iRAP

INTERNATIONAL ROAD ASSESSMENT PROGRAMME

Vaccines for Roads

The new iRAP tools and their pilot application

Lord Robertson of Port Ellen – Commission for Global Road Safety

Every year over 1.2 million people are killed in road crashes worldwide. If we continue with 'business as usual' then we can expect to see 250 million people killed or seriously injured over the next 20 years. Road crashes will remain the leading cause of death among the young. This appalling road casualty epidemic has led the UN to vote for the first ever ministerial conference on tackling the problem in 2009. It is essential that we now bring forward the practical, affordable, economic solutions that will deliver.

It makes sound economic sense to invest to prevent the road casualties which bleed away up to 3% of world GDP. The immediate costs of crashes are obvious – the costs of damage, emergency services, hospitals and doctors. To this must also be added the cost of decades of care for those disabled for life and the loss of productive young breadwinners, which often throws whole families into poverty.

The world experience is that major reductions in road casualties can quickly be achieved by taking action on basics – wearing seat belts and helmets, obeying speed limits, preventing drink driving, keeping vehicles in roadworthy condition and providing safe basic road infrastructure so that road users know how they are expected to act and traffic law can be enforced.

It has been known for over half a century that low-cost engineering improvements to the safety of roads can save lives quickly and affordably. The methodology, however, has not been available to inspect existing roads systematically and then target programmes where they can save the most lives. Even new roads often fail to improve overall safety, particularly for pedestrians.

This report from the International Road Assessment Programme (iRAP) describes the work done to invest in practical new tools for low and middle income countries and then pilot their application in four countries around the globe.

The recommendations in this report for targeted programmes of basic safety improvements such as footpaths, crossings and junctions not only appeal to common sense but also make a compelling case for investment. All the recommended national programmes in this report have estimated returns on investment of at least 10 times their costs and will make a measurable difference to national casualty rates.

These results show clearly why the Commission for Global Road Safety is calling on the international community to ensure that 10% of road infrastructure budgets funded by international donors are earmarked for safety programmes like those identified by iRAP.

I am delighted to learn that iRAP's recommendations are already being adopted by some pilot countries into national safety programmes. The World Bank Global Road Safety Facility has also moved quickly to help enable road inspections and assessment in five further countries where national governments are committed to invest on the findings.

The global partnership between leading research institutions, international bodies, national governments, automobile clubs and other stakeholders has been an impressive feature of this pilot programme. The generous funding of the FIA Foundation has made it possible. I am therefore deeply grateful to iRAP and its partners for this pioneering programme. The measure of success is that these new tools – these 'vaccines for roads' – are already in such high demand across the world.

About iRAP

The International Road Assessment Programme (iRAP) is dedicated to saving lives in developing countries by promoting safer road design.

iRAP targets high-risk roads where large numbers are killed and seriously injured, and inspects them to identify where affordable programmes of safety engineering can reduce large numbers of deaths and serious injuries.

The initiative relies on a strong partnership of key local stakeholders and international experts to work together to make roads safe.

iRAP aims to:

- Generate and prioritise large, affordable, high-return programmes of safety engineering countermeasures using a globally consistent methodology
- Operate on a scale that is cost-efficient and can be project managed to deliver reductions in the cost of death and crippling injury that are economically significant
- Provide the methodology and procedures to implement performance tracking so that funding agencies are able to track outcomes and outputs and enable continuous global improvement in safety performance
- Provide the training, technology and reporting tools to build and sustain national, regional and local capability
- Share experience and knowledge of effective road safety programmes worldwide

John Dawson – iRAP Chairman

In 2006, iRAP won the generous support of the FIA Foundation for an ambitious investment programme to develop tools to help low and middle income countries find the high social and economic returns possible through the provision of safer roads. The major Road Assessment Programmes in developed countries (AusRAP, EuroRAP and USRAP) worked in partnership with global road safety research organisations and local experts to develop and test these tools.

The investment in a new inspection methodology for low and middle income countries was significant because there are major differences in the tools needed for developed and developing countries. Firstly, the iRAP tools needed to be used in the complete absence of any reliable crash data. Road inspection data, supported by aggregate national statistics for total road deaths, are used in the new iRAP methodology to estimate the number of casualties on a stretch of road.

Secondly, in most developed countries, the majority of road deaths are car occupants whereas in developing countries the majority are vulnerable road users. The new tools assess each stretch of road for its safety for pedestrians, bicyclists, motorcyclists and car occupants.

Thirdly, in developed countries, well-resourced safety departments can identify engineering countermeasures once RAP inspections have highlighted general deficiencies. With the new tools iRAP identifies high-return countermeasures for consideration by local stakeholders.

iRAP was invited to work in four pilot countries: South Africa, Malaysia, Chile and Costa Rica. These countries offered exposure to a variety of road safety scenarios from a high proportion of motorcyclists in Malaysia to single carriageway roads with high speed limits in South Africa. The pilot countries also had better than average data for validation and some progressive examples of engineering countermeasures.

In each pilot country the automobile club proved to be a key stakeholder acting as an NGO bridge between government agencies and departments.

The pilot country inspections covered over 10,000 kilometres of road, focussing on high volume roads where large numbers are killed and injured. The iRAP results include:

- ‘Star Rating’ tables and maps showing the safety of roads for car occupants, motorcyclists, bicyclists and pedestrians
- A road inventory database with over 30 inspected attributes describing the inspected network
- An estimate of the numbers being killed and seriously injured on each inspected road
- A recommended cost-effective, network-wide countermeasure programme for consideration by local stakeholders and funding bodies

In Malaysia the estimated average Benefit-Cost Ratio is over 15 and the estimated programme cost of US$ 180 million should deliver US$ 3 billion in benefits over 20 years, saving over 30,000 deaths and serious injuries. In Costa Rica an initial US$ 50 million programme is likely to save over 10% of total national casualties.

Combined, it is estimated that the programmes in the four pilot countries could save more than 70,000 deaths and serious injuries over 20 years. The total benefit is estimated at US$ 7 billion for an investment of US$ 360 million.

Based on the success of the pilot country projects, the World Bank Global Road Safety Facility is funding further inspections in Serbia, Peru, Argentina, Nigeria and Kenya following national commitments in each to invest in safe road infrastructure. A further AusAID funded iRAP programme is also underway in Vietnam.

This new methodology offers ‘vaccines for roads’. There is demand for inspections from across the world but the urgency with which inspections can be rolled out globally will depend upon the speed with which leading aid donors and the development banks recognise the scale of the road injury crisis and commit to action.

A global epidemic

Deaths and injuries from road traffic crashes are a major and growing public health epidemic.

Each year 1.2 million people die in road crashes and the number of seriously injured could be as high as 50 million. Road crashes are now the leading cause of death for children and young people aged between 10 and 24.

The burden of road crashes is comparable with malaria and tuberculosis, and costs 1-3% of the world's GDP.

More than 85% of global road deaths and serious injuries occur in developing countries. Whereas road deaths are expected to fall in high-income countries, they are likely to increase by more than 80% in the rest of the world.

In developing countries it is the poor that are most vulnerable. Pedestrians, bicyclists, motorcyclists and those using informal public transport are many times more likely to be harmed on the roads.

The role of the road

Most crashes are caused by human error. For this reason, road safety initiatives have traditionally focussed on 'fixing' the driver in order to prevent crashes. Approaches typically involve education, testing and enforcement. However, to 'err is human'; psychology tells us that people will always make mistakes.

More recently, engineers have focussed on mediating the outcome of a crash by designing safe vehicles and safe roads. It is possible to protect the road user in the event of a crash by designing vehicles and roads to work together to ensure crash energies do not overwhelm the human. For vulnerable road users the road design must work even harder to ensure they are not exposed to high-speed traffic.

In leading developed countries where great progress has already been made on driver behaviour and vehicle safety, national safety strategies show investment in safer infrastructure is expected to deliver twice the casualty saving provided by investment in either behaviour or vehicles.

There are still many countries in which fundamental road-safety education and enforcement (seat belts, helmets, drink-driving and general adherence to traffic law) are not in place. In these countries basic infrastructure, such as clear signs and road markings, is essential if road users are to know what they are expected to do and if traffic law is to be effectively enforced.

Getting organised

What can give us hope is that other health epidemics that seemed impossible to fix have been eliminated. As recently as 1967, some 10-15 million cases of smallpox claimed two million lives every year, with many survivors left disfigured or blind. In 1967, the World Health Organization launched a mass vaccination programme that was later followed by Operation Smallpox Zero – a programme with a vision to eliminate the disease altogether. The vision zero was brought to fruition when the last case of smallpox was reported in Somalia in 1977. The programme was described as a triumph of management, not of medicine.

In the same way, we know what can be done to prevent road deaths. However, in order to combat this public health epidemic we must ensure that we create a sustainable and structured approach to aim for vision zero – we must get organised to make roads safe.

Designing safer roads

Safe roads are designed to be *self-explaining* and *forgiving*.

Self-explaining roads show all road users where they should be and how to use the road safely. Clear road layouts not only explain where road users are expected to be, but they also take into account the road user's ability to process information and make decisions.

An inexpensive, simple pedestrian refuge island not only shows where to cross but makes safe crossing much easier – the pedestrian has to check only one stream of oncoming traffic at a time. The refuge also calms drivers' speed and restricts overtaking at the crossing point.

Forgiving roads are designed to protect road users in the event of a crash. The design of the road must recognise that crashes can occur and ensure that fatalities and injuries are minimised by protecting road users from hazards. Engineering features, such as safety barriers can be used to separate fast moving traffic from people and cushion crashes when they happen.

Crashes are less likely to occur on self explaining roads and injuries are less severe on forgiving roads.

Crashes that kill

Vulnerable road users

Pedestrians are most vulnerable when they must cross busy roads without crossing facilities, and where they have to mix with motorised traffic as they move along a road because separate facilities are not provided.

In developing countries motorcyclists and moped riders can account for a high percentage of road deaths; in some Asian countries over 70% of road deaths are motorcyclists.

Engineering countermeasures that work to reduce the likelihood of a serious or fatal crash for vulnerable road users include:

- Exclusion of traffic from areas where there is high pedestrian activity
- Slowing of traffic (traffic calming) in areas where there is high pedestrian activity
- Paths for pedestrians and bicyclists so they do not mix with motorised traffic
- Crossing facilities that follow crossing demand and show where pedestrians are expected to cross and reduce the complexity of crossing the road
- Provision of separate motorcycle lanes or facilities
- Crash barriers that are passively safe for motorcyclists

Vehicle occupants

For vehicle occupants, fatal and serious crashes fall into three main categories:

- Run-off crashes – typically a single vehicle leaves the carriageway and crashes into a fixed object such as a tree or lighting column
- Junction crashes – the most serious crashes occur at T-junctions or crossroads where side impacts occur at high speeds
- Head-on crashes – vehicles travelling in opposing directions have high-energy collisions

Engineering countermeasures that work to reduce the likelihood of a serious or fatal crash for vehicle occupants include:

- Clearing roadsides of fixed objects (such as trees, lighting columns, road signs), replacing fixed objects with passively safe alternatives (e.g. deformable signposts and lighting columns), or protecting the road user with crash barriers
- Limiting the number of minor accesses to main roads, providing turning pockets, and replacing cross roads and T-junctions with roundabouts and grade separated junctions
- Separating opposing traffic travelling at high-speeds with a safety barrier or wide median

Formal safer road infrastructure programmes

The casualty reduction strategy for any country at any stage of its road safety development needs to define the contribution that simple, affordable infrastructure improvements can make. Footpaths, paint and fencing save lives.

Designing, building, financing, procuring and evaluating a motorway scheme is possible nearly everywhere in the world. But projects that upgrade the safety of an entire route or network are rare, even though they would often offer the most competitive economic returns in a national, regional or local project pool.

Affordable road infrastructure improvements have the potential to cut road casualties on a scale significant at the national level in the short, medium and long term. This is only possible if whole routes and networks, on which large numbers of deaths and serious injuries are concentrated, are targeted systematically with the application of effective countermeasures.

Network safety management

In order to effectively manage the safety of an existing road network, three basic activities need to be established:

- Reliable crash data should be collected. Police and statisticians must work together to ensure that serious crashes are recorded accurately – according to internationally accepted protocols and definitions. iRAP Risk Mapping can be produced using these data in order to show where people and communities face high levels of risk.
- Road authorities must have information about the level of safety and traffic flow on their network. They must have an understanding of how road features on their network contribute to risk and the potential for a serious or fatal crash. Star Rating inspections document this road attribute information and more detailed road safety audits can be used to identify specific sites and problems.
- As safety treatments are used, the outcomes must be measured, analysed and recorded so that lessons can be learnt about the impact of different schemes. The evidence base should direct future action, ensuring that the most efficient life-saving measures are implemented.

Effective safety management should involve infrastructure improvements at targeted locations throughout the road network and should not focus on just a few black spots that might have high short-term crash experience.

Risk Mapping and Performance Tracking

Where complete, accurate, and plentiful data are available, two RAP protocols that use real crash data can provide clear information on risk and can guide infrastructure improvements.

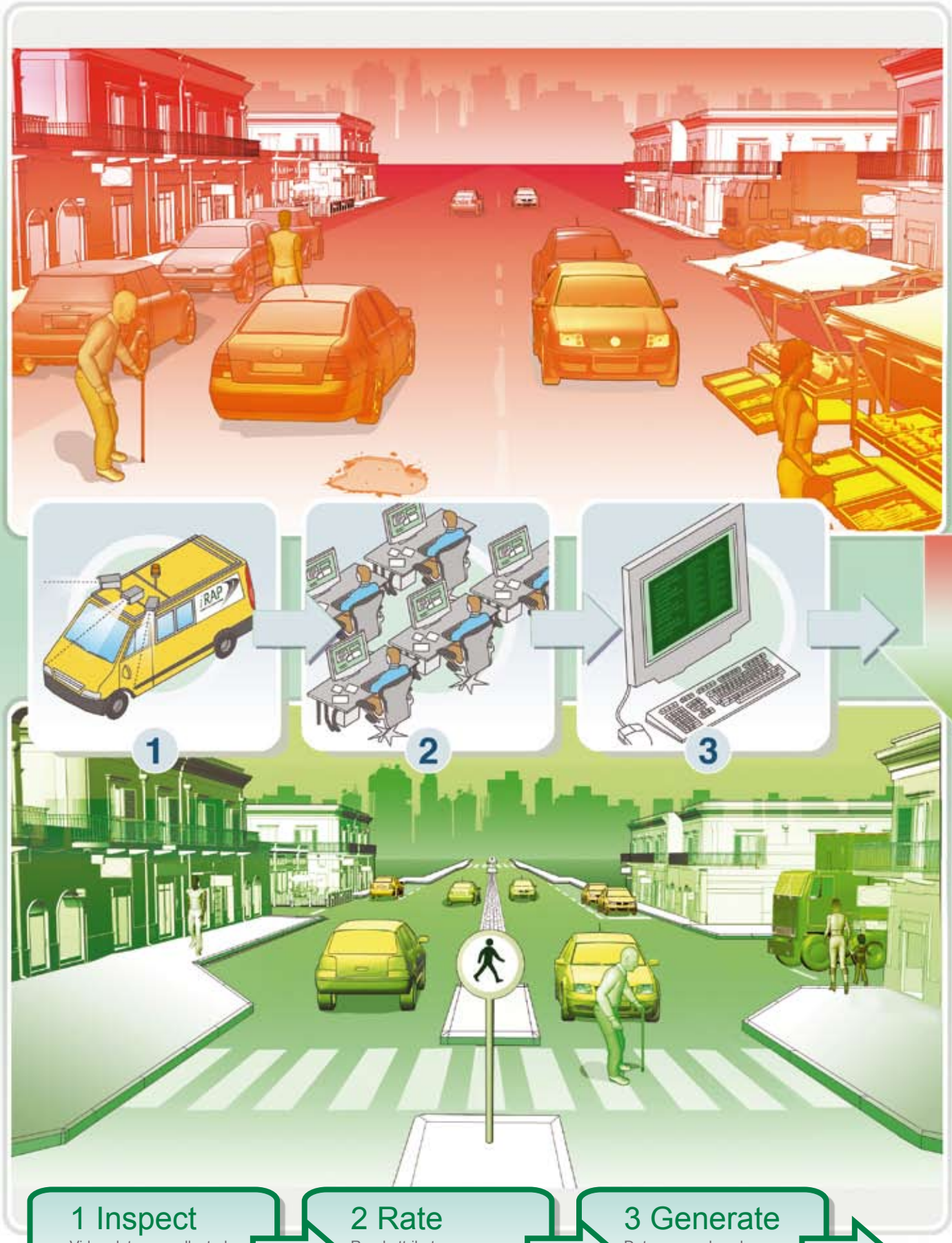
Risk Mapping: Maps are produced using crash history data, showing the risk of being killed or seriously injured.

Performance Tracking: RAP enables tracking of the rate at which high-risk roads are eliminated. Performance tracking identifies ‘consistently high-risk roads’ where authorities need to do more and the ‘most improved roads’ to highlight good practice and encourage competition in excellence. To date, the RAP programmes have used Risk Mapping data to track performance based on historical crash data, however it will also be possible to use road inspection data to measure improvements in road infrastructure.

Good quality crash history data are rarely available in low and middle income countries, so it is necessary to use other methods for assessing safety upgrading needs.

Star Rating roads for safety

The Star Rating of roads provides a methodology to measure the safety performance of a road network. This is particularly valuable where crash data records are unavailable, inaccurate or sparse.



1 Inspect
Video data are collected using specialised equipment

2 Rate
Road attributes are recorded by inspectors

3 Generate
Data are analysed and options generated

Inspectors record over 30 road attributes known to influence the likelihood and severity outcome of road crashes. The road attributes are scored and combined to reflect the overall safety of the road for car occupants, motorcyclists, bicyclists and pedestrians. Scores are then assigned 1-5 stars, allowing cartographic presentation.

The examples below show urban and rural roads that would achieve a low Star Rating (black and red) and a high Star Rating (yellow and green).

4 Appraise

High-return investment programmes are recommended

5 Design

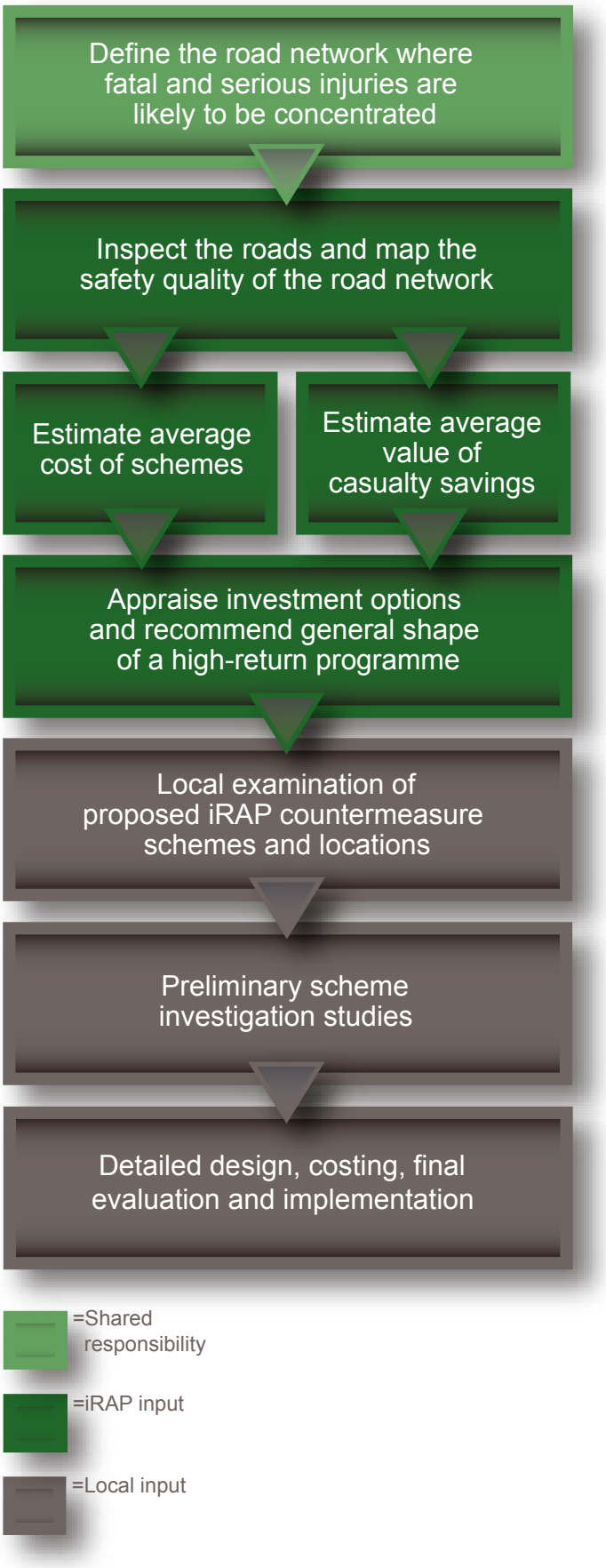
Detailed design of schemes is undertaken

6 Build

Safety upgrades are implemented

The iRAP process

The diagram below shows the scope of the iRAP methodology, from road selection through to the recommendation of a network level investment programme. Local knowledge and detailed planning and design are then required to finalise the exact countermeasure programmes to be implemented.



iRAP pilot countries

Success in each of the pilot countries has been largely dependent on the formation of a multi-agency stakeholder team to steer and help provide leadership for the project. This ensures that national, regional and local capability is fostered throughout the project and that local expertise is fully exploited.

South Africa

Population: 47.4 million

Roads: 276,000 kms, 21% paved

Fatalities: 15,393[1] (2006)

Death rate per 100,000 population: 32.5

Road safety: 42% of fatalities are pedestrians, multiple fatality crashes are relatively common

Cost to economy: 2.3% of GDP

Targets: 5% fatality reduction target

iRAP team: EuroRAP coordinates the work in South Africa. The regional team consists of AASA (Automobile Association South Africa), EuroRAP AISBL, TRL (Transport Research Laboratory), ADAC (German motoring club) and SWECO. The local government of KwaZulu-Natal supports the iRAP inspections.

Inspections: 2,100 kms of roads in KwaZulu-Natal, approximately 4% of South Africa's paved roads

Chile

Population: 16.5 million

Roads: 80,000 kms, 20% paved

Fatalities: 1,652[2] (2006)

Death rate per 100,000 population: 10.0

Road safety: 46% of fatalities are pedestrians, 10% are bicyclists

Cost to economy: No estimate found

Targets: No formal numerical target found

iRAP team: The usRAP team coordinates work in Chile. The team consists of ACCHI (Automobile Club of Chile), AAAFTS (AAA Foundation for Traffic Safety), MRI (Midwest Research Institute), SRSS (Speier Road Safety Solutions Ltda), ISU (Iowa State University), RACC (Spain), Conaset (the Road Safety Council of Chile) and the Ministry of Public Works.

Inspections: 2,500 kms, approximately 17% of paved national highways

Malaysia

Population: 26.6 million

Roads: 74,000 kms, 79% paved

Fatalities: 6,282 (2007)

Death rate per 100,000 population: 22.8

Road safety: Over 60% of fatalities are motorcyclists

Cost to economy: Nearly 2% of GDP

Targets: Cut road deaths to a rate of 10 deaths per 100,000 population by 2010

iRAP team: The AusRAP team coordinates the work in Malaysia. The regional team consists of AAM (Automobile Association Malaysia), JKJR (Malaysian Road Safety Department), MIROS (Malaysia Institute of Road Safety Research), AAA (Australian Automobile Association) and ARRB Group. The project in Malaysia is supported by the Ministry of Works and Ministry of Transport, JKR (Malaysian Public Works Department), LLM (Malaysian Highway Authority), JPJ (Malaysian Road Transport Department), Royal Malaysian Police, PLUS & MTD (Toll road operators), UPM (University Putra Malaysia) and IKRAM.

Inspections: 3,700 kms of roads in peninsula Malaysia, approximately 6% of paved roads

Costa Rica

Population: 4.4 million

Roads: 30,000 kms, 14% paved

Fatalities: 616 (2005)

Death rate per 100,000 population: 14.0

Road safety: 57% of fatalities are pedestrians, bicyclists are also over represented in crash data

Cost to economy: 2.3% of GDP

Targets: Fatality reduction of 19% over the next 5 years

iRAP team: The usRAP team coordinates work in Costa Rica. The regional team consists of ACCR (Automobile Club Costa Rica), AAAFTS (AAA Foundation for Traffic Safety), MRI (Midwest Research Institute), ISU (Iowa State University), and RACC (Spain). The project is supported by the Road Safety Council (Cosevi), and the Ministry of Public Works and Transportation (MOPT).

Inspections: 2,801 kms, approximately 64% of paved national highways

[1] Road traffic fatalities in South Africa include deaths that occur within seven days of the accident, rather than 30 days that has been adopted by most countries. If all fatalities within 30 days were included, estimates suggest an increase of 8 per cent.

[2] Includes only deaths at the accident scene and some additional deaths that occur within 24 hours of the accident.

Star Rating results

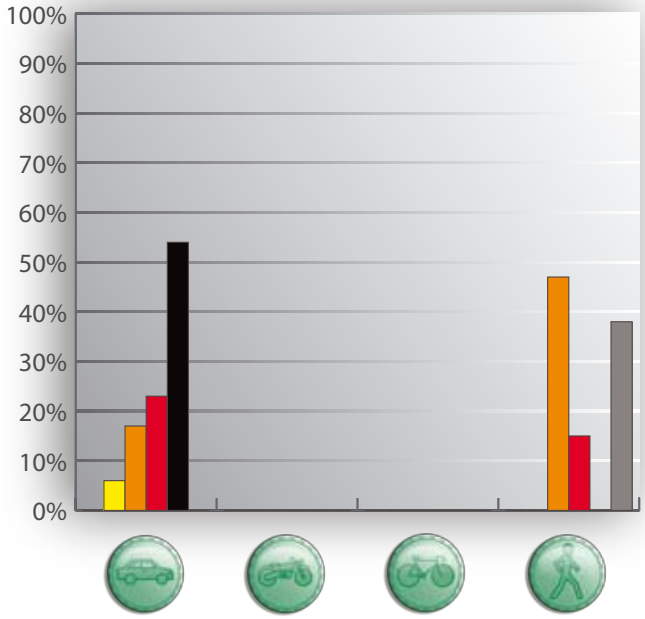
The Star Ratings represent the safety of the road infrastructure as it relates to the risk faced by an individual member of each road user group (Car Occupants, Motorcyclists, Bicyclists and Pedestrians).

- A 5-star rating represents the safest road infrastructure design for the prevailing speed environment
- A 1-star rating represents a road with relatively poor infrastructure design for the prevailing speed environment

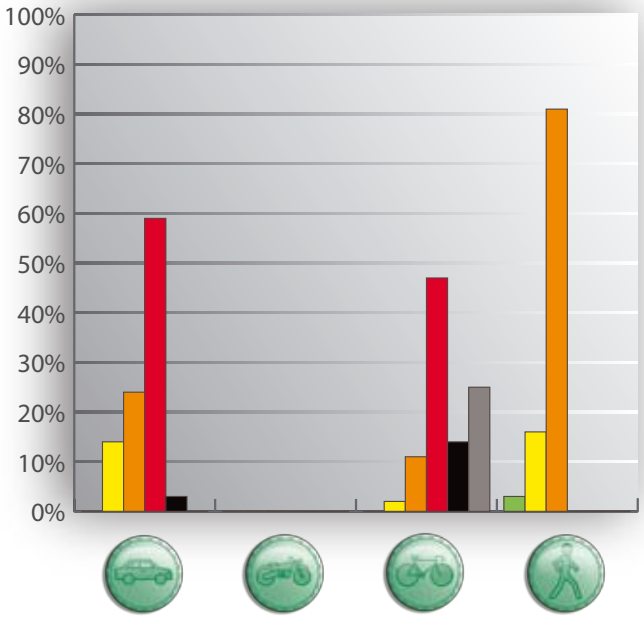
It is important to note that the Star Rating represents the safety risk faced by an individual road user if they (or the traffic around them) are travelling within the speed limit. Traffic flow and estimates of actual speeds are not included in the calculation. For example, speed limits in Costa Rica appear significantly lower than many countries, and in South Africa they appear significantly higher. These differences impact upon the Star Ratings achieved regardless of the actual speed of traffic.

The charts below show the overall Star Rating results by road user for each pilot country.

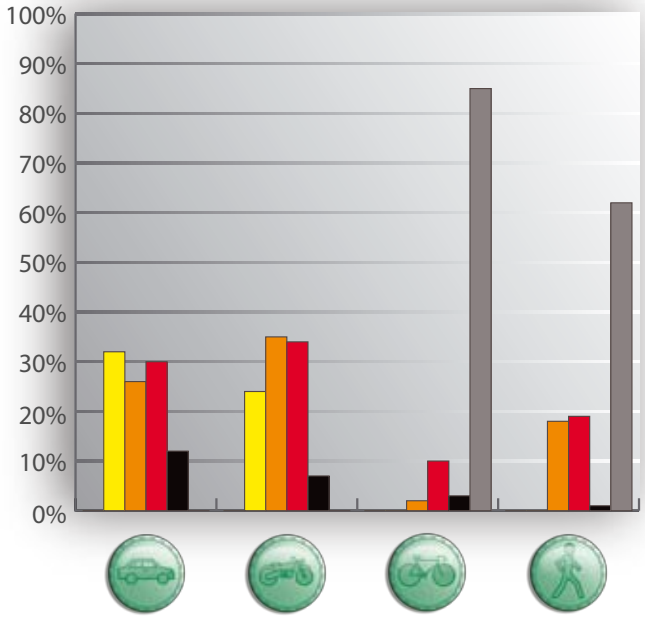
South Africa



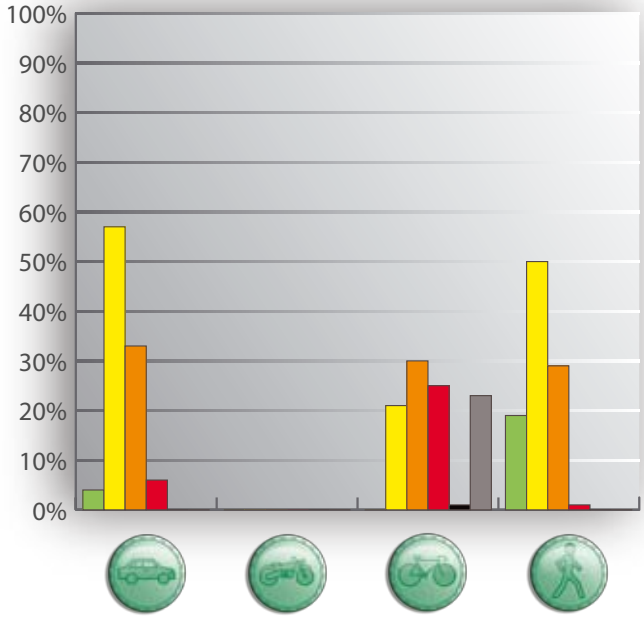
Chile



Malaysia



Costa Rica



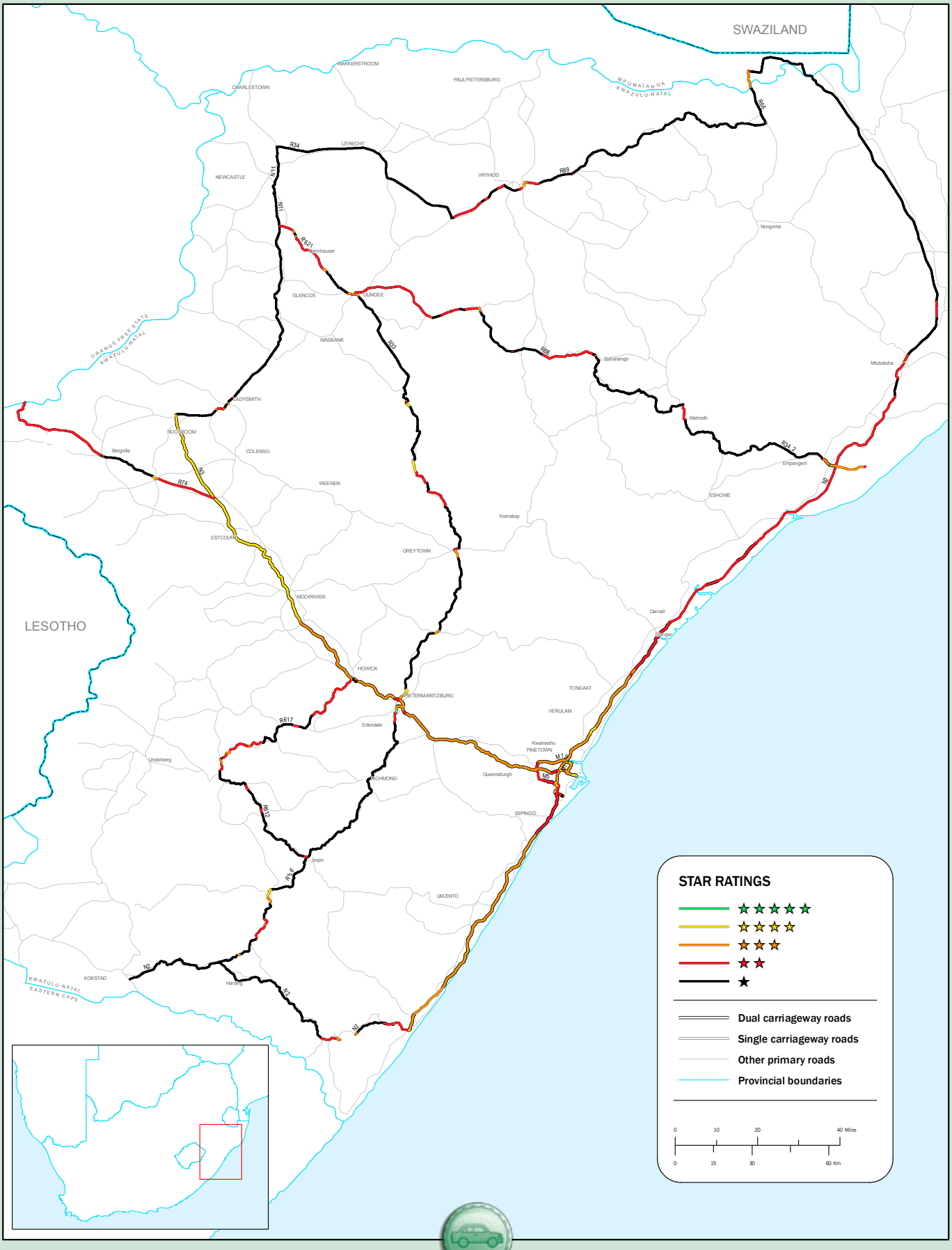
Motorcycling is relatively uncommon in Chile and Costa Rica, and so results are not presented for Motorcyclists. Motorcycling and bicycling are relatively uncommon in South Africa and so results for Motorcyclists and Bicyclists are not presented.

Star ratings

South Africa (KwaZulu-Natal) – Car Occupant Star Ratings

This map shows the individual risk faced by a car occupant travelling within the speed limit on the inspected road network in KwaZulu-Natal, South Africa.

A 5-star rating represents the safest road infrastructure design for the prevailing speed environment; a 1-star rating represents a road with relatively poor infrastructure design.

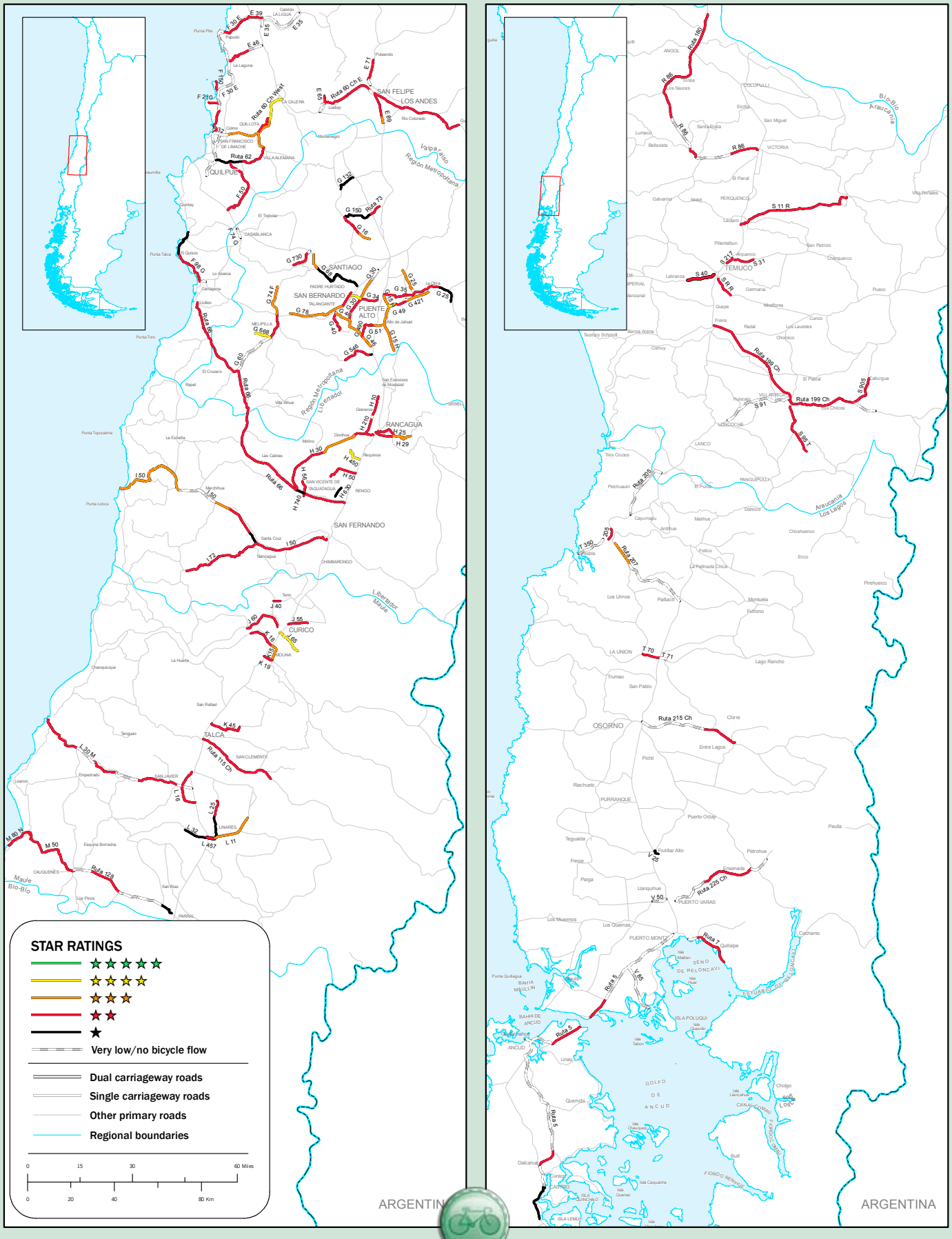


Malaysia – Motorcyclist Star Ratings

This map shows the individual risk faced by a motorcyclist travelling within the speed limit on the inspected road network in Malaysia. A 5-star rating represents the safest road infrastructure design for the prevailing speed environment; a 1-star rating represents a road with relatively poor infrastructure design.

Chile – Bicyclist Star Ratings

This map shows the individual risk faced by a bicyclist travelling on the inspected road network in Chile. A 5-star rating represents the safest road infrastructure design for the prevailing speed environment; a 1-star rating represents a road with relatively poor infrastructure design.

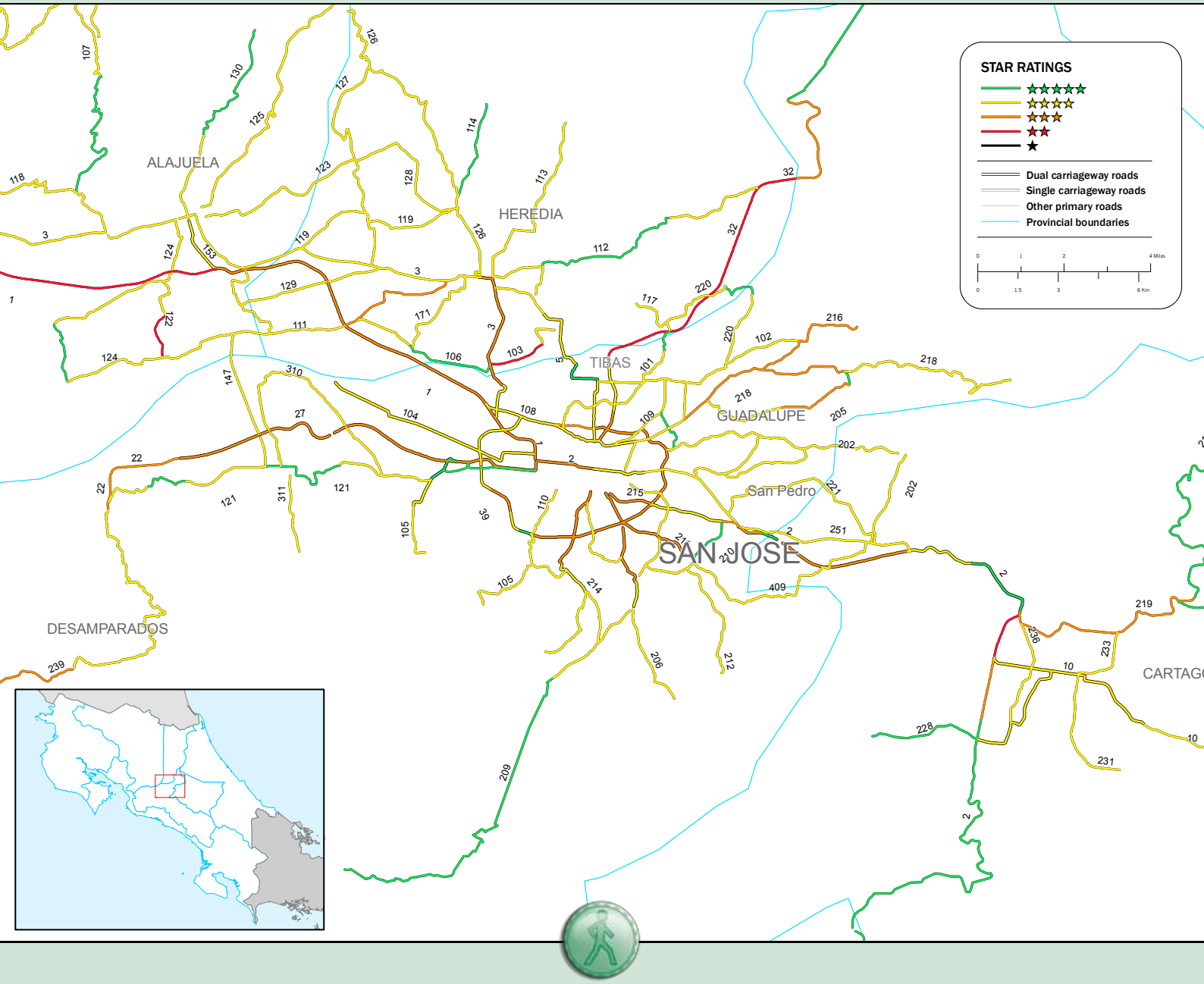


Costa Rica – Pedestrian Star Ratings

This map shows the individual risk faced by a pedestrian travelling on the inspected road network in Costa Rica. A 5-star rating represents the safest road infrastructure design for the prevailing speed environment; a 1-star rating represents a road with relatively poor infrastructure design.

Costa Rica Central Valley – Pedestrian Star Ratings

This map shows the individual risk faced by a pedestrian travelling on the inspected road network in the Central Valley region of Costa Rica. A 5-star rating represents the safest road infrastructure design for the prevailing speed environment; a 1-star rating represents a road with relatively poor infrastructure design.



Examples of roads achieving each Star Rating

South Africa – Car Occupant

A 5-star Car Occupant road would be median separated, have clear roadsides, have only a few grade separated junctions with long merging lanes and would have a speed limit suitable for the design environment

No illustrative example available

This is 5-star in the foreground and up until the bend in the distance. The bend causes it to be 4-star overall. The South Africa maps do not have any 5-star sections.

Straight road, sealed shoulder, forgiving roadside (long grass) reasonable quality markings, few junctions

Single carriageway – trees at frequent intervals causing the low score

Single carriageway, no run-off protection – hazards to left and drop to right – bendy route, poor road condition, poor markings

Malaysia – Motorcyclist

Fully separated facility with one way flows, no side friction, good delineation and forgiving roadsides, 80 km/h

Divided carriageway, separate motorcycle path on road, 60 km/h

Single carriageway road, wide paved shoulder for motorcycle use, 50 km/h

Single carriageway road, straight, narrow sealed shoulder, 90 km/h

Single carriageway road, narrow paved shoulder, sharp curves, poor roadsides, 90 km/h

Chile – Bicyclist

A 5-star road for Bicyclists would have bicycle facilities physically separated from the main road carriageway with either a barrier or a wide run-off zone

No illustrative example available

Separated bicycle path

Paved shoulder for bicycle use

Narrow unpaved shoulder for bicycle use

Bicyclists riding in a narrow road

Costa Rica – Pedestrian

A 5-star road for Pedestrians would either be a pedestrian zone where motorised vehicles are excluded, or a road where pedestrian facilities are physically separated from the main road carriageway with signalised crossings available where pedestrians wish to cross

No illustrative example available

Paved sidewalk separated from traffic by a deep ditch

Separated paved sidewalk

Unpaved shoulder for pedestrian use

Pedestrians walking in a narrow road

South Africa recommended countermeasure programme

iRAP has recommended that those countermeasures with a minimum BCR of 4 be considered for future funding. Further consultation with local stakeholders will be required following this report.

The recommended programme with an initial construction cost of US$ 49 million is expected to save 6,900 lives and serious injuries over 20 years. On average, each life and serious injury would cost US$ 7,600 to save and overall the investment benefits are estimated to be worth US$ 0.6 billion.

Priority countermeasure programme

Estimated initial construction cost/ US$	49 m
Estimated cost to build and maintain (20 years)/ US$	52 m
KSIs saved (20 years)	6,900
Value of safety benefit (20 years)/ US$	0.6 bn
Cost per KSI saved/ US$	7,600
Overall programme Benefit-Cost Ratio	12

Top 5 recommended countermeasures

Within the programme, the top 5 countermeasures for immediate investigation are shown in the following table:

Countermeasure type	Length or number of sites	Estimated initial construction cost/ US$	Estimated cost to build and maintain (20 years)/ US$	KSIs saved (20 years)	Value of safety benefit (20 years)/ US$	Cost per KSI saved (20 years)/ US$	Programme Benefit-Cost Ratio (BCR)
Shoulder sealing/provision	260 km	12 m	12 m	1,600	143 m	7,600	12
Median barrier	70 km	11 m	11 m	1,500	128 m	7,700	11
Roadside safety - barriers	140 km	12 m	12 m	1,300	118 m	8,900	10
Pedestrian footpath	60 km	4 m	4 m	1,000	87 m	3,900	23
Duplication with median barrier	10 km	6 m	6 m	500	44 m	11,200	8

Priority life-saving countermeasure – roadside barriers

In South Africa, it is estimated that around 60% of fatalities are vehicle occupants. On a sample of the roads inspected, about 10% of the fatal crashes involved collisions with fixed objects and another 40% involved vehicles overturning, many after leaving the carriageway. Roadside barriers represent an important network-wide countermeasure that has the potential to save many lives in South Africa.

Current road network

Without facilities

Inspection data

Roadside severity – total length of left and right hand side of carriageway	Length/ km	%
Safety barrier	733	17
Cut	281	7
Deep drainage ditches	10	0
Steep fill embankment slopes	248	6
Distance to object 0-5 m	624	15
Distance to object 5-10 m	1,251	30
Distance to object > 10m	614	15
Not recorded/other	434	10

Proposed countermeasure scheme

With facilities

Recommended upgrade

Length/ km	140
Estimated initial construction cost/ US$	12 m
Estimated cost to build and maintain (20 years)/ US$	12 m
KSIs saved (20 years)	1,300
Value of safety benefit (20 years)/ US$	118 m
Cost per KSI saved/ US$	8,900
Programme Benefit-Cost Ratio	10

Safety benefits are present value figures discounted over 20 years at a rate of 4% per annum.

Malaysia recommended countermeasure programme

The iRAP Malaysia Steering Group has recommended that those countermeasures with a minimum BCR of 5 be considered for future funding.

The recommended programme with an initial construction cost of US$ 174 million is expected to save 31,800 lives and serious injuries over 20 years. On average, each life and serious injury would cost US$ 5,700 to save and overall the investment benefits are estimated to be worth nearly US$ 3 billion.

Priority countermeasure programme

Estimated initial construction cost/ US$	174 m
Estimated cost to build and maintain (20 years)/ US$	181 m
KSIs saved (20 years)	31,800
Value of safety benefit (20 years)/ US$	2.9 bn
Cost per KSI saved/ US$	5,700
Overall programme Benefit-Cost Ratio	16

Top 5 recommended countermeasures

Within the programme, the top 5 countermeasures for immediate investigation are shown in the following table:

Countermeasure type	Length or number of sites	Estimated initial construction cost/ US$	Estimated cost to build and maintain (20 years)/ US$	KSIs saved (20 years)	Value of safety benefit (20 years)/ US$	Cost per KSI saved (20 years)/ US$	Programme Benefit-Cost Ratio (BCR)
Roadside safety - hazard removal	1,650 km	7 m	7 m	9,700	892 m	800	121
Motorcycle lanes	270 km	5 m	5 m	900	81 m	6,000	15
Intersection upgrades	380 sites	11 m	11 m	2,000	185 m	6,800	14
Overtaking and capacity improvements	380 km	56 m	56 m	8,200	756 m	6,800	14
Shoulder sealing/provision	270 km	11 m	11 m	1,400	127 m	7,800	12

Priority life-saving countermeasure – motorcycle lanes

In Malaysia, approximately 60% of fatalities are motorcyclists. The provision of safe road infrastructure for motorcyclists is essential to minimise the risk of death and injury. Motorcycle lanes represent an important network-wide countermeasure that has the potential to save many lives in Malaysia.

Current road network

Without facilities

Inspection data

Motorcycle percentage	Length/ km	%
0%	0	0
1-5%	1,042	28
6-10%	268	7
11-20%	1,378	37
21-40%	983	27
41-60%	16	0
61-100%	0	0

Facilities for motorised two-wheelers	Length/ km	%
Segregated motorcycle path with barrier	1	0
Segregated motorcycle path	2	0
Dedicated motorcycle lane on roadway	79	2
Not present	3,605	98

Proposed countermeasure scheme

With facilities

Recommended upgrade

Length/ km	270
Estimated initial construction cost/ US$	5 m
Estimated cost to build and maintain (20 years)/ US$	5 m
KSIs saved (20 years)	900
Value of safety benefit (20 years)/ US$	81 m
Cost per KSI saved/ US$	6,000
Programme Benefit-Cost Ratio	15

Safety benefits are present value figures discounted over 20 years at a rate of 4% per annum.

Chile recommended countermeasure programme

The iRAP team has recommended that those countermeasures with a minimum BCR of 8 be considered for future funding.

The recommended programme with an initial construction cost of US$ 68 million is expected to save 19,400 lives and serious injuries over 20 years. On average, each life and serious injury would cost US$ 3,800 to save and overall the investment benefits are estimated to be worth nearly US$ 2.3 billion.

Priority countermeasure programme

Estimated initial construction cost/ US$	68 m
Estimated cost to build and maintain (20 years)/ US$	74 m
KSIs saved (20 years)	19,400
Value of safety benefit (20 years)/ US$	2.3 bn
Cost per KSI saved/ US$	3,800
Overall programme Benefit-Cost Ratio	32

Top 5 recommended countermeasures

Within the programme, the top 5 countermeasures for immediate investigation are shown in the following table:

Countermeasure type	Length or number of sites	Estimated initial construction cost/ US$	Estimated cost to build and maintain (20 years)/ US$	KSIs saved (20 years)	Value of safety benefit (20 years)/ US$	Cost per KSI saved (20 years)/ US$	Programme Benefit-Cost Ratio (BCR)
Shoulder sealing/provision	1,100 km	25 m	27 m	9,100	1,099 m	2,900	41
Pedestrian footpath	520 km	26 m	26 m	6,100	738 m	4,300	28
Intersection - roundabout	560 sites	7 m	7 m	1,600	187 m	4,800	25
Traffic calming	130 km	2 m	3 m	1,500	176 m	2,300	52
Pedestrian crossing	190 sites	2 m	4 m	500	55 m	8,500	14

Priority life-saving countermeasure – provision of sealed shoulders

In Chile, vulnerable road users make up over half of national road fatalities. The provision of sealed shoulders not only gives a safe run-off area for vehicle occupants, but also somewhere for pedestrians to walk and bicyclists to cycle out of the direct path of motorised traffic. Providing sealed shoulders represents an important network-wide countermeasure that has the potential to save many lives in Chile.

Current road network

Without facilities

Inspection data

Paved shoulder width	Length/ km	%
Paved 1 < width < 2.4m	501	20
Paved 0 < width <= 1m	1,577	62
None	463	18

Unpaved shoulder width	Length/ km	%
Unpaved >= 2.4m	0	0
Unpaved 1 < width < 2.4m	76	3
Unpaved 0 < width <= 1m	158	6
None	2,307	91

Proposed countermeasure scheme

With facilities

Recommended upgrade

Length/ km	1,100
Estimated initial construction cost/ US$	25 m
Estimated cost to build and maintain (20 years)/ US$	27 m
KSIs saved (20 years)	9,100
Value of safety benefit (20 years)/ US$	1.1 bn
Cost per KSI saved/ US$	2,900
Programme Benefit-Cost Ratio	41

Safety benefits are present value figures discounted over 20 years at a rate of 4% per annum.

Costa Rica recommended countermeasure programme

The iRAP team has recommended that those countermeasures with a minimum BCR of 5 be considered for future funding.

The recommended programme with an initial construction cost of US$ 50 million is expected to save 14,700 lives and serious injuries over 20 years. On average, each life and serious injury would cost US$ 3,600 to save and overall the investment benefits are estimated to be worth US$ 1.2 billion.

Priority countermeasure programme

Estimated initial construction cost/ US$	50 m
Estimated cost to build and maintain (20 years)/ US$	53 m
KSIs saved (20 years)	14,700
Value of safety benefit (20 years)/ US$	1.2 bn
Cost per KSI saved/ US$	3,600
Overall programme Benefit-Cost Ratio	22

Top 5 recommended countermeasures

Within the programme, the top 5 countermeasures for immediate investigation are shown in the following table:

Countermeasure type	Length or number of sites	Estimated initial construction cost/ US$	Estimated cost to build and maintain (20 years)/ US$	KSIs saved (20 years)	Value of safety benefit (20 years)/ US$	Cost per KSI saved (20 years)/ US$	Programme Benefit-Cost Ratio (BCR)
Pedestrian footpath	190 km	14 m	14 m	6,900	543 m	2,100	38
Pedestrian crossing	170 sites	9 m	11 m	2,500	200 m	4,200	19
Shoulder sealing/provision	180 km	6 m	7 m	1,500	121 m	4,400	18
Intersection - signalise	80 sites	9 m	9 m	900	68 m	9,800	8
Intersection - roundabout	230 sites	3 m	3 m	700	56 m	4,000	20

Priority life-saving countermeasure – pedestrian footpaths

In Costa Rica, 57% of the national fatalities are pedestrians. The provision of safe road infrastructure for pedestrians is essential to minimise the risk of death and injury. Pedestrian footpaths represent an important network-wide countermeasure that has the potential to save many lives in Costa Rica.

Current road network

Without facilities

Inspection data

Footpath provision	Length/ km	%
Physical barrier	3	0
Non-physical separation > 3m	52	2
Non-physical separation > 1m ≤ 3m	249	9
Adjacent to traffic	338	12
None	2,160	77

Pedestrian flow along road	Length/ km	%
Low	332	12
Medium	1,058	38
High	1,410	50

Proposed countermeasure scheme

With facilities

Recommended upgrade

Length/ km	190
Estimated initial construction cost/ US$	14 m
Estimated cost to build and maintain (20 years)/ US$	14 m
KSIs saved (20 years)	6,900
Value of safety benefit (20 years)/ US$	543 m
Cost per KSI saved/ US$	2,100
Programme Benefit-Cost Ratio	38

Safety benefits are present value figures discounted over 20 years at a rate of 4% per annum.

20 year casualty savings in Malaysia

The map below shows the casualty savings over 20 years expected as a result of the recomended programme in Malaysia.

Conclusions

The pilot programme had a number of objectives – to develop the new iRAP tools; to test these tools in real applications in a variety of environments across the world; and to explore how partnerships can best be put together to apply them.

iRAP tools

The iRAP inspection methodology has been successfully applied in a variety of environments. Two differing technologies were used to capture and analyse data and proved that the market can be invited to offer competing methods to provide inspection data conforming to iRAP specifications.

The Star Rating of roads for each of four different user groups – car occupants, motorcyclists, bicyclists and pedestrians – was successful. Scope for continuous improvement is built into the architecture of the Star Rating calculation: as more inspections are done, the learning can be captured and the Star Ratings improved. The main issue to emerge was how posted speed limits, which may not be obeyed, should be handled (see page 24).

The challenging task of triggering and evaluating possible countermeasures based on the inspection results also worked well. The volume of data involved in considering the attributes attached to sections of road every 50 or 100 metres over thousands of kilometres is formidable. The logical analysis behind the generation and discarding of possible options for countermeasures is complex even before the economic analysis.

A key moment arises when the iRAP team and local engineers come together after the inspections have been completed to review, sense check and refine the recommended countermeasure programmes generated by the tools. The pilot results were convincing in this respect and pilot countries are already beginning to plan to implement recommendations.

A suitable method of economic analysis was developed with support from the World Bank. This can be applied satisfactorily to any country at any point of economic development.

iRAP recommended programmes

The recommended countermeasure programmes are shown below. In Malaysia, Chile and Costa Rica these have been selected in consultation with government representatives and the iRAP steering committee. In South Africa, consultation will occur following this report.

The recommended programmes in each of the pilot programmes not only have the potential to save many lives and serious injuries, but also offer attractive investment returns. The overall Benefit-Cost Ratio for the recommended programmes is 12 in South Africa, 16 in Malaysia, 32 in Chile and 22 in Costa Rica.

In addition to these summary data presented in the current report, iRAP results include a detailed breakdown of these countermeasures and the precise locations where they should be considered for implementation. Although iRAP data can show the precise location of a recommended countermeasure, it is necessary to complete detailed planning and design with extensive local knowledge before detailed countermeasure programmes can be developed.

The example shows the location of a recommended improvement to horizontal alignment in Malaysia.

	Estimated cost to build and maintain (20 years)/ US$	KSIs saved (20 years)	Value of safety benefit (20 years)/ US$	Cost per KSI saved/ US$	Average programme Benefit-Cost Ratio	Casualty reduction on the roads inspected
South Africa	52 m	6,900	0.6 bn	7,600	12	12 %
Malaysia	181 m	31,800	2.9 bn	5,700	16	32 %
Chile	74 m	19,400	2.3 bn	3,800	32	44 %
Costa Rica	53 m	14,700	1.2 bn	3,600	22	17 %

Safety benefits are present value figures discounted over 20 years at a rate of 4% per annum.

Casualty savings

The iRAP pilot studies have been applied on a sample of roads in each of the countries, with significant casualty reductions expected following the implementation of the recommended programmes.

- In South Africa the recommended countermeasure programme is estimated to save 6,900 lives and serious injuries over the next 20 years. This represents a 12% reduction in the casualties on the roads surveyed.
- In Malaysia the recommended countermeasure programme is estimated to save 31,800 lives and serious injuries over the next 20 years. This represents a 32% reduction in the casualties on the roads surveyed.
- In Chile the recommended countermeasure programme is estimated to save 19,400 lives and serious injuries saved over the next 20 years. This represents a 44% reduction in the casualties on the roads surveyed.
- In Costa Rica the recommended countermeasure programme is estimated to save 14,700 lives and serious injuries over the next 20 years. This represents a 17% reduction in the casualties on the roads surveyed.

Extension of the iRAP approach to the remaining high volume, high fatality road sections in each country is expected to result in similar returns and potential for reduction in casualties.

Speed management

Vehicle speeds have an important role in the safety level of a road network. Speed management is a critical aspect of managing a safe road system. The risk of death or serious injury is minimised in any crash, where:

- Vulnerable road users (e.g. motorcyclists, bicyclists and pedestrians) are physically separated from cars and heavier vehicles, or traffic speeds are 40km/h or less
- Opposing traffic is physically separated and roadside hazards are well managed
- Traffic speeds are 70km/h or less for occupants of cars on roads where opposing traffic is not physically separated or roadside hazards exist

iRAP star ratings are based on the posted speed limits of the inspected roads and so implicitly assume that traffic operates at that speed. However, where posted traffic speeds are not enforced or accompanied by other engineering solutions such as traffic calming, their effectiveness may be reduced.

Traffic speeds also vary greatly during the day as a function of congestion, volumes, side friction, incidents, enforcement activities and the general conformance of the driving population with speed limits.

In the iRAP results, roads with very low posted speed limits may achieve a relatively high star rating (e.g. four or five star), even though the engineering features may be of a lower standard and/or the road environment does not support the speed limit (e.g. lack of traffic calming). The detailed measurement of actual speed profiles does not form part of the iRAP assessment and may be considered as part of more detailed site assessments at the project planning level.

The iRAP model may therefore underestimate the casualties and associated countermeasure benefits on roads where typical speeds are in excess of the posted speed limit. Moreover, traffic calming countermeasures may not be triggered, even though they may offer good investment returns.

The raw condition data collected as part of the iRAP process will provide a valuable resource to authorities investigating appropriate speed management initiatives. This may include a more detailed analysis of results to investigate where there are low speed limits without accompanying engineering solutions, or may include a review of the speed limits and facilities in place on roads that rate poorly for pedestrian or bicycle safety.

Using the iRAP results

An important outcome for the iRAP inspections is that the local government and engineers consider the iRAP recommended programmes for investment. The iRAP inspection database is available to all stakeholders and so individual parts of the recommended programme can be considered in detail and can be used for detailed planning and consultation.

The iRAP pilot studies have been completed in cooperation with the various Steering Committees in each country. The assessments have demonstrated the potential for simple low-cost engineering improvements to result in a significant reduction in road trauma, and that this investment is economically viable and responsible.

The iRAP teams are now working closely with the treasury, finance, planning and implementation agencies within each country to ensure the necessary site investigations and reviews are undertaken and the projects implemented. This investment in safer roads today will continue to save lives well into the future.

Partnership building

Success in each of the pilot countries has been largely dependent on the formation of an enthusiastic and highly-skilled multi-agency stakeholder team to steer, lead and help execute the programmes. The greater the cross-agency involvement, the more successful the programmes have been. The pilot programmes have worked variously with policy Ministers, with Road Safety Councils, and with roads delivery agencies at both national and regional level. The general lesson is that time taken to ensure that national, regional and local capability is fostered throughout the project and that local expertise is fully utilised is time well spent. However this does increase both time and costs in delivering results.

The automobile clubs (AASA, AAM, ACCHI and ACCR) have led and executed the 'in-country' aspects of the programme and, where appropriate, have also ensured that the aims and results of the programme have been communicated effectively in the media. They have also provided an excellent representation of civil society and have provided links to other stakeholders including government officials and other local road safety experts.

The involvement of government representatives has ensured good access to background data necessary for the iRAP inspections. Support and cooperation from government and public road agency stakeholders has ensured assistance in the execution of the project and also the adoption of iRAP methodology and/or results into the national road safety strategy. More importantly, the involvement of government representatives and local development banks is critical to the funding and implementation of the recommended programmes.

Key iRAP resources

Road Deaths in Developing Countries – The challenge of dysfunctional roads. This paper explores the link between economic development, rising motorisation and road deaths. Dr John Mumford OBE finds that road deaths do not rise and fall inevitably with growing income, and examines the contribution that tackling dysfunctional roads can make *(see www.irap.net).*

The True Cost of Road Crashes – Valuing life and the cost of a serious injury. Development banks want to assess investment opportunities on a consistent basis geared to the state of economic development in each country. This work provides economic values suitable for use in any country. iRAP is grateful to the World Bank for its support in this work *(see www.irap.net).*

iRAP Road Safety Toolkit. iRAP is grateful to the Global Transport Knowledge Partnership (gTKP) who funded this web-based Toolkit. This toolkit allows engineers in developing countries to explore local casualty problems, known countermeasure solutions and share experiences *(see www.irap.net).*

International Transport Statistics Database. An essential step when the iRAP team visits a country is to understand its transport data and statistics. In a separate FIA Foundation funded project, iRAP has now released its international transport statistics database website at which collates transport statistics from many countries worldwide and permits site visitors to build their own charts and tables *(see www.iraptranstats.net).*

iRAP

INTERNATIONAL ROAD ASSESSMENT PROGRAMME

Already 1.2 million people die annually on the world's roads and the number of seriously injured could be as high as 50 million. The growing burden of road crashes is comparable with malaria and tuberculosis and costs a staggering 1-3% of the world's GDP.

This scale of human tragedy is preventable. Road deaths have been falling for decades in developed countries by applying known effective measures to improve driving, vehicles and roads.

Simple affordable road infrastructure improvements like footpaths, safe crossing points and safe junctions can save huge numbers of lives if targeted to where serious crashes are taking place.

iRAP has drawn upon the developed world's Road Assessment Programmes (EuroRAP, AusRAP and usRAP) to tailor a methodology for low and middle income countries. This methodology does not require detailed crash data and works directly from road inspections.

This report describes the results from over 10,000kms of road inspections in four countries with very different patterns of road casualties - South Africa, Malaysia, Chile and Costa Rica. The new iRAP methodology delivers:

- 'Star Rating' tables and maps showing the safety of roads for car occupants, motorcyclists, bicyclists and pedestrians
- a road inventory database with 30 inspected attributes describing the inspected network
- an estimate of the numbers being killed and seriously injured on each inspected road
- a recommended network-wide countermeasure programme for consideration by local stakeholders and funding bodies

This report shows how inspections lead to high-return, affordable countermeasure programmes that can save literally tens of thousands of lives and serious injuries in each country. In Malaysia, for example, an investment of US$ 180 million can deliver US$ 3 billion of benefits saving over 30,000 deaths and serious injuries. In Costa Rica, national casualties would be reduced by some 10% for US$ 50 million.

This new methodology offers 'vaccines for roads'. There is demand for inspections from across the world but the pace with which they can be rolled out globally will depend upon the speed with which leading aid donors and the development banks recognise the scale of the road injury crisis and commit to action.

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