Rating Maps, Cayman Islands









6.4 Star Rating Examples

The following images illustrate sections of roads, their Star Ratings and the road attributes that influenced the Star Rating. The figures show Star Ratings for vehicle occupants and pedestrians, as these road users account for a significant number of deaths and illustrate typical road layouts. However, similar examples can be produced for motorcyclists and bicyclists.

In the figures:

- **Green** coloured attributes are associated with a reduced level of risk
- **Yellow** coloured attributes are associated with an intermediate level of risk
- **Red** coloured attributes are associated with an increased level of risk
- **Black** coloured attributes are associated with an extreme level of risk

The figures help to illustrate the fact that the level of risk associated with a road's infrastructure, and hence its Star Rating, is a function of numerous attributes, including travel speeds.

Figure 10 Example of a 1-Star rating for vehicle occupants

Figure 11 Example of a 1-Star rating for pedestrians

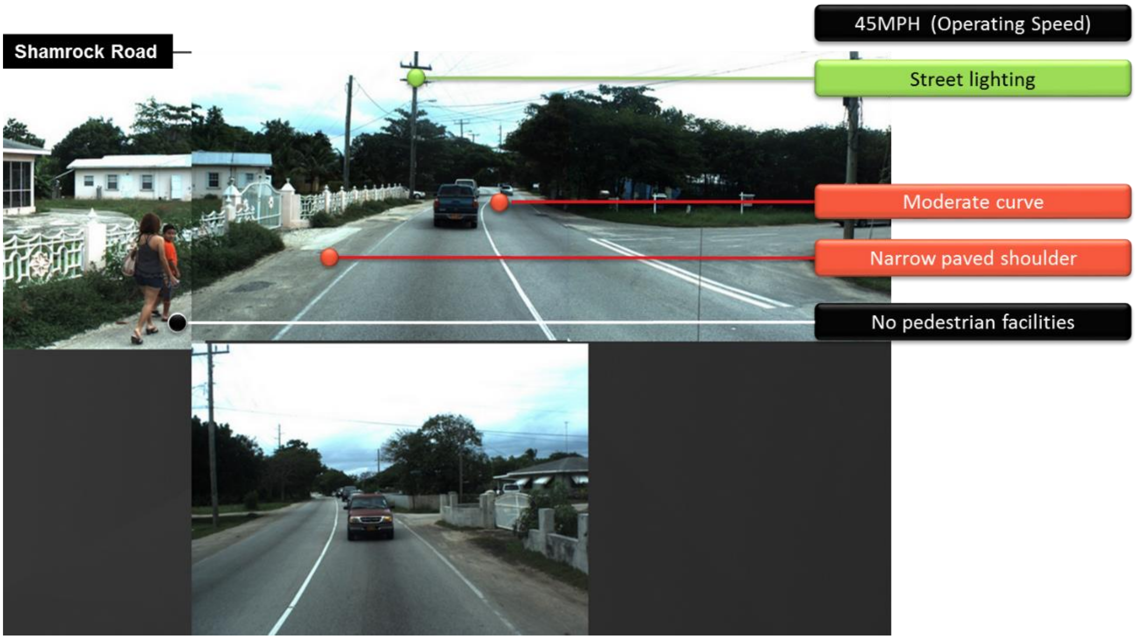


Figure 12 **Example of a 2-Star rating for vehicle occupants**

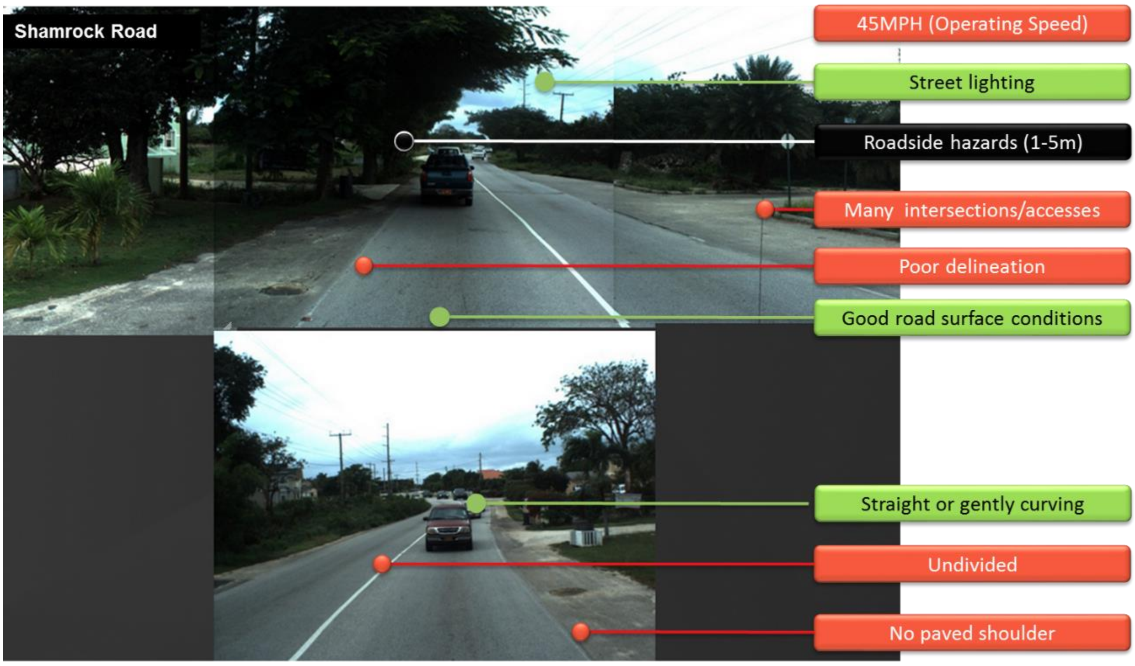


Figure 13 **Example of a 3-Star rating for vehicle occupants**

Figure 14 Example of a 4-Star rating for vehicle occupants

Figure 15 Example of a 5-Star rating for vehicle occupants

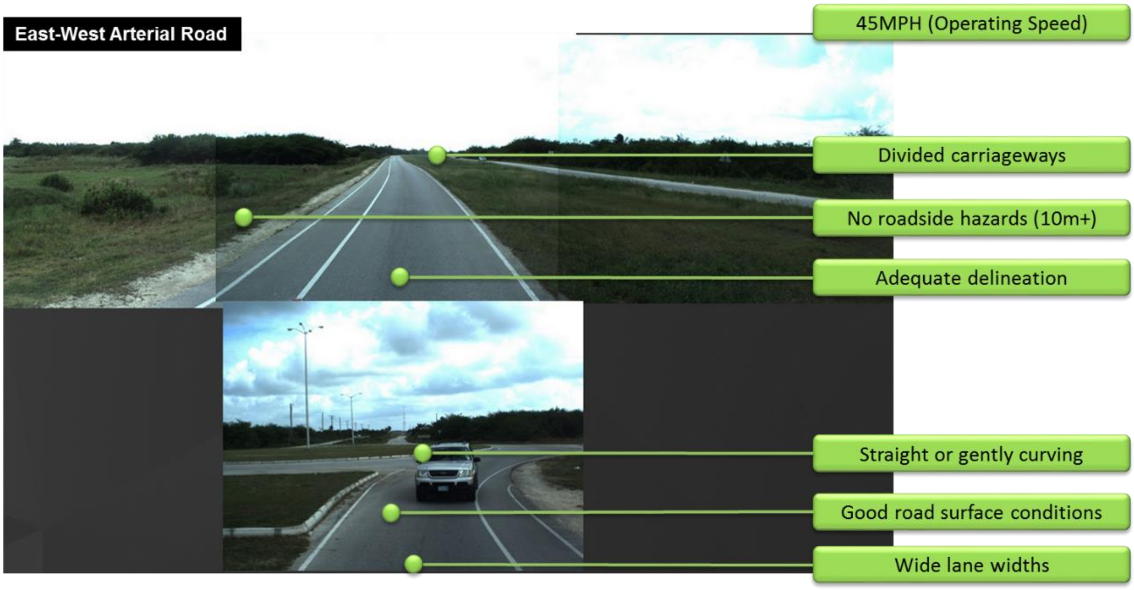


Figure 16 Example of a 5-Star rating for pedestrians

7 Safer Roads Investment Plans

iRAP considers more than 90 proven road improvement options to generate affordable and economically sound Safer Road Investment Plans (SRIP) that will save lives. Road improvement options range from low-cost road markings and pedestrian refuges to higher-cost intersection upgrades and full highway duplication.

Plans are developed in three key steps:

1. Drawing on the Star Ratings and traffic volume data, estimated numbers of deaths and serious injuries are distributed across the road network.
2. For each 100 metre segment of road, countermeasure options are tested for their potential to reduce deaths and injuries. For example, a section of road that has a poor pedestrian Star Rating and high pedestrian activity might be a candidate for a footpath or pedestrian crossing facility.
3. Each countermeasure option is assessed against affordability and economic effectiveness criteria. The economic benefit of a countermeasure (measured in terms of the economic benefit of the deaths and serious injuries prevented) must, at a minimum, exceed the cost of its construction and maintenance.

A SRIP shows a list of affordable and economically sound road safety treatments, specifically tailored to reduce risk on the corridors assessed in the Cayman Islands. Each countermeasure proposed in the SRIPs is supported by strong evidence that, if implemented, it will prevent deaths and serious injuries in a cost-effective way. Nevertheless, each countermeasure should be subject to additional prioritisation, concept planning and detailed design before implementation.

Two SRIP options were produced to prioritise countermeasure options that could maximise the prevention of deaths and serious injuries within the available budget. The plans largely focus on:

- reducing the risk associated with run-off road crashes by improving shoulders and reducing the severity of roadsides,
- reducing the risk associated with head-on crashes by reducing the opportunity for vehicles to cross into the path of oncoming vehicles, and
- providing facilities for pedestrians and bicyclists.

Plan 1 was produced using a threshold BCR of 1 (that is, the economic benefit of each countermeasure must be greater than or equal to the cost), and Plan 2 was produced using a threshold BCR of 3 (economic benefit of each countermeasure must exceed 3 times the cost). Creating the two investment plans with differing threshold BCRs helps to provide more flexibility for decision makers and the responsible use of public money. An overview of the plans is provided in Table 8. Note that the details shown in the tables below are a summary of the plans for all roads surveyed in the Cayman Islands, individual plans for each road corridor within the Cayman Islands project are available within the iRAP online software.

Table 8 Investment Plan options (20 year analysis)

	Plan 1	Plan 2
Present value of investment	$114 million KYD	$51 million KYD
	US$139 million	US$62 million
Deaths and serious injuries prevented	530	440
Present value of safety benefits	$384 million KYD	$316 million KYD
	US$468 million	US$385 million
Cost per death and serious injury prevented	$ 212,069 KYD	$ 115,338 KYD
	US$258,621	US$ 140,656
Benefit cost ratio (BCR)	3	6
Reduction in death and serious injuries	35%	29%

Exchange rate: $0.82 KYD = US$1 (as at February 1, 2014)

The most comprehensive SRIP (Plan 1), an investment of $114 million KYD could reduce the number of deaths and serious injuries on the road by 35%, preventing approximately 530 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 3:1. This BCR value is calculated by comparing the expected costs of installing and maintaining the proposed set of countermeasures over a period of 20 years against the reduction in KSI crash costs that would be realised during the 20 years if all the proposed countermeasures were applied. Plan 2 shows that, by investing $51 million KYD, the number of deaths and serious injuries on the road could be reduced by 29%, equivalent to a reduction of approximately 440 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 6:1.

The list of countermeasures shown in each of the plans suggest that significant safety improvements can be made to the surveyed road network in the Cayman Islands state through the implementation of several key road safety and mass action treatments. Removing or shielding roadside risks and installing rumble strips are estimated to prevent over 150 fatalities and serious injuries over a 20 year period. Countermeasures focused on reducing risk for vulnerable users also have the potential to save lives. Countermeasures aimed at improving pedestrian safety alone, such as pedestrian footpaths and crossings, pedestrian fencing and traffic calming could prevent almost 100 fatalities and serious injuries over the 20 years.

The countermeasures identified in Plan 2 are shown in Table 9 . For countermeasures identified in Plan 1 refer to Appendix B.

Table 9 Safer Road Investment, Plan 2 (BCR>3)

Countermeasure	Length / sites	FSI saved (20 years)	BCR
Duplication with median barrier	8.8 km	63	6
Roadside barriers - passenger side	41.6 km	57	5
Roadside barriers - driver side	29.9 km	37	5
Improve Delineation	57.5 km	30	8
Traffic calming	10.8 km	23	11
Clear roadside hazards - passenger side	45.3 km	20	21
Shoulder rumble strips	27.0 km	19	6
Footpath provision passenger side (adjacent to road)	12.9 km	17	5
Central median barrier (no duplication)	5.5 km	16	14

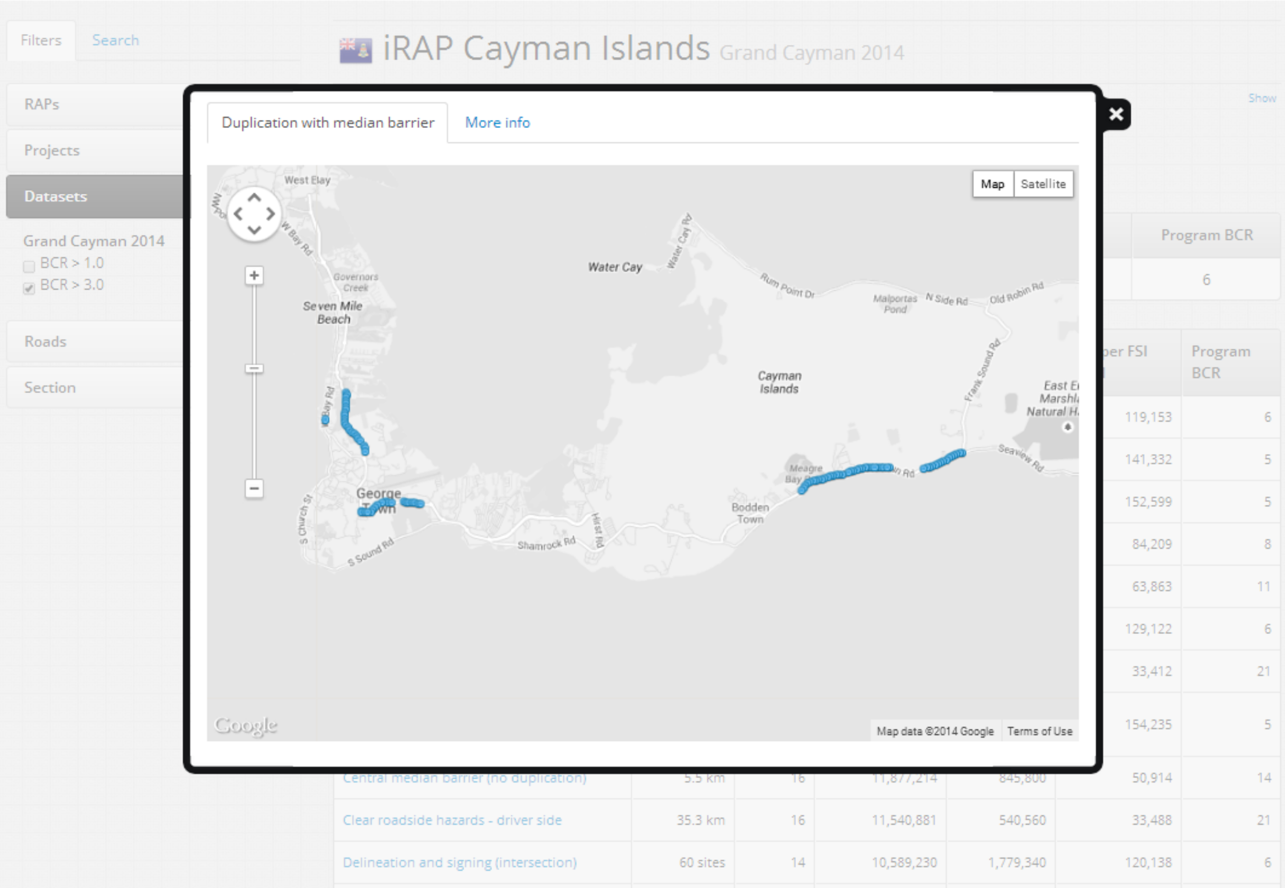
Countermeasure	Length / sites	FSI saved (20 years)	BCR
Clear roadside hazards - driver side	35.3 km	16	21
Delineation and signing (intersection)	56 sites	13	6
Pedestrian fencing	5.2 km	13	19
Footpath provision driver side (adjacent to road)	10.8 km	13	5
Signalise intersection (3-leg)	15 sites	10	5
Bicycle Lane (off-road)	4.2 km	8	5
Bicycle Lane (on-road)	12.0 km	7	6
Side road unsignalised pedestrian crossing	21 sites	7	5
Shoulder sealing driver side (>1m)	16.1 km	7	5
Refuge Island	14 sites	6	8
Shoulder sealing passenger side (>1m)	13.3 km	6	5
Footpath provision passenger side (informal path >1m)	14.5 km	6	4
Footpath provision driver side (informal path >1m)	11.1 km	4	4
Protected turn lane (unsignalised 3 leg)	9 sites	3	5
Skid Resistance (paved road)	1.0 km	3	11
Additional lane (2 + 1 road with barrier)	1.7 km	2	5
Street lighting (mid-block)	7.6 km	2	5
Street lighting (intersection)	11 sites	2	6
Central median barrier (1+1)	0.6 km	2	7
Improve curve delineation	0.9 km	1	20
Lane widening (up to 0.5m)	0.2 km	1	3
Lane widening (>0.5m)	0.2 km	1	4
Protected turn lane (unsignalised 4 leg)	4 sites	1	5
Signalise intersection (4-leg)	2 sites	1	4
Central hatching	1.5 km	1	4
Centreline rumble strip / flexi-post	0.7 km	1	7
Duplicate - <1m median	0.3 km	1	15
Upgrade pedestrian facility quality	3 sites	1	3
Unsignalised crossing	3 sites	1	3
Signalised crossing	5 sites	1	3
Road surface rehabilitation	1.4 km	1	14
Sideslope improvement - passenger side	0.5 km	1	3
Sideslope improvement - driver side	0.7 km	1	4
Shoulder sealing passenger side (<1m)	3.4 km	1	3
Clear roadside hazards (bike lane)	2.7 km	1	29
Roadside barriers (bike lane)	0.5 km	1	2
Skid Resistance (unpaved road)	0.1 km	1	6
Street lighting (ped crossing)	1 sites	1	28
Parking improvements	2.4 km	1	7

Countermeasure	Length / sites	FSI saved (20 years)	BCR
Side road signalised pedestrian crossing	3 sites	1	4
Shoulder sealing driver side (<1m)	2.0 km	1	3
Footpath provision driver side (>3m from road)	0.3 km	1	4
Wide centreline	10.0 km	1	9
Unsignalised raised crossing	2 sites	1	3
		440	6

FSI = fatal and seriously injured *BCR = benefit cost ratio*

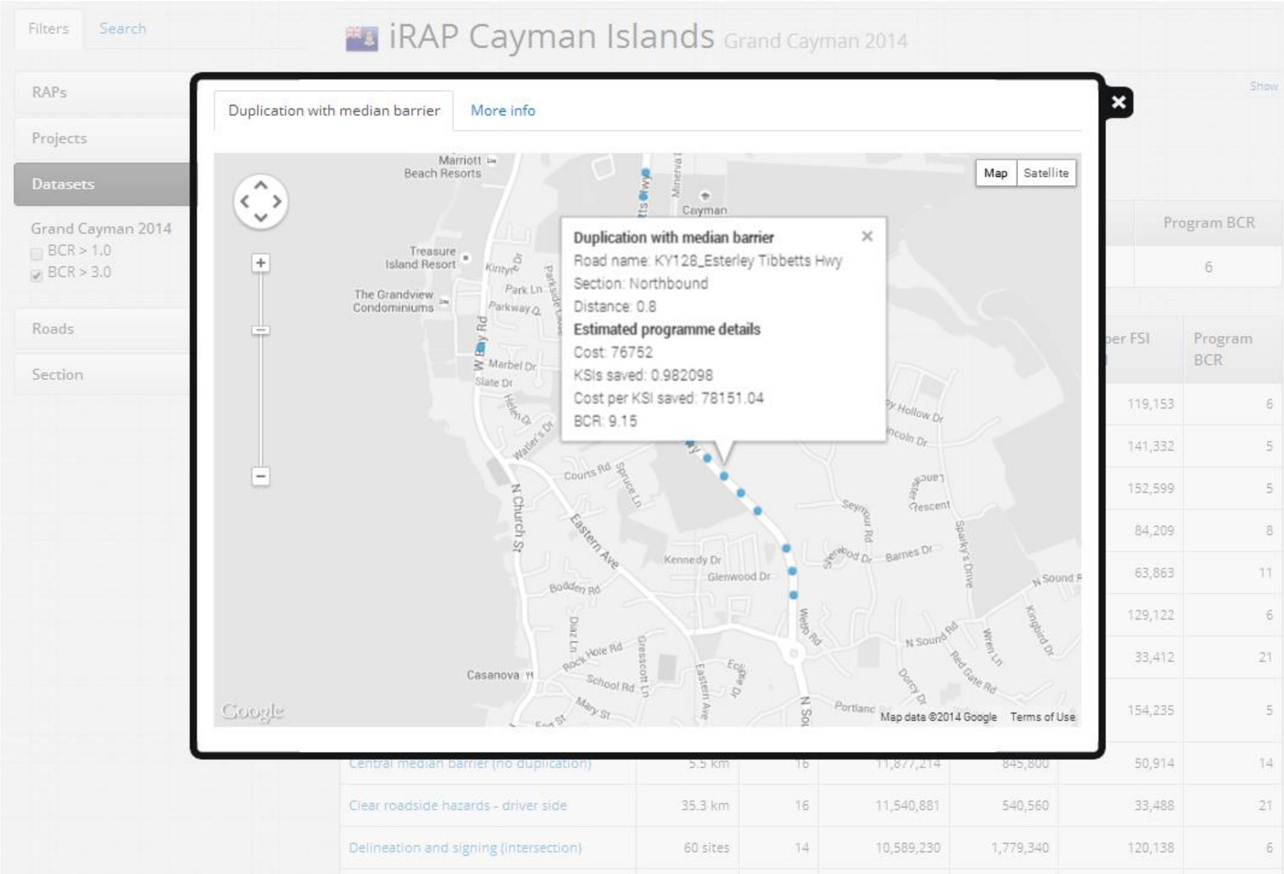
Maps showing the location of each countermeasure listed within Safer Roads Investment Plan can be accessed through the SRIP Table within ViDA as shown below.

Figure 17 Map showing location of a treatment (clear roadside hazard – driver side)



Full details of each recommended countermeasure, including location description, geo-reference data and economics is provided by clicking on an individual icon as shown in Figure 18 below. Strip plans showing the location, by distance, of up to five recommended countermeasures for each road section, are also available within ViDA, the iRAP online software at http://vida.irap.org/.

Figure 18 Individual countermeasure details



7.1 Road Safety Toolkit

Descriptions of the countermeasures proposed by iRAP, and many other road safety treatments, including advice on implementation issues and crash reduction effectiveness can be found at the Road Safety Toolkit http://toolkit.irap.org. Building on decades of road safety research, the Toolkit helps engineers, planners and policy makers develop safety plans for car occupants, motorcyclists, pedestrians, bicyclists, heavy vehicle occupants and public transport users.

The Road Safety Toolkit is the result of collaboration between iRAP, the Global Transport Knowledge Partnership and the World Bank Global Road Safety Facility.

7.2 Star Ratings after Countermeasure Implementation

The Star Rating (After) table provides details of the projected Star Ratings based on the countermeasures within Plan 2 (BCR>3) and the percentage change for each star rating category relative to the original Star Rating, this can be seen in the table below.

Table 10 Star Ratings After (smoothed), Plan 2 (BCR>3)

Road User	Vehicle Occupants			Motorcyclists			Pedestrians			Bicyclists		
	Length (km)	Percent	Change	Length (km)	Percent	Change	Length (km)	Percent	Change	Length (km)	Percent	Change
5 Stars	54.2	26%	+15%	20.5	10%	+2%	3.9	2%	+1%	37.9	18%	+1%
4 Stars	124.0	60%	+30%	92.4	45%	+30%	34.7	17%	+12%	43.9	21%	+6%
3 Stars	27.0	13%	-25%	90.5	44%	-6%	62.1	30%	+9%	79.9	39%	+5%
2 Stars	0.0	0%	-19%	1.8	1%	-21%	10.4	5%	-13%	16.8	8%	-12%
1 Star	0.0	0%	-3%	0.0	0%	-5%	0.2	0%	-9%	1.0	0%	-2%
Not applicable	0.0	0%	±0%	0.0	0%	±0%	93.9	46%	±0%	25.7	13%	±0%
Totals	205.2	100%		205.2	100%		205.2	100%		205.2	100%	

Analysis of the projected Star Ratings after implementation of Plan 2 shows that it is economically viable to increase all the roads surveyed to a level of 3-stars and above for the vehicle occupants. There is the potential to increase the length of road rated at 3-star and above to all excluding 5% for pedestrians. Only 1% of the network would remain high-risk (1- or 2-star) for motorcyclists and 8% would remain high-risk (1- or 2-star) for bicyclists if all countermeasures were implemented.

The Star Ratings (After) for Plan 1 is given in Appendix C.

7.3 Economic Assessment

Using actual crash data, an estimate of the number of deaths and serious injuries that occur on the surveyed network is made. Crash modification factors are then used to provide an estimate of the number of road deaths and serious injuries that are likely to be prevented through the infrastructure improvements that are proposed in each SRIP. More information on the crash modification factors used in the model is available in the iRAP Road Attribute Risk Factor factsheets in the Documents section of the iRAP website at: http://irap.org/about-irap-3/methodology.

It is important to ensure that improvements such as lane widening, resurfacing, additional lanes and paved shoulders do not result in excessive vehicle speeds, particularly where vulnerable road users such as pedestrians and bicyclists are present. In such cases vehicle speeds must be effectively managed in order to minimise risk.

Assuming that the proposed countermeasures do not lead to an increase in vehicle operating speeds, it is estimated that fatal and serious injuries (FSIs) would reduce by 29%, preventing more than 20 deaths and serious injuries each year and approximately 440 deaths and serious injuries over the next 20 years by implementing the countermeasure recommendations put forward in Plan 2 (BCR > 3).

Table 11 Economic analysis

Economic Analysis: Cayman Islands, Plan 2 (BCR>3)			
Road length	205.2km		
Investment	$51 million KYD		US$62 million
Economic benefit (per year)	$16 million KYD		US$19 million
Economic benefit (20 years)	$313 million KYD		US$381 million
Benefit cost ratio (BCR)	6		
Deaths and serious injuries	Deaths (per year)	Deaths and serious injuries (per year)	Deaths and serious injuries (20 years)
Before countermeasures	*7*	*77*	*1,540*
After countermeasures	*5*	*55*	*1103*
Prevented	*2*	*22*	*437*
Reduction	29%		
Cost per death and serious injury prevented	$ 115,338 KYD		US$ 140,656

Exchange rate: $0.82 KYD = US$1 (as at February 1, 2014)

It is estimated that the economic benefits of a reduction in the numbers of deaths and serious injuries from 77 to 55 per year, as estimated in this study, would total approximately US$28 million per year in crash costs saved.

8 Implementation and Recommendations

The iRAP Cayman Islands project successfully assessed 205 kilometres of road, and generated Star Ratings for vehicle occupants, motorcyclists, bicyclists and pedestrians. The Star Rating results show that road infrastructure poses some risks for all users across parts of the surveyed network. For vehicle occupants and motorcyclists, risks varied greatly across the network, ranging from low risk 5-star roads with excellent safety features to high risk 1-star roads with numerous hazards in the roadsides and little in the way of safety features. For vulnerable road users, many of the roads assessed lacked the safety features that would lower the risk and/or consequence of an accident with a motorised vehicle. Almost 50% of the surveyed network where pedestrians are likely to be present is rated as high risk for pedestrians and 25% of the surveyed network where bicyclists are likely to be present for bicyclists.

The road attribute data show that the majority of the survey was conducted along the single carriageway network, with physical separation between opposing flows only present on a number of key routes. Roadside hazards are numerous, with approximately 90% of the survey length having hazardous objects within 5m of the running lane and limited road side protection (such as safety barriers).

The available data from a Road Assessment such as this provides extensive planning and engineering information such as road attribute records, road user risk, countermeasure proposals and economic assessments for 100 metre sections of road network. The assessments are supported by the iRAP online software which makes this information highly accessible. Each countermeasure proposed in a SRIP is backed by strong evidence that, if implemented, it will prevent deaths and serious injuries in a cost-effective way, with engineering improvements that will all provide a positive return on investment. Review of speed limits, enforcement and ultimately reductions in 85th percentile operating speeds at locations where engineering improvements are not economically viable can ensure most, if not all roads reach 3-star operating conditions.

In interpreting the results of this report, it is important to recognise that iRAP is designed to provide a network-level assessment of risk and cost-effective countermeasures. As such, a SRIP should be considered as just the first step in building a safe road. For this reason, implementation of the proposals in this report will ideally include the following steps:

- local examination of proposed countermeasures (including a ‘value engineering’ type workshop including all relevant stakeholders),
- detailed analysis of traffic survey and crash data (if available),
- preliminary scheme investigation studies, including site surveys and preliminary design,
- detailed design, star ratings of the designs, road safety audit, detailed costing and procurement, final evaluation and construction, and
- post-construction evaluation and road safety audit, including Star Ratings for the upgraded road and analysis of crash data (if it is available).

The detailed results of the project and access to the iRAP online software (http://vida.irap.org) have been provided to key stakeholders for further exploration and use. Detailed briefings are also able to be held with key funding bodies, elected members, government officials, design engineers and planners to ensure a common understanding of the investment priorities and potential to save lives and reduce serious injuries.

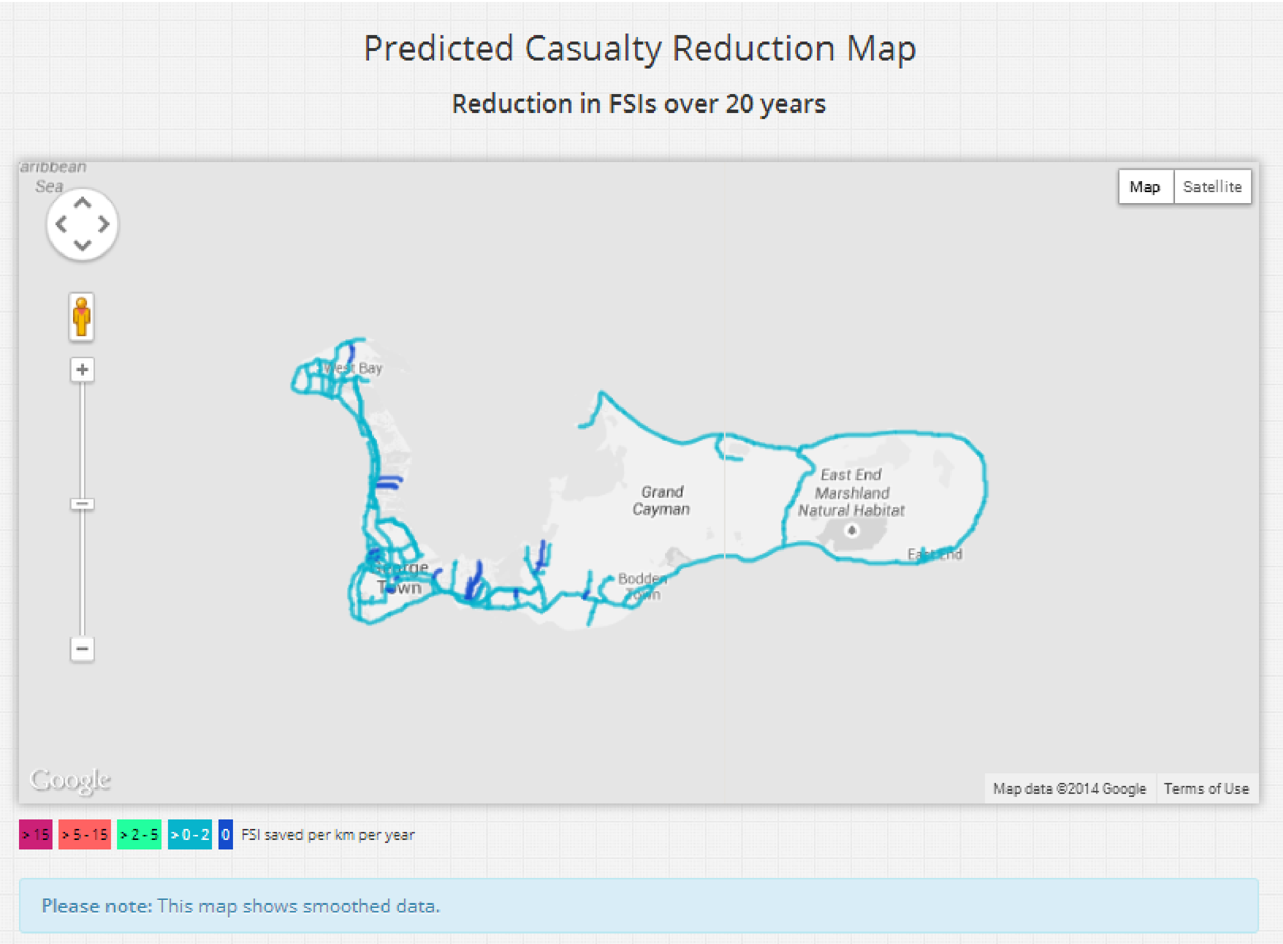
In the following sections, key issues that should be taken into consideration during the implementation process are discussed.

8.1 Prioritisation

Previous projects have shown that, when presented with a large-scale plan of proposed countermeasures, potentially requiring millions of dollars of investment, the decisions about what to do first and how to prioritise can be challenging.

In order to prioritise work on the remaining network the Predicted Casualty Reduction map can be used to show the annual number of fatal and serious injuries that are likely to be prevented per kilometre if the complete Safer Roads Investment Plan was implemented. This map can help to prioritise the implementation of countermeasures by identifying specific locations or road sections where the potential to save lives is greatest.

Figure 19 Predicted Casualty Reduction Map (Plan 2)



Countermeasure implementation might be undertaken according to each countermeasure's likely source of funding and the ease with which it can be built. This was the approach taken during crash reduction investigations on major roads in Indonesia. The approach involved assigning countermeasures to one of four categories, as illustrated in Table 12. By doing so, the responsibilities and procedures in implementing the countermeasures was clarified, with patterns emerging about what can be done in the short-term and which countermeasures require further work.

Table 12 Potential countermeasure categories

Category	Description	Lead time	Example countermeasure
A	Countermeasures for immediate implementation by the region/district public works office as part of its maintenance programme	Immediate	Delineation, Road surface improvement, Footpath.
B	Countermeasures that require reconstruction or other works that do not add capacity to the road and which can be defined by simple diagrams or typical cross-sections but cost estimates are required to schedule the works in the region/district public works office annual budget programme for funding road works	1 year	Shoulder sealing, Pedestrian crossing, Bicycle lane.
C	Countermeasures that require reconstruction or other works that do not add capacity to the road, but for which topographical survey and / or detailed design is required, and for which cost estimates are required to schedule the works in the region/district public works office annual budget programme for funding road works	2-5 years	Intersection, Horizontal realignment.
D	Countermeasures that require major new works and would result in an increase in capacity of the road. These require coordination with broader planning strategy and support from development banks, donors and consulting engineers might be necessary	5-10 years	Duplication, Grade separation of intersections.

Having identified a priority location or section of road, it is possible to further tailor the countermeasure plan to suit specific circumstances. This is especially useful if budget constraints have changed. Figure 20 below provides an example of the way in which cost-effectiveness may be used to generate a list of priority countermeasures within a limited budget. In this example the SRIP was used to produce a list of all countermeasures that could feasibly be built on the road, sorted in order of descending BCR. The countermeasure download file, available online, was used to generate this list.

The initial SRIP for the Indonesian project showed that the cumulative cost of investments with a BCR of 1 or more was slightly over $100 million, as indicated by the red line in Figure 20, which was considered to be unaffordable by the local authorities. As an alternative, an initial budget of was set at $2 million. This is indicated by the green line in Figure 20. For this budget, all countermeasures with a BCR of 45.6 or more could be implemented.

Figure 20 Prioritising countermeasures on a particular road according to different budgets

Chainage (km)	Countermeasure	Cost (20 years)	Cumulative cost (20 years)	BCR
14.0	Improve curve delineation	$2,367	$2,367	717.6
13.5	Improve curve delineation	$2,367	$4,734	583.9
13.6	Improve curve delineation	$2,367	$7,100	547.2
13.9	Improve curve delineation	$2,367	$9,467	531.8
37.7	Improve curve delineation	$1,775	$11,242	352.7
12.6	Improve curve delineation	$2,367	$13,609	319.4
14.0	Improve delineation	$4,636	$18,245	303.6
28.2	Improve curve delineation	$1,775	$20,020	285.3
17.3	Road resurface	$32,836	$1,962,972	47.0
92.5	Improve curve delineation	$1,775	$1,964,747	46.4
101.0	Improve curve delineation	$1,775	$1,966,522	46.4
101.5	Improve curve delineation	$1,775	$1,968,297	46.4
101.7	Improve curve delineation	$1,775	$1,970,072	46.4
88.6	Improve delineation	$3,477	$1,973,549	45.6
10.3	Shoulder sealing (>1m)	$29,000	$2,002,549	45.4
17.0	Shoulder sealing (>1m)	$29,000	$2,031,549	45.2
32.5	Shoulder sealing (>1m)	$17,400	$2,048,949	45.2
16.3	Shoulder sealing (>1m)	$17,400	$2,066,349	45.1
72.0	Improve curve delineation	$2,959	$2,069,308	44.5
107.556	Sideslope improvement - right	$27,270	$100,532,381	1.0
107.856	Sideslope improvement - left	$27,270	$100,559,651	1.0
107.956	Sideslope improvement - left	$27,270	$100,586,921	1.0
18.096	Grade separated pedestrian facility	$2,727,300	$103,314,221	0.9
30.39	Roadside barriers - left	$26,400	$103,340,621	0.9
30.39	Roadside barriers - right	$26,400	$103,367,021	0.9
97.259	Footpath provision (separated from road)	$36,000	$103,403,021	0.9

The most cost effective countermeasure is listed first

With a $2 million budget, all countermeasures with a BCR greater than 45.6 could be considered

If budget was unlimited, all countermeasures with a BCR greater than 1 could be considered

Countermeasures with a BCR below 1.0 should not be considered

8.2 Commit to a Safe System Approach

The investment plans contain infrastructure improvements that can be set in place immediately. To complement those improvements, a series of additional measures need to be implemented, and a longer-term safety strategy set in place.

The Safe System approach is based on the theory that all humans make mistakes, but that a mistake made on the highway should not result in death or serious injury. It recognises that the human body is vulnerable and is unlikely to survive an uncushioned impact at speeds of 30km/h or more.

When these occasional, but inevitable mistakes occur on our busy roads, it stands to reason that collisions or crashes will result. Currently some of these collisions have fatal consequences, and others are less severe. The Safe System provides a forgiving highway infrastructure, one which recognises that mistakes will be made and attempts to minimise their occurrence, and the forces involved in a resulting crash, to reduce its severity to survivable levels.

The Safe System approach includes engineering measures such as the removal or protection of roadside hazards, the re-design of roads, roadsides and intersections to reduce risk to a minimum and the setting of appropriate speed limits according to the existing levels of infrastructure safety. The adoption of this approach is recommended.

8.3 Engage with the Communities

It is recommended that public participation be encouraged, in order to maximise the benefits from road safety projects. Community engagement and cooperation between road authority and local interest groups is regarded as providing a useful two-way flow of information that will not only educate and inform local road users and communities on how they are expected to use the road network, but can also provide designers and decision makers with an understanding of the needs and requirements of affected groups.

Star Ratings can be used to effectively communicate the need for safe road design, not only within the NRA, but also to local residents and other stakeholders. Using Star Ratings will allow opportunities to celebrate success i.e. Ministers, local politicians, and/or road authorities can celebrate road safety upgrades "1-star road upgraded to 3-star standard" etc.

In addition to the road safety engineering upgrades, significant benefits could also be realised through the coordinated targeting of behavioural risk factors for road users (such as speeding, seat belt wearing, helmet use, the adherence to traffic regulations and alcohol use) and road vehicle safety (i.e. ABS brakes, side-impact bars and airbags). This would be consistent with taking a Safe System approach to the programme. The Road Safety Toolkit (toolkit.irap.org) and United Nations Road Safety Collaboration Good Practice Manuals provide further information on these issues.[11]

8.4 Set policy targets

It is strongly recommended that the Cayman government sets policy targets to reduce the level of road traffic fatalities in line with the recommendations discussed in the *Global Plan for the Decade of Action for Road Safety 2011-2020*. Recommendations include:

- Set a target to eliminate high risk (1- and 2-star) roads on the primary network by the end of the Decade of Action for Road Safety (2020).
- Set minimum Star Ratings for all new road designs to ensure that no more 'killer roads' are built. For example, adopt the policy that all new roads shall be built to a minimum 3-star standard for all road users.
- iRAP Star Rating and Investment Plans for the highest risk or highest volume 10% of roads on the network.

For further information on the setting of road safety policy targets, the development of local and national action plans and implementing sustainable road safety strategies, refer to the *Global Plan for the Decade of Action for Road Safety 2011-2020*.

8.5 Training and support

It is recommended that the NRA encourages and supports the training needs of employees so that the Road Assessment Programme becomes an established road safety tool within the road authority. In order to take full advantage of the ViDA software tool, iRAP arranged for two local experts from the NRA to be participate in the iRAP course in Road Safety, held at the University of Birmingham, England in September 2014.

Ongoing iRAP technical support will also be available to the NRA.

[11] UN Road Safety Collaboration manuals: http://www.who.int/roadsafety/projects/manuals/en/index.html

9 Airport Connector Road Design

9.1 Proposed Design

Included within the scope of this project was the assessment of infrastructure related risks of the proposed 3 km (2 miles) dual carriageway Airport Connector Road. With the road still in the design stage, coding was undertaken using details obtained from the tender design drawings. The figure below shows the proposed design for the Airport Connect Road.

Figure 21 Proposed Airport Connector Road Layout

9.2 iRAP Analysis of the Airport Connector Road Design

The iRAP assessment showed that if the road were to be constructed as per the tender design and assumptions regarding operating speeds, traffic volumes, roadside hazards and presence of cyclists and pedestrians were correct, the road would receive the following star ratings for the different road users:

Table 13 Star Ratings, Proposed Airport Connector Road

	Vehicle Occupant		Motorcycle		Pedestrian		Bicycle	
Star Ratings	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
5 Stars	0.0	0%	0.0	0%	0.0	0%	0.0	0%
4 Stars	3.4	53%	0.0	0%	0.0	0%	0.0	0%
3 Stars	3.0	47%	6.0	94%	0.0	0%	2.8	44%
2 Stars	0.0	0%	0.4	6%	0.1	2%	3.6	56%
1 Star	0.0	0%	0.0	0%	2.3	36%	0.0	0%
Not applicable	0.0	0%	0.0	0%	4.0	63%	0.0	0%
Totals	6.4	100%	6.4	100%	6.4	100%	6.4	100%

Note: the table shows 'smoothed' Star Ratings.

While the results indicated that the road was generally well designed for vehicle occupants, the lack of detail in the design for vulnerable road users meant that for pedestrians and cyclists, the road on average received a star rating below 3. It is expected that as the project progresses from the tender stage through to detailed design and construction, road safety for vulnerable road users will be considered in more detail. The SRIP table below highlights the need to improve facilities for vulnerable road users.

Table 14 Safer Road Investment for Proposed Airport Connector Road, Plan 2 (BCR>3)

Countermeasure	Length / sites	FSI saved (20 years)	BCR
Footpath provision passenger side (adjacent to road)	2.3 km	4	5
Refuge Island	2 sites	3	24
Side road unsignalised pedestrian crossing	4 sites	2	9
Shoulder rumble strips	0.3 km	1	6
		10	8

9.3 Achieving 4-Star Minimum Star Rating for Vehicle Occupants

At the request of the NRA, iRAP explored methods that would lift the minimum star rating for vehicle occupants to 4-Star for the Proposed Airport Connector Road. Following an inspection of the results, it was discovered that the key attributes that were responsible for reducing the star rating in the design were the intersection types and the operating speeds. iRAP proposed an alternative design for the Airport Connector Road in which:

- the intersection with North Sound Road is signalised,
- the access to the Camana Bay development is left in/out only, and
- the posted speed limit between the Airport and the North Sound Road intersection is set at 30mph.

When this alternative design was analysed using the iRAP methodology in ViDA, the road received a 4-Star rating for vehicle occupants for the entire length, as shown in the figure below.

Figure 22 Proposed Airport Connector Road Layout

Full results including data tables and charts, interactive maps and download files as well as data underpinning the analyses, are available in the iRAP online software at **http://vida.irap.org** for the proposed Airport Connector Road and all other roads assessed.

10 Appendices

10.1 Appendix A: Countermeasure Costs

The following table list estimated countermeasure costs used in the economic analysis. Estimates are categorised according countermeasure type, area type and cost. All costs shown are in Caymanian dollars.

Countermeasure	Unit of Cost	Service Life	Cost – Rural			Cost - Urban		
			Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)	Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)
Improve Delineation	lane km	3	4797	6396	7995	7626	9533	11439
Bicycle Lane (on-road)	per km	20	63960	127920	191880	91512	160146	228780
Bicycle Lane (off-road)	per km	20	95940	127920	191880	190650	228780	305040
Motorcycle Lane (Painted logos only on-road)	per km	5	1599	3198	4797	3813	5720	7626
Motorcycle Lane (Construct on-road)	per km	20	47970	95940	143910	76260	152520	228780
Motorcycle Lane (Segregated)	per km	20	255840	319800	383760	381300	457560	533820
Horizontal Realignment	lane km	20	127920	255840	383760	190650	381300	5719500
Improve curve delineation	per c/way km	3	4797	6396	7995	7626	9533	11439
Lane widening (up to 0.5m)	lane km	10	25584	51168	76752	38130	76260	114390
Lane widening (>0.5m)	lane km	10	63960	127920	191880	91512	160146	228780
Protected turn lane (unsignalised 3 leg)	Intersection	10	41000	51250	61500	49200	61500	73800
Protected turn lane (unsignalised 4 leg)	Intersection	10	41000	51250	61500	49200	61500	73800
Delineation and signing (intersection)	Intersection	3	4797	6396	7995	7626	9533	11439
Protected turn provision at existing signalised site (3-leg)	Intersection	10	41000	51250	61500	49200	61500	73800
Protected turn provision at existing signalised site (4-leg)	Intersection	10	41000	51250	61500	49200	61500	73800
Signalise intersection (3-leg)	Intersection	20	32800	49200	65600	65600	82000	98400

Countermeasure	Unit of Cost	Service Life	Cost – Rural			Cost - Urban		
			Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)	Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)
Signalise intersection (4-leg)	Intersection	20	49200	65600	82000	82000	98400	114800
Grade separation	Intersection	50	6396000	9594000	12792000	9151200	13726800	18302400
Rail crossing upgrade	Unit	20	63960	89544	115128	76260	106764	137268
Roundabout	Intersection	20	434600	533000	738000	820000	1025000	1230000
Central hatching	per km	10	31980	59163	86346	45756	85793	125829
Centreline rumble strip / flexi-post	per km	10	19188	25584	31980	22878	30504	38130
Central turning lane full length	per km	10	95940	143910	19188	114390	171585	228780
Central median barrier (no duplication)	per km	10	159900	207870	255840	190650	247845	305040
Duplication with median barrier	per c/way km	20	767520	1535040	2302560	1143900	2287800	3431700
Duplicate - <1m median	per c/way km	20	57564	1151280	1726920	915120	1830240	2745360
Duplicate - 1-5 m median	per c/way km	20	767520	1535040	2302560	1143900	2287800	3431700
Duplicate - 5-10m median	per c/way km	20	959400	1918800	2878200	1372680	2745360	4118040
Duplicate - 10-20m median	per c/way km	20	1151280	2302560	3453840	1601460	3202920	4804380
Duplicate - >20m median	per c/way km	20	1343160	2686320	4029480	1830240	3660480	5490720
Service road	per km	20	1343160	2686320	4029480	1830240	3660480	5490720
Additional lane (2 + 1 road with barrier)	per km	20	255840	511680	767520	457560	915120	1372680
Implement one way network	per c/way km	20	319800	479700	639600	381300	571950	762600
Upgrade pedestrian facility quality	unit	10	9594	19188	28782	15252	30504	38130
Refuge Island	unit	10	6396	19188	31980	7626	22878	38130
Unsignalised crossing	unit	10	12792	25584	38376	152520	30504	45756

Countermeasure	Unit of Cost	Service Life	Cost – Rural			Cost - Urban		
			Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)	Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)
Signalised crossing	unit	20	51168	63960	76752	61008	76260	91512
Grade separated pedestrian facility	unit	50	191880	383760	575640	305040	610080	915120
Road surface rehabilitation	lane km	10	6150	6888	7872	15252	15252	15252
Clear roadside hazards - passenger side	per linear km	20	6396	12792	19188	7626	15252	22878
Clear roadside hazards - driver side	per linear km	20	6396	12792	19188	7626	15252	22878
Sideslope improvement - passenger side	per linear km	20	47970	95940	143910	76260	152520	228780
Sideslope improvement - driver side	per linear km	20	47970	91594	143910	76260	152520	228780
Roadside barriers - passenger side	per linear km	20	159900	207870	255840	190650	247845	305040
Roadside barriers - driver side	per linear km	20	159900	207870	255840	190650	247845	305040
Shoulder sealing passenger side (<1m)	per linear km	20	31980	63960	95940	57154	114390	171872
Shoulder sealing passenger side (>1m)	per linear km	20	63960	152520	191880	9512	236406	305040
Restrict/combine direct access points	per km	10	15990	31980	47970	19065	38130	57195
Footpath provision passenger side (adjacent to road)	per linear km	20	95940	127920	191880	190650	228780	305040
Footpath provision passenger side (>3m from road)	per linear km	20	115128	153504	230256	228780	274536	366048
Speed management reviews	per c/way km	5	3198	3198	3198	3813	3813	3813
Traffic calming	per c/way km	10	19188	38376	57564	30504	61008	91512
Vertical realignment (major)	lane km	20	479700	959400	1439100	762600	1525200	2287800

Countermeasure	Unit of Cost	Service Life	Cost – Rural			Cost - Urban		
			Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)	Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)
Overtaking lane	per linear km	20	319800	639600	959400	457560	915120	1372680
Median crossing upgrade	intersec tion	10	31980	79950	127920	38130	95325	152520
Clear roadside hazards (bike lane)	per km	20	6396	12792	19188	7626	15252	22878
Sideslope improvement (bike lane)	per km	20	53300	106600	159900	76260	152520	228780
Roadside barriers (bike lane)	per km	20	159900	207870	255840	190650	247845	305040
Clear roadside hazards (seg MC lane) passenger side	per km	20	NA	NA	NA	NA	NA	NA
Sideslope improvement (seg MC lane) passenger side	per km	20	NA	NA	NA	NA	NA	NA
Roadside barriers (seg MC lane) passenger side	per km	20	NA	NA	NA	NA	NA	NA
Speed management reviews (MC Lane)	per c/way km	5	NA	NA	NA	NA	NA	NA
Central median barrier (MC lane)	per km	10	NA	NA	NA	NA	NA	NA
Skid Resistance (paved road)	lane km	10	17828	31199	46628	21370	42854	68321
Skid Resistance (unpaved road)	per c/way km	10	7554	13220	19757	9051	18150	28936
Pave road surface	lane km	10	38376	67158	100368	45756	91758	146288
Street lighting (mid-block)	lane km	20	40865	51081	61297	48826	61032	73239
Street lighting (intersection)	intersec tion	20	20490	25613	30736	24365	30456	36547
Street lighting (ped crossing)	unit	20	5094	6367	7640	6091	7614	9137
Shoulder rumble strips	per c/way km	10	50968	67958	84947	57672	72090	86507
Parking improvements	per c/way km	20	15990	31980	47970	19065	38130	57195

Countermeasure	Unit of Cost	Service Life	Cost – Rural			Cost - Urban		
			Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)	Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)
Sight distance (obstruction removal)	per linear km	20	5955	11910	17865	6739	13479	20218
Pedestrian fencing	per c/way km	20	41410	52070	72570	59450	74210	103730
Side road grade separated pedestrian facility	intersection	20	143910	287820	431730	228780	457560	686340
Side road signalised pedestrian crossing	intersection	20	38376	47970	57564	45756	57195	68634
Side road unsignalised pedestrian crossing	intersection	10	9594	19188	28782	114390	22878	34317
Footpath provision passenger side (with barrier)	per linear km	20	115128	153504	230256	228780	274536	366048
Footpath provision passenger side (informal path >1m)	per linear km	10	16482	21976	32964	32517	39020	52027
Shoulder sealing driver side (<1m)	per linear km	20	31980	63960	95940	57154	114390	171872
Shoulder sealing driver side (>1m)	per linear km	20	63960	152520	191880	9512	236406	305040
Footpath provision driver side (adjacent to road)	per linear km	20	95940	127920	191880	190650	228780	305040
Footpath provision driver side (>3m from road)	per linear km	20	115128	153504	230256	228780	274536	366048
Footpath provision driver side (with barrier)	per linear km	20	115128	153504	230256	228780	274536	366048
Footpath provision driver side (informal path >1m)	per linear km	10	16482	21976	32964	32517	39020	52027
Realignment (sight distance improvement)	lane km	20	3310750	4138540	5793710	4729760	5912200	8277080
Central median barrier (1+1)	per km	20	266500	346450	426400	317750	413075	508400

Countermeasure	Unit of Cost	Service Life	Cost – Rural			Cost - Urban		
			Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)	Low Upgrade Cost ($)	Medium Upgrade Cost ($)	High Upgrade Cost ($)
Clear roadside hazards (seg MC lane) driver side	per km	20	NA	NA	NA	NA	NA	NA
Sideslope improvement (seg MC lane) driver side	per km	20	NA	NA	NA	NA	NA	NA
Roadside barriers (seg MC lane) driver side	per km	20	NA	NA	NA	NA	NA	NA
Wide centerline	per linear km	20	5648	7061	8473	6863	8579	10295
School zone warning - signs and markings	lane km	5	3847	4153	4153	6924	8082	11141
School zone warning - flashing beacon	unit	20	7964	8931	10863	9621	11001	13761
School zone - crossing guard or supervisor	unit	1	7694	8307	8307	13848	16163	22283
Unsignalised raised crossing	unit	10	25584	51168	76752	305040	61008	91512

10.2 Appendix B: Safer Road Investment Plan 1 (BCR>1)

Safer Road Investment Plan 1

Countermeasure	Length / sites	FSI saved (20 years)	BCR
Duplication with median barrier	14.6 km	99	3
Roadside barriers - passenger side	61.3 km	65	4
Roadside barriers - driver side	49.6 km	46	3
Improve Delineation	86.1 km	31	5
Shoulder rumble strips	49.0 km	26	4
Footpath provision passenger side (adjacent to road)	31.0 km	25	2
Traffic calming	16.9 km	23	7
Delineation and signing (intersection)	131 sites	18	3
Footpath provision driver side (adjacent to road)	24.1 km	18	2
Central median barrier (no duplication)	5.5 km	16	14
Additional lane (2 + 1 road with barrier)	14.7 km	12	2
Pedestrian fencing	6.0 km	12	16
Bicycle Lane (off-road)	11.7 km	11	3
Protected turn lane (unsignalised 3 leg)	56 sites	10	2
Signalise intersection (3-leg)	19 sites	10	4
Shoulder sealing passenger side (>1m)	23.1 km	10	3
Shoulder sealing driver side (>1m)	28.5 km	10	2
Bicycle Lane (on-road)	20.0 km	9	4
Clear roadside hazards - passenger side	34.9 km	9	11
Side road unsignalised pedestrian crossing	35 sites	8	4
Refuge Island	17 sites	6	6
Unsignalised raised crossing	28 sites	6	1
Clear roadside hazards - driver side	23.2 km	5	10
Central hatching	7.0 km	3	2
Skid Resistance (paved road)	2.7 km	3	5
Signalised crossing	8 sites	2	2
Overtaking lane	4.0 km	2	1
Street lighting (mid-block)	8.2 km	2	4
Street lighting (intersection)	17 sites	2	4
Improve curve delineation	1.1 km	1	16
Lane widening (up to 0.5m)	0.3 km	1	2
Lane widening (>0.5m)	0.3 km	1	2
Protected turn lane (unsignalised 4 leg)	6 sites	1	4
Signalise intersection (4-leg)	4 sites	1	3

Countermeasure	Length / sites	FSI saved (20 years)	BCR
Roundabout	1 sites	1	2
Centreline rumble strip / flexi-post	0.8 km	1	2
Duplicate - <1m median	0.3 km	1	1
Upgrade pedestrian facility quality	3 sites	1	2
Unsignalised crossing	14 sites	1	0.9
Road surface rehabilitation	1.8 km	1	11
Sideslope improvement - passenger side	0.1 km	1	2
Shoulder sealing passenger side (<1m)	3.6 km	1	2
Footpath provision passenger side (>3m from road)	0.4 km	1	1
Clear roadside hazards (bike lane)	5.2 km	1	31
Pave road surface	0.1 km	1	1
Street lighting (ped crossing)	1 sites	1	26
Parking improvements	4.6 km	1	4
Side road signalised pedestrian crossing	3 sites	1	4
Footpath provision passenger side (informal path >1m)	12.4 km	1	1
Shoulder sealing driver side (<1m)	4.2 km	1	2
Footpath provision driver side (>3m from road)	0.8 km	1	2
Footpath provision driver side (informal path >1m)	11.9 km	1	1
Wide centreline	19.0 km	1	3
		530	3

10.3 Appendix C: Star Ratings (After) for Plan 1 (BCR>1)

Star Ratings After (smoothed) - Plan 1 (BCR>1)

Road User	Vehicle Occupants			Motorcyclists			Pedestrians			Bicyclists		
	Length (km)	Percent	Change	Length (km)	Percent	Change	Length (km)	Percent	Change	Length (km)	Percent	Change
5 Stars	99.3	48%	+37%	31.0	15%	+7%	20.0	10%	+9%	53.6	26%	+9%
4 Stars	89.2	43%	+13%	117.0	57%	+42%	56.6	28%	+23%	38.1	19%	+4%
3 Stars	16.7	8%	-30%	55.4	27%	-23%	32.3	16%	-5%	76.4	37%	+3%
2 Stars	0.0	0%	-19%	1.8	1%	-21%	2.2	1%	-17%	11.4	6%	-14%
1 Star	0.0	0%	-3%	0.0	0%	-5%	0.2	0%	-9%	0.0	0%	-2%
Not applicable	0.0	0%	±0%	0.0	0%	±0%	93.9	46%	±0%	25.7	13%	±0%
Totals	205.2	100%		205.2	100%		205.2	100%		205.2	100%	

10.4 Appendix D: List of Abbreviations and Acronyms

AADT	Annual Average Daily Traffic
ARRB	Australian Road Research Board
AusRAP	Australian Road Assessment Programme
BCR	Benefit cost ratio
DVDL	Department of Vehicle and Drivers' Licensing
EuroRAP	European Road Assessment Programme
FIA	Fédération Internationale de l'Automobile
FSI	Fatal and serious injury
GDP	Gross domestic product
GIS	Government Information Services
GPS	Global Positioning System
iRAP	International Road Assessment Programme
KSI	Killed and seriously injured
NRA	The National Road Authority
PWD	Public Works Department
RAP	Road Assessment Programme
RCIPS	Royal Cayman Islands Police Service
SRIP	Safer Roads Investment Plan
SRS	Star Rating Score
US $	United States dollar
usRAP	United States Road Assessment Programme
WHO	World Health Organization

11 References

iRAP, *Safer Roads Investment Plans: The iRAP Methodology,* 2009. http://irap.org/library.aspx.

iRAP, *Star Rating Roads for Safety: The iRAP Methodology*, 2009. http://irap.org/library.aspx.

iRAP, *Vehicle Speeds and the iRAP Protocols*, 2010. http://irap.org/library.aspx

iRAP, *Quality Assurance Guide – Coding Edition,* 2011.

iRAP, gTKP, GRSF, ARRB Group (2010) *Road Safety Toolkit*. www.irap.org/toolkit.

K. McMahon and S. Dahdah, *The True Cost of Road Crashes: Valuing life and the cost of a serious injury*, iRAP, 2008. http://irap.org/library.aspx.

OECD, Towards Zero – Ambitious road safety targets and the safe systems approach (2008)

Vulcan, P. and Corben, B., *Prediction of Australian Road Fatalities for the Year 2010,* Monash University Accident Research Centre (MUARC), Melbourne, 1998.

World Health Organisation, *Global Status Report on Road Safety,* 2013. http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/

World Health Organisation, *Data systems: a road safety manual for decision-makers and practitioners*, 2010.

World Health Organisation, *Global Plan for the Decade of Action for Road Safety 2011-2020*, 2011.