About iRAP

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

We provide tools and training to help countries make roads safe. Our activities include:

- 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 EuroRAP, AusRAP, usRAP, KiwiRAP and ChinaRAP. Road Assessment Programmes (RAP) are now active in more than 80 countries throughout Europe, Asia Pacific, North, Central and South America and Africa.

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

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

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To find out more about the programme, visit www.irap.org. You can also subscribe to ‘WrapUp’, the iRAP e-newsletter, by sending a message to icanhelp@irap.org.


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1 Introduction

Deaths and injuries from road vehicle crashes are a major and growing public health epidemic. Each year an estimated 1.3 million people die and a further 50 million are injured or permanently disabled in road crashes. Road crashes are now the leading cause of death for children and young people aged between 15 and 29. The burden of road crashes is comparable with malaria and tuberculosis and costs 1-3% of the world’s GDP.

In low and middle income countries, road crashes represent a major health concern. More than 85% of the global death toll and serious injuries occur in developing countries. Whereas road deaths are expected to fall in high-income countries, they are set to increase in the rest of the world unless action is taken.

The International Road Assessment Programme (iRAP - www.irap.org) has drawn upon the extensive knowledge base of the developed world’s Road Assessment Programmes (EuroRAP, AusRAP and usRAP), with the generous support of the FIA Foundation, to develop a road survey methodology for low and middle income countries. This Star Rating methodology does not require detailed crash data and works directly from road surveys.

1.1 About this document

The iRAP Star Rating and Investment Plan Implementation Support Guide provides help and guidance to road authority engineers, design consultants and others using the iRAP Star Rating and Investment Plan results to assess road user risk and improve the safety of road infrastructure for all users. This guidance document builds on the experience of RAP users around the world and is designed to assist those using the iRAP results to maximise the benefits of the road assessment outputs and shows users how to use the Star Rating Scores to identify high risk locations and how to analyse and prioritise road safety countermeasure treatments for inclusion in routine maintenance, local safety schemes, planned road upgrades and rehabilitation projects. The document will assist users with the implementation phase shown on the right of the process diagram below.

Figure 1 The iRAP Star Rating and Safer Roads Investment Plan process diagram
This Implementation Support Guide has primarily been developed in order to bridge the gap between a road assessment being completed (with results published) and the design and construction phase, whether it be a small scale road safety scheme, route treatment programme or major corridor upgrade. The document will enable users to make best use of their data including instructions on conducting economic appraisals, presenting results, step-by-step instructions on how to prioritise and create lists of recommended treatments for further investigation and the importance of monitoring and evaluation.

It is designed to be a flexible document that will change and develop as new tools, reports and functionality are added to the iRAP Star Ratings and Investment Plan protocols and associated software.

1.2 Star Ratings overview

iRAP Star Ratings are an objective measure of the likelihood of a road crash occurring and its severity. The focus is on identifying and recording the road attributes which influence the most common and severe types of crash, based on scientific evidence-based research. In this way, the level of road user risk on a particular road section or network can be defined without the need for detailed crash data, which is often the case in low and middle income countries where data quality is poor. Research shows that a person’s risk of death or serious injury is highest on a one-star (black) road and lowest on a five-star (green) road.

Star Ratings are also particularly useful in order to objectively quantify the level of risk associated with new road designs (where crash data is not available) enabling evidence based decisions on road improvements and also for use in high-performing countries where the relatively low frequency of crashes limits the ability of crash analysis to influence performance monitoring and investment prioritisation. For further information on iRAP Star Rating methodology and access to training courses visit http://capacity.irap.org/.

1.3 Safer Road Investment Plan overview

iRAP considers more than 90 proven road safety countermeasure treatments to generate affordable and economically sound Safer Road Investment Plans (SRIP) that will reduce road user risk, improve a road's Star Rating and will save lives. Road improvement options range from low cost road markings and pedestrian refuges to higher cost intersection upgrades and full highway duplication.

The investment plans are developed in three key steps:

1. Drawing on the Star Ratings, traffic volume data and crash data (if available), estimated numbers of deaths and serious injuries are distributed across the road network.

2. For each 100 metre segment of road, countermeasure options are tested for their potential to reduce deaths and serious injuries. A series of triggers are used to select suitable countermeasure treatments at viable locations. For example, a section of road that has a poor pedestrian Star Rating and high pedestrian activity might be a candidate for a footpath or pedestrian crossing facility.

3. Each countermeasure option is assessed against affordability and economic effectiveness criteria. The economic benefit of a countermeasure (measured in terms of the economic benefit of the deaths
and serious injuries prevented) is compared to the cost of construction and maintenance over a set period to give a benefit to cost ratio (BCR) of each individual countermeasure plus a BCR for the overall SRIP. In many cases, the ‘threshold’ BCR for an investment plan is set at 1 which means that the benefit must at least equal the cost. The BCR setting can be lifted above one, which has the effect of making the plan more cost-effective and 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.


2 Securing funding for your project

Simple, affordable improvements to road infrastructure have the power to dramatically reduce both the risk of crashes occurring and their severity. By investing in life-saving features like sealed shoulders, footpaths, safety barriers and traffic signals, high-risk roads can be made more forgiving – they can be made safe. iRAP’s systematic approach helps to justify investment in safer roads.

Large-scale, targeted road infrastructure improvements make good financial sense. The iRAP results can help to secure funding for road upgrades that will reduce the cost of crashes for the life of the countermeasures, saving government spending further down the line. Proposed road safety upgrades that are often not cost-effective when considered in isolation can often be justified as part of a network-wide mass action treatment.

2.1 The business case for safer roads

Road crashes kill over 1 million people each and every year worldwide with an estimated 30-50 million additional people injured annually. Road crashes impact the young and economically productive and impose a significant burden on health, insurance and legal systems. The cost of road crashes globally is estimated at more than US$2,000 billion a year. Investment does not match the scale of the problem. Road infrastructure often has an unacceptable risk of head-on, run-off road, intersection and pedestrian deaths and injuries built in to current designs. Proven and cost effective solutions exist for most crash outcomes and all that is missing is the appropriate scale of response to the problem.

The gross underfunding of road infrastructure safety relates to the disconnection and incorrect apportionment of funds between prevention and funding of consequences. That is the US$2,000 billion in annual road crash costs are primarily borne by the health and welfare system, the legal system, the insurance sector, the commercial and business sector and the families of those impacted. Without a whole of government / whole of system response to solving this significant problem the scourge of road death and injury will remain for future generations.
The preventative solutions for road death and injury are primarily in:

- road infrastructure (e.g. significant lengths of our road network are 1- or 2-star where 5-star is the safest and research shows that crash costs halve for each one star improvement in a road network)
- policing and behaviour change (e.g. enforcement, education, technology improvements such as alcohol interlocks)
- vehicles (e.g. rapid modernisation of fleets to 5-star safety levels)

Road Assessment Programmes can help to provide the metrics which enable benefits to be captured and the rightful, accelerated investment in safer road infrastructure to be delivered.

### 2.2 Setting policy targets

Funding for road safety improvements can be leveraged if policy targets are set. It is recommended that Government agencies at regional or national level set policy targets to stabilise and then reduce the forecasted level of road traffic fatalities in line with the recommendations discussed in the *Global Plan for the Decade of Action for Road Safety 2011-2020*. Setting targets to improve Star Ratings can have a significant impact, suggestions include:

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

Star rating targets and risk mapping are being actively used by road agencies, development banks and auto-clubs around the world. Some examples from high-income countries include:

- The Dutch Government was the first to adopt a “no one or two star road by 2020” policy.
- [Highways England](http://www.saferjourneys.govt.nz/action-plans/safe-roads-and-roadsides/) has adopted a target for 90% of travel to be on 3-star or better roads by 2020. This is linked to broader goals for 4 and 5-star motorways.
- The [New Zealand Government](http://www.saferjourneys.govt.nz/action-plans/safe-roads-and-roadsides/) has a target for 4-star Roads of National Significance (RONS) and recently adopted a review of design standards that ensure Roads of National Significance will be implemented with a minimum 4-star rating, see [http://www.saferjourneys.govt.nz/action-plans/safe-roads-and-roadsides/](http://www.saferjourneys.govt.nz/action-plans/safe-roads-and-roadsides/)
• Performance tracking using risk mapping is active across Europe (EuroRAP), the US (usRAP) and New Zealand (KiwiRAP), with AusRAP releasing a new performance tracking report in 2016. Example reports include the 2014 UK results and the 2012 New Zealand results.

• Benchmarking of the European road system was undertaken as part of the 2011 European Road Safety Atlas project supported by the EU.

Low and middle-income country examples:

• The MDB Road Safety Guidelines have identified road safety rating as one of the issues to be considered in all stages of a road project.

• The Ministry of Transport in China is rolling out ChinaRAP assessments to an expected 350,000km of roads as part of their Highway Safety Enhancement Project titled “highway safety to cherish life”.

• The road authority in Mexico (SCT) has assessed over 60,000km of roads and has implemented targeted maintenance spending to reduce 1 and 2-star road sections by 20%.

• The SLoCaT Results Framework developed to support achieving the proposed SDG target to halve road deaths includes an implementation measure to eliminate one or two star roads by 2030 (p23).

• The World Bank SSATP programme has developed the Managing Road Safety in Africa publication that provides a framework for national lead agencies that “can develop a prioritised program of works towards achieving at least 3 star safety ratings for all road users” (p46).

• The ADB Sustainable Transport Appraisal Rating integrates the star rating performance targets into their Sustainable Transport Appraisal Rating (see Figure 2 below).

Figure 2 Extract from ADB Sustainable Development Working Paper

SOC-4 Safety

To what extent will the project improve transport safety and security?

This question seeks to measure the contribution of the project to the following agendas:

• Transport, particularly road safety. Road crashes cause around 1.3 million deaths and injure or disable as many as 50 million people each year.
• Security. The intervention may affect personal safety ranging from crime to harassment.

Road safety considerations will need to be taken for most road-based projects. The attached safety scoring tool can be used on a pilot basis to derive the rating for safety issues. Alternatively, when an International Road Assessment Programme (iRAP) rating is available, the difference between before and after cases is a prime indicator. Preferably, (i) all new or rehabilitation road designs should always have a higher safety rating than the existing road and have at least a three-star rating standard for all road users, (ii) roads with more than 50,000 vehicles per day should have a minimum of four stars for all users, and (iii) roads or sections of roads passing through linear settlements should have a minimum four-star standards for pedestrians and cyclists.

Recommended quantitative indicators are

• predicted number of road death fatalities, serious road injuries, and non-motorized transport users deaths; and
• length of roads with an iRAP rating of two stars or less/three stars or more.
• The World Bank and relevant state governments have applied minimum star rating standards as part of road projects in Karnataka, Assam, Gujarat and Kerala in India. The Gujarat Results Report includes the monitoring of the length of the corridor meeting the star rating target.

• The ADB has also applied a similar star rating approach in Shaanxi and Anhui in China.

Figure 3  Example LMIC Policy Documents recommending safety ratings and iRAP metrics

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. Further information on the setting of iRAP Star Rating policy targets can be found at http://irap.org/en/about-irap-3/research-and-technical-papers.

3 Understanding and using the iRAP results

Accessed via ViDA https://vida.irap.org, the iRAP online road safety software platform, the results can be used to create and analyse interactive safety reports including road condition reports, Star Ratings and Safer Roads Investment Plans.

ViDA is a suite of online tools for calculating, managing, analysing and presenting RAP Star Ratings and Safer Road Investment Plans. By using state-of-the-art cloud-computing technology, ViDA provides tools, services and workflows to manage the RAP data lifecycle, from initial dataset pre-processing to on-screen reports and downloadable detailed data. The ViDA user guide is available at http://downloads.irap.org/docs/ViDA_tour.pdf.

3.1 Star Rating maps and charts

Star Ratings are a measure of individual risk and are based on Star Rating Scores (SRS). The iRAP models are used to calculate an SRS at 100 metre intervals for four different road user types, vehicle occupants, motorcyclists, pedestrians and bicyclists and are based on relative risk factors for each road attribute. 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. Star
Ratings are available in map, table, chart or risk worm format and are a simple and practical way of communicating road user risk (derived from road infrastructure) to the public and for setting policy targets as discussed above in section 2.2.

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

**Figure 4** Raw Star Rating Scores (blue) and smoothed SRS (white)

Star Rating Maps show the smoothed (averaged) Star Rating results for different road user groups allowing the user to see the change in risk across a road network. 5-star roads are shown as a green line on the map, 4-star roads are coloured yellow, 3-star orange, 2-star red and 1-star black. ‘Not applicable’ (grey) is used where no Star Rating results have been generated for a particular road user. This may be because the road user type is not present on the surveyed network (for example, often no pedestrian Star Rating is produced on Expressways and Motorways), or the presence of major road works at the time of the road survey has made it difficult to accurately record the infrastructure attributes needed to generate the Star Ratings.

Star Rating results are also available in a table showing results by length (in kilometres) and percentage for each of the four road user groups (where available) for the dataset(s) selected and in charts. Reporting options allow the user to display the results for different road user types, and either ‘Before’ implementation of the Safer Roads Investment Plan (SRIP), that is, showing the existing or baseline condition, or ‘After’ SRIP implementation, that is, assuming all countermeasures identified within the SRIP have been implemented.
Further details on the reporting options for each report type are available in the ViDA user guide at http://downloads.irap.org/docs/ViDA_tour.pdf.

### 3.2 Safer Road Investment Plans

A Safer Road Investment Plan (SRIP) shows a list of affordable and economically sound road safety treatments, specifically tailored to reduce risk on the surveyed network. Each countermeasure proposed in the SRIP 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.

The Safer Roads Investment Plan table available within ViDA provides a summary of the SRIP and details of the recommended countermeasures. The summary includes:

- **Total FSIs Saved** – an estimate of the total number of fatal and serious injuries (FSIs) that could be prevented over the life of the plan (analysis period is usually 20 years) assuming all the recommended countermeasures are implemented.

- **Total PV of Safety Benefits** – an estimate of the total present value (PV) of the economic benefits (from crash cost savings) that could be realised over the life of the plan, assuming all the recommended countermeasures are implemented.

- **Estimated Cost** – estimated total cost of implementation and maintenance of the recommended countermeasures over the life of the plan.

- **Cost per FSI saved** – cost of implementing the countermeasures per fatal and serious injury avoided.

- **Program BCR** – the benefit to cost ratio (BCR) is the estimated economic benefit divided by the estimated cost of the countermeasures.

By default the countermeasures are listed in order of effectiveness in terms of the numbers of FSIs that the individual treatment type is estimated to save over the analysis period if implemented. The column headers within the SRIP table can be selected to sort the data based on other criteria. For example clicking on ‘Program BCR’ will sort the data in order of cost effectiveness (BCR).

Users can click on any of the countermeasure names to see a map showing the location of the recommended treatment and to find out more information on the countermeasure from the Road Safety Toolkit http://toolkit.irap.org/. Zoom in and select one of the blue dots to show the countermeasure details at that 100 metre location.
There may be a need to manually adjust the SRIP to suit specific project requirements, for example to remove some recommended treatments from the list or to reduce the overall cost of the investment plan to match available budgets. See Appendix D for guidance notes on how to amend countermeasure costs and other aspects of the SRIP within ViDA.

### 3.3 Strip plans

The strip plan lists countermeasures identified in the Safer Roads Investment Plan (SRIP) by distance along a section of road. A strip plan can be created by filtering the data to a single road section and then selecting up to five different countermeasures to be displayed in the report table. The report will show a marker for each 100 metre segment of road where each of the selected countermeasures are recommended. Click on a marker to provide location details including a map, plus economic details (in local currency) of the proposed countermeasure at that 100 metre location as shown in Figure 6.
3.4 Road survey data and detailed road attribute report

iRAP safety inspections take place in two parts, a road survey and road attribute coding. Surveys involve the collection of digital, panoramic images or videos of the roads and GPS data. These images and data can be collected using a range of equipment - from simple handheld devices to highly sophisticated survey vehicles as part of asset data or pavement condition surveys. The images are then used to record (or ‘code’) more than 50 road attributes that are known to influence the likelihood of a crash and its severity. The inspections create a permanent video and database record that can be easily reviewed by local engineers and planners and can also be used to supplement (or as a review of) any highway asset databases.

The Detailed Road Condition tables within ViDA provide the length and percentage for each category of road attribute recorded during the survey. The data is presented in different groups including roadside attributes, mid-block features, intersections, facilities for vulnerable road users (VRU), traffic flow information and vehicle speeds. The information can be used to compare the infrastructure attributes of different roads or road sections and can help to provide an understanding of the safety features that are present on a given road section and particularly those features that are not present which are known to influence crash risk.
3.5 Download files

Within ViDA there are several downloadable Excel files available that contain all the information collected and produced during the assessment. There are three main types of download file:

3.5.1 Core Data download file

The Core Data download file contains:

- location information for each 100 metre segment of road including road name, section name distance (chainage), longitude and latitude [columns E to J]
- traffic volumes [column BK]
- pedestrian and bicycle peak hour flows [columns BM to BP]
- road attribute codes [columns M to BJ and BY to BZ]
- vehicle operating speeds [columns BQ and BR]
- Star Rating Score for each road user crash type [columns CB to CG; CL to CR; CW to CY and DD to DF]
- Star Ratings (smoothed and raw) [columns CH to CK; CS to CV; CZ to DC and DG to DJ]
3.5.2 Fatality Estimation download file

The Fatality Estimation download file contains:

- location information for each 100 metre segment of road [columns A to F]
- estimated (modelled) number of annual deaths for each 100m segment of road given as the rate per km by crash type [columns H to M; O to U; W to Z and AB to AD]
- estimated (modelled) number of annual deaths for each 100m segment of road given as the rate per km by road user [columns N; V; AA and AE]
- estimated (modelled) total number of annual deaths for each 100m segment of road [column AI]
- estimated (modelled) total number of annual deaths and serious injuries for each 100m segment of road [column AJ].

3.5.3 Countermeasures download file

The Countermeasure download file contains:

- location information for each listed countermeasure [columns A to H]
- a list of countermeasures for further investigation [column K]
- countermeasure service life [column M]; analysis period [column N] and discount rate [column T]
- an economic assessment of each countermeasure including initial costs [column V]; construction and maintenance costs for the duration of the analysis period [column W]; FSIs saved [columns Q and R]; economic cost savings and value of safety benefits [columns S and U]; benefit-cost ratio [column Y] and internal rate of return [column Z]

The Core Data and Fatality Estimation files are available ‘Before’ implementation of the Safer Roads Investment Plan (SRIP), that is, showing the existing or baseline conditions, or ‘After’ SRIP implementation, that is, assuming all countermeasures identified within the SRIP have been implemented.

3.6 Calculating the reduction in fatal and serious injuries

A SRIP (example shown in Figure 8) shows an estimate of the total number of fatal and serious injuries (FSIs) likely to be prevented over the analysis period if all proposed countermeasures were to be implemented.
In order to calculate the reduction in FSIs we must first know how many fatal and serious injuries are occurring on the network. We can calculate how many annual FSIs have been distributed (modelled) across the surveyed network by using the Fatality Estimations - Before download file and summing the column AJ. For example if the sum of column AJ is 10,150.5 this means that 10,150.5 annual fatal and serious injuries have been distributed (modelled) across the surveyed network. Multiplying the annual number of modelled FSIs (the sum of column AJ) by 20 will give us the number of FSIs on the surveyed network over the next 20 years. Therefore in this example we have 10,150.5 x 20 = 203,010 FSIs on the surveyed network in 20 years.

The percentage reduction can be calculated by dividing the decrease (120,067) by the original number (203,010) and multiplying the answer by 100. Example (120,067/203,010)*100 = 59.1%

Note – the Fatality Estimations – After download file can be used to analyse the projected reduction in FSIs by crash type.
4 How to prioritise road safety upgrades and investment plans

In order to reduce the numbers of deaths and serious injuries on our road networks it is important to identify and prioritise cost-effective road safety countermeasures at hazardous locations.

The analysis and investigation of detailed crash data enables road safety engineers to identify high-risk locations, define collision problems and enables the design of cost-effective solutions that reduce the occurrence and/or severity of road crashes.

Where detailed crash data does not exist, or where crashes are so sparsely and randomly distributed that cluster sites are difficult to identify, the iRAP Star Ratings can help to proactively identify potential hazardous locations from road infrastructure features based on road safety research conducted by the world’s leading research agencies. Safer Road Investment Plans can help to identify road safety countermeasures that are proven to reduce both the likelihood and severity of common road crashes. Many different methods of identifying and prioritising road safety upgrades using RAP outputs are available, several of which are described in this section.

4.1 Using the **Core Data – Before download file to identify high risk locations**

The Core Data – Before download file can be used to identify the highest risk locations within the surveyed network. Using the Sort function in Excel the highest risk 100m segments can be displayed in order of risk. For example by sorting the data by Vehicle SRS Total (column CH) and ordering the data from Largest to Smallest as shown in Figure 9 below, the data will be listed in order of vehicle occupant risk with the highest risk segments shown first. The locations can be identified using the columns E (Road Name), F (Section Name), G (Distance or chainage), and columns I and J (Latitude and Longitude). Copy the latitude and longitude values of each location into Google Earth to show the location.

Note, in order to identify the highest risk corridors sort the data by Vehicle SRS Total Smoothed (column CI).

**Figure 9** Sorting the Core Data – Before Download file by Car Star Rating
4.2 Using the Core Data – Before download file and the iRAP Star Rating Demonstrator to understand road user risk

While the Safer Road Investment Plan provides a list of measures that will reduce the risk of a road and improve the Star Rating, it is important to consider what makes a road section high risk.

The core data download file and the iRAP Star Rating Demonstrator (https://vida.irap.org/en-gb/demonstrator) can be used together to gain an understanding of the contribution of different road attributes to road user risk.

In the Core Data - Before download file, the highest risk sections can be identified by filtering the roads which score 1-star in column CJ (the raw Star Rating for each 100m segment). For each road segment that requires investigation the recorded road attributes (input data) in columns M to BZ is fed into the iRAP Demonstrator using the drop down lists. The input data in the download file is shown in numerical codes which should be compared with the Upload File Specification http://downloads.irap.org/docs/RAP-SR-3-3_Upload_file_specification.xlsx. For example, column AC gives the Roadside severity - driver-side distance. The codes are shown in Figure 10.

Figure 10 Coding values for Roadside severity – driver-side distance

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</tr>
<tr>
<td>2</td>
<td>1 to &lt;5m</td>
</tr>
<tr>
<td>3</td>
<td>5 to &lt;10m</td>
</tr>
<tr>
<td>4</td>
<td>&gt;= 10m</td>
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The numerical code given in the Core Data – Before download file for the selected road segment needs to be compared with the far left column in Figure 10 and then the corresponding attribute category (in this case distance to object) is selected in the Demonstrator (Figure 11).

Figure 11 iRAP Demonstrator input for Roadside severity – driver-side distance

Once all the road attributes in the iRAP Demonstrator have been selected to match the row of data from the download file the corresponding Star Rating Score and Star Rating will be shown.
The crash type risk that contribute to the Star Rating Score for each road user is shown by selecting “Chart” at the top of the Demonstrator home page (Figure 13).

In Figures 12 and 13 there are no Star Ratings given for pedestrians or bicyclists as there was no flow recorded for these two road user types. The results for both vehicle occupant and motorcyclist are 1-star and the two large proportions shown in the graph are contributed from the run-off risk either side of the carriageway.

The measures that would be required to reduce the likelihood and/or severity of run-off road crashes therefore should be considered and tested using the Demonstrator.

The input data in this example had trees located within 1 metre (0-1m) of the carriageway edge. By introducing a concrete roadside safety barrier adjacent to the carriageway, the input data would change simply from a tree (numerical code 11) to a safety barrier (code 2) for “Roadside severity - driver-side object” (Figure 14).
Figure 14 shows that as a result of introducing a roadside barrier the Star Rating becomes a 3-star for vehicle occupants and 2-star for motorcyclists. Studying the charts further there is another crash type that has a large proportion contributing to the risk. The head-on loss of control crash type. In the input data, delineation has been recorded as poor. Figure 15 shows the effects of changing the quality of delineation from poor to adequate.

The results now show 3-star for both vehicle occupants and motorcyclists.
The aim of this exercise is to try out different scenarios based on a ‘what if’ analysis. Although both treatments reduce risk, barriers and improved delineation may not be the most economically viable option in this example and so other input variations need to be tested and it is recommended that the treatments suggested in the Countermeasure download file also be considered. For example, instead of installing a roadside safety barrier, the closest trees could be removed to create a 5m safety zone so that the distance to the trees is 5-10 metres (Figure 16).

4.3 Comparing Star Rating with Risk Mapping

In countries where detailed crash and traffic data are available, RAP Risk Maps can be produced to give an objective view of where people are being killed or seriously injured on a road network and where their crash risk is greatest. By showing the number of fatal and serious collisions per kilometre travelled the results demonstrate the risk arising from the interaction of road users, vehicles and the road environment.

Prioritising routes for improvement can be undertaken using the Star Rating data and comparing it with available crash data in the form of Risk Maps. The RAP Risk Mapping protocol [http://downloads.irap.org/docs/RAP-RM-2-1_Risk_Mapping_technical_specification.pdf](http://downloads.irap.org/docs/RAP-RM-2-1_Risk_Mapping_technical_specification.pdf) uses crash and traffic data for the network surveyed to show individual risk rates per vehicle kilometres travelled. Individual risk is calculated by dividing the frequency of crashes per year by the distance travelled on each section of highway.
per year. Routes with an average length of 25km should be produced with a risk rate and an average Star Rating Score (SRS) assigned. Figure 17 shows the results for plotting the risk rates and Star Rating scores for an example selection of routes.

Note, ‘Collective risk maps’ showing the density, or total number of casualty crashes over a given length of road can also be produced by dividing the number of casualty crashes per year by the length of highway.

**Figure 17  Average Star Rating Score vs Risk Mapping rates for example routes**

![Graph showing the relationship between risk rates and Star Rating scores for example routes.]

Figure 18 below provides a suggested treatment prioritisation plan that can be used to guide road safety intervention based on crash rates and infrastructure risk based on the Star Rating Score. Note, the higher the Star Rating Score the higher the potential risk of fatal and serious injury from the road design.

**Figure 18  Prioritising routes using risk rates and Star Rating Scores**

![Diagram illustrating a suggested treatment prioritisation plan based on risk rates and Star Rating scores.]

Overlaying the risk data shown in Figure 17 with the suggested intervention prioritisation chart (Fig.18) can help to identify an appropriate road safety treatment strategy.
4.4 Identifying common severe crash types using the Fatality Estimations – Before download file

A detailed analysis of available crash data can be used in order to better understand the safety issues along a section of road. However, where the quality of crash data is poor or in cases where crash data does not exist the Fatality Estimations – Before download file can be used to estimate the number of fatalities that occur on the surveyed network by crash type. For example, the annual number of vehicle occupant run-off road fatalities estimated to occur on a particular corridor can be calculated by using the Filter to select the required road or road section and then summing the total in columns H (run-off road driver side) and I (passenger side) and dividing by 10 (to convert from per km per year to per 100m per year).

4.5 Identifying high risk sections (predicted casualty maps)

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

Although a countermeasure may be listed in the Safer Road Investment Plan as being identified as a cost-effective treatment this does not mean that it should or will be implemented in any future road safety upgrade. This is because the proposed treatment/s may be inappropriate at a given location. It is therefore important that each proposed countermeasure be subject to investigation and prioritisation prior to design and implementation.

In some cases a countermeasure shown on the SRIP may not be suitable or may not be a viable option in a given location. Some road authorities may wish not to consider certain treatment types and in some cases design standards do not allow for a treatment type in certain locations. It is possible to customise the SRIP by using the ignore function on the Countermeasures page in Dataset setup within ViDA to remove individual countermeasure treatments from being considered as an option in the SRIP.

Unwanted countermeasures can also be deleted from the Countermeasure download file in order to customise the investment plan for local conditions. However it is advised that this only be done after the initial investigation and site visit to ensure that all cost effective treatments are considered when evaluating possible solutions.

4.7 Exploring countermeasure options

Countermeasure options can be explored by amending the iRAP upload file to reflect proposed changes to the road. For example if a mass-action programme of rumble strips is planned then that attribute can be changed; if it is proposed that all horizontal curves will have enhanced curve delineation those sections can be filtered and the road attribute code adjusted. The amended input file can then be uploaded back to the
iRAP ViDA software and with fatality calibration factors remaining the same, reprocessed to produce new Star Rating Scores and a new estimate of the number of deaths and serious injuries on the network, allowing for the associated economic benefits from the proposed upgrades to be determined. Users may wish to upload the amended input file to a newly created dataset in order to avoid overwriting the original.

This same approach is also applied when Star Rating designs where any proposed changes to road attributes identified during the design process can be amended within the upload file and reanalysed. See Section 6 for more information on Star Rating designs.

Countermeasure options, and their influence on crash risk can also be explored using the iRAP Demonstrator software which is explained further in Section 6.2.

4.8 Grouping countermeasures by works categories

Countermeasure implementation might be undertaken according to each countermeasure’s works category or likely source of funding and the ease with which it can be built. This was the approach taken by the Directorate General of Highways and VicRoads during recent crash reduction investigations on major roads in Indonesia. Their approach involved assigning countermeasures to one of four categories, as illustrated in Table 1. By doing so, the responsibilities and tasks in designing and implementing the countermeasures were clarified, with patterns emerging about what can be done in the short-term and which countermeasures require further planning.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Lead time</th>
<th>Example countermeasure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Countermeasures for immediate implementation by the region/district public works office as part of its routine maintenance programme</td>
<td>Immediate</td>
<td>Delineation, road surface improvement, informal footpaths.</td>
</tr>
<tr>
<td>B</td>
<td>Countermeasures that require reconstruction or other works that do not add capacity to the road and which can be defined by simple diagrams or typical cross-sections but cost estimates are required to schedule the works in the region/district public works office annual budget programme for funding road works</td>
<td>1 year</td>
<td>Shoulder sealing, sidewalks, pedestrian crossing, bicycle lane.</td>
</tr>
<tr>
<td>C</td>
<td>Countermeasures that require reconstruction or other works that do not add capacity to the road, but for which topographical survey and / or detailed design is required, and for which cost estimates are required to schedule the works in the region/district public works office annual budget programme for funding road works</td>
<td>2-5 years</td>
<td>Intersection improvement, horizontal realignment.</td>
</tr>
<tr>
<td>D</td>
<td>Countermeasures that require major new works and would result in an increase in capacity of the road. These require coordination with broader planning strategy and support from development banks, donors and consulting engineers might be necessary</td>
<td>5-10 years</td>
<td>Duplication, grade separation of intersections.</td>
</tr>
</tbody>
</table>
4.9 Using Benefit Cost Ratios to prioritise investment options

Having identified a priority location or section of road, it is possible to further tailor the countermeasure plan to suit specific circumstances. This is especially useful if budget constraints have changed. Figure 21 provides an example of the way in which cost-effectiveness may be used to generate a list of priority countermeasures within a limited budget. In this example the SRIP was used to produce a list of all countermeasures that could feasibly be built on the road, sorted in order of descending benefit cost ratio (BCR). The countermeasure download file, available within ViDA, was used to generate this list.

In the example shown below, the initial SRIP showed that the cumulative cost of investments with a BCR of 1 or more was slightly over $100 million, as indicated by the red line in Figure 21. An alternative option is to set an initial budget of, say, $2 million. This is indicated by the green line in Figure 21. For this budget, all countermeasures with a BCR of 45.6 or more could be implemented.

**Figure 21** Prioritising countermeasures on a particular road according to different budgets

<table>
<thead>
<tr>
<th>Chainage (km)</th>
<th>Countermeasure</th>
<th>Cost (20 years)</th>
<th>Cumulative cost (20 years)</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0</td>
<td>Improve curve delineation</td>
<td>$2,367</td>
<td>$2,367</td>
<td>717.6</td>
</tr>
<tr>
<td>13.5</td>
<td>Improve curve delineation</td>
<td>$2,367</td>
<td>$4,734</td>
<td>583.9</td>
</tr>
<tr>
<td>13.6</td>
<td>Improve curve delineation</td>
<td>$2,367</td>
<td>$7,100</td>
<td>547.2</td>
</tr>
<tr>
<td>13.9</td>
<td>Improve curve delineation</td>
<td>$2,367</td>
<td>$9,467</td>
<td>531.8</td>
</tr>
<tr>
<td>13.7</td>
<td>Improve curve delineation</td>
<td>$1,775</td>
<td>$11,242</td>
<td>352.7</td>
</tr>
<tr>
<td>12.6</td>
<td>Improve curve delineation</td>
<td>$2,367</td>
<td>$13,609</td>
<td>319.4</td>
</tr>
<tr>
<td>14.0</td>
<td>Improve delineation</td>
<td>$4,636</td>
<td>$18,245</td>
<td>303.6</td>
</tr>
<tr>
<td>28.2</td>
<td>Improve curve delineation</td>
<td>$1,775</td>
<td>$20,020</td>
<td>285.3</td>
</tr>
<tr>
<td>17.3</td>
<td>Road resurface</td>
<td>$32,838</td>
<td>$1,962,972</td>
<td>47.0</td>
</tr>
<tr>
<td>92.5</td>
<td>Improve curve delineation</td>
<td>$1,775</td>
<td>$1,964,747</td>
<td>46.4</td>
</tr>
<tr>
<td>101.0</td>
<td>Improve curve delineation</td>
<td>$1,775</td>
<td>$1,966,522</td>
<td>46.4</td>
</tr>
<tr>
<td>101.5</td>
<td>Improve curve delineation</td>
<td>$1,775</td>
<td>$1,968,297</td>
<td>46.4</td>
</tr>
<tr>
<td>101.7</td>
<td>Improve curve delineation</td>
<td>$1,775</td>
<td>$1,970,072</td>
<td>46.4</td>
</tr>
<tr>
<td>88.6</td>
<td>Improve delineation</td>
<td>$3,477</td>
<td>$1,973,549</td>
<td>45.6</td>
</tr>
<tr>
<td>10.3</td>
<td>Shoulder sealing (&gt;1m)</td>
<td>$25,000</td>
<td>$2,002,549</td>
<td>45.4</td>
</tr>
<tr>
<td>17.0</td>
<td>Shoulder sealing (&gt;1m)</td>
<td>$29,000</td>
<td>$2,031,549</td>
<td>45.2</td>
</tr>
<tr>
<td>32.5</td>
<td>Shoulder sealing (&gt;1m)</td>
<td>$17,400</td>
<td>$2,048,949</td>
<td>45.2</td>
</tr>
<tr>
<td>16.3</td>
<td>Shoulder sealing (&gt;1m)</td>
<td>$17,400</td>
<td>$2,066,349</td>
<td>45.1</td>
</tr>
<tr>
<td>28.2</td>
<td>Improve curve delineation</td>
<td>$2,959</td>
<td>$2,069,308</td>
<td>44.5</td>
</tr>
</tbody>
</table>

- The most cost effective countermeasure is listed first.
- With a $2 million budget, all countermeasures with a BCR greater than 45.6 could be considered.
- If budget was unlimited, all countermeasures with a BCR greater than 1 could be considered.
- Countermeasures with a BCR below 1.0 are often not considered.
4.10 Route treatments

Road safety countermeasures can be identified, designed and implemented using a prioritization method based on a corridor or route action approach. This involves systematically investigating collisions along a section of road where the road character is relatively homogeneous. A study of such routes should include investigation of each hazardous location (i.e. where SRS are highest) and sections of road that experience repeated crash type (if detailed crash data is available). The aim is to identify common features that contribute to collisions and identify engineering solutions that can be applied along the entire route or corridor. Examples of route treatments include delineation improvements such as carriageway edge markings or retro-reflective road studs (cats-eyes), roadside safety barriers on rural curves with hazardous roadsides and shoulder sealing. These types of treatments can be filtered using the Countermeasure download file available in ViDA to produce a schedule of works for further investigation and prioritisation.

4.11 Mass action treatments

The mass action approach uses data for an entire or a selected part of a road network to identify hazardous locations with similar road infrastructure features for which there is a proven countermeasure treatment. This involves applying a specific, cost-effective treatment to proactively address a particular issue at all locations where the feature is present, irrespective of whether collisions have yet occurred at all of them. An evaluation should be made of the viability (perhaps by BCR) of applying the proven treatment to all or some of these locations. Examples of mass action treatments include dedicated turn lanes at priority junctions, footpaths where pedestrians are prominent, pedestrian crossings and school safety zones at schools and other educational establishments, gateway treatments and traffic calming features at rural towns and villages. These types of treatments can be filtered using the Countermeasure download file available in ViDA to produce a schedule of works for further investigation and prioritisation.

4.12 Building safety into road maintenance budgets

Best practice examples from high income countries shows that low-cost measures can make a significant impact on road safety and return high BCRs. Table 2 provides a list of road attribute improvements that are often reported on roads that have seen a significant reduction in deaths and serious injuries. The associated relative risk factors used in the Star Rating model are also given.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Risk Factor</th>
<th>Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection quality</td>
<td>Lowest Score (vehicle occupant)</td>
<td>Medium/Highest score (vehicle occupant)</td>
</tr>
<tr>
<td></td>
<td>1.0 (adequate)</td>
<td>1.2 (poor)</td>
</tr>
<tr>
<td>Delineation</td>
<td>1.0 (adequate)</td>
<td>1.2 (poor)</td>
</tr>
</tbody>
</table>
Comparing the combination of measures recorded as medium/poor with those considered adequate we can see a significant reduction in road user risk with research suggesting a possible reduction in deaths and serious injuries of up to 40%. Therefore, on many road sections simple low-cost routine maintenance improvements can improve the Star Rating and influence the likelihood and severity of common crash types.

It is therefore important that specific combinations of countermeasures are considered during the analysis process. The optimum SRIP will provide suggestions for countermeasures which meet the minimum BCR and aim to save the highest number of lives and serious injuries. Maintenance measures will achieve higher BCRs but can also save a significant number of lives and meet minimum Star Rating targets if implemented on a large scale. Achieving a higher number of routes meeting minimum 3-star may be possible using selected highway maintenance treatments in place of high cost countermeasures at individual sites which may improve a smaller proportion of the network.

5 Designing safer roads

It is important to appreciate that an iRAP Safer Road Investment Plan (SRIP) does not imply that the proposed countermeasures should be implemented exactly as shown. Rather, that countermeasures should be subject to further investigation because there is strong evidence they could prevent deaths and serious injuries in a cost effective way.

Having recognised various road safety problems/issues (through the iRAP results and/or analysis of available crash data) and identified and evaluated potential countermeasures for further investigation, this section looks at how to go about finalising treatment options - from the initial concept plans and site investigations to detailed designs, road safety audit and implementation.

5.1 Site visits - Safety

The site visit is an integral part of any crash investigation or road improvement scheme as it may help to identify additional issues that are not apparent from the RAP results or crash data alone. Safety is a priority for iRAP and all RAP associated projects. Prior to undertaking any site visits or field work during the investigation, concept planning and design stages, it is strongly recommended that a risk assessment that includes the identification of potential hazards and mitigating actions is completed. This might include, for example,

<table>
<thead>
<tr>
<th>Quality of curve</th>
<th>1.0 (adequate)</th>
<th>1.25 (poor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road surface condition</td>
<td>1.0 (adequate)</td>
<td>1.2 (medium)/1.4 (poor)</td>
</tr>
<tr>
<td>Sight distance restriction</td>
<td>1.0 (adequate)</td>
<td>1.42 (poor)</td>
</tr>
<tr>
<td>Skid resistance (sealed)</td>
<td>1.0 (adequate)</td>
<td>1.4 (medium)/2.0 (poor)</td>
</tr>
</tbody>
</table>
ensuring that temporary traffic management is put in place while the site visit is being conducted and that all members of the team wear high-visibility safety equipment while working on the road.

5.2 Concept planning and preliminary design

A preliminary design or concept plan helps to demonstrate the practicalities, suggested locations and estimated costs of a proposed road upgrade for consideration and review.

The complexity of the concept (or feasibility) planning stage can vary depending on the type and location of the scheme and the proposed road infrastructure upgrades. For relatively simple delineation improvements such as line marking or traffic signs a simple plan and reference to the relevant design standards may be sufficient to guide implementation. For more complex treatments such as intersection upgrades or road widening schemes more detailed planning and design is likely to be required.

The function of concept planning is to:

- identify the problem or problems
- collect additional information through site visits, surveys and desk top studies
- test the feasibility of proposed countermeasures through a preliminary design
- communicate what is proposed to stakeholders including elected officials, senior staff and members of the local community and review feedback
- provide a basis for generating initial cost estimates.

RAP outputs such as the Star Rating Scores for each crash type, fatality estimations and strip plans are all useful resources to help build up a picture of the potential hazards and remedial treatments at each location.

Other useful sources of information to be used during the preliminary design stage include:

- traffic survey data (volumes and speeds) including data on motorcycles and commercial vehicles
- pedestrian and bicyclist counts
- detailed crash data (location specific)
- location of public utility equipment and services apparatus within the highway
- site visit observations (may include conflict study) and photographs
- Stage 1 Road Safety Audit

VicRoads, the road authority in Victoria, Australia used the details from the Safer Roads Investment Plan and other data sources to create a concept plan for proposed road safety upgrades.
5.3 Detailed designs

Following the review and design options agreed during the preliminary design stage, the detailed design will incorporate all the information required to enable the countermeasures or road safety upgrades to be implemented accurately and safely. This will include details such as traffic sign and road markings schedules, street lighting, landscaping, detailed junction layout and design, standard drawings and cross sections.

5.4 Countermeasures and the Road Safety Toolkit

The countermeasures identified in the iRAP Safer Roads Investment Plans provide a starting point for an initial investigation. Engineering judgement should be used when selecting and designing appropriate remedial measures. It is also important that the countermeasures selected for implementation are designed and built according to the relevant design standards and best practice.

Countermeasures identified in the iRAP plans are described in more detail in the Road Safety Toolkit (http://toolkit.irap.org). The Toolkit provides free information on the causes and prevention of road crashes that cause death and injury. Building on decades of road safety research, the Toolkit helps engineers, planners and policy makers develop safety plans for vehicle occupants, motorcyclists, pedestrians, bicyclists, heavy vehicles and public transport users.

The Road Safety Toolkit is the result of collaboration between the International Road Assessment Programme (iRAP), the Global Transport Knowledge Partnership (gTKP) and the World Bank Global Road Safety Facility. ARRB Group provided expert advice during the Toolkit’s development.
5.5 Road Safety Audit

The iRAP results should be used in conjunction with other road safety techniques. Road Safety Audit is a systematic method of checking the safety aspects of new road improvement schemes. The term is generally considered to refer to a formal independent and multi-disciplinary detailed assessment of the safety performance of all new highway and traffic management schemes, including modifications to existing layouts, and are undertaken at different stages during the design, planning and construction process.

The number of countries worldwide adopting Road Safety Audits as a formal procedure is increasing, making a significant contribution to improving highway safety. iRAP recommend that all road improvement schemes that lead to a significant change in the highway features are, as a minimum, subject to Road Safety Audit during design and before being opened to the public.

Road Safety Audits and RAP projects are not mutually exclusive, they can and should be used together to identify road user risk and to improve the safety of road designs. iRAP results are often used to deliver broad network level outcomes that provide road authorities and others with risk assessment data and programme costs for high level planning, budgeting and the setting of road safety policy targets.

Road Safety Audits can provide a very detailed level of scrutiny, identifying particular issues and design failings at specific locations that may conform to relevant design standards but nonetheless increase road user risk. Recommendations are based on the knowledge and experience of the audit team. Both methods can and are being used in conjunction to successfully improve safe road design.

5.6 Safety at Roadworks

Roadworks can be hazardous for both road users and road workers as temporary changes in road layout can lead to driver error, especially if the road users do not understand what is expected of them.
Road authorities, design consultants, road worker operatives and supervisors all have an important responsibility to ensure that roadwork sites are safe and that operatives and road users (including vulnerable road users such as motorcyclists, pedestrians and bicyclists) are not put at undue risk. Road users should be warned well in advance of any roadwork sites, informed about the size and nature of any obstruction and directed around the site in a clear and concise manner. Attention should be given to the signing, guarding and lighting of roadworks to ensure that a safe system of working is in place at all times.

Many jurisdictions have local codes of practice, design guides and manuals for the design, signing requirements and layout of temporary road works that must be followed in order to minimise risk. See for example https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/321056/safety-at-streetworks.pdf.

6 Star Rating designs

A number of road agencies worldwide are setting policy and operational targets to eliminate one-star or two-star roads (e.g. Netherlands, Paraguay), or lift high volume roads to minimum four-star standard (e.g. New Zealand).

The specification of minimum star rating standards as part of new road designs or existing road upgrades is increasing worldwide. The process involves the star rating of the proposed road design prior to construction commencing. Examples include the World Bank in India, Asian Development Bank in China, the Millennium Challenge Corporation in Moldova and the Department of State Growth, Tasmania, Australia.

Star Ratings can objectively quantify the level of risk associated with new road designs and provide a platform to make evidence-based improvements and many road authorities are now using Star Ratings during the road design process to help ensure the safety of proposed designs is optimised.

The Star Rating of designs enables the projected road user risk to be assessed prior to construction and allows designs to be amended and improved to include recommended treatments that are proven to reduce the likelihood and severity of road crashes. By adjusting the design and measuring the projected safety outcomes prior to construction, road authorities can avoid the need to undertake expensive retrofit upgrades.

It is important to appreciate the distinction between raw Star Ratings and smoothed Star Ratings when setting minimum star rating targets for road designs. This is because the 100m segments that include intersections score almost exclusively 1- and 2-stars at speeds of over 60km/h regardless of design, layout and capacity due to the increased risk of death and serious injury at these sites when compared to mid-block sections. It is recommended that targets be set according to smoothed Star Rating results. Smoothing is discussed further in section 3.1.

A comparison of existing (baseline) Star Ratings with those based on proposed designs will often show that it is possible to significantly reduce the proportion rated as 1 and 2-star (high risk). Further improvements can be realised by adopting the iterative approach shown in the process diagram below.
6.1 A guide to Star Rating designs

There are two different situations in which designs may be required to be star rated. The first is where an existing (baseline) survey has been conducted and the data collected during the baseline survey can be used and amended to reflect the proposed design changes and the star rating results and projected fatal and serious collision reduction compared.

The second situation is where no baseline road assessment has been conducted and the analysis, and in particular the creation of an iRAP specification upload file, must be undertaken based on the available design data. Both cases are described in more detail below.

6.1.1 Star Rating designs using baseline survey data

Where baseline data is available the original upload file can be amended to create a new upload file by changing the road attribute codes to reflect design proposals. Alternatively, the Core Data – Before download file available within ViDA can be accessed and amended according to the proposed design. See the step by step guide in Appendix B for further details.

6.1.2 Star Rating designs when no previous survey data is available

Where no previous iRAP survey has been conducted and therefore there is no existing baseline data with which to create an upload file, a new .csv upload file will need to be created including proposed road attribute details, projected traffic volumes and speeds and GPS data.
Coding software is available from several accredited suppliers [http://irap.org/en/resources/accredited-suppliers](http://irap.org/en/resources/accredited-suppliers) which can help to make the recording of road attributes easier using drop down lists and converting the file to the required codes, or alternatively the upload file can be created using Excel and the numerical codes shown in the Upload File Specification [http://downloads.irap.org/docs/RAP-SR-3-3_Upload_file_specification.xlsx](http://downloads.irap.org/docs/RAP-SR-3-3_Upload_file_specification.xlsx). This file can be used as the basis for a new upload file. The road attribute codes for each 100m segment of road will be entered based on the proposed design documents including drawings, plans, schedules and cross-sections. If GPS data (latitudes and longitudes) are not available at 100m intervals within the design documents they can be created using Google Earth, see Appendix C - Using Google Earth and the iRAP Preprocessor to create GPS points for use in iRAP specification upload files.

### 6.2 iRAP Star Rating Demonstrator

Available within the ViDA software, the iRAP Star Rating Demonstrator enables users to produce Star Ratings for a 100 metre length of road. By amending the road attributes from the drop down lists provided, you can change the road’s Star Rating Score (SRS) for vehicle occupants, motorcyclists, pedestrians and bicyclists.

Star Ratings are only produced where there is a road user flow recorded. For example, if pedestrians do not use a length of road (i.e. a motorway), then a pedestrian Star Rating will not be produced and the pedestrian Star Rating Score will be shown as NA (not applicable). You can adjust the flows by changing attributes in the Flow tab.

The risk of death or serious injury on a road is highly dependent on the speed at which traffic travels. Star Ratings are based on the greater of the speed limit and the 85th percentile speed. You can adjust the speed limit and 85th percentile speed attributes in the Speeds tab.

By changing different road attributes users can explore the changes in road user risk associated with different road layouts and designs. The Demonstrator is particularly useful when undertaking a ‘what if’ analysis to compare different design options and can also be used effectively to star rate standard cross-sections.

### 6.3 Case study

7 Monitoring and measuring the impact of your investment

7.1 Star rate and compare baseline and upgraded roads

The monitoring and evaluation of the effects of road safety upgrades on road user risk and the number of fatal and serious injury crashes is important in order to assess effectiveness, improve our understanding of the types of treatment that work in certain locations and environments and to allow funding agencies and road authorities to track performance.

Detailed crash data should be used to enable before and after studies to be undertaken. To complement the evaluation of crash data, and in cases where this type of data is unavailable, it is useful to compare the Star Ratings of the baseline (original road layout) with the as-built Star Ratings of the upgraded road. This will help to give confidence that road user risk has reduced even before detailed crash data is available.

Where a baseline and as-built dataset exists within ViDA the two sets of results can be compared in order to evaluate the reduction in risk. Star Rating maps, tables and charts can be used to show the changes in Star Ratings due to the road safety upgrades. Perhaps the most useful ViDA report available for this type of comparison is the Risk Worm. This report can be used to compare two sets of results, for example baseline and design, or baseline and upgraded (as-built) within the same chart as shown below.

Figure 25 Example Risk Worm showing comparison of baseline and as-built SRS
To create a Risk Worm similar to the one shown above two datasets must be selected from the Project filters within ViDA that contain matching survey locations and the same road section must be selected for display. Using the Reporting options users can choose to show smoothed or raw results for each road user group.

The Core Data – Before download files can also be used to compare crash type Star Rating Scores for each 100m road segment.

### 7.2 Estimated FSI reduction

The Safer Roads Investment Plan shows the number of fatal and serious injuries (FSIs) that are likely to be prevented over the analysis period assuming that all treatments shown on the countermeasure list are implemented with further detail available via the download files. However, in order to calculate the projected reduction in the number of fatal and serious injuries likely to occur on the surveyed network based on a proposed design or the as-built road conditions a comparison must be made between the baseline *Fatality Estimations – Before* file and the design or post-construction *Fatality Estimations – Before* file.

To calculate the number of FSIs allocated to the baseline network download the *Fatality Estimations – Before* file from the appropriate dataset and sum column AJ to calculate the annual number of FSIs on the surveyed network. Note if this number looks incorrect based on the available data there may be a problem with the fatality calibration.

Next, calculate the number of FSIs estimated to occur within the design (or as-built) dataset. See Section 6 for a guide to creating new datasets (design or as-built) using amended road attributes. Download the *Fatality Estimations – Before* file from the appropriate dataset and sum column AJ. This will show the projected number of annual FSIs estimated to occur on the new or amended network and can be used to calculate any reduction when compared to the baseline figure. For example if the annual number of fatal and serious injuries was calculated as 108.4 in the baseline data and 64.6 in the as-built analysis we can say that the FSI reduction is estimated to be 43.8 per year, a decrease of 40%.

Through analysis of the other columns users can calculate the projected reduction in FSIs by crash type and road user.

### 7.3 Economic analysis


Once a value of life and cost of a serious injury have been acknowledged the benefits from a reduction in FSIs can be calculated. When compared with the costs associated with the road safety upgrades a benefit to cost ratio (BCR) can be determined. BCRs of greater than 1 provide a positive return on investment.
7.4 Before and after studies


As part of the implementation process, traffic volume and crash data collection for a before-and-after evaluation of the improvements, that will demonstrate their success and enable further analysis and investment as needed, should be collected. The WHO Good Practice Guide on Data Systems (2010) provides guidance on this issue [http://www.who.int/roadsafety/projects/manuals/data/en/](http://www.who.int/roadsafety/projects/manuals/data/en/).

8 Communicating and celebrating success

There is no greater reward than saving lives and it is important that successful projects that improve road safety and reduce the likelihood and severity of road crashes are communicated to road authorities, funding agencies, politicians and the wider public.

8.1 What to report, where and how

The iRAP outputs are valuable to many different sections of government and society and exactly what to report, where and how can be confusing. The benefits of improving the Star Ratings of a road and in providing a safe and efficient road transport system are felt in many areas including:

- The community: high return road infrastructure improvements can typically save at least 1 in every 3 fatalities and injuries on high-risk roads. The reduction in personal suffering will be enormous and should be celebrated.

- Road authorities: will benefit from an increased safety level across their road networks driven by a robust, internationally recognised methodology with backing of the world’s leading research agencies. Road funding levels will be at appropriate increased levels.

- Government: use of the iRAP Star Rating protocol will provide the ability to immediately measure the before and after Star Rating of any upgraded section. The new upgrade, small or large, can be celebrated as the auto-club and government stand together to ribbon cut the road going from one star to three star – or two star to four star immediately upon completion. This will drive community knowledge, interest and demand for further improvements.

- Health and legal sector: the direct costs associated with the long term treatment of head, spinal, limb and internal injuries sustained in road crashes will be immediately reduced. Hospital beds and medical resources will be freed up. Third party insurance costs will be reduced, as will the legal costs associated with coronial inquiries and crash investigation.
Finance sector: the iRAP Safer Road Investment Plan provides the objective data to guide road investment priorities and the returns on investment associated with any highway improvement scheme. An international model now applied in 80+ countries worldwide, the iRAP results will provide confidence to investors and governments.

### 8.2 Raising community awareness

The raising of community awareness and increasing stakeholder engagement through community workshops, public displays and publicity campaigns to explore viable solutions and highlight the importance of safe road infrastructure and how it can help to reduce fatal and serious injuries is an increasingly valuable tool in achieving community buy-in and acceptance for engineering improvements.

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.

In addition to the 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 and drink driving) and road vehicle safety (i.e. anti-lock braking systems, 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 (http://www.who.int/roadsafety/projects/manuals/en/index.html) provide further information on these issues.

### 8.3 Good news stories, ribbon cutting 4 and 5 star roads

Any measured reduction in risk can and should be celebrated. Just as a reduction in the crash data can be reported, for example in EuroRAP’s Risk Mapping reports that celebrate Britain’s most improved roads http://www.roadsafetyfoundation.org/media/30870/eurorap_brochure_2014.pdf, Star Ratings can be used to effectively communicate the need for safe road design and celebrate success, not only within road authorities, but also to local residents and other stakeholders where Ministers, politicians, and the local community can celebrate road infrastructure safety upgrades with roads being improved from 1-star to 3-stars for example.

**Figure 26** A ribbon-cutting ceremony to celebrate the opening of a new road in New Zealand
Appendix A – Creating a strip plan using data from ViDA

Using the Strip Plan report in ViDA (Reports > Tables > Strip Plan), you can list countermeasures by distance (or chainage) along a section of road. You can also produce more advanced strip plans using the Countermeasure Download files in ViDA and Microsoft Excel.

1. Log in to http://vida.irap.org using your email address and password.

2. In the top menu, select Reports.

3. In the report type menu, select Downloads > Download Files.

4. In the Filters, select your RAP, Project, Dataset, Road(s) and Section(s).

5. Click on ‘Countermeasures (zip)’.

6. You will receive an email containing a link to the download file. Click on the link to download the file. Open the .zip file and open the ‘countermeasures_.csv’ file.

7. Save the ‘countermeasures_.csv’ file as an .xls or .xlsx file (so that you can use multiple sheets and save formulas).


9. In the Create Pivot Table box, ensure that all the countermeasure data is contained in the Table/Range box. Then Click OK.
10. In the PivotTable Field List:

   a. Put the ‘Override’ field into the Report Filter box.

   b. Put the ‘Road’ field into the Report Filter box (below the Override field).

   c. Put the ‘Section’ field into the Report Filter box (below the Road field).

   d. Put the ‘Distance’ field into the Row Labels box.

   e. Put the ‘Countermeasure’ field into the Column Labels box.

   f. Put the ‘Length’ field into the Values box.
11. In the Values box of the PivotTable Field List, click on ‘Sum of Length’ to show the options. Click on ‘Value Field Settings…’ In the ‘Summarize Values By’ tab, select ‘Count’ and click OK.

12. In Cell B1, click on the Override drop down box, select ‘0’ and click OK.
Your Pivot Table now shows a number 1 at each distance (or chainage) location where it is has been suggested for installation. Use the Road and Section filters (cells B2 and B3 respectively) to select the Road and Section that you are interested in.

You can also use various formatting options to suit your purposes. For example, you can use the Text Direction or Wrap Text functions to make the columns narrower, which helps with printing. You can also use the Condition Formatting function to colour cells / draw icons in cells that contain data.
Appendix B – Star Rating Designs: creating an upload file using baseline data

Using the Core Data – Before download file available within ViDA, you can create an upload file for your proposed design.

1. Using the Project filter within the Results menu in ViDA https://vida.irap.org locate your dataset.

2. Download the Core Data – Before download file from the Downloads menu.

3. To convert the Core Data – Before file into an upload file delete the Star Rating results in columns CA to DJ.

4. Enter your name in column A – Coder Name

5. Enter date in column B – Coding Date

6. Ensure that the distance (chainage) shown in column G replicates the design chainage. Amend as necessary ensuring that each 100m row of data has a unique distance value.

7. Highlight the columns that will need to be amended according to the design documents.

   For example if the design will involve improvements to the delineation (road markings, traffic signs, road studs), intersection upgrades, wider paved shoulders, a wider median and footpaths highlight the columns listed below:

   - Delineation – column AV
   - Quality of curve – column AR
   - Intersection type – column AJ
   - Intersection quality – column AM (and possibly Intersection channelization – column AK)
- Paved shoulder width driver side – column AH
- Paved shoulder width passenger side – column AI
- Median type – column AA
- Sidewalk driver side – column BD
- Sidewalk passenger side – column BE

8. Using the available design documents (drawings, plans, schedules, cross-sections etc) change the road attribute codes at the relevant locations to reflect the design proposals. Note, the road attribute codes are listed in the iRAP Upload File Specification and further guidance on how to code road attributes is found in the iRAP Coding Manual.

9. Once all changes have been made save your new upload file as a .csv file and upload to ViDA. The new dataset should have the same setup inputs as the baseline dataset (including the same fatality calibration factors) in order to make a like-for-like comparison.

Note, once your dataset has processed check the Detailed Condition Report within the Road Data menu in ViDA to compare the road attributes with the baseline data to ensure that all relevant design changes have been made. Compare the Fatality Estimations – Before download files to calculate the projected change in fatal and serious injuries as a result of the proposed design.

Useful links


iRAP Upload File Specification: http://downloads.irap.org/docs/RAP-SR-3-3_Upload_file_specification.xlsx

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Appendix C – Star Rating Designs: creating 100m GPS points using Google Earth

Using Google Earth and the iRAP Preprocessor you can create GPS points (latitudes and longitudes) for each 100m segment of road to use in iRAP specification upload files.

1. Open Google Earth and zoom in to the road that you want to analyse ensuring that the full length of the road can be seen on the screen.

2. Select the Add Path tool from the tools menu bar, shown below circled in red.

3. Click on the map at the start point of the road and draw a path along the road (clicking on the map at each change of direction as necessary) until you reach the end.

4. Enter the road name in the New Path window and click OK.

5. Save the file as a .kml file by right clicking on the file name and selecting Save Place As…

6. Open a new workbook in MS Excel, name and save it.

7. Open the iRAP Preprocessor, available from https://dl.dropboxusercontent.com/u/30884138/iRAP_Star_Rating_preprocessor.zip. Click on ‘Enable content’ on the top message bar and click on the Run iRAP Preprocessor button.

8. Click on Open file and select the Excel workbook that you created in step 6.

9. Select Sheet 1 from the Raw Inspection Data – Sheet Name drop down list.

10. Select V3c Coding from the Lookup Table list.
11. From the *Specials* menu select **KML to 100m**.

12. Select the .kml file that you created in step 5.

13. Once processing has finished click OK. You can now close the Preprocessor.

14. Your Excel file will now contain the iRAP V3 specification upload file header row plus data in the Distance, Length and Latitude and Longitude columns.

15. This file can now be used to enter the road attribute codes for an iRAP assessment for existing roads or to create Star Ratings for proposed designs.

**Useful links**


iRAP Upload File Specification: [http://downloads.irap.org/docs/RAP-SR-3-3_Upload_file_specification.xlsx](http://downloads.irap.org/docs/RAP-SR-3-3_Upload_file_specification.xlsx)

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Appendix D – How to adjust your Safer Road Investment Plans (SRIPs) in ViDA

Introduction
The iRAP Safer Road Investment Plan (SRIP) shows a list of affordable and economically sound road safety treatments, specifically tailored to reduce risk on the surveyed network. Each countermeasure proposed in the SRIP is supported by strong evidence that, if implemented, it will prevent deaths and serious injuries in a cost-effective way. However, there may be a need to manually adjust the SRIP to suit specific project requirements, for example to remove some recommended treatments from the list or to reduce the overall cost of the investment plan.

There are several ways in which a ViDA user (with Creator access) can amend the SRIP:
1. Delete (ignore) countermeasures
2. Adjust countermeasure costs
3. Adjust the value of life (and serious injury)
4. Change the threshold BCR value used for the SRIP

In order to make these changes the ViDA user must edit the dataset, this can be done through the Project Setup & Access tool on the ViDA dashboard.

How to select your dataset for editing
To select the dataset for editing the user must open the Programme, Region and Project that contains the dataset and then select Edit from the Dataset drop down list. In the example shown below the ‘ANRAM_DPTI_Stage3’ dataset has been selected for editing.
Now that the dataset has been selected for editing the changes can be made as described below.

1. **How to delete (ignore) countermeasures**
   
   In the Edit dataset page select **Stage 6 – Investment Plan** as shown below.

**Figure 3**  
Edit the Investment Plan
To select the countermeasure to be ignored click on the **Edit** button in the right-hand column of the chosen countermeasure row.

**Figure 4** *Edit the Countermeasure*

The **Ignore** option can now be checked by clicking in the box shown below and then **Save changes**.

**Figure 5** *Selecting a Countermeasure to be ignored*
The countermeasure will now be shown as ‘ignored’ on the Countermeasure costs page.

**Figure 6  Showing countermeasure ignored**

2. **How to adjust countermeasure costs**

Upon review of the SRIP it may be necessary to adjust the cost of certain countermeasures. The countermeasure costs (and Service Life) can be changed using the Countermeasure Edit function as shown in Figure 4. To amend the countermeasure cost highlight the value you wish to change and enter the new value or use the up/down arrows to increase/decrease the cost. Remember to save changes.

**Figure 7  Adjusting countermeasure costs**

Note – decreasing countermeasure costs will make them more cost-effective, increasing the benefit cost ratio and potentially increasing their presence within the SRIP. Increasing the costs will have the opposite effect.

3. **How to adjust the value of life (and serious injury)**

The value of human life is used to calculate the economic benefits of road safety treatments and is entered in the dataset setup stage within ViDA. Changing the value of life and/or serious injury will affect the bcr of countermeasures.

The values can be changed in Stage 6 – Investment Plan (see figure 3). Enter the value of life in the space provided, alternatively the value of life can be calculated from GDP per capita via the **Action** option.

**Figure 8  Adjusting the value of life**
To adjust the value of a serious injury enter the figure in the space provided, alternatively the value of a serious injury can be calculated from GDP per capita via the Action option.

**Figure 9  Adjusting the value of a serious injury**

![Image of adjusting the value of a serious injury]

The figure should reflect the official national or jurisdiction value of serious injury if available. If not available the default value of 0.25 x Value of Life multiplier can be used.

Value of serious injury  | 234573

4. **How to change the threshold BCR value used for the SRIP**

The benefit cost ratio (BCR) qualification criteria is also set within the dataset setup page within ViDA. It is the threshold benefit to cost ratio that the model will use in determining whether a countermeasure is included in the Safer Roads Investment Plan. For example, a BCR qualification value \( \geq 5.00 \) means that the benefits of all proposed countermeasures will be at least 5 times greater than the cost. In this example all individual countermeasures that do not have a BCR of at least 5 will not be included in the Safer Roads Investment Plan. Ensure that the Qualification criteria is set to 'bcr', then enter the value in the space provided or use the up/down arrows to increase/decrease the qualification value.

**Figure 10  Adjusting the Investment Plan qualification value**

![Image of adjusting the Investment Plan qualification value]

Select the Countermeasure Qualification criteria. This is used to select type of threshold used for the Investment Plan. - BCR, Benefit Cost Ratio - IRR, Internal Rate of Return - Cost per PSI saved

Qualification criteria  | bcr

Provide the Qualification value. This is the threshold value used for the Investment Plan. For example if the Qualification criteria is set to BCR and Qualification value is set at \( \geq 5 \) only those countermeasures estimated to have a BCR of 5 or more will be considered for further investigation.

Qualification value  | \( \geq 5 \)

Once the changes have been made click the Save changes button and go to Stage 7 – Processing and click on 'Reprocess all'.