South African Road Assessment Programme (SA-RAP)

Assessment of a Section of the P2-2(R102) Road in the KwaZulu-Natal Province

and the

Roll-out of the SA-RAP in South Africa

March 2019

Compiled by:
RTMC: Research and Development Unit

Preamble

The International Road Assessment Programme (iRAP) is the umbrella programme for Road Assessment Programmes (RAPs) worldwide that are working to save lives. The iRAP.is a proven programme that seeks to ensure the elimination of high-risk roads with the ultimate objectives of saving lives. The iRAP method gives consideration to both engineering and economic factors in road design by identifying risks, developing countermeasures and proposing investment plans. This is a sound quantifiable approach that enhances the quality of management and policy decisions. To this end many countries have successfully implemented the iRAP and can show the impact of specific targeted interventions. The South African Road Assessment Programme (SA-RAP), which is one of the RAP partners under the iRAP, is yet to be institutionalised as a method of choice in network level road assessments in South Africa.

Collaborative efforts between the Road Traffic Management Corporation (RTMC), so mandated to manage road infrastructure audits by the Road Traffic Management Corporation Act No. 20 of 1999 and the Department of Transport (DoT), resulted in a decision to jointly rollout the SA-RAP on the provincial strategic road network South Africa. An iRAP accredited service provider was appointed in 2018 by the DoT to conduct surveys and coding of the strategic road networks of the Kwa-Zulu Natal and Free State provinces as the first phase of the roll-out. Ultimately, approximately 3,000 km of provincial roads will be assessed per province, resulting in Star-Rated roads and Safer Road Investment Plans (SRIPs) proposals towards providing more forgiving roads in line with the 'Safe System' approach.

The report presents the results of a section of hazardous road (50.0 km) of the R102 (P2-2) in the KwaZulu-Natal province. The collaborative effort entailed the evaluation and analysis of a sample of the surveyed and coded data on a section of the identified hazardous road. The exercise will also be used to test the process that will be used in rolling out the SA-RAP to the rest of the provinces. The improvement of the methodology will keep SA-RAP abreast of developments, allow for process improvements and modernisation towards providing more forgiving roads.

Even though one life lost or one injury due to a road crash is one too many, the fact remains that humans are fallible and are bound to err, resulting in the unfortunate burden and consequences of fatalities and injuries on our roads. We however strive to minimise fatalities and injuries due to road crashes by attempting to provide road infrastructure that is forgiving: in the event of a crash, the risk of serious injury or death should be minimised.

Increasingly governments are forced to improve the considerations in making investment and operational decisions in view of the declining growth levels in the economies globally and in South Africa. This translates into maximising value for every rand spent on government spending including social and economic infrastructure. Road Safety is not spares the brunt of this exercise where competition for limited resources is a reality. It is critical that road safety measures should find expression in the prevailing set of circumstances including existing budgets.

Providing forgiving road infrastructure is expensive and with current funding challenges, the most effective and affordable road safety countermeasures need to be determined to ensure that the most possible lives and serious injuries are prevented in the event of a crash. This report illustrates the effects of investing in the best possible countermeasures by providing various Safer Road Investment Plans (SRIP) for consideration.

The SRIP chosen for implementation by the provincial authority will depend on available funds, and strategic objectives towards reducing the risk of fatal and serious injuries of particular road users. Taking ownership of this report is an important consideration. The relationship with authorities responsible for the provision of road infrastructure is sacrosanct in the realisation of national priorities. It is with the sprit of the Intergovernmental Relations Framework Act that this report is presented to the implementing authority for consideration.

.

About iRAP/SA-RAP

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
- track road safety performance so that funding agencies can assess the benefits of their investments.

The programme is the umbrella organisation for inter alia SA-RAP, EuroRAP, AusRAP, usRAP and KiwiRAP. Road Assessment Programmes (RAP) are now active in more than 80 countries throughout Europe, Asia Pacific, North, Central and South America and Africa.

SA-RAP is the South African Road Assessment Programme under the auspices of the Road Traffic Management Corporation (RTMC).

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 compiled by Deon Roux, RTMC: Research and Development (DeonR@rtmc.co.za).

For general enquiries, contact:

Road Traffic Management Corporation (RTMC)
Eco Origin Park, 349 Witch-Hazel Street, Highveld Ext 79, Gauteng, South Africa
Telephone: +27 (0) 12 999 5200
Email: Info@rtmc.co.za
www.rtmc.co.za

Document version history

Version	Date	Description
SA-RAP P2-2 V1.1	08 February 2019	Document created

Reviewed	Date	By
SA-RAP P2-2 V1.1	08 February 2019	RTMC: Research & Development
SA-RAP P2-2 V1.2	12 February 2019	RTMC: Research & Development
SA-RAP P2-2 V1.3	16 February 2019	RTMC: Research & Development
SA-RAP P2-2 V1.4	20 February 2019	RTMC: Research & Development
SA-RAP P2-2 V1.5	24 February 2019	RTMC: Research & Development
SA-RAP P2-2 Report	14 March 2019	RTMC: Research & Development

Acronyms

AADT	Average Annual Daily Traffic
AMSS-CMV	The Automobile and Motorcycle Association of Serbia - Centre for Motor Vehicles
AusRap	Australian Road Assessment Programme
ARRB	Australian Road Research Board
BCR	Benefit cost ratio
CPIX	Consumer Price Index
DoT	Department of Transport, South Africa
DoT	Department of Transport, South Africa
EuroRAP	Europe Road Assessment Programme
FSI	Fatal And Serious Injury
FIA	Federation Internationale de l'Automobile
GDP	Gross Domestic Product
iRAP	International Road Assessment Programme
km	Kilometre
LASA	LEA Associates South Asia Pty. Ltd.
VIDA	Meaning 'Life' In Spanish (Refers to the online VIDA Analysis Software)
MUARC	Monash University Accident Research Centre, Melbourne
KiwiRAP	New-Zealand Road Assessment Programme
PCU	passenger car equivalent
RTC	Road Traffic Crashes
RTMC	Road Traffic Management Corporation, South Africa
SRIP	Safer Roads Investment Plan
ZAR	South African Rand
SA-RAP	South African Road Assessment Programme
SRS	Star Rating Scores
UNDA	United Nations Decade of Action
UsRAP	United States Road Assessment Programme
VRU	Vulnerable Road User
WHO	World Health Organisation

Executive Summary

The number of road traffic deaths continues to rise steadily, reaching 1.35 million in 2016. However, the rate of death relative to the size of the world's population has remained constant. When considered in the context of the increasing global population and rapid motorisation that has taken place over the same period, this suggests that existing road safety efforts may have mitigated the situation from getting worse. However, it also indicates that progress to realise Sustainable Development Goal (SDG) target 3.6 – which calls for a 50% reduction in the number of road traffic deaths by 2020 – remains far from sufficient.[1]

As part of the collaborative effort between the Road Traffic Management Corporation (RTMC) and the Department of Transport (DoT) to roll-out the SA-RAP or iRAP in South Africa, towards providing safer and more forgiving road infrastructure, a section of hazardous road (50.0 km) of the R102 (P2-2) in the KwaZulu-Natal province was assessed.

Ultimately, approximately 3,000 km of provincial roads will be assessed per province, Star-Rated and Safer Investment Plans (SRIPs) proposed towards providing more forgiving roads in line with the 'Safe System 'approach.

The DoT appointed an iRAP accredited service provider in 2018 to conduct the surveys and coding of the strategic road networks of the KwaZulu-Natal and Free State provinces.

This technical report describes the P2-2(R102) project, undertaken to identify risks and propose countermeasures through Safer Roads Investment Plan (SRIP) options in an effort to reduce road deaths and serious injuries on the section hazardous road. The report 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 for each of the dual carriageway sections.

For the purpose of this report, to illustrate the effects of investing in the best possible countermeasures or choosing a lower benefit cost with less investment, to take into account funding challenges, two SRIPs are interrogated and the improved Star-Ratings, estimated fatal and serious injuries (FSIs) saved and estimated cost of countermeasures for each of the two SRIP options discussed.

With the most expensive investment, SRIP Plan A (Estimated Countermeasure Cost = R27,144,974), it is estimated that FSIs are likely to reduce by 7.0%, preventing an estimated 10 FSIs each year and an estimated reduction of 190 FSIs over a 20-year period. SRIP Plan J (Estimated Countermeasure Cost = R 2,906,701), with the lowest investment, it is estimated that FSIs are likely to reduce by 4.8%, preventing an estimated 7 FSIs each year and an estimated reduction of 130 FSIs over a 20-year period.

The four Star Rating tables below provide details of the projected Star Ratings based on the countermeasures within the analysed Plans. before and after countermeasure implementation for Plan A and Plan J for Vehicle Occupants and the same for Pedestrians.

---

[1] WHO Global Status Report on Road Safety (2018)

Star Ratings Before and After Countermeasures – Plan A (Vehicle Occupant)

Star Ratings Before and After Countermeasures (Smoothed)	Plan A - Vehicle Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,0	0,00%	+58.32%	0,0	0,00%	+81.36%	+0.00%	+23.04%
4 Stars	4,0	8,02%		9,8	19,64%		+0.12%	
3 Stars	25,1	50,30%		30,8	61,72%		+0.11%	
2 Stars	17,3	34,67%	+41.68%	9,3	18,64%	+18.64%	-0.16%	-23.05%
1 Star	3,5	7,01%		0,0	0,00%		-0.07%	
Not applicable	0,0	0,00%	-	0,0	0,00%	-	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

With the most expensive investment, SRIP Plan A (Estimated Countermeasure Cost = R27,144,974), 81.36% of the road will have a Star Rating of 3 or more for Vehicle Occupants with only 18.64% having a Star Rating less than 3, an increase in the Star Rating of 23.05% for 3 Stars or better. For Pedestrians, the increase to a Star Rating 3 or more is 18.64% with only 0.6% of the road that is used by pedestrians having a Star Rating less than 3.

Star Ratings Before and After Countermeasures – Plan A (Pedestrian)

Star Ratings Before and After Countermeasures (Smoothed)	Plan A - Pedestrian Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,3	0,60%	+13.42%	2,4	4,81%	+32.06%	+0.04%	+18.64%
4 Stars	0,6	1,20%		10,6	21,24%		+0.20%	
3 Stars	5,8	11,62%		3,0	6,01%		-0.06%	
2 Stars	3,4	6,81%	+19.23%	0,3	0,60%	+0.60%	-0.06%	-18.64%
1 Star	6,2	12,42%		0,0	0,00%		-0.12%	
Not applicable	33,6	67,33%	67,33%	33,6	67,33%	67,33%	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

Star Ratings Before and After Countermeasures – Plan J (Vehicle Occupant)

Star Ratings Before and After Countermeasures (Smoothed)	Plan J - Vehicle Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,0	0,00%		0,0	0,00%		+0.00%	
4 Stars	4,0	8,02%	+58.32%	4,0	8,02%	+60.93%	+0.00%	+2.61%
3 Stars	25,1	50,30%		26,4	52,91%		+0.03%	
2 Stars	17,3	34,67%	+41.68%	17,5	35,07%	+39.08%	+0.00%	-2.61%
1 Star	3,5	7,01%		2,0	4,01%		-0.03%	
Not applicable	0,0	0,00%	-	0,0	0,00%	-	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

With the more economical option, SRIP Plan J (Estimated Countermeasure Cost = R 2,906,701), 60.93% of the road will have a Star Rating of 3 or more for Vehicle Occupants with 39.08% having a Star Rating less than 3, an increase in Star Rating of 2.61% for 3 Stars or better. For Pedestrians, the increase to a Star Rating 3 or more is 11.63% with 11.63% of the road that is used by pedestrians having a Star Rating less than 3.

Star Ratings Before and After Countermeasures – Plan J (Pedestrian)

Star Ratings Before and After Countermeasures (Smoothed)	Plan J - Pedestrian Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,3	0,60%		2,0	4,01%		+0.03%	
4 Stars	0,6	1,20%	+13.42%	3,5	7,01%	+25.05%	+0.06%	+11.63%
3 Stars	5,8	11,62%		7,0	14,03%		+0.02%	
2 Stars	3,4	6,81%	+19.23%	3,3	6,61%	+7.61%	-0.00%	-11.63%
1 Star	6,2	12,42%		0,5	1,00%		-0.11%	
Not applicable	33,6	67,33%	67,33%	33,6	67,33%	67,33%	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

Due to the low pedestrian flow, a grade-separated pedestrian crossing as countermeasure did not trigger in the VIDA analysis due to it not being economically feasible with not adequate return on investment. Pedestrian activity need to be addressed separate from this analysis by means of either education and/or law enforcement.

The project also involved the creation of Safer Roads Investment Plans (SRIP), that consider the relative benefits of over 90 different countermeasure options, ranging from low cost road markings and pedestrian refuges to higher cost intersection upgrades and full highway duplication. Three SRIP 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 providing facilities for pedestrians.

In total, 10 investment plans were produced ranging from Plan A with a threshold BCR of 1 (that is, the economic benefit of each countermeasure must be at least greater than the cost) up to Plan J with a threshold BCR of 10 (that is, the economic benefit of each countermeasure must exceed 10 times the cost). the ten plans analysed are summarized in the Table below:

Summary - Safer Road Investment (Plans A-J)

SRIP Plans A-J						*Currency: R ZAR - Analysis Period: 20 years iod: 20 years*		
SRIP Plan	BC QV Value	Total FSIs Saved	Total PV of Safety Benefits	Estimated Cost (ZAR)	Cost per FSI saved (ZAR)	Program BCR	No. of CM	% Reduction FSI
A	1	190	83,923,859	27,144,974	142,611	3	27	7,0%
B	2	169	74,358,258	13,071,204	77,506	6	22	6,2%
C	3	161	70,805,653	8,684,585	54,079	8	19	5,9%
D	4	152	67,044,472	6,548,914	43,068	10	15	5,6%
E	5	150	65,974,294	5,287,820	35,339	12	15	5,5%
F	6	146	64,359,602	4,474,672	30,655	14	11	5,3%
G	7	143	63,067,464	3,818,770	26,697	17	11	5,2%
H	8	139	61,332,725	3,363,349	24,178	18	8	5,1%
I	9	135	59,382,594	3,094,013	22,973	19	6	4,9%
J	10	130	57,367,017	2,906,701	22,340	20	6	4,8%

Recorded Average Annual Fatal:	27,3	SRIP	Safer Investment Plan
Serius Injury Factor:	4	BC QV	Benefit Cost Qualification Value
Annual FSIs:	136,7	FSI	Fatal and Serious Injury
Analysis Period:	20	BCR	Benefit Cost Ratio
Estimated FSIs over Analysis Period:	2733	CM	Countermeasures

The most comprehensive SRIP (Plan A) shows that, by investing ZAR 27.1 million over a 20-year period, the number of deaths and serious injuries on the road could be reduced by 7.0%, preventing an estimated 190 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 3:1. Plan B shows that, by investing ZAR 13.1 million, the number of deaths and serious injuries on the road could be reduced by 6.2%, preventing an estimated 169 deaths and serious injuries over 20 years with an overall benefit cost ratio of 6:1.

The list of countermeasures shown in each of the plans suggest that significant safety improvements can be made to the P2-2(R102) section of road through the implementation of several key safety treatments, countermeasure treatments such as footpath provision on the driver side and passenger side adjacent to road.

The most economical of the plans analysed (Plan J) shows that by investing ZAR 2.9 million, the number of deaths and serious injuries on the road could be reduced by 4.8%, preventing an estimated 130 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 20:1.

Plan A proposes 27 possible countermeasures amounting which could save the estimated 190 FSIs over a 20-year period with Plan J, the more economical plan, proposing only 6 possible countermeasures amounting which could save the estimated 130 FSIs over a 20-year period.

The selection of an appropriate level of investment need to be decided on by the respective provincial road authorities. 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 – local experience with different countermeasures, effectivity thereof in the South African context.
- 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
- 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 (http://vida.irap.org).

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 improving speed limit compliance, seat belt and helmet wearing rates and reducing alcohol use, improving the safety of the vehicle fleet, 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.

Further, research has demonstrated that it is crucial to ensure that local communities have the opportunity to both contribute to road designs but also understand the intended use of various road design features (see for example, BRAC, 2005). The respective road authority should pursue these complementary approaches as part of the ongoing core road network development programme.

Taking into account the improved Star Ratings, and the estimated 10 annual FSIs saved or 190 FSIs over a 20-year period for Plan A versus the estimated 7 Annual FSIs or 130 FSIs over a 20-year period saved with Plan J, for only 50km of the provincial road network and the massive financial impact to improve the provincial surfaced road network in South Africa (estimated 46,805km), the more economical option might be more realistic in the short and medium term.

The SRIPs chosen to be implemented by the provincial authority will depend on available funds and strategic objectives towards reducing the risk of FSIs of particular road users on different classes of road.

Ultimately, the same process of producing Star-Ratings and SRIPs need to be conducted for each of the provincial strategic road networks with countermeasures implemented to reduce the risk of FSIs.

Acknowledgments

The collaboration between the Road Traffic Management Corporation (RTMC) and the Department of Transport (DoT) towards the rolling out of the South African Road Assessment Programme (SA-RAP) under the umbrella organisation, the International Road Assessment Programme (iRAP) in South Africa would not have been possible without the support of:

- Refilwe Mongale (RTMC: Chief Strategy Officer)
- Mzondezi Futshane (DoT: Chief Director - Road Engineering for Development)

The surveying and coding of the data was conducted by VNA Consulting, an accredited iRAP service provider; special thanks to the following VNA Consulting officials:

- Yeshveer Balaram
- Verushka Balaram

The quality assurance of the coded data was conducted by Indian Road Survey and Management Pvt. Ltd (IRSM), an Australian Road Research Board (ARRB) joint venture in India.

The Quality Assurance of the iRAP VIDA Data Set (Stage 1 – Stage 6) was conducted ARRB / IRSM

The project was funded by the DoT, the VIDA Analysis and the Report was executed by the RTMC.

Contents

List of Figures and Tables:

1 Introduction

The number of road traffic deaths continues to rise steadily, reaching 1.35 million in 2016. However, the rate of death relative to the size of the world's population has remained constant. When considered in the context of the increasing global population and rapid motorisation that has taken place over the same period, this suggests that existing road safety efforts may have mitigated the situation from getting worse. However, it also indicates that progress to realise Sustainable Development Goal (SDG) target 3.6 – which calls for a 50% reduction in the number of road traffic deaths by 2020 – remains far from sufficient.[2]

As progress is made in the prevention and control of infectious diseases, the relative contribution of deaths from non-communicable diseases and injuries has increased. Road traffic injuries are the eighth leading cause of death for all age groups. More people now die as a result of road traffic injuries than from HIV/AIDS, tuberculosis or diarrhoeal diseases. Road traffic injuries are currently the leading cause of death for children and young adults aged 5–29 years, signalling a need for a shift in the current child and adolescent health agenda which, to date, has largely neglected road safety.[1]

A number of countries have seen success in reducing road traffic deaths over the last few years, but progress varies significantly between the different regions and countries of the world. There continues to be a strong association between the risk of a road traffic death and the income level of countries. With an average rate of 27.5 deaths per 100,000 population, the risk of a road traffic death is more than three times higher in low-income countries than in high-income countries where the average rate is 8.3 deaths per 100,000 population. Furthermore, the burden of road traffic deaths is disproportionately high among low- and middle-income countries in relation to the size of their populations and the number of motor vehicles in circulation.[1]

1.1 Road safety in South Africa

It is recognised that investment in the transport network plays an important role in a country's economic development and poverty reduction. To this end, investment in road building programmes is often focused on improving mobility and reducing journey times. However, it is of paramount importance that every opportunity be taken to ensure that these new roads and rehabilitation projects focus on the need for safe road infrastructure for all road users, particularly the young and vulnerable.

The high number of Road Traffic Crashes[3] (RTCs) and their associated consequences have a significant impact on the South African society, which continues to hamper socio-economic development and impact on the well-being of all South Africans. This impact is measured in terms of human lives lost, 'pain, grief and suffering', as well as an increasing cost to the economy. The total cost of RTCs on South Africa's road network for 2015 amounted to an estimated R142.95 billion.[4] This figure, adjusted by the RTMC with CPIX and the

[2] WHO Global Status Report on Road Safety (2018)

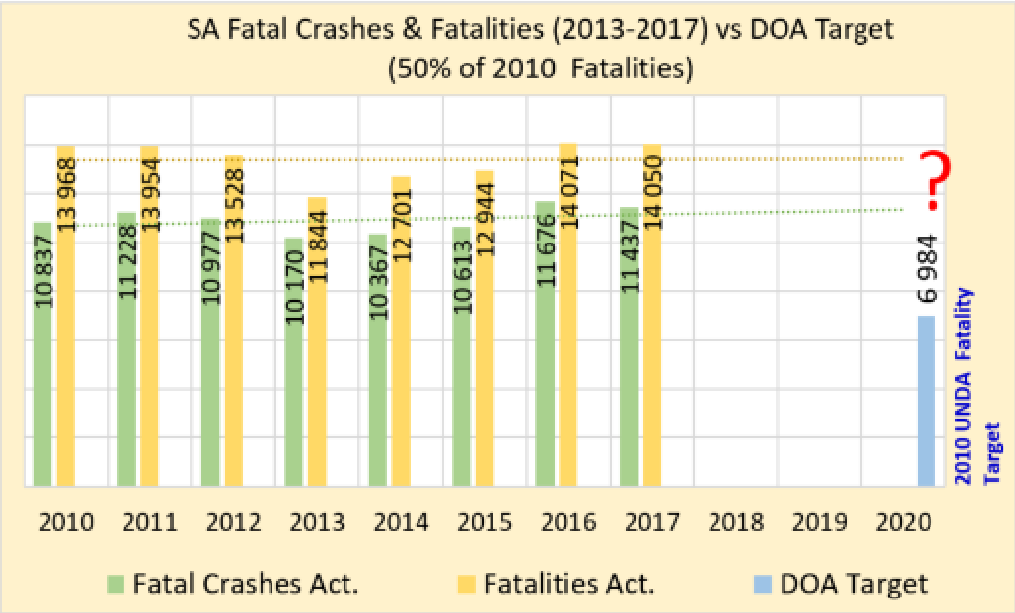
[3] The term 'crash' imparts the same meaning as "accident" noted in the National Road Traffic Act, 93 of 1996.

[4] F. Labuschagne, E. de Beer, D. Roux and K. Venter, (2016). *Cost of Crashes in South Africa 2016*. Road Traffic Management Corporation (RTMC), http://www.rtmc.co.za.

number of fatalities for 2017 amounted to an estimated cost of crashes for 2017 at R162,045 billion equating 3.48% of the South African Gross Domestic Product (GDP-2017)[5]

It is evident that the target of the 2010 United Nations Decade of Action (UNDA) initiative to which South Africa is a signatory, to halve road fatalities by 2020, will not be reached with fatal road traffic crashes and fatalities in South Africa not showing the desired annual decrease from 2010 onwards to achieve the 2020 UNDA target of 6,984 fatalities as shown in Figure 1.1 below.

Figure 1. 1: SA Fatal Crashes & Fatalities (2010-2017) vs UNDA Target



A small decrease in fatal crashes and fatalities were recorded from 2010 to 2012 with a sharp decrease in 2013 to 11,844 fatalities. From 2013 to 2016 a steady increase in fatalities was recorded with 11,844 in 2013 to 14,071 fatalities in 2016; the recorded 14,051 fatalities in 2017 is 21 less than in 2016.

Further analysis of the fatality data recorded by the RTMC indicates that when calculating the fatalities per 10,000 registered motorised vehicles, it indicates that this ratio has declined from 2010 to 2017 (Figure 1.3 below) and the linear projection predicts a further decrease in the ratio of fatalities vs 10,000 registered motorised vehicles.

When analysing the fatalities and fatal crashes from 2010 to 2017, as depicted in Figure 1.1 above, with linear trend lines shown for both fatalities and fatal crashes from 2010 to 2020, it could be argued that even though registered motor vehicles have increased drastically since 2010 on an annual basis (Figure 1.2 below), the fatalities have stayed more or less the same from 2010 to 2017. If this 'trend' continues, it in fact means that theoretically, road safety efforts in South Africa were not in vain, as one would expect fatal crashes and fatalities to increase with an increase of registered motor vehicles on the road network which would create more points of conflict and a greater probability of crashes.

---

[5] RTMC Research and Development Unit – Adjusted Cost of Crashes 2017

Figure 1. 2: Registered Motorised Vehicles in South Africa (2010-2017)[6]

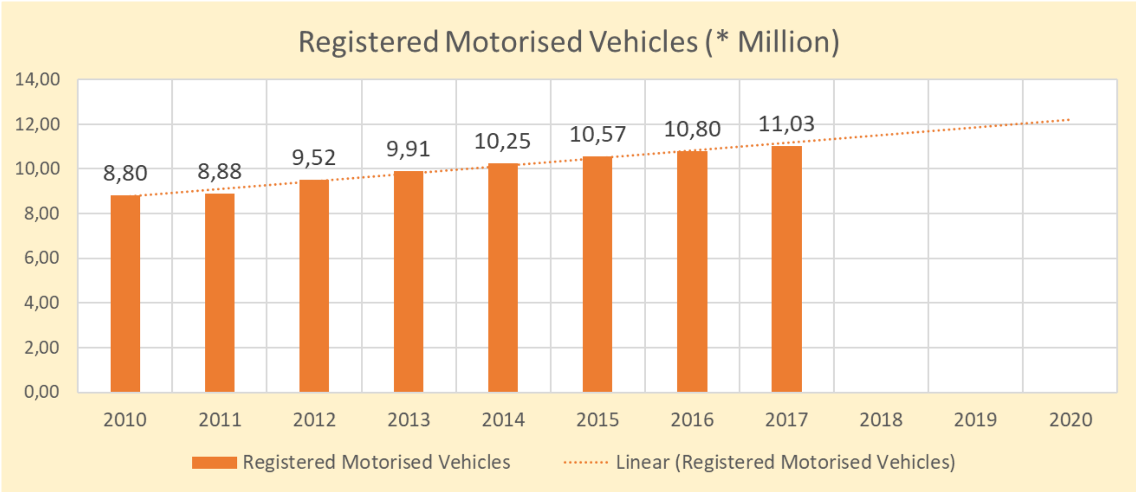
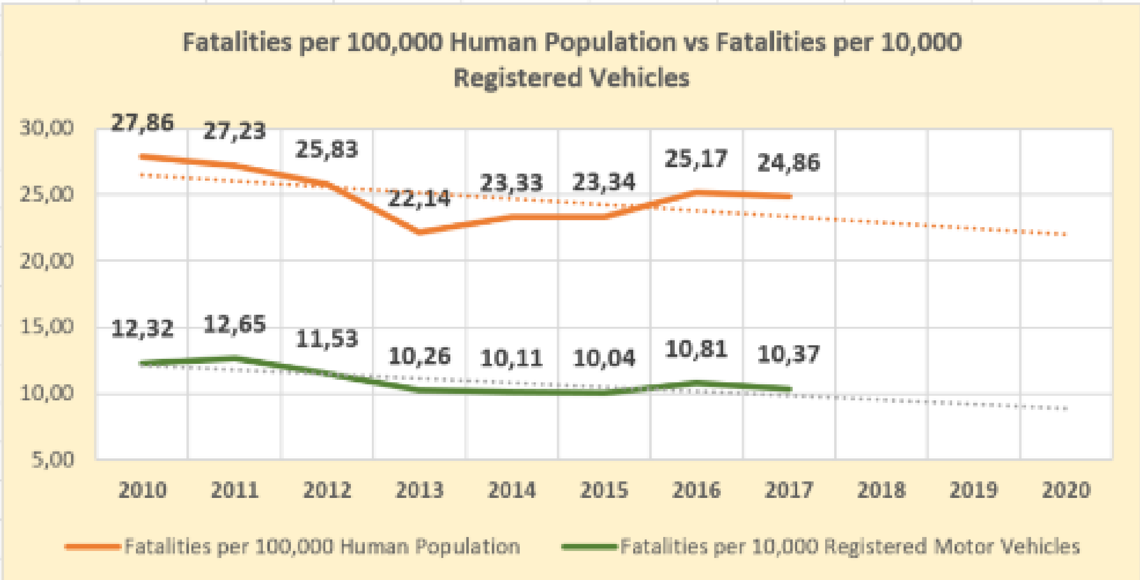


Figure 1. 3: Fatalities per 100,000 Human Population and per 10,000 Registered Vehicles (2010-2017)



In addition, even though the ratio of fatalities per 100,000 population (24.86 for 2017) is still unacceptably high when benchmarked internationally, there has been a decline in this ratio from 2010 as depicted in Figure 1.3 above.

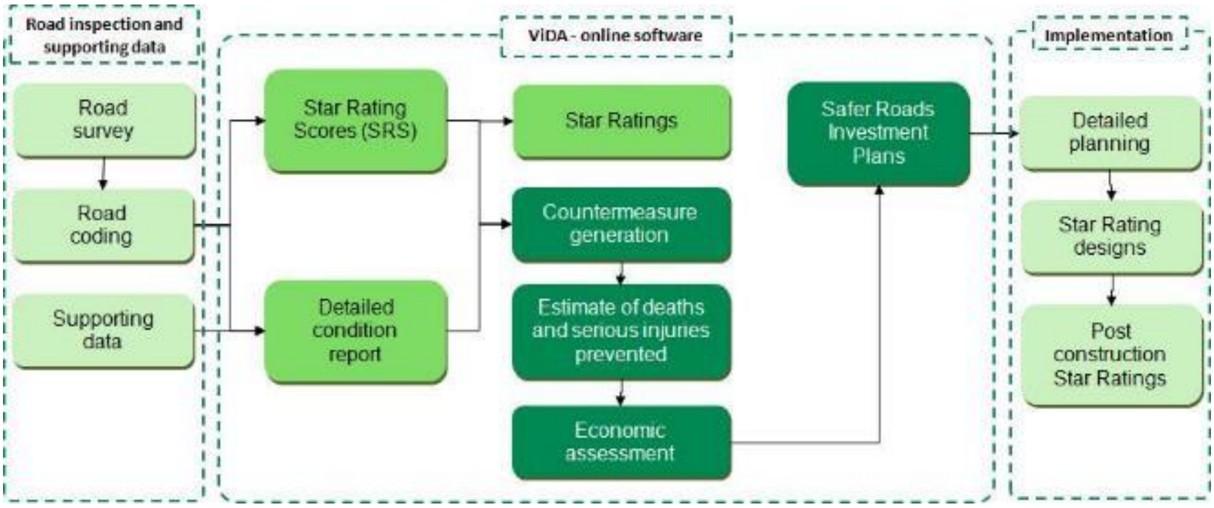
The RTMC however strives, in line with the 'Safe System' approach, and the UNDA initiatives to reduce road traffic fatalities and fatal crashes. One of the key interventions that forms part of the National Road Safety Strategy 2016-2030, which the RTMC is mandated to manage, is road infrastructure audits that includes the roll-out of the SA-RAP.

[6] RTMC NaTIS Reports 2010-2017

1.2 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 2.1 The iRAP assessments make use of road attribute data for more than 50 variables at 100-metre intervals along a road. This data was compiled through road surveys that collect digital images of the road using multi-view high-resolution cameras as it is driven. After the images were collected and were viewed by coders using specialised software in the office to record the road attributes.

Figure 2. 1: 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 is described in the following fact sheets:

- iRAP Methodology Fact Sheet 3: Road Attributes
- iRAP Methodology Fact Sheet 4: Crash Types
- iRAP Methodology Fact Sheet 5: External Flow and Median Traversability
- iRAP Methodology Fact Sheet 6: Star Rating Score Equations
- iRAP Methodology Fact Sheet 7: Star Rating Bands
- iRAP Methodology Fact Sheet 8: Smoothed Star Ratings
- iRAP Methodology Fact Sheet 9: Star Rating Worked Example
- iRAP Methodology Fact Sheet 10: Casualty Estimation and Calibration
- iRAP Methodology Fact Sheet 11: Countermeasures
- iRAP Methodology Fact Sheet 12: Multiple Countermeasures
- iRAP Methodology Fact Sheet 13: Economic Analysis

The methodology fact sheets 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 Ratings and Investment Plans: Coding Manual (August 2014)*
- *iRAP Star Ratings and Investment Plans: Quality Assurance Guide*

1.3 Online results

This report provides details of the methodology used and summarises the results produced in the '*South Africa RAP > RTMC 2019 > RTMC/DOT/VNA > KZN R102 Section'* 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 register as a new user 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 can be gained by registering for an account. Following this access to the '*KZN R102 Section' file* can be requested from support@irap.org.

2 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.[7] 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 having the apparent problem areas patched up
- 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 safe 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.

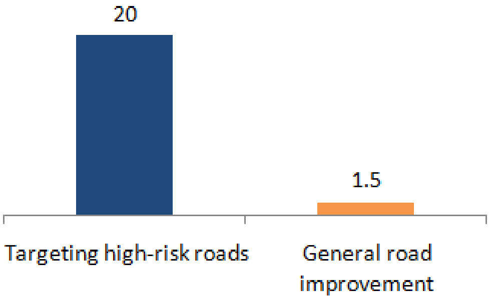
Evidence shows that affordable, safe road infrastructure can cut vehicle occupant, motorcyclist, pedestrian and bicyclist deaths dramatically. Few infrastructure investments can match the economic benefits of those generated by targeted road safety measures (see Figure 3.1 below). Research from Australia, the United States, he United Kingdom, Norway, 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.[8] 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 shown first year rates

[7] See for example www.who.int/violence_injury_prevention/road_traffic/strategies/en/index.html and www.ors.wa.gov.au/.

[8] OECD (2008) Towards Zero – Ambitious road safety targets and the safe systems approach -- page 96, section 4.2 "The road safety management system".

of return of 300%.[9] 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.

Figure 3 1: Number of lives saved for each $100m invested [10]



Engineering solutions exist for all of the primary crash types that kill road users, Table 1.1 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 1 1: 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 in trying to cross the road.	Solutions include: Footpaths, pedestrian fencing, speed management and traffic calming, safe crossing points.	
Hit Motorcyclist Crash Motorcyclists are killed when they are hit by heavier vehicles and trucks.	Solutions include: Fully separated motorcycle lanes, on-road motorcycle lanes.	
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.	

[9] Road Safety Foundation (2008).

[10] 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
Run-off Road Crash Vehicle leaves the road and strikes a fixed object (tree, pole, structure) or steep embankment.	Solutions include: Protection of the hazard with barriers, remove hazard, provide safe run-off area.	
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 South African road network over the Decade of Action can make a significant contribution to the eradication of road traffic death and injury.

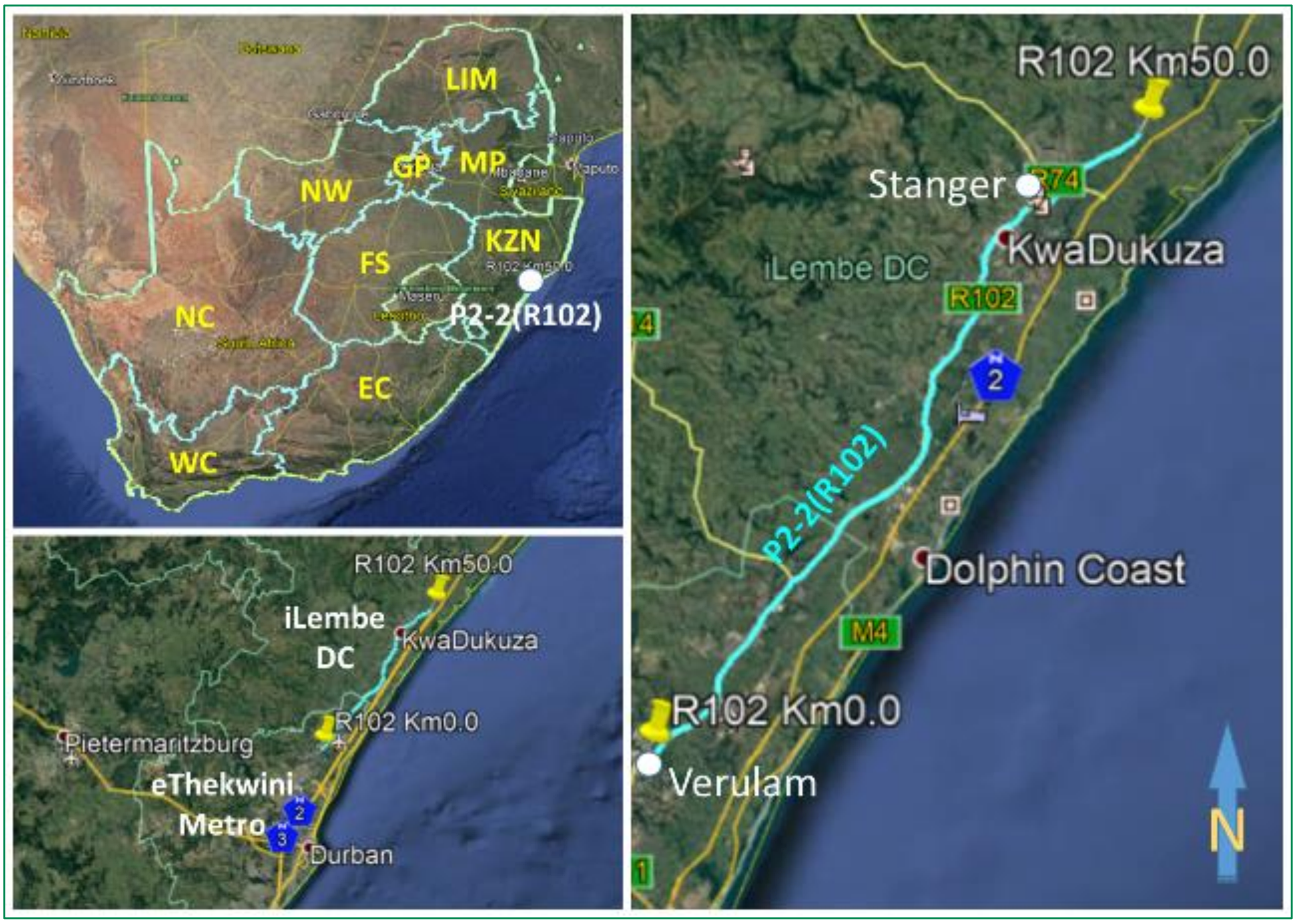
3 Road Survey and Coding

Using a specially equipped vehicle (Figure 4.1), VNA Consulting that was appointed by DoT, surveyed the road section in concern, recording continuous digital images and geo-reference data to enable the coding of more than 50 road attributes relating to the likelihood and severity of a crash.

3.1 Location (R102 / P2-2)

The ±50.0 km section of undivided dual carriageway P2-2 (R102) is situated in the KwaZulu-Natal province in South Africa, in the eThekwini and iLembe municipal areas. The hazardous section of road, which ranks high on the RTMCs Hazardous Areas Model, stretches from Verulam to the South past Stanger to the North.

Image 1 1: Location of (R102 / P2-2)



3.2 Road surveys

The surveys were undertaken by VNA Consulting using the Hawkeye 2000 Series system. The features of the inspection system are inter alia:

- High resolution, full colour digital images referenced against chainage or GPS (optional)
- Less than 1 m image position error (with DMI distance sensor).

Figure 4 1: The road survey vehicle

3.3 iRAP coding

Upon completion of the surveys, the VNA coding team recorded road attributes in accordance with the iRAP Star Ratings and Investment Plans: Coding Manual. The coded data was subject to quality assurance checks in accordance with the iRAP Star Ratings and Investment Plans: 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. The quality assurance of the data was conducted internally by VNA and externally by the iRAP accredited Indian Road Survey and Management Pvt. Ltd (IRSM), an Australian Road Research Board (ARRB) joint venture in India.

3.4 Road attributes

The following tables summarises the road attributes recorded and helps to illustrate the relationship between road infrastructure attributes and road user risk. A full data set of the coded attributes is available as a downloadable file from http://vida.irap.org.

3.4.1 Detailed Road Conditions (survey length: 50.0 km)

The Detailed Road Condition tables within ViDA provide the length and percentage for each category of recorded road attribute. The tables 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.

The road conditions of the 50 km of the R102 are detailed in the following 4 Tables:

- Table 2.1: Mid-block
- Table 2.2: Roadside
- Table 2.3: Intersections
- Table 2.4: Vulnerable Road User (VRU) Facilities and Land Use

For example, the data shows that 6.2km or 12% of the road section a divided carriageway road, 1.1km or 2% of the road section is in a poor condition and there is no street lighting on the section of road.

Table 2 1: Mid-block

Carriageway label	km	%
Carriageway A of a divided carriageway road	6.20	12
Undivided road	43.70	88
Upgrade cost	**km**	**%**
Low	9.40	19
Medium	30.00	60
High	10.50	21
Median type	**km**	**%**
Safety barrier - metal	0.60	1
Physical median width >= 10.0m to < 20.0m	3.60	7
Physical median width >= 5.0m to < 10.0m	0.70	1
Physical median width >= 1.0m to < 5.0m	1.20	2
Physical median width >= 0m to < 1.0m	0.10	0
Central hatching (>1m)	5.10	10
Centre line	22.80	46
Wide centre line (0.3m to 1m)	15.80	32
Centreline rumble strips	**km**	**%**
Not present	49.90	100
Number of lanes	**km**	**%**
One	43.90	88
Two	4.60	9
Two and one	1.40	3
Lane width	**km**	**%**
Wide (>= 3.25m)	48.30	97
Medium (>= 2.75m to < 3.25m)	1.60	3
Curvature	**km**	**%**
Straight or gently curving	35.70	72
Moderate	14.20	28
Quality of curve	**km**	**%**
Adequate	14.20	28
Not applicable	35.70	72

Grade	km	%
>= 0% to <7.5%	21.60	43
Not applicable	2.60	5
Not applicable	7.80	16
>= 7.5% to <10%	17.90	36
Road condition	**km**	**%**
Good	33.80	68
Medium	15.00	30
Poor	1.10	2
Skid resistance / grip	**km**	**%**
Sealed - adequate	41.60	83
Sealed - medium	8.30	17
Delineation	**km**	**%**
Adequate	33.80	68
Poor	16.10	32
Street lighting	**km**	**%**
Not present	37.30	75
Present	12.60	25
Vehicle parking	**km**	**%**
None	41.70	84
One side	6.70	13
Two sides	1.50	3
Service road	**km**	**%**
Not present	49.00	98
Present	0.90	2
Roadworks	**km**	**%**
No road works	48.60	97
Minor road works in progress	1.30	3
Sight distance	**km**	**%**
Adequate	49.30	99
Poor	0.60	1

Table 2 2: Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	2.20	4
1 to <5m	37.20	75
5 to <10m	4.80	10
>= 10m	5.70	11
Roadside severity - driver-side object	**km**	**%**
Safety barrier - metal	3.90	8
Safety barrier - concrete	0.20	0
Aggressive vertical face	0.50	1
Upwards slope - rollover gradient	0.60	1
Upwards slope - no rollover gradient	6.00	12
Cliff	0.10	0
Tree >=10cm dia.	12.60	25
Sign, post or pole >= 10cm dia.	11.80	24
Rigid structure/bridge or building	0.10	0
Semi-rigid structure or building	0.70	1
Unprotected safety barrier end	8.60	17
Large boulders >=20cm high	0.10	0
None	4.70	9
Roadside severity - passenger-side distance	**km**	**%**
0 to <1m	1.20	2
1 to <5m	38.00	76
5 to <10m	6.10	12
>=10m	4.60	9

Roadside severity - passenger-side object	km	%
Safety barrier - metal	3.90	8
Safety barrier - concrete	0.20	0
Aggressive vertical face	0.40	1
Upwards slope - rollover gradient	0.70	1
Upwards slope - no rollover gradient	7.60	15
Deep drainage ditch	0.30	1
Cliff	0.10	0
Tree >= 10cm dia.	9.10	18
Sign, post or pole >=10cm dia.	15.40	31
Rigid structure/bridge or building	0.70	1
Semi-rigid structure or building	0.90	2
Unprotected safety barrier end	7.40	15
None	3.20	6
Shoulder rumble strips	**km**	**%**
Not present	49.90	100
Paved shoulder - driver-side	**km**	**%**
Medium (>= 1.0m to < 2.4m)	2.80	6
Narrow (>= 0m to < 1.0m)	31.40	63
None	15.70	31
Paved shoulder - passenger-side	**km**	**%**
Wide (>= 2.4m)	0.60	1
Medium (>= 1.0m to < 2.4m)	9.60	19
Narrow (>= 0m to < 1.0m)	26.10	52
None	13.60	27

Table 2 3: Intersections

Intersection type	km	%
3-leg (unsignalised) with protected turn lane	2.00	4
3-leg (unsignalised) with no protected turn lane	3.50	7
3-leg (signalised) with protected turn lane	0.20	0
4-leg (unsignalised) with protected turn lane	0.90	2
4-leg (unsignalised) with no protected turn lane	0.70	1
4-leg (signalised) with protected turn lane	0.20	0
4-leg (signalised) with no protected turn lane	0.60	1
None	41.20	83
Median crossing point - informal	0.10	0
Median crossing point - formal	0.40	1
Mini roundabout	0.10	0
Intersection channelisation	**km**	**%**
Not present	49.20	99
Present	0.70	1

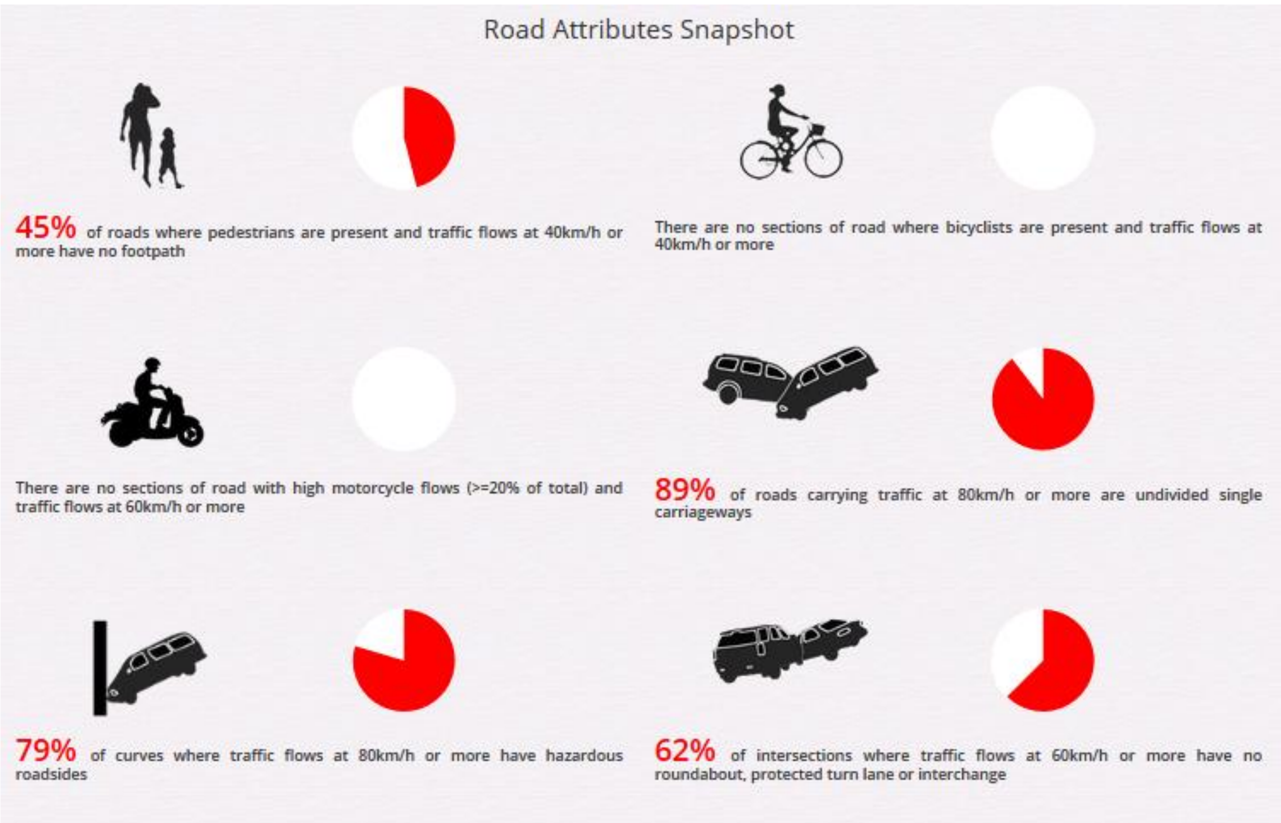
Intersecting road volume	km	%
5,000 to 10,000 vehicles	0.10	0
1,000 to 5,000 vehicles	7.30	15
100 to 1,000 vehicles	0.70	1
1 to 100 vehicles	0.60	1
None	41.20	83
Intersection quality	**km**	**%**
Poor	8.70	17
Not applicable	41.20	83
Property access points	**km**	**%**
Commercial Access 1+	11.00	22
Residential Access 3+	0.10	0
Residential Access 1 or 2	4.90	10
None	33.90	68

Table 2 4: Vulnerable Road User (VRU) Facilities and Land Use

Land use - driver-side	**km**	**%**
Undeveloped areas	13.60	27
Farming and agricultural	19.30	39
Residential	6.10	12
Commercial	10.50	21
Educational	0.40	1
Land use - passenger-side	**km**	**%**
Undeveloped areas	16.40	33
Farming and agricultural	14.50	29
Residential	7.70	15
Commercial	10.60	21
Educational	0.70	1
Area type	**km**	**%**
Rural / open area	20.50	41
Urban / rural town or village	29.40	59
Pedestrian crossing facilities - inspected road	**km**	**%**
Signalised with refuge	0.20	0
Signalised without refuge	0.80	2
Unsignalised marked crossing with refuge	0.10	0
Unsignalised marked crossing without a refuge	0.80	2
No facility	48.00	96
Pedestrian crossing quality	**km**	**%**
Adequate	1.50	3
Poor	0.40	1
Not applicable	48.00	96
Pedestrian crossing facilities - intersecting road	**km**	**%**
Signalised with refuge	0.10	0
Signalised without refuge	0.70	1
Refuge only	0.10	0
No facility	49.00	98

Pedestrian fencing	**km**	**%**
Not present	49.90	100
Sidewalk - driver-side	**km**	**%**
Physical barrier	3.50	7
Non-physical separation 0m to <1.0m	3.40	7
None	42.00	84
Informal path 0m to <1.0m	1.00	2
Sidewalk - passenger-side	**km**	**%**
Physical barrier	4.50	9
Non-physical separation >= 3.0m	0.90	2
Non-physical separation 1.0m to <3.0m	0.40	1
Non-physical separation 0m to <1.0m	4.50	9
None	38.20	77
Informal path >= 1.0m	0.10	0
Informal path 0m to <1.0m	1.30	3
Facilities for motorised two wheelers	**km**	**%**
None	49.90	100
Facilities for bicycles	**km**	**%**
None	48.20	97
Extra wide outside (>=4.2m)	1.70	3
School zone warning	**km**	**%**
No school zone warning	1.10	2
Not applicable (no school at the location)	48.80	98
School zone crossing supervisor	**km**	**%**
School zone crossing supervisor not present	1.10	2
Not applicable (no school at the location)	48.80	98

Figure 5 1: Road Attribute Snapshot of high level of risk



Supporting information (Road Attribute Snapshot of high level of risk):

- Of the 16.0km where pedestrians are present and traffic flows at 40km/h or more, 7.0km have no footpath
- There are no sections of road where bicyclists are present and traffic flows at 40km/h or more
- There are no sections of road with high motorcycle flows (>=20% of total) and traffic flows at 60km/h or more
- Of the 18.0km of roads carrying traffic at 80km/h or more, 16.0km are undivided single carriageways
- Of the 5.0km of curves where traffic flows at 80km/h or more, 4.0km have hazardous roadsides
- Of the 32 intersection(s) where traffic flows at 60km/h or more, 20 have no roundabout, protected turn lane or interchange

4 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.

4.1 The role of speed

The issue of speed management is of paramount importance in road safety and 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 where traffic speeds are 40km/h or less
- opposing traffic is physically separated and roadside hazards such as trees and other fixed objects (including concrete guard posts) are well managed
- traffic speeds are restricted to 70km/h 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 is based on 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.

4.1.1 Speed data

For much of the section of the P2-2(R102) where speed limit signs were observed, vehicle operating speeds often appeared to be in excess of the posted limit.

The method adopted to estimate 85th percentile and mean operating speeds and the assumptions inter alia made are detailed below:

Table 3 1: Speed

Speed limit	km	%
40km/h	1.70	3
60km/h	27.50	55
80km/h	18.30	37
100km/h	2.40	5
Motorcyclist speed limit	**km**	**%**
40km/h	1.70	3
60km/h	27.50	55
80km/h	18.30	37
100km/h	2.40	5
Truck speed limit	**km**	**%**
40km/h	1.70	3
60km/h	27.50	55
80km/h	18.30	37
100km/h	2.40	5
Differential speed limits	**km**	**%**
Not present	49.90	100
Speed management / traffic calming	**km**	**%**
Not present	44.30	89
Present	5.60	11

Operating Speed (85th percentile)	km	%
<30km/h	0.20	0
35km/h	0.10	0
45km/h	1.50	3
50km/h	2.60	5
55km/h	2.80	6
65km/h	22.10	44
70km/h	1.20	2
75km/h	1.20	2
85km/h	15.80	32
95km/h	0.10	0
105km/h	2.30	5
Operating Speed (mean)	**km**	**%**
40km/h	1.80	4
60km/h	27.50	55
80km/h	18.20	36
100km/h	2.40	5

4.2 Traffic flows

4.2.1 Vehicle traffic volumes

Total traffic flow (or volume) for all motorised vehicles is required for the road 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 is required to be in Annual Average Daily Traffic (AADT) format and should not be adjusted to passenger car equivalent (PCU) volumes.

The AADT for this assessment was provided by VNA consulting and is shown in Table 4.1 below.

Table 4 1: Vehicle Flow

ROADNUM	LANE_CODE	START_KM	END_KM	LENGTH	DT_LST_CNT	AADT_L	AADT_TL	AADT_B	AADT_M	AADT
P2-2	P	0,000	0,802	0,802	2017/08/22	6268	598	26	204	7096
P2-2	S	0,159	0,000	0,159	2017/08/22	6757	732	19	203	7711
P2-2	P	0,802	6,150	5,348	2017/08/22	6147	536	24	193	6900
P2-2	S	5,238	0,159	5,079	2017/08/22	6428	674	14	200	7316
P2-2	P	6,150	6,756	0,606	2017/08/23	5288	535	18	132	5973
P2-2	S	6,756	6,150	0,606	2017/08/23	5044	586	16	193	5839
P2-2	P	6,756	7,826	1,070	2017/08/23	5294	537	18	132	5981
P2-2	S	7,826	6,756	1,070	2017/08/23	5145	589	16	196	5946
P2-2	P	14,165	17,244	3,079	2017/07/28	2530	447	3	160	3140
P2-2	S	17,244	14,165	3,079	2017/07/28	2239	505	0	166	2910
P2-2	P	17,244	20,763	3,519	2017/07/28	2484	404	2	148	3038
P2-2	S	20,763	17,244	3,519	2017/07/28	2322	482	0	197	3001
P2-2	P	20,763	21,570	0,807	2017/07/31	2797	159	0	95	3051
P2-2	S	21,570	20,763	0,807	2017/07/31	2930	430	11	168	3539
P2-2	P	21,570	22,919	1,349	2017/07/31	2265	305	2	293	2865
P2-2	S	22,919	21,570	1,349	2017/07/31	2095	284	2	224	2605
P2-2	P	22,919	24,959	2,040	2017/08/01	3749	583	0	464	4796
P2-2	S	24,959	22,919	2,040	2017/08/01	3041	576	1	245	3863
P2-2	P	24,959	25,487	0,528	2017/08/01	2706	514	0	432	3652
P2-2	S	25,487	24,959	0,528	2017/08/01	2344	541	1	191	3077
P2-2	P	25,487	28,102	2,615	2017/08/01	2786	570	3	929	4288
P2-2	S	28,102	25,487	2,615	2017/08/01	2954	679	2	843	4478
P2-2	P	28,102	29,691	1,589	2017/08/01	3425	644	4	977	5050
P2-2	S	29,691	28,102	1,589	2017/08/01	3723	659	4	892	5278
P2-2	P	29,691	34,078	4,387	2017/08/03	2035	431	3	604	3073
P2-2	S	34,078	29,691	4,387	2017/08/03	2092	523	4	622	3241
P2-2	P	34,078	35,213	1,135	2017/08/03	2024	422	3	625	3074
P2-2	S	35,213	34,078	1,135	2017/08/03	2131	524	5	628	3288
P2-2	P	35,213	36,542	1,329	2017/08/01	1852	317	4	520	2693
P2-2	S	36,542	35,213	1,329	2017/08/01	2236	360	6	651	3253
P2-2	P	36,542	37,997	1,455	2017/08/01	2050	241	4	731	3026
P2-2	S	37,997	36,542	1,455	2017/08/01	2262	272	5	706	3245
P2-2	P	37,997	44,603	6,606	2017/08/01	2068	248	4	761	3081
P2-2	S	44,603	37,997	6,606	2017/08/01	2500	274	5	709	3488
P2-2	P	44,603	48,021	3,418	2017/08/01	2072	360	30	228	2690
P2-2	S	48,021	44,603	3,418	2017/08/01	2059	222	17	187	2485
P2-2	P	48,021	49,721	1,700	2017/08/01	1942	394	28	225	2589
P2-2	S	49,721	48,021	1,700	2017/08/01	2113	213	17	187	2530

Table 4 2: Vehicle Flow (AADT)

Vehicle flow (AADT)	km	%
5000 - 10000	49.90	100
Motorcyclist observed flow	**km**	**%**
None	49.80	100
1 motorcycle observed	0.10	0
Bicyclist observed flow	**km**	**%**
None	49.70	100
1 bicycle observed	0.20	0
Pedestrian observed flow across the road	**km**	**%**
None	49.50	99
1 pedestrian crossing observed	0.20	0
2 to 3 pedestrians crossing observed	0.20	0
Pedestrian observed flow along the road driver-side	**km**	**%**
None	41.20	83
1 pedestrian along driver-side observed	4.00	8
2 to 3 pedestrians along driver-side observed	2.70	5
4 to 5 pedestrians along driver-side observed	1.40	3
6 to 7 pedestrians along driver-side observed	0.20	0
8+ pedestrians along driver-side observed	0.40	1
Pedestrian observed flow along the road passenger-side	**km**	**%**
None	40.60	81
1 pedestrian along passenger-side observed	3.60	7
2 to 3 pedestrians along passenger-side observed	3.10	6
4 to 5 pedestrians along passenger-side observed	0.60	1
6 to 7 pedestrians along passenger-side observed	0.40	1
8+ pedestrians along passenger-side observed	1.60	3

Motorcyclist %	km	%
Not recorded	49.90	100
Pedestrian peak hour flow across the road	**km**	**%**
0	45.40	91
1 to 5	0.10	0
6 to 25	1.50	3
26 to 50	2.90	6
Pedestrian peak hour flow along the road driver-side	**km**	**%**
0	38.40	77
1 to 5	3.10	6
6 to 25	3.70	7
26 to 50	1.80	4
51 to 100	2.90	6
Pedestrian peak hour flow along the road passenger-side	**km**	**%**
0	38.10	76
1 to 5	4.50	9
6 to 25	2.70	5
26 to 50	1.10	2
51 to 100	1.30	3
101 to 200	2.20	4
Bicyclist peak hour flow	**km**	**%**
None	49.90	100

4.2.2 Motorcycle volumes

Motorcycle volume data was unavailable for the P2-2(R102) project and was thus not analysed. Only one motorcycle was observed during the survey of the section of road.

4.2.3 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 by VNA Consulting. The approach used for estimating pedestrian along and crossing flows was as follows:

- An estimate was made for each 100 metre segment of road based on adjacent 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.
- If the estimate was less than the observed flow, then the observed flow was selected. It is noted that from time to time, this step could create an artificially high number if an unusually large number of people happened to be observed. However, in the case of South Africa, very high pedestrian movements are not unusual and it is also common that pedestrians walk along rural sections of road.
- The pedestrian flows along the road were 'smoothed' across 500 metre lengths for pedestrians by taking the highest value in that length (pedestrian crossing volumes were not smoothed).

Provision for Vulnerable Road Users (VLUs) is inadequate with insufficient footpath provision and crossing facilities where pedestrian activities are present on the 16.3km or 32.7% of the 50.0km road with no bicycle facilities present.

4.3 Number of deaths

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

The total number of deaths for a three-year period (2015-2017) was 41. The distribution of deaths by road user type are based on the recorded road death data provided and is shown in Table 5 for both Part and B combined. The data shown in Table 5 below is for the study area i.e. for the 50.0 km of the P2-2(R102).

Table 5 1: Road deaths by user type (2015-2017)

Year	Vehicle occupant	Pedestrian
2015 (Recorded)	9	10
2016 (Recorded)	16	22
2017 (Recorded)	7	18

An estimated ratio for Fatal vs Serious Injury in South Africa of 1:4[3] was used in the analysis which amounts to 410 FSIs; 82 fatalities and an estimated 328 serious Injuries..

4.4 The economic cost of a death and serious injury

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.

The global iRAP estimates were however not used in the analysis due to RTMC having calculated the economic cost of crashes in South Africa published in September 2016[3]. The following estimated economic costs of fatalities and serious injuries were used in the analysis (adjusted with annual CPIX):

- the economic cost of a death is estimated to be ZAR 4,119,437.
- the economic cost of a serious injury is estimated to be ZAR 445,847.

To calculate present value costs and benefits, a discount rate of 12% was used.

4.5 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. This means that up to six different costs can be assigned to the same countermeasure treatment, although for some countermeasures the costs may be the same regardless of area type and environment.

The countermeasure costs used in this study were based on estimates calculated by engineering staff from LEA Associates South Asia Pvt. Ltd. (LASA) who are currently working as consulting engineers with the Roads & Buildings Department, Government of Gujarat and converted into ZAR. Indian countermeasures costs were used in this project due to similarities in the economies between India and South Africa. The full data set for the study is available in the iRAP online software http://vida.irap.org/.

5 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 are used to 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 within the Methodology Documents at www.irap.org.

5.1 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 charts below, which shows unsmoothed (raw) Star Rating Scores (SRS) in blue and smoothed SRS in white.

Figure 6 1: Raw Star Rating Scores (blue) and smoothed SRS (white) – Vehicle Occupant

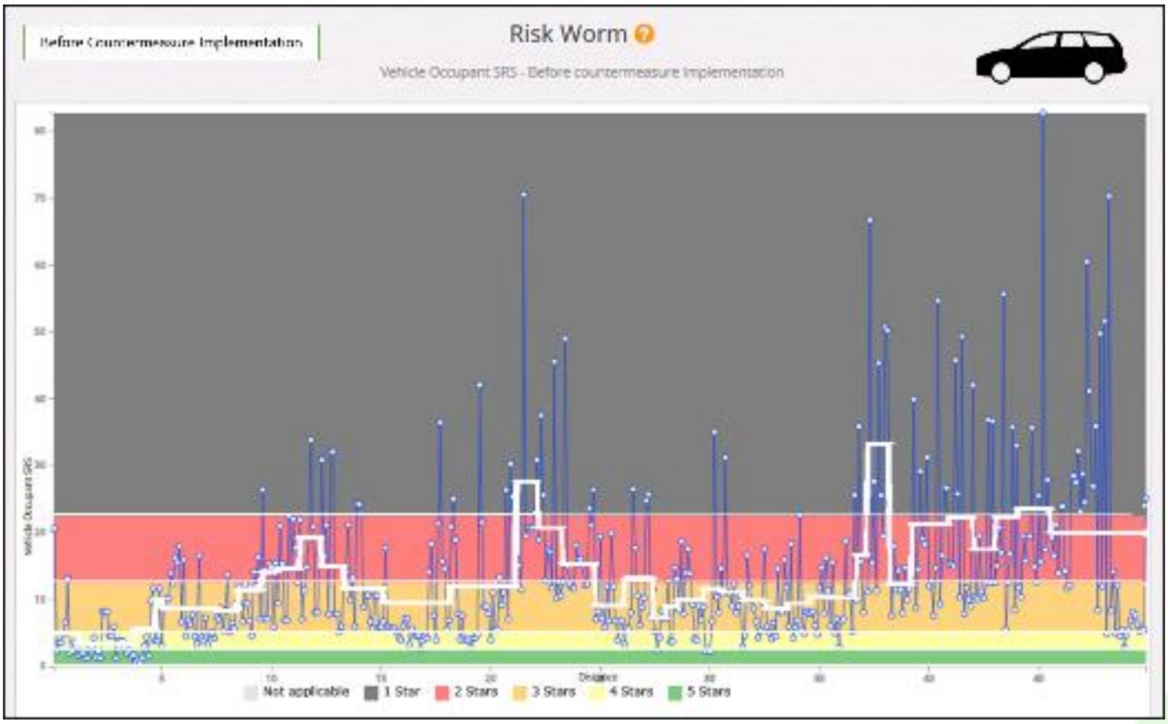
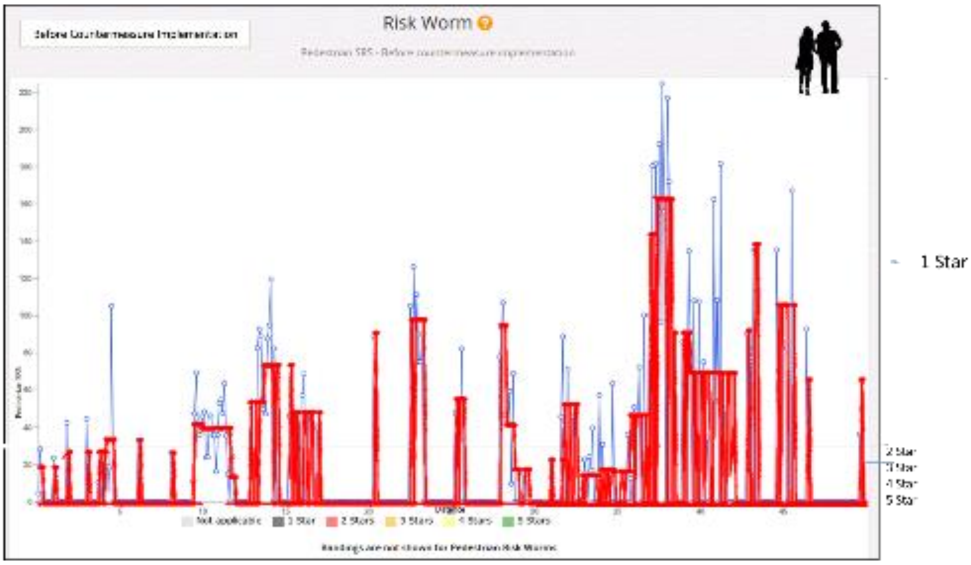


Figure 6 2: Raw Star Rating Scores (blue) and smoothed SRS (Red) – Pedestrian



5.2 Star Rating results

The Star Rating results for the P2-2(R102) section of road in Table 6 and Figure 6.3 below, demonstrate that there is potential to improve the safety of road infrastructure for all users. High-risk road sections feature significantly in the results with the majority of the surveyed road rated 2-stars or less (out of a possible of 5-stars) for all road user types.

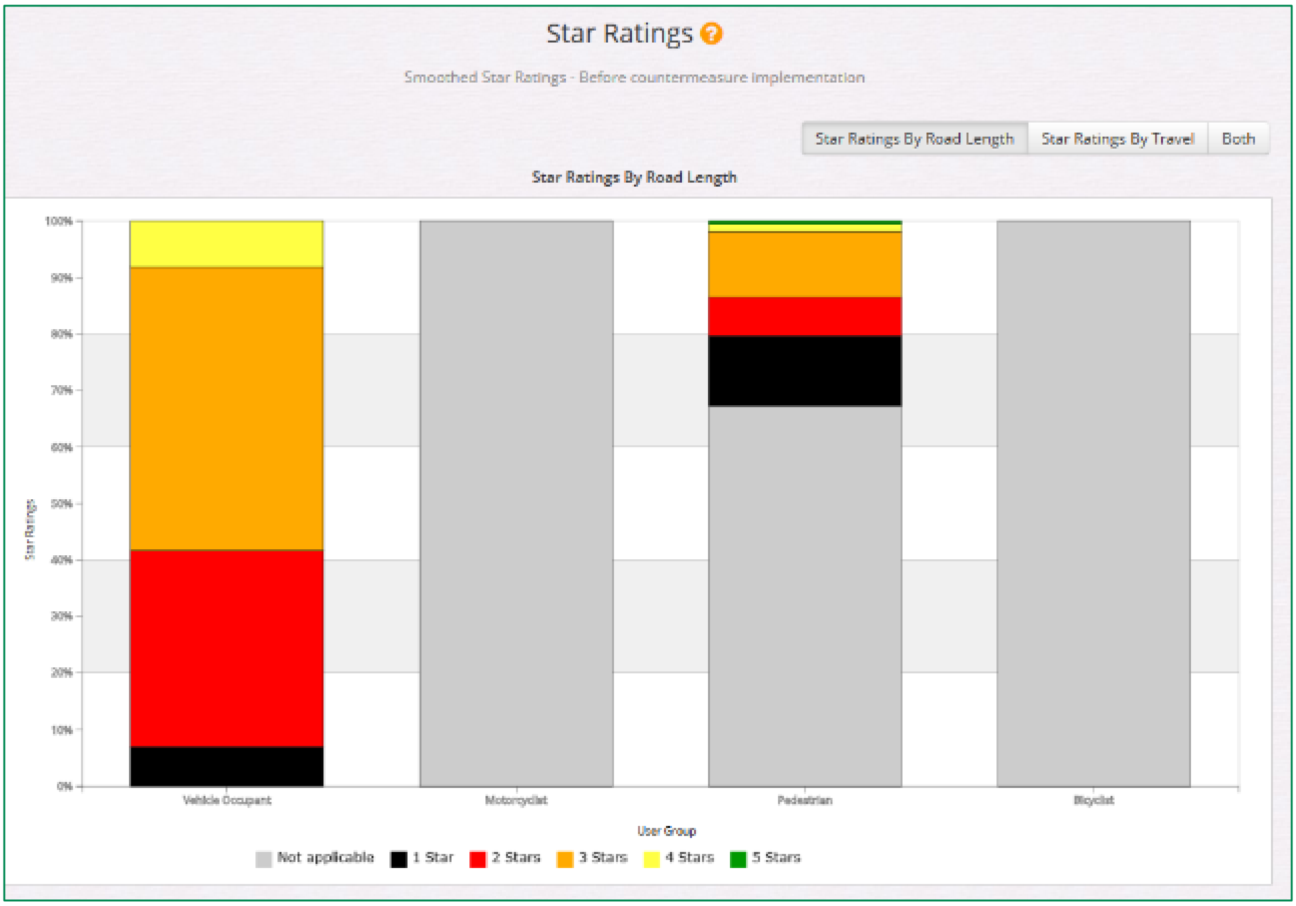
Table 6 1: Star Ratings Table

Star Ratings (Smoothed)	Vehicle Occupant		Pedestrian	
	Length (km)	Percent	Length (km)	Percent
5 Stars	0.00	0.00%	0.30	0.60%
4 Stars	4.00	8.02%	0.60	1.20%
3 Stars	25.10	50.30%	5.80	11.62%
2 Stars	17.30	34.67%	3.40	6.81%
1 Star	3.50	7.01%	6.20	12.42%
Not applicable	0.00	0.00%	33.60	67.33%
Totals	49.90	100.00%	49.90	100.00%

The star ratings show that:

- For vehicle occupants, 20.8km of the 50km or 41.8% of road length is rated as less than a 3-Star, with 3.5km or 7.01% rated an unacceptable 1-Star.
- For pedestrians, 33.6km or 67.33% were indicated as 'not applicable' or without pedestrian activity. It further depicts that 9.6km or 19.23% of the road length are below the internationally acceptable 3-Star rating. Provision for pedestrians are poor in the sections of road in concern and insufficient footpath provision and crossing facilities where pedestrians are active.

Table 6 2: Star Ratings Graph

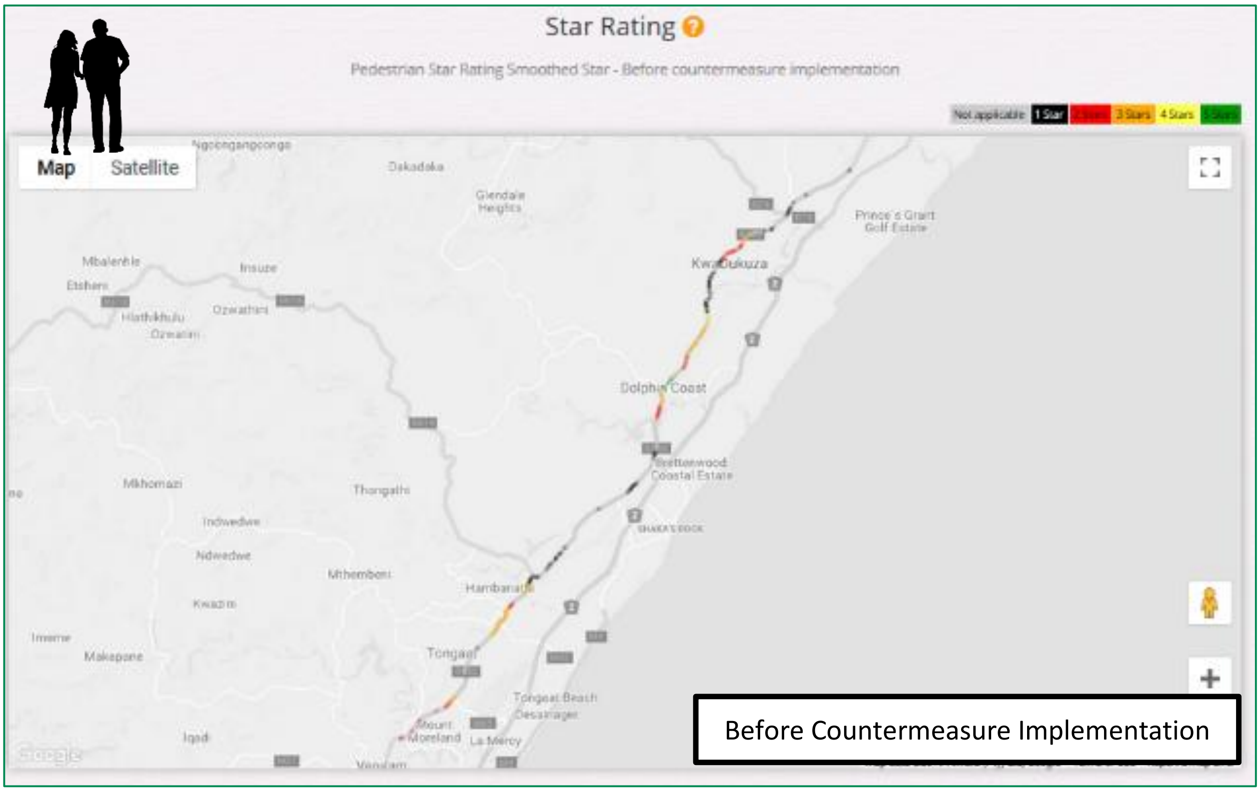


5.3 Star Rating maps

The following images show the Star Rating maps for vehicle occupants and pedestrians. The maps show how road user risk can change along a route based on the safety aspects provided by the road infrastructure and can be used to identify the high-risk areas for priority treatment.

Figure 7 1: Vehicle occupant Star Ratings

Figure 7 2: Pedestrian Star Ratings



6 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:

- Drawing on the Star Ratings and traffic volume data, estimated numbers of deaths and serious injuries are distributed across the road network.
- 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.
- 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 (that is, it must have a benefit cost ratio (BCR) greater than one). In many circumstances, the ‘threshold’ BCR for a plan is lifted above one, which has the effect of reducing the overall cost of the plan. This helps to ensure that the plan is affordable while representing a positive return on investment and the responsible use of public money.

The SRIP shows a list of affordable and economically sound road safety treatments, specifically tailored to reduce risk on the P2-2(R102). 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.

Ten SRIP options were produced to illustrate countermeasure options that could maximise the prevention of deaths and serious injuries within available budgets. The plans largely focus on providing facilities for pedestrians.

Plan A was produced using a threshold BCR of 1 (that is, the economic benefit of each countermeasure must be at least greater than the cost), Plan B was produced using a threshold BCR of 2 (economic benefit of each countermeasure must exceed 2 times the cost) up to Pan J with a threshold BCR of 10.

In total, 10 investment plans were produced ranging from Plan A with a threshold BCR of 1 (that is, the economic benefit of each countermeasure must be at least greater than the cost) up to Plan J with a threshold BCR of 10 (that is, the economic benefit of each countermeasure must exceed 10 times the cost). the ten plans analysed are summarized in Table 7.1 below:

Table 7 1: Summary - Safer Road Investment Plans A-J

SRIP Plans A-J						*Currency: R ZAR - Analysis Period: 20 years iod: 20 years*		
SRIP Plan	BC QV Value	Total FSIs Saved	Total PV of Safety Benefits	Estimated Cost (ZAR)	Cost per FSI saved (ZAR)	Program BCR	No. of CM	% Reduction FSI
A	1	190	83,923,859	27,144,974	142,611	3	27	7,0%
B	2	169	74,358,258	13,071,204	77,506	6	22	6,2%
C	3	161	70,805,653	8,684,585	54,079	8	19	5,9%
D	4	152	67,044,472	6,548,914	43,068	10	15	5,6%
E	5	150	65,974,294	5,287,820	35,339	12	15	5,5%
F	6	146	64,359,602	4,474,672	30,655	14	11	5,3%
G	7	143	63,067,464	3,818,770	26,697	17	11	5,2%
H	8	139	61,332,725	3,363,349	24,178	18	8	5,1%
I	9	135	59,382,594	3,094,013	22,973	19	6	4,9%
J	10	130	57,367,017	2,906,701	22,340	20	6	4,8%
Recorded Average Annual Fatal:			27,3			SRIP	Safer Investment Plan	
Serius Injury Factor:			4			BC QV	Benefit Cost Qualification Value	
Annual FSIs:			136,7			FSI	Fatal and Serious Injury	
Analysis Period:			20			BCR	Benefit Cost Ratio	
Estimated FSIs over Analysis Period:			2733			CM	Countermeasures	

The most comprehensive SRIP (Plan A) shows that, by investing ZAR 27.1 million over a 20-year period, the number of deaths and serious injuries on the road could be reduced by 7.0%, preventing an estimated 190 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 3:1. Plan B shows that, by investing ZAR 13.1 million, the number of deaths and serious injuries on the road could be reduced by 6.2%, preventing an estimated 169 deaths and serious injuries over 20 years with an overall benefit cost ratio of 6:1.

The list of countermeasures shown in each of the plans suggest that significant safety improvements can be made to the P2-2(R102) section of road through the implementation of several key safety treatments, countermeasure treatments such as footpath provision on the driver side and passenger side adjacent to road.

The most economical of the plans analysed (Plan J) shows that by investing ZAR 2.9 million, the number of deaths and serious injuries on the road could be reduced by 4.8%, preventing an estimated 130 deaths and serious injuries over 20 years. The overall benefit cost ratio of this approach would be 20:1.

Plan A proposes 27 possible countermeasures amounting which could save the estimated 190 FSIs over a 20-year period with Plan J, the more economical plan, proposing only 6 possible countermeasures amounting which could save the estimated 130 FSIs over a 20-year period.

The detailed countermeasures identified in Plan A and Plan J are shown in Table 8.1 and Table 8.2 below:

Table 8 1: Safer Road Investment Plan A

Safer Roads Investment Plan A							Currency: R ZAR - Analysis Period: 20 years
	Total FSIs Saved	**Total PV of Safety Benefits**	**Estimated Cost**	**Cost per FSI saved**	**Program BCR**		
	190	**83,923,859**	**27,144,974**	**142,611**	**3**		
#	**Countermeasure**	**Length / Sites**	**FSIs saved**	**PV of safety benefit**	**Estimated Cost**	**Cost per FSI saved**	**Program BCR**
1	Footpath provision driver side (adjacent to road)	5.40 km	39	17,025,213	1,413,811	36,614	12
2	Footpath provision passenger side (adjacent to road)	5.20 km	28	12,252,131	1,333,190	47,977	9
3	Shoulder rumble strips	18.30 km	15	6,508,672	450,409	30,511	14
4	Footpath provision driver side (>3m from road)	1.90 km	14	6,277,091	1,786,908	125,514	4
5	Improve Delineation	14.70 km	12	5,485,451	1,137,947	91,466	5
6	Roadside barriers - driver side	6.60 km	11	4,674,511	3,380,475	318,852	1
7	Roadside barriers - passenger side	6.20 km	10	4,554,495	3,136,368	303,623	1
8	Traffic calming	2.70 km	9	4,043,379	1,822,884	198,775	2
9	Footpath provision passenger side (>3m from road)	0.90 km	8	3,347,087	784,724	103,371	4
10	Skid Resistance (paved road)	1.90 km	6	2,437,477	1,394,248	252,201	2
11	Central hatching	18.30 km	5	2,348,609	589,063	110,586	4
12	Overtaking lane	1.00 km	5	2,407,516	1,605,572	294,042	1
13	Signalised crossing	8 sites	4	1,643,926	1,344,224	360,527	1
14	Parking improvements	1.30 km	4	1,646,428	513,371	137,479	3
15	Pedestrian fencing	1.20 km	3	1,386,926	70,295	22,347	20
16	Shoulder sealing driver side (>1m)	0.90 km	3	1,187,068	682,297	253,423	2
17	Street lighting (intersection)	6 sites	3	1,534,869	1,265,861	363,633	1
18	Street lighting (mid-block)	0.70 km	2	675,322	576,327	376,276	1
19	Clear roadside hazards - driver side	2.30 km	2	929,801	832,155	394,605	1
20	Clear roadside hazards - passenger side	2.00 km	2	845,27	752,377	392,454	1
21	Side road unsignalised pedestrian crossing	7 sites	2	1,085,764	909,289	369,245	1
22	Central median barrier (1+1)	0.70 km	2	743,879	573,285	339,795	1
23	Unsignalised crossing	5 sites	1	570,051	435,841	337,103	1
24	School zone warning - signs and markings	0.20 km	0	19,234	19,718	451,997	1
25	Shoulder sealing passenger side (>1m)	0.30 km	0	159,892	219,723	605,895	1
26	Sight distance (obstruction removal)	0.10 km	0	77,254	52,866	301,717	1
27	School zone warning - flashing beacon	2 sites	0	56,543	61,75	481,508	1
	Total		190	83,923,859	27,144,974	142,611	3

FSI = Fatal and Serious Injuries
BCR = Benefit Cost Ratio
PV = Present Value

Table 8 2: Safer Road Investment Plan J

Safer Roads Investment Plan J							Currency: R ZAR - Analysis Period: 20 years
	Total FSIs Saved	Total PV of Safety Benefits	Estimated Cost	Cost per FSI saved	Program BCR		
	130	57,367,017	2,906,701	22,34	20		
#	Countermeasure	Length / Sites	FSIs saved	PV of safety benefit	Estimated Cost	Cost per FSI saved	Program BCR
1	Footpath provision driver side (adjacent to road)	5.60 km	68	29,809,674	1,542,067	22,808	19
2	Footpath provision passenger side (adjacent to road)	3.60 km	40	17,427,037	952,271	24,093	18
3	Improve Delineation	2.70 km	9	3,871,315	215,434	24,536	18
4	Shoulder rumble strips	3.50 km	8	3,444,593	86,144	11,026	40
5	Central hatching	1.80 km	3	1,296,691	77,167	26,239	17
6	Pedestrian fencing	0.60 km	3	1,517,708	33,619	9,767	45
	Total		130	57,367,017	2,906,701	22,34	20

FSI = Fatal and Serious Injuries
BCR = Benefit Cost Ratio
PV = Present Value

Maps showing the location of each countermeasure listed within the Safer Roads Investment Plan can be accessed through the SRIP Table within ViDA. Full details of each recommended countermeasure, including location description, geo-reference data and economics are provided, by distance within ViDA, the iRAP online software at http://vida.irap.org/. Descriptions of these countermeasures, 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.

6.1 Star Ratings after countermeasure implementation

The Star Rating tables (Tables 9.1 – Table 9.4) below provide details of the projected Star Ratings based on the countermeasures within the analysed Plans. Tables 9.1 and 9.3 illustrate the Star Ratings before and after countermeasure implementation for Plan A and Plan J for Vehicle Occupants and Tables 9.2 and 9.4 the same for Pedestrians.

Table 9 1: Star Ratings Before and After Countermeasures – Plan A (Vehicle Occupant)

Star Ratings Before and After Countermeasures (Smoothed)	Plan A - Vehicle Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,0	0,00%		0,0	0,00%		+0.00%	
4 Stars	4,0	8,02%	+58.32%	9,8	19,64%	+81.36%	+0.12%	+23.04%
3 Stars	25,1	50,30%		30,8	61,72%		+0.11%	
2 Stars	17,3	34,67%	+41.68%	9,3	18,64%	+18.64%	-0.16%	-23.05%
1 Star	3,5	7,01%		0,0	0,00%		-0.07%	
Not applicable	0,0	0,00%	-	0,0	0,00%	-	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

Table 9 2: Star Ratings Before and After Countermeasures – Plan A (Pedestrian)

Star Ratings Before and After Countermeasures (Smoothed)	Plan A - Pedestrian Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,3	0,60%		2,4	4,81%		+0.04%	
4 Stars	0,6	1,20%	+13.42%	10,6	21,24%	+32.06%	+0.20%	+18.64%
3 Stars	5,8	11,62%		3,0	6,01%		-0.06%	
2 Stars	3,4	6,81%	+19.23%	0,3	0,60%	+0.60%	-0.06%	-18.64%
1 Star	6,2	12,42%		0,0	0,00%		-0.12%	
Not applicable	33,6	67,33%	67,33%	33,6	67,33%	67,33%	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

With the most expensive investment, SRIP Plan A (Estimated Countermeasure Cost = R27,144,974), 81.36% of the road will have a Star Rating of 3 or more for Vehicle Occupants with only 18.64% having a Star Rating less than 3, an increase in Star Rating of 23.05% 3 Stars or better. For Pedestrians, the increase to a Star

Rating 3 or more is 18.64% with only 0.6% of the road that is used by pedestrians having a Star Rating less than 3.

Table 9 3: Star Ratings Before and After Countermeasures – Plan J (Vehicle Occupant)

Star Ratings Before and After Countermeasures (Smoothed)	Plan J - Vehicle Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,0	0,00%		0,0	0,00%		+0.00%	
4 Stars	4,0	8,02%	+58.32%	4,0	8,02%	+60.93%	+0.00%	+2.61%
3 Stars	25,1	50,30%		26,4	52,91%		+0.03%	
2 Stars	17,3	34,67%	+41.68%	17,5	35,07%	+39.08%	+0.00%	-2.61%
1 Star	3,5	7,01%		2,0	4,01%		-0.03%	
Not applicable	0,0	0,00%	-	0,0	0,00%	-	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

Table 9 4: Star Ratings Before and After Countermeasures – Plan J (Pedestrian)

Star Ratings Before and After Countermeasures (Smoothed)	Plan J - Pedestrian Occupant							
	Before Countermeasures			After Countermeasures			Before and After	
	Length (km)	Percent	Below and Above 2-Star	Length (km)	Percent	Below and Above 2-Star	Difference	Below and Above 2-Star
5 Stars	0,3	0,60%		2,0	4,01%		+0.03%	
4 Stars	0,6	1,20%	+13.42%	3,5	7,01%	+25.05%	+0.06%	+11.63%
3 Stars	5,8	11,62%		7,0	14,03%		+0.02%	
2 Stars	3,4	6,81%	+19.23%	3,3	6,61%	+7.61%	-0.00%	-11.63%
1 Star	6,2	12,42%		0,5	1,00%		-0.11%	
Not applicable	33,6	67,33%	67,33%	33,6	67,33%	67,33%	0,00%	+0.00%
Totals	49,9	100%	100%	49,9	100%	100%	0,00%	-

With the more economical option, SRIP Plan J (Estimated Countermeasure Cost = R 2,906,701), 60.93% of the road will have a Star Rating of 3 or more for Vehicle Occupants with 39.08% having a Star Rating less than 3, an increase in Star Rating of 2.61% 3 Stars or better. For Pedestrians, the increase to a Star Rating 3 or more is 11.63% with 11.63% of the road that is used by pedestrians having a Star Rating less than 3.

Due to the low pedestrian flow, a grade-separated pedestrian crossing as countermeasure did not trigger in the VIDA analysis due to it not being economically feasible with not adequate return on investment. Pedestrian activity need to be addressed separate from this analysis by means of either education and/or law enforcement.

The Star Ratings (after – with proposed countermeasures) for Plan A and Plan J are available in ViDA.

6.2 Economic assessment

Using actual crash data, an estimate of the number of deaths and serious injuries that occur on the surveyed section of road were made. Crash modification factors were 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 investment plan. 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 when improvements such as lane widening, resurfacing, additional lanes and paved shoulders are proposed, it do not result in excessive vehicle speeds, particularly where vulnerable road users such as pedestrians are present. In such cases vehicle speeds must be effectively managed in order to minimise risk.

Taking into account the improved Star Ratings, and the estimated 10 annual FSIs saved or 190 FSIs over a 20-year period for Plan A versus the estimated 7 Annual FSIs or 130 FSIs over a 20-year period saved with Plan J, for only 50km of the provincial road network and the massive financial impact to improve the provincial surfaced road network in South Africa (estimated 46,805km), the more economical option might be more realistic in the short and medium term.

7 Implementation and recommendations

The road attribute data shows that the dual carriageway mostly has no physical separation between opposing flows. Roadside hazards are numerous, with 35% of the survey length having hazardous objects on the driver-side within 5m of the running lane with limited roadside protection (such as safety barriers); and 69% of the survey length having hazardous objects on the passenger-side within 5m of the running lane with limited roadside protection (such as safety barriers).

The physical median of the total surveyed section of road consists of 4.3 km (16%) metal safety barrier; 1.0km (4%) median width between 10m and 20m; 20.8km (78%) median width between 5m and 10m and 0.4 (2%) median width between 1m and 5m.

Provision for vulnerable road users is poor in the sections of road in concern (5.8km or 21.9% of the 26.5km) with no motorcycle or bicycle facilities present and insufficient footpath provision and crossing facilities where pedestrian activities are present.

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.

Nevertheless, 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 just the first step in ensuring 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 available traffic survey and crash data
- 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
- post-construction evaluation and road safety audit, including Star Ratings for the upgraded road and analysis of crash data.

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.

The SRIPs chosen to be implemented by the provincial authority will depend on available funds and strategic objectives towards reducing the risk of FSIs of particular road users on different classes of road.

Ultimately, the same process of producing Star-Ratings and SRIPs need to be conducted for each of the provincial strategic road networks with countermeasures implemented to reduce the risk of FSIs.

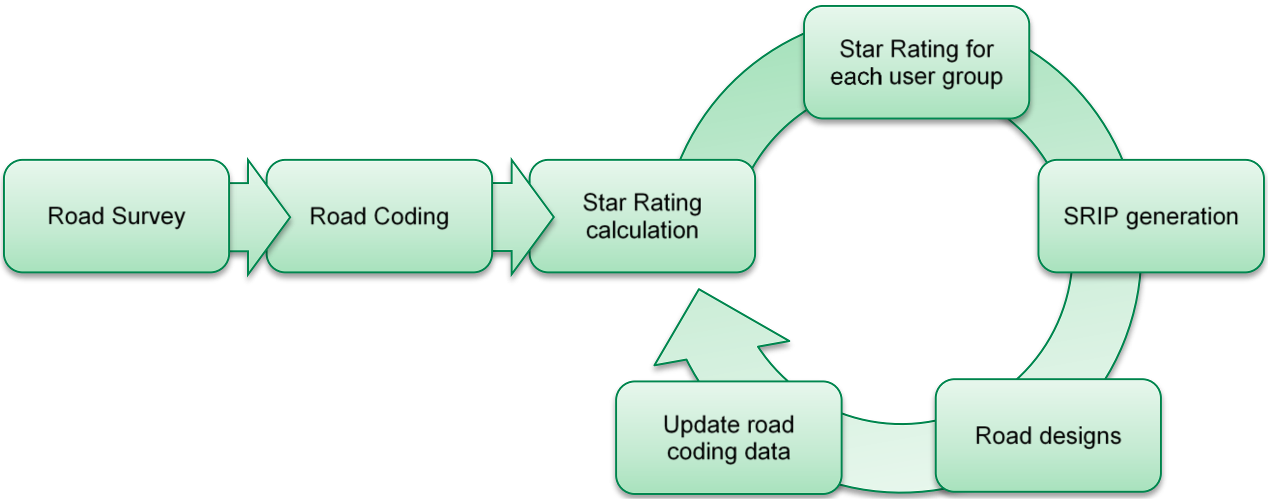
Once the strategic provincial road networks are surveyed, coded, quality assurance conducted and analysed with the VIDA software, each provincial authority will have a picture of not only the condition of the roads for which the authority are responsible, but the analysis and economic investment needed for the road network can be established and budgeted for in the short, medium and long term towards reducing the risk of FSIs on the respective road provincial networks.

The findings and recommendations of this report will be corroborated with the DoT towards provincial road authorities using this report as a scientific base when designing countermeasures on the provincial road networks towards safer roads in South Africa i.e. better Star Rating designs

A number of countries around the world are now using Star Ratings during the road design process to help ensure that safety of designs is optimized. Star Ratings can objectively quantify the level of risk associated with new road designs and provide a platform to make evidence-based improvements.

The iterative star rating process is shown in Figure 8.1 below:

Figure 8 1:   Using Star Ratings to improve road designs - process diagram



By engaging consultants to Star Rate proposed designs, the road authorities are able to assess the potential risk to road users prior to construction and amend the designs to include recommended treatments that are proven to reduce the likelihood and severity of road crashes.

As an example of such a process, see the *Star Rating Road Designs: Performance Indicators for Roads in India* report for further information regarding the star rating of new road designs http://www.irap.net/about-irap-3/research-and-technical-papers?download=64:star-rating-road-designs-performance-indicators-roads-in-india.

7.1 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 un-cushioned 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.

7.2 Engage with local communities

In order to maximise the benefits from road safety projects it is recommended that public participation is encouraged. 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. For example, research has demonstrated that it is crucial to ensure that local communities not only have the opportunity to contribute to new road designs but that they also understand the intended use of various road design features.[11]

Star Ratings can be used to effectively communicate the need for safe road design, not only within road authorises, 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.[12]

7.3 Set policy targets

With the increasing death toll on the South African road network it is strongly recommended that the Government set policy targets to stabilise and then reduce the forecasted level of road traffic fatalities in line

[11] BRAC Annual Report 2009 http://www.brac.net/

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

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 by the end of the NRSS (2016-2030).
- 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.
- SA-RAP / iRAP Star Rating and Investment Plans for the highest risk or highest volume 10% of roads in the state.

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 References

BRAC *Annual Report 2009* http://www.brac.net/

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, *Star Rating Road Designs: Performance Indicators for Roads in India*, 2012.

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

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

iRAP *Coding Manual*, Jan.2011.

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

F. Labuschagne, E. de Beer, D. Roux and K. Venter, (2016) *Cost of Crashes in South Africa 2016*. Road Traffic Management Corporation (RTMC), http://www.rtmc.co.za.

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.

NRTA (1996). *National Road Traffic Act (NRTA)*, Act No. 93 of 1996. pp7-9

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

UN Road Safety Collaboration '*How to' manuals* http://www.who.int/roadsafety/projects/manuals/en/index.html

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. Time for Action*, 2009.

World Health Organisation, *Global Status Report on Road Safety*, 2015.

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.