iRAP Rajasthan Demonstration Corridors Preliminary Technical Report

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Submitted by

EPTISA – RACC – ITE

iRAP

About iRAP

The International Road Assessment Programme (iRAP) is a charity dedicated to saving lives through safer roads. Our vision is for a world free of high-risk roads.

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

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

Road Assessment Programmes (RAP) is now active in more than 70 countries throughout Europe, Asia Pacific, North, Central and South America and Africa.

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

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

For more information

For more information on using the *iRAP Star Rating and Investment Plan - Analysis and Reporting Specification*, refer to the iRAP online training resource RAP capacity at http://capacity.iRAP.org

For improvement suggestions contact:

James Bradford
iRAP Global Operations Manager
james.bradford@iRAP.org

+44 1256 345 598 *(GMT+0)*

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.

Executive Summary

Deaths and injuries from road vehicle crashes are a major and growing public health epidemic. Each year 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 10 and 24. The burden of road crashes is comparable with malaria and tuberculosis and costs 1-3% of the world's GDP.

In 2010, the Government of India and the World Bank launched a road safety initiative to reduce fatalities and serious injuries on Indian roads. The project will apply the iRAP's methodology to assist Indian states improve road safety on high-risk roads of the country.

Among the states of India, Rajasthan experiences a huge number of road deaths last three years (2013, 2014 and 2015) in seven highways corridors of that region: 590 people were reportedly killed in 719km of roads. Hence, there is a very serious risk that road trauma will increase unless commensurate road safety efforts are made.

The Government of India (GOI) has received a Credit from International Development Association (IDA) toward the cost of the Rajasthan Road Sector Modernization Project (RRSMP), and it intends to apply part of the proceeds for consulting services. The Consulting Services ("the Services") include "Carrying out iRAP survey, designing of counter measures and supervision of implementation of targeted multi sector road safety interventions on demo corridor(s)" in Public Works Department, Government of Rajasthan, Jaipur.

The objective of the assignment is to develop and manage the implementation of a Safe Demonstration Corridor Program (SDCP) aimed at reducing the number of road accident fatalities and serious injuries through coordinated multi-sectoral interventions. As part of the strategy, it has identified seven corridors for road safety improvements, as follows:

Corridor No	Road name	Section	Start location	End location	Road Length (km)
1	Nasirabad to Deoli	SH-26	Nasirabad	Deoli	99
2	Bharatpur to Narnaul	SH-14	Bharatpur	Behror	172
3	Jaipur-Nagaur	SH-90	Ch 64.00	Tarnau	126
4	Deoli to Triveni Chaurasia	MDR - 7	Deoli	Triveni Chaurasia	75
5	Salamber to Keer Ki Chouki	SH - 53	Salamber	Keer Ki Chouki	73
6	Suket to Dug	SH 19A MDR 109	Suket	Dug	103
7	Mahuwa to Karauli	SH - 22	Mahuwa	Karauli	71

This objective is proposed to be achieved through the following:

- Survey pre-identified high-risk road corridors and establish Star Ratings and develop Safer Roads Investment Plans
- Provide training, technology and support that will build and sustain national, regional and local capability
- Supervise the implementation of targeted multi-sector interventions on safe demo corridors

iRAP Road Protection Scores and Star Ratings based on detailed inspection and assessment of 50 road attributes at 100m intervals indicate that there are significant opportunities for improvement on the demonstration corridors. The majority of the roads are rated 3-stars (out of a base of a possible of 5-stars) but there remains considerable scope for improvement in some stretches for car occupants, pedestrians, motorcycles and bicyclists.

The inspections indicate that sections of the roads were built without prevision for the huge number of vulnerable road users such as motorcyclists, bicyclists and pedestrians. In addition, many relatively high speed roads pass through densely populated areas. This is a common challenge, when roads are improved, allowing vehicles to travel at higher speeds, deaths and injuries increase, unless special steps are taken.

Speed management is a complex area of policy for any country. The setting and enforcement of speed limits compatible with the road use at a location is an essential component of a safe road system. Roads should be engineered to reflect the road use and desired speed environment. This involves political leadership, community engagement, enforcement and engineering to achieve the best outcomes.

The overall iRAP Safer Roads Investment Plans identified in this project largely focus on:

- Reducing the likelihood and severity of head-on crashes (car occupants and motorcyclists) by incorporating barriers, central hatchings, additional lanes, widening shoulders and improving delineation.
- Reducing the likelihood and severity of run-off (both sides) by incorporating rumble strips and removing roadside hazards.
- Reducing the likelihood and severity of pedestrian crashes by installing footpaths on both sides and improving intersections.

The analysis and results in this report are presented for discussion. It is anticipated that after consultation on the report has occurred – which will ideally include a ‘value engineering’ type workshop including relevant stakeholders – the results will be amended based on the advice received. As part of this process, the detailed results of the project and online software that enabled the iRAP analyses to be undertaken will be made available to stakeholders for further exploration and use.

Overall, this project has demonstrated that the application of iRAP in Rajasthan region is feasible and would assist in the prevention of deaths and serious injuries.

Acknowledgements

The iRAP Rajasthan Demonstration Corridors project would not have been possible without the direct support of numerous people and organisations. These include:

PWG Group Members:

- Mr. Shailendra Agarwal – Principal Secretary Transport & Transport Commissioner, Government of Rajasthan
- Mrs. Venu Gupta, Principal Secretary, Medical, Health & Family Welfare Department
- Mr. Naresh Pal Gangawar, Principal Secretary, Education Department
- Principal Secretary, Urban Development Department
- Principal Secretary, Public Works Department
- Mr. B I Soni, Additional DGP (Traffic), Police Department
- Mr. C. L. Verma – CE(PMGSY) - PWD

Other Senior personnel of stakeholder departments and consultants:

- Mrs. Nidhi Singh – Dy. Commissioner – Transport Department, Rajasthan
- Shri Tejpal Singh, Deputy Superintend of Police
- Mr. Rajeev Kumar Agarwal – SE (WB) – PWD
- Shri Ajeet Kumar Gupta – SE (Traffic) – PWD
- Smt. Preety Mathur, Project Director, DLB
- Dr. Laxminidhi Pandey, Medical Officer (P.S.M.), Medical & Health
- Shri Jainarayan Diwedi, Deputy Director – Elementary Education
- Shri Vishnu Prasad Swami, Deputy Director – Secondary Education
- Mr. S.K. Singhvi – Team Leader – PMC, Consulting Engineers Group Ltd.

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1 Introduction

1.1 Information about Rajasthan region

Rajasthan in terms of area is the biggest state of the Country covering approximately 10% of the total area. It encompasses most of the area of the large, inhospitable Great Indian Desert (Thar Desert), which has an edge paralleling the Sutlej-Indus river valley along its border with Pakistan. The region borders Pakistan to the west, Gujarat to the southwest, Madhya Pradesh to the southeast, Uttar Pradesh and Haryana to the northeast and Punjab to the north. It is one of the low income states of India. Its per capita income (USD943) is about 20 percent lower than the national average (USD 1185). 75% of its population is in rural area and main livelihood depends upon agriculture.

Indicators	Year	Particulars
Geographical Area	2011	342,000 Sq.km
Population	2011	6.85milion
Population Density	2011	200 Sq.km
Urban Population to Total Population	2011	24.9 %
GDP Current Price	2015-2016	674.13milion
GDP Constant Price (2011-12)	2015-2016	544.01milion
Per 100 Sq.Km area	2016	62.59 km
Per Lakh of Population	2016	312.73 km
Total No. of Vehicles in Rajasthan	2015	13,350,646
Total No. of Accidents in the year	2015	24,072
Total No. of Fatalities	2015	10,510
Total No. of Injured	2015	26,153
Deaths per 10,000 Vehicles	2015	18.03
Accidents per 10,000 Vehicles	2015	7.87
Injured per 10,000 Vehicles	2015	19.59
Deaths+Serious Injured per 100 Accident	2015	68.87
Deaths per 100 Accidents	2015	43.66

Rajasthan has a state road network of 193017 Km that includes 7,260 Km of NH,10953 Km of SH, 9,900 Km of MDR,25,033 Km of ODR and 139,871 Km of Village/Rural Roads. Road density in Rajasthan is 60 Km per 100 sq. km whereas national density is 110 Km. For this quantum of road a huge amount is required initially to build it and then to maintain and periodically improvement of the same.

1.2 Project Background

For maintaining such a quantum of road a systematic, scientific and rationale method is required so that single spent money has justification. In view of such a huge road network of public roads that ranges from strategic to arterial to feeder to village roads some critical deficiencies and difficulties in the current system have been identified that need immediate attention. These sectors are;

- Need for modernizing the Public Works Department
- Need for enhanced planning of investments
- Need to enhance road engineering practices and business procedures
- Need to enhance capacity of road agency staff
- Inadequate sector funding
- Maintenance backlog / Initial capitals
- **Gaps in Road Safety management**

The above objectives will be achieved through implementing following components viz; (a) Rural Connectivity Improvement; (b) Road Sector Modernization and Performance Enhancement and (c) Road Safety Management. To this effect, the GOR stepped into loan agreement with World Bank IDA Credit No.5310-IN. The agreement was signed on 02 January 2014 for rural connectivity, enhancement of road safety and strengthening of road sector management of the 1056 villages with population 250-499. The World Bank board approved $161.90 million IDA Credit for Rajasthan Road Sector Modernization Project. The total Project cost is ₹ 13800 million (US $ 230 million). The objective of the project is to improve rural connectivity, enhance road safety and strengthen road sector management capacity of the state.

Component C will support the strengthening of road safety management systems in Rajasthan with the objective of reducing the number of fatalities and serious injuries from traffic accidents in the state. This will be accomplished through.

- Safe Corridor Demonstration Program (SCDP)
- iRAP surveys financed by GOR on some major state roads with high volume and high-risk,
- Multi-sector road safety interventions on selected road corridors.
- Establishing a multi-sector Road Safety Strategy through:
- SCDP (incorporating safe system principles),
- Select policy reviews (such as crash investigation training for Police, for the state.
- Road safety education and awareness programs.
- Road safety audits in some of the Rural Roads constructed under Component "A" above (in each zone), including roads linking to them.
- Support to the state's other stakeholder Departments on procurement of some road safety equipment and related training under some ongoing initiatives.

With the above background, EPTISA – RACC - ITE have been selected to provide Consultancy Services for carrying out iRAP Survey, Designing of Countermeasures and Supervision of Implementation of Targeted Multi-Sector Road Safety Interventions of demo corridor (s) under Rajasthan Road Sector Modernization Project.

1.3 Methodology

The International Road Assessment Programme (IRAP) has drawn upon the extensive knowledge base of established Road Assessment Programmes (AusRAP and usRAP), with the generous support of the FIA Foundation and ACEA, to target high-risk roads where large numbers of people are killed and seriously injured and inspect them to identify where affordable programmes of safety engineering can reduce death and injury. IRAP's vision is a "world free of high-risk roads", and this helped shape the approach taken in this project. The road network included in the evaluation consists of seven corridors which include over than 700 km.

This report presents the study methodology, detailed condition reports, Star Ratings, and Safer Roads Investments Plans. The report also includes discussion on implementation of proposed road safety countermeasures and a series of recommendations.

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

- **Star Ratings and Investment Plans**: Coding Manual: This manual defines the road infrastructure attributes that are used in the production of documents and explains how they are to be coded.
- **Star Ratings and Investment Plans**: Road Survey and Coding Specification: This document sets out the minimum specifications for an iRAP Inspection (survey and coding). The purpose of the road inspections is to collect data that can be used in the creation of iRAP Star Ratings and Safer Roads Investment Plans (SRIP).

Further information is available at:

http://www.iRAP.org/protocols/star-ratings

http://www.iRAP.org/protocols/safer-roads-investment-plans.

1.4 Results Online

This report provides an overview of the results produced in the project. Full results, including data tables, interactive maps and download files, as well as data underpinning the analyses, are available in the IRAP online software at https://vida.iRAP.org/en-gb/results/star_rating/map.

Stakeholders in India will have access to this IRAP online software, which enables examination of risk factors and countermeasure triggers. Access to the IRAP online software is protected with password access. For further information about using the software, contact Marc Figuls at marc.figuls@racc.es.

Results Online

Web address: https://vida.iRAP.org/en-gb/results/star_rating/map

Username: To be provided

Password: To be provided

2 Project

2.1 Road network

The iRAP project focused on seven demonstration corridors, which were selected by the Government of Rajasthan for inclusion in the study. The roads are:

- Corridor 1: 99km section of the Nasirabad to Deoli road (SH-26)
- Corridor 2: 172km section of the Bharatpur to Narnaul road (SH-14)
- Corridor 3: 126km section of the Jaipur to Nagaur road (SH-90)
- Corridor 4: 75km section of the Deoli to Triveni Chaurasia road (MDR-7)
- Corridor 5: 73km section of the Salamber to Kirkichouki road (SH-53)
- Corridor 6: 103km section of the Suket to Dug road (SH-19A / MDR-109)
- Corridor 7: 71km section of the Mahuwa to Karauli road (SH-22)

The study network includes 719km and most of them are undivided single-carriageway road. Figure 2.1 shows the location and extent of the IRAP network.

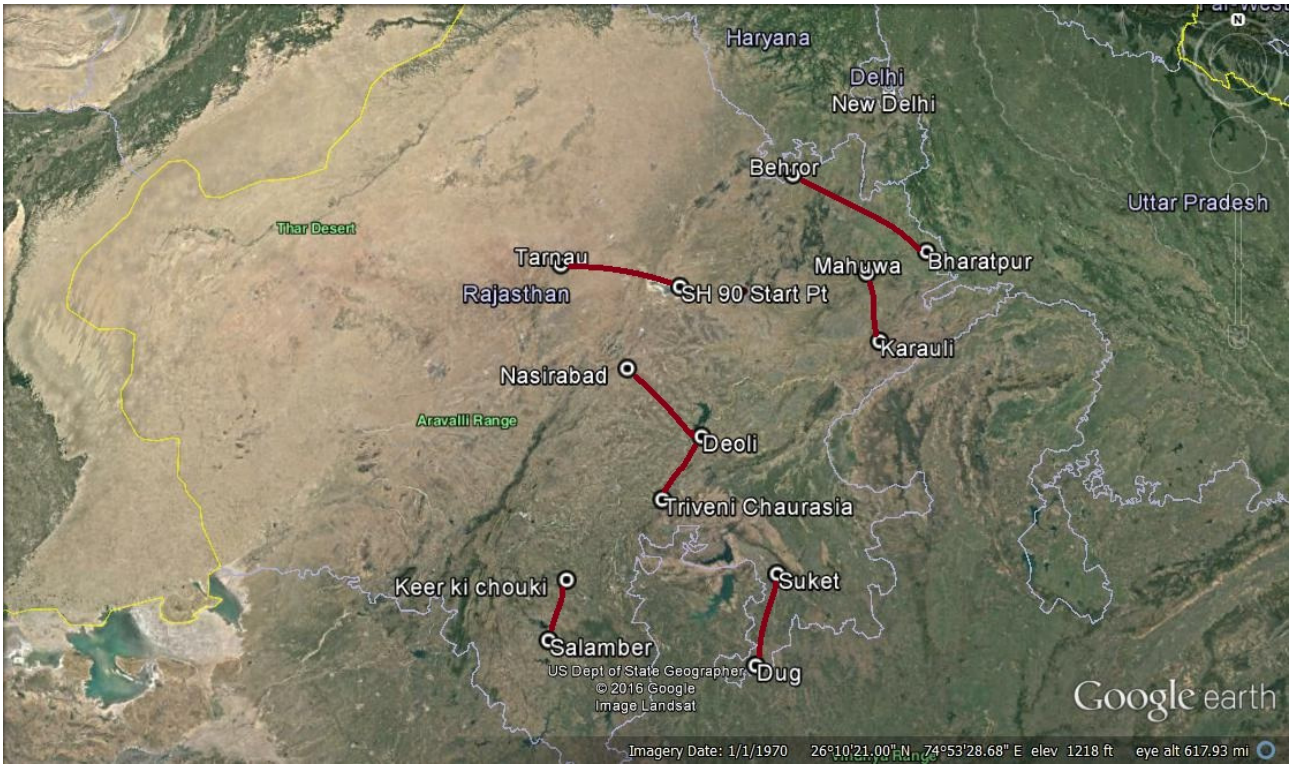


Figure 2.1: Project road network

2.2 Task objectives

The objectives of this project are:

- Survey 719km of roads managed by Rajasthan Public Works Department and carry out coding of the video survey data according to the International Road Assessment Program (iRAP) Survey and Coding specification.
- Collect crash data, traffic flow and speed data for the network in all the States according to the iRAP Data Analysis and Reporting specification.
- Produce an iRAP input file which includes all road attributes and collected data.
- Produce Star Rating results and Safer Roads Investment Plan to identify areas of high risk and to shape future road safety investment.
- Produce a detailed technical report in accordance with iRAP Data Analysis and Reporting specification
- Support the setting of design standards and the commitment of funds to implement the recommendations

3 Methodology

To attain task objectives mentioned in previous section, following Methodology have been followed: As described in flow diagram below (figure 3.1), the iRAP execution plan is divided in 5 phases or Working Packages (WP). Each one of these contains all the tasks and subtasks, which cover all the conditions required for this project. The methodology has been optimized with the best practices learnt after similar experiences of the Consultant in other International iRAP projects.

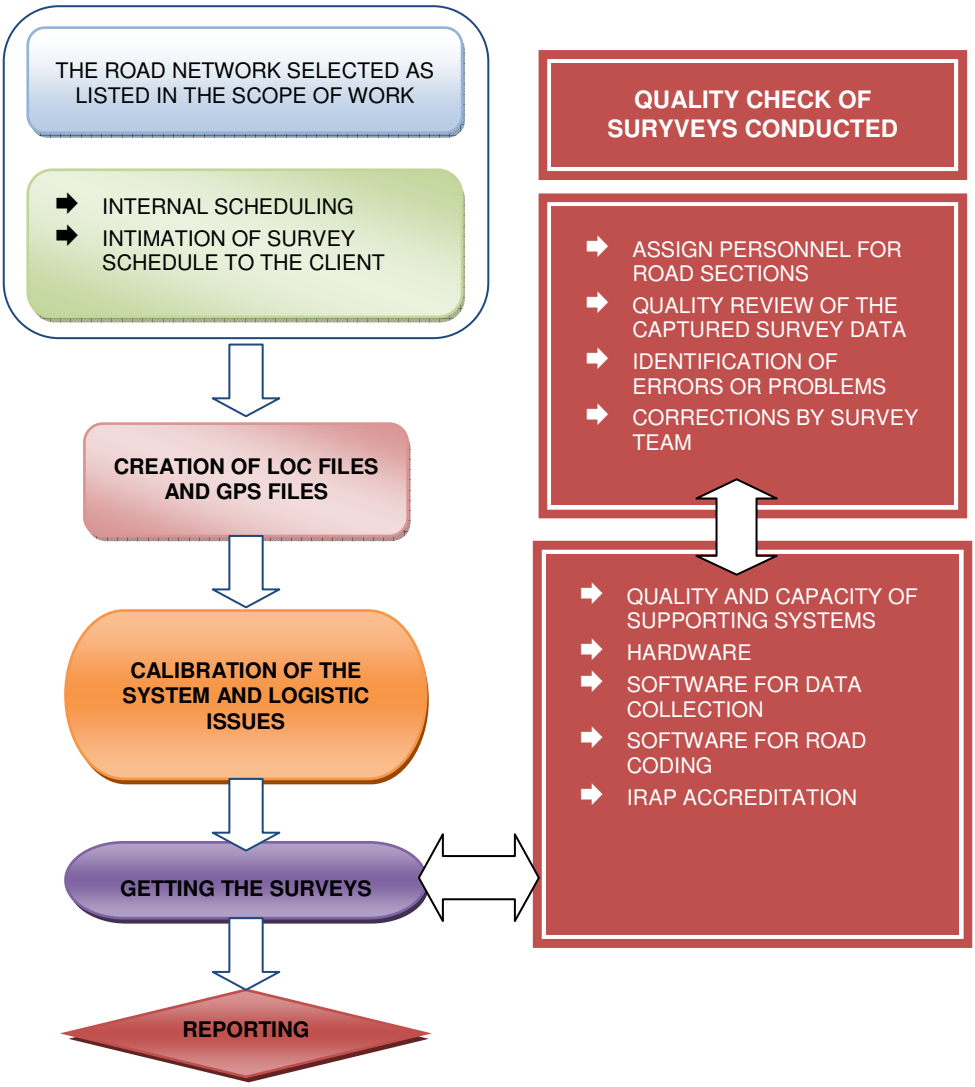


Figure 3.1: iRAP Methodology

Phase 1: Road Survey:

It consists of the preparation and planning, which contains all the tasks to be done before starting the field work. This include WP tasks such as: Project kick-off meeting, selection of Road network to inspect, creation of loc files and GPS files, calibration of the system and managing the logistics issues. In this part of the project, we gather required information of the road network selected. In this, a map of all roads along with baseline data such as AADT, length, starting and end points, traffic speeds (V85% and V50%), pedestrian flows and other relevant data about the road is recorded. The field work include the tasks related to the

collection of data on the road, training of the surveyors, calibration of the system, conducting the surveys, performing quality check on the road and other related tasks.

Phase 2: Road Coding

It is the most important phase of the whole project, considering that from this phase the core information for the calculations is created, and processing and analysis of the data inside the ViDA software is carried out. Considering this, the phase is divided in 3 tasks. The first one is the Preliminary database creation in which we create all documentation needed, prepare the tools to be used and do the training to the road coders about the Trimble Trident Systems Processing Toolkit software and explain how to interact in order to follow the procedures and protocols as per the RAP-SR-2.2 Star rating coding manual. The other task is the Road feature coding where all the roads are coded to get the required attributes from the network surveyed and same is exported to csv format. The last task of this phase is the Internal Quality Check Ratings which is done at the same time as the road feature coding. In this task, the principal aim is to ensure that the data coded fulfils the protocols with the minimum mistakes while coding is in process.

Phase 3: Processing and Analysis

At this stage, all the preparation and pre-processing of the data coded (add speeds, AADT, pedestrian and bicycle flows, etc) are done under the Preparation of the coded survey data task. Once everything is clear, the task of Upload data to ViDA starts and in the process, translation of the data into ViDA software language, creation of the country project, setting up of requirements for calculation of the countermeasures and the processing of the data are done. Finally, once the processing of the data has been completed, the Analysis tasks starts. This task consists of checking the accuracy of the data processed (results) with stakeholders and reprocessing the data when it is required. This phase is very important since it is from this phase that the final reports will be generated based on the information related to the countermeasures.

Phase 4: Reporting

Once the calculations are finished and checked, a report will be created under in order to manage all the requirements of the client. In here, the report will be done as it is specified in the tender: Detailed Technical report. This task will include the creation of a draft version in accordance with the reporting specifications included inside the tender, release of the document to stakeholders and client for feedback and finally, submission of the final version of the document, which will be the base for the work for the next phase.

Phase 5: Technical engagement

Finally, there is a final phase called Technical engagement. In this phase, we will be able to check the quality assurance review from an external company, execute the amendments as required (if any) and re-do all the documents that can vary due to this feedback. All this subtasks are included inside the Quality Assurance review task. In parallel to this activity, the in-country review of results tasks will be executed and will consist principally of different meetings with the stakeholders and client, explaining all the protocols used, the ViDA

reports and use of the software, countermeasures obtained and how these were finalized, and finally if necessary, an additional training to the stakeholders about the Trimble Trident Systems Processing Toolkit software. With all this, our final task will be to establish a common base, supported in the iRAP protocols in order to follow the implementation of the countermeasures once the phase 1 is over.

3.1 Quality Control for the tasks

In order to ensure a good quality control of the tasks under this project, we have followed the actual quality control requirements of the iRAP. All the requirements included inside the documents created by iRAP about this topic will be followed in order to get the highest quality possible as mentioned inside the file RAP-SR-2-4 Road Coding QA Guide.

An example of the approach that has been followed with regard to road coding internal quality controls is described as follows:

To help attain a high level of accuracy in the data collected and rated, the following procedures have been followed:

1. The name of the coder who has rated the attributes has been recorded. This information is included to help trace and correct any inconsistencies in the data.
2. Approach: This concept is already included as part of the rating form that the Consultant used in code feature rating. Actually, this field is the first attribute that all the coders must complete in order to proceed with the other attributes of the rating form. With this information the Consultant is able to perform a trace of the inconsistencies in the data rated.
3. A coder is responsible for a segment/length of road. This is done to ensure consistency.
4. Approach: This is resolved when the road coding matrix vs. coder is done. In this matrix the Consultant specifies the road to be rated and the coder assigned for it.
5. Data should be backed up on a regular basis throughout the rating process.
6. Approach: Trimble Trident Systems Processing Toolkit software is enabled to save every change inside the rating form, so that there is no problem of lost data. Besides that, when coding of the road (partial or total) is completed, a backup is created in order to avoid any loss of data which will impact the project schedule.
7. Following completion of the rating process for each length of road the data is reviewed for accuracy by a separate coder and any errors or inconsistencies corrected and noted. Errors are reviewed by the rating team to help build consistency in the ratings.
8. Approach: A Quality Check (QC) of 10% of the total surveyed roads is carried out. Road coding supervisor who is in charge of the review and accuracy of the data is responsible for QC, according to the RAP-SR-2.2 Star Rating Coding Manual. The principal tasks of this position are described below:
9. Check the road coding done by Coders
10. Create internal reports about inconsistencies and problems detected

11. Communicate the report to the Coder
12. Verify that all the inconsistencies are rated again in order to have good quality data.
13. Besides that, while coders are rating the roads, a Road Coding Leader is available on site to solve doubts and questions about the road features in order to complete the rating form in a correct way.
14. A sample of the data is reviewed by an iRAP nominated rating team, to help in ensuring consistency across the programme.
15. Approach: Part of the Quality Check of the data is rechecked by the core team of iRAP in order to certify that a good quality job has been done. This is a standard procedure of iRAP consortium.

3.2 Quality and Capacity of supporting systems

A brief description of Trimble survey system components for road survey tasks are show in the next lines. The road survey equipment has 4 parts: The vehicle, Hardware, Software for the field work and the software for back-office work.

Figure 3.2: iRAP Navigation Survey Vehicle

The technological equipment that the Consultant has used for the data collection is the Trimble Road-I/MX2 system. The equipment is installed on a Toyota Innova MUV. This vehicle complies with all the requirements specified under iRAP Road Survey Vehicle Specifications.

The vehicle features are listed as follows:

- Brand: Toyota
- Model: Innova 2.5D
- Year:2009
- Type of fuel: Diesel
- Capacity (fuel): Between 65 and 80 litres
- Consumption (aprox.): Between 8-12 Km per litre.

Note: The human resources, who had been dedicated to carry on the tasks while the road survey was made, are personnel with a lot of experience in this work. A professional driver with knowledge of the roads was considered for this work. Besides this one, there had been one person in charge of the road surveys who is capable to control the system, responsible to take decisions on the road and able to provide any explanation

of the project to experts and stakeholders as required. The project team in charge of the work followed the specification established by iRAP about Road Survey Team Requirements

The Trimble survey system is composed of a series of latest technological devices that enable optimal collection of data, because the capture rate of these is defined by the speed limit of the road to assess. This means that the speed at which data is collected is not limited by the system, but only by the speed limit of the surveyed road. The system is totally automatic and only requires the specific knowledge of a technical staff to understand the data collected while surveying the road.

The Trimble system complies with all the specifications included in the document 'Road Survey Inspection System Specifications' in accordance with the iRAP class B & class C inspection system referred n the RAP-SR-2.3 Star Rating Inspection System Accreditation Specification and Record. Also, the minimum requirements of iRAP are covered completely by the system functionalities.

3.2.1 Hardware

The hardware elements of the acquisition system Trimble Road-I equipped are as shown below:

1. 12 Megapixels (six 2MP cameras) (1600 X 1200) 360° coverage, 6 CCD sensor panoramic camera (1600x1200 each sensor), capable of 30 fps over FireWire 1394b 800 Mbps bus for single shot 30-degree wide angle capture.

2. Trimble AgGPS332 with OmniStar correction service for consistent <1m accuracy. This receiver-correction combination give us the highest accuracy, on the go without a separate periodic control network

3. Tachometer and IMU (Inertial Measurement Unit) inputs used to enhance position accuracy. The IMU is tightly coupled with GPS (optional – to improve accuracy)

4. DMI (Distance Measurement Unit) is an encoder coupled to the vehicle's rear wheel, which accurately measures the actual on-ground distance covered by the vehicle

5. Powerful and rugged Panasonic Tough Book PC running custom data-capture and integration software.

6. On-board Data multiplexer: The multiplexer makes sure all on-board sensors are hooked onto the computer and synchronises the timing and real-time data capture process.

3.2.2 Software for data collection

The software used on the road to collect all the data is called Trimble Trident Analyst.

While inspecting the road, this software application allows controlling the various components of the data acquisition system. It's easy to use interface allows pre-configuration at the beginning of any inspection, starting and stopping the inspection, viewing the footage made by digital cameras, controlling the uptake of GPS satellites (11 satellites at most) and recording the information it collects, such as the map produced after the tour, the latitude, longitude and altitude among others and the geometry of the road areas per the convenience of the data collection.

Further, the software has highly advanced location extraction, attributes coding and GIS database functionalities, allowing operators to extract location, attributes and imagery and store them directly into industry-standard GIS formats.

3.2.3 Software for road coding

The software used to do the tasks relative the road coding is the Trimble Trident Analyst.

The data processing software in back-office allows building a database of road features from the videos collected during the field work/survey. This software makes use of rating forms (checklists) that are fully configurable to the client's requirements and needs. The consultant has used in similar projects rating forms for data processing of SRS according to iRAP protocols, so that vehicle, motorcyclist, pedestrian and bicyclist related data can be stored in a database.

The software that has been used in this project complies with all the technical requirements stated in the document - Star Ratings and Investment Plans: Road Survey and Coding Specification (www.iRAP.org)

Once the roads have been coded with guarantees of good quality data, the information is exported into a ".csv file" in order to be able to upload it to process and analyse with the ViDA software.

3.2.4 iRAP Site Survey & Vehicle Demonstration Images

Figure 3.3: iRAP Site Visit and Vehicle Demonstration

3.3 Star Rating Methodology

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

- Comparative analysis among different roads in the same country.
- Define road safety objectives for road infrastructures.

The Star Ratings are based on Road Protection Scores (RPS). The IRAP models calculate an RPS at 100-m intervals for each of the four road user types, based on relative risk factors for each of the road features shown. The scores are developed by combining relative risk factors using a multiplicative model.

As an example of a risk factor, the relationship between delineation and the likelihood of vehicle occupants being killed or seriously injured in a crash is shown below. It indicates that the relative risk of death or serious injury on a rural road is 20% greater when the delineation is poor, all other things being similar.

Delineation	Relative Risk
Adequate	1.00
Poor	1.20

Vehicle occupant risk factors for the likelihood of death or serious injury on a rural road.

More information on risk factors, RPS and Star Ratings is available in IRAP (2016) Methodology (see http://www.IRAP.org/en/about-IRAP-3/methodology).

3.3.1 Star Rating Scores

A Star Rating Score (SRS) is calculated for each 100 metre segment of road and each of the four road users, using the following equation:

SRS = Σ Crash Type Scores

Where:

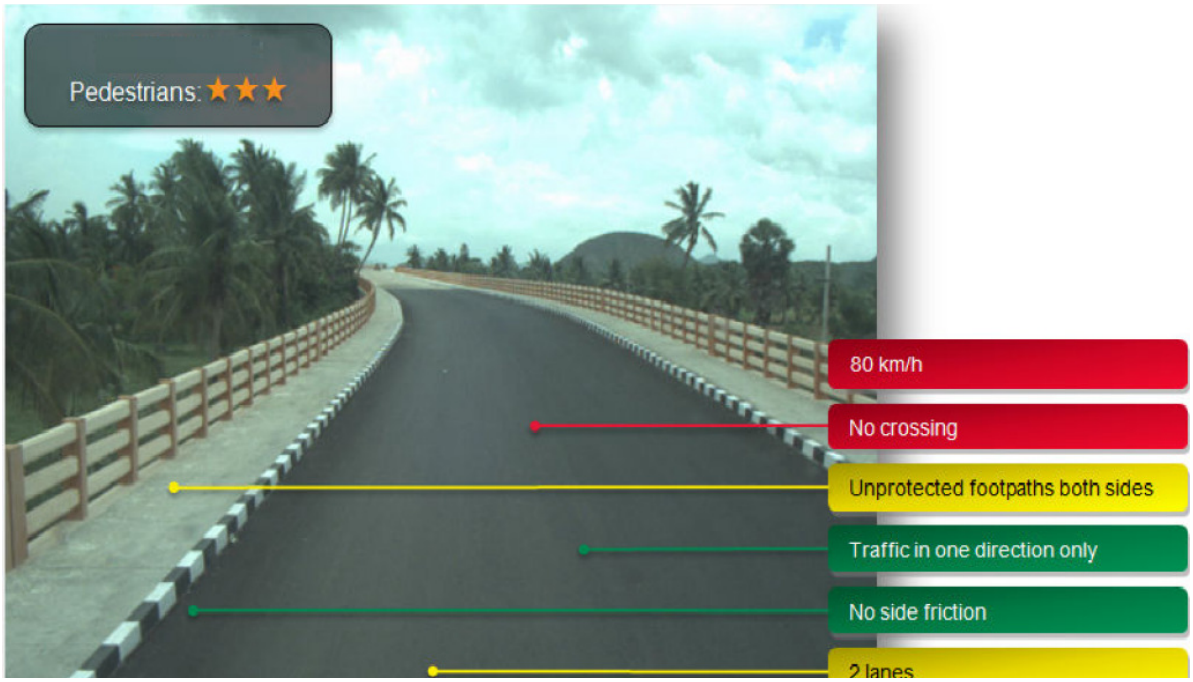
- The SRS represents the relative risk of death and serious injury for an individual road user; and
- Crash Type Scores = Likelihood x Severity x Operating speed x External flow influence x Median traversability

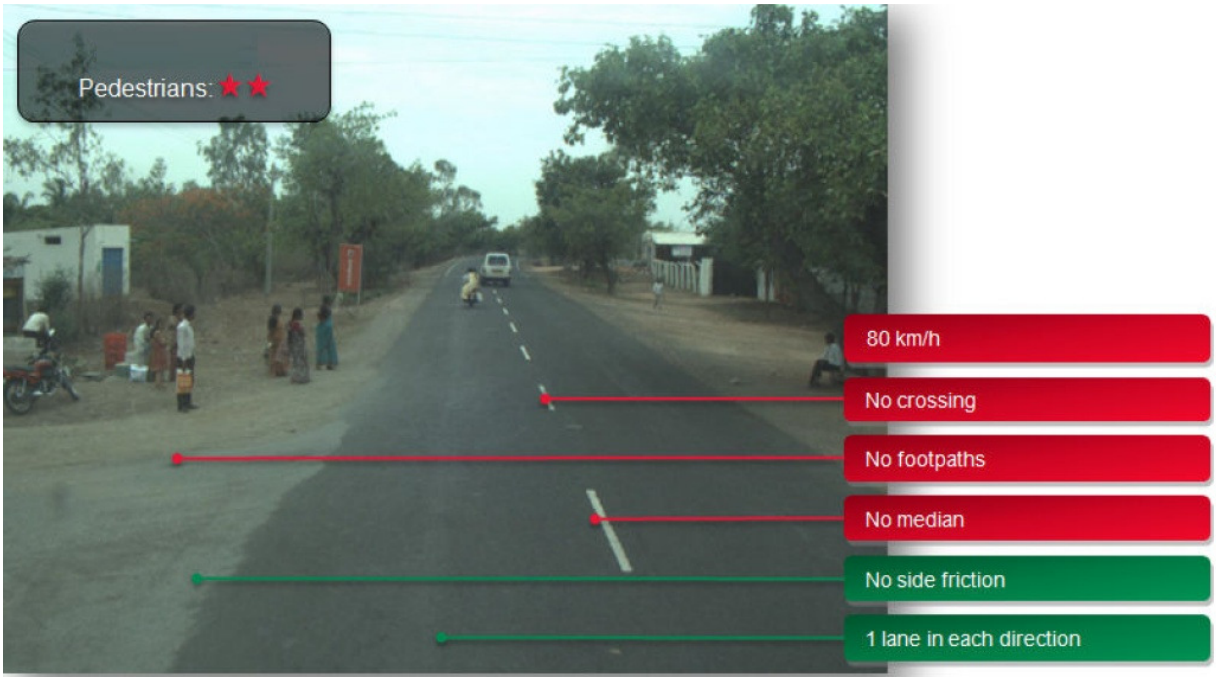
3.3.2 Examples of Star Ratings

Figures 3.4 and 3.5 show examples of sections of roads that include their Star Ratings and the road attributes that influenced their assessment. The figures illustrate Star Ratings for car occupants and pedestrians, as they account for the majority of roads deaths. However, similar figures are able to be produced for motorcyclists and bicyclist.

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

Figure 3.4 Examples of Star Ratings for Pedestrians.





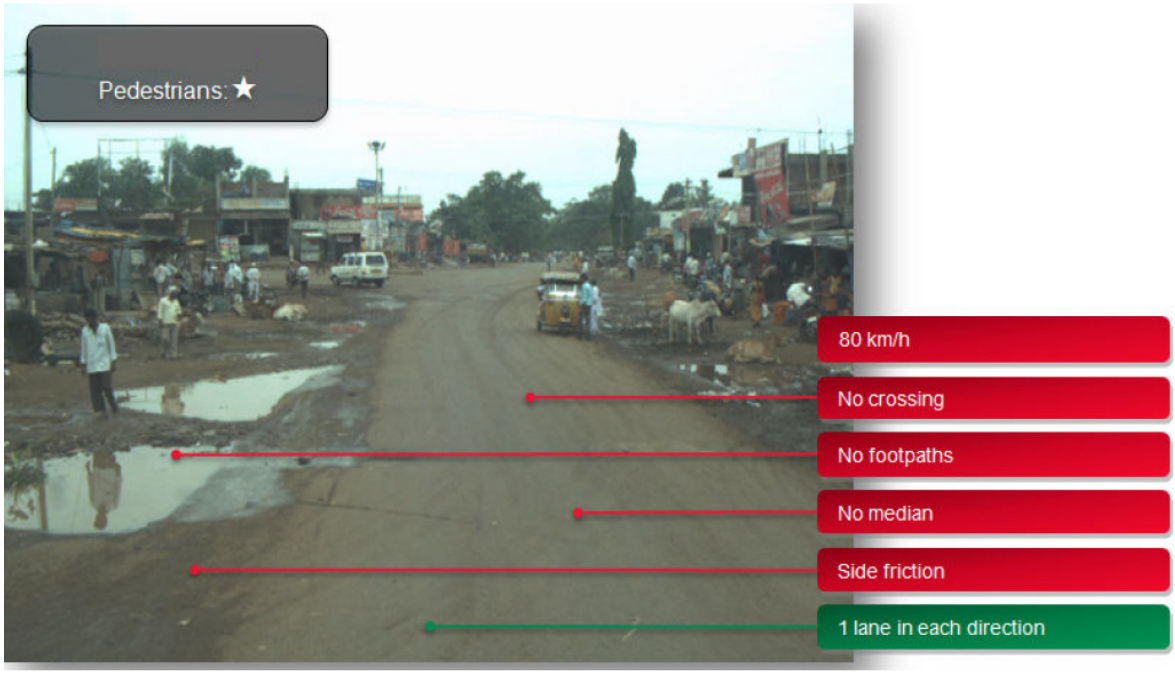
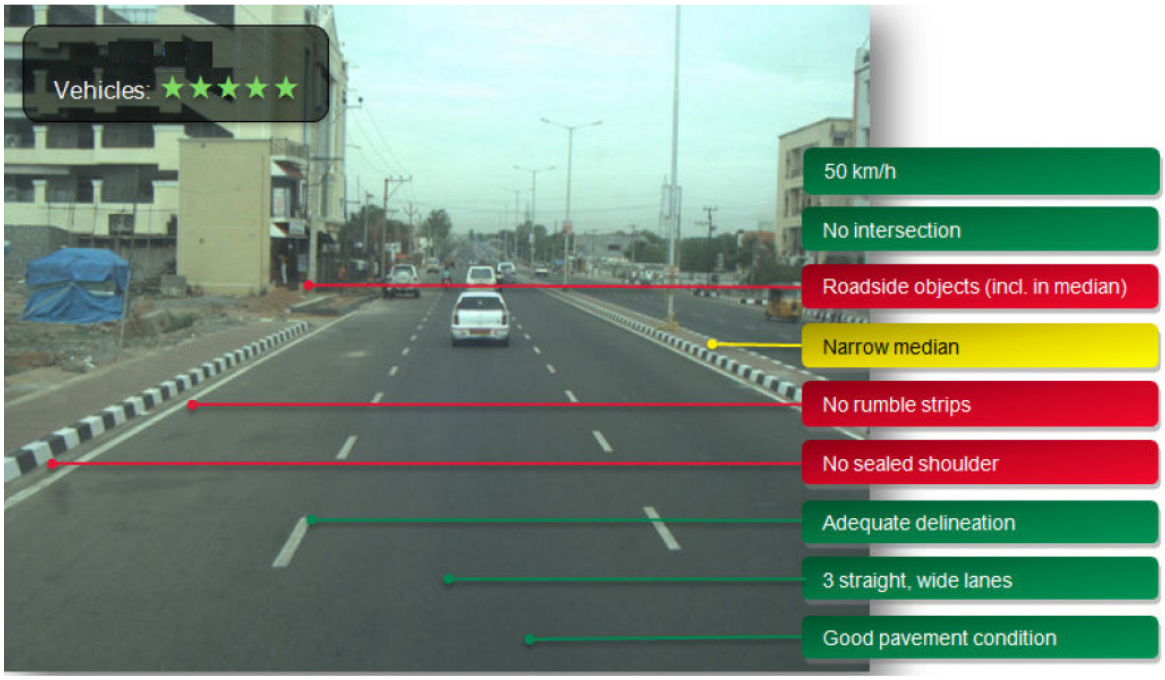
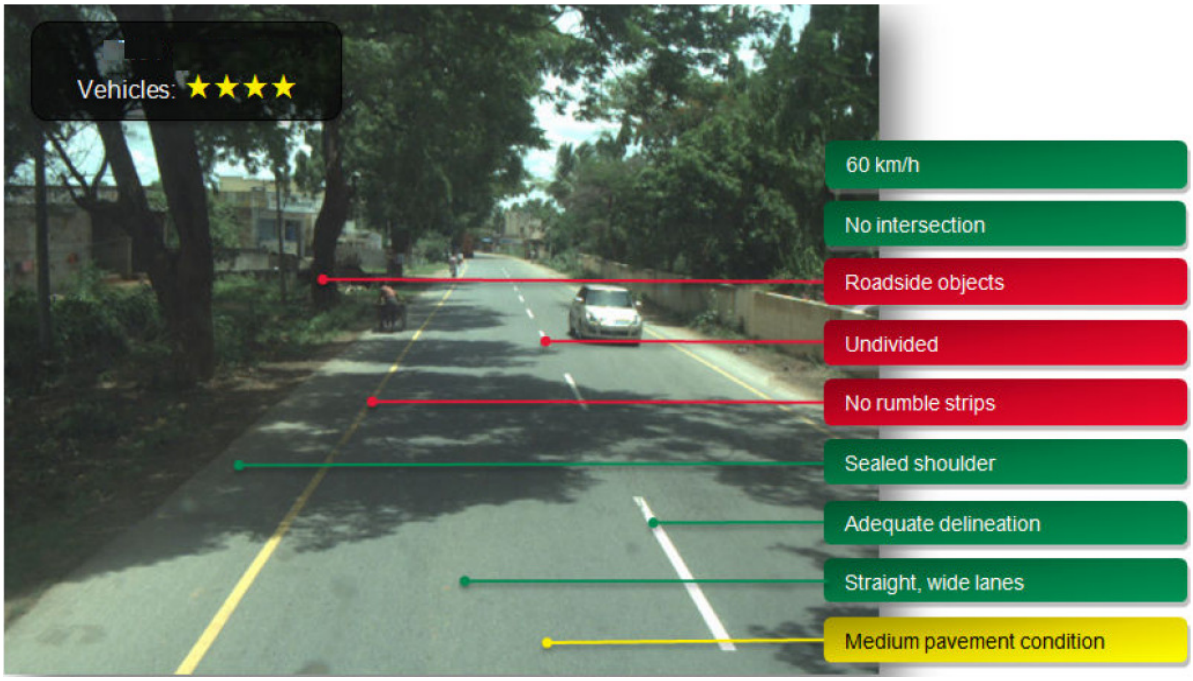
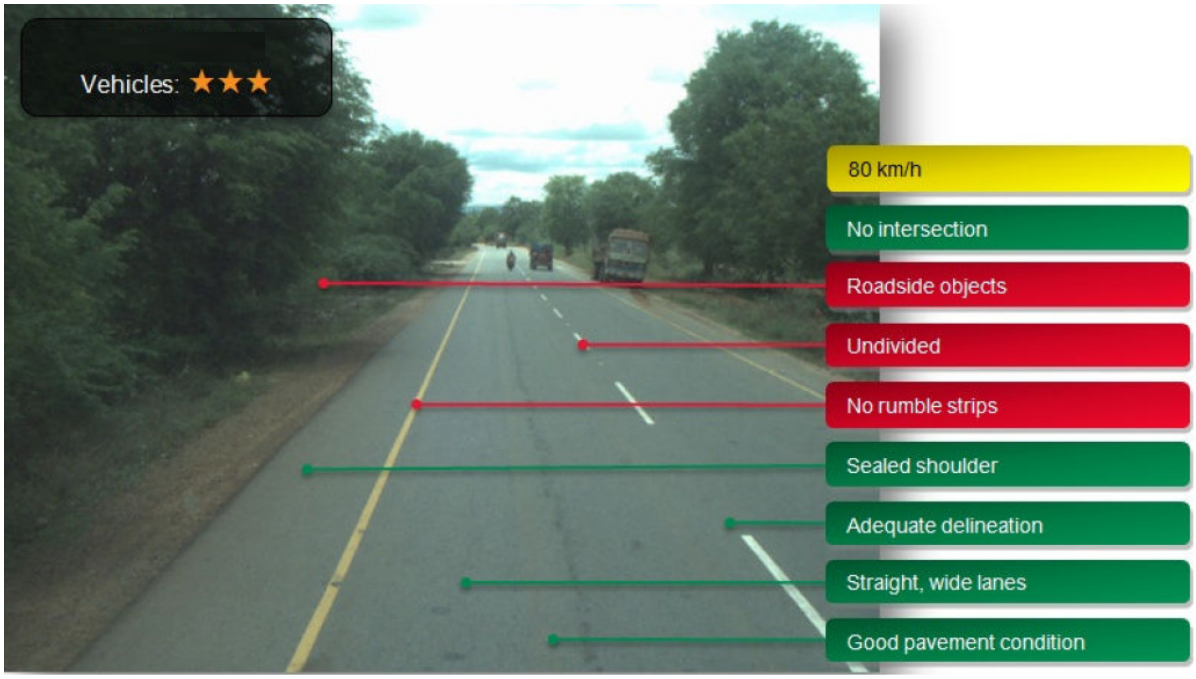
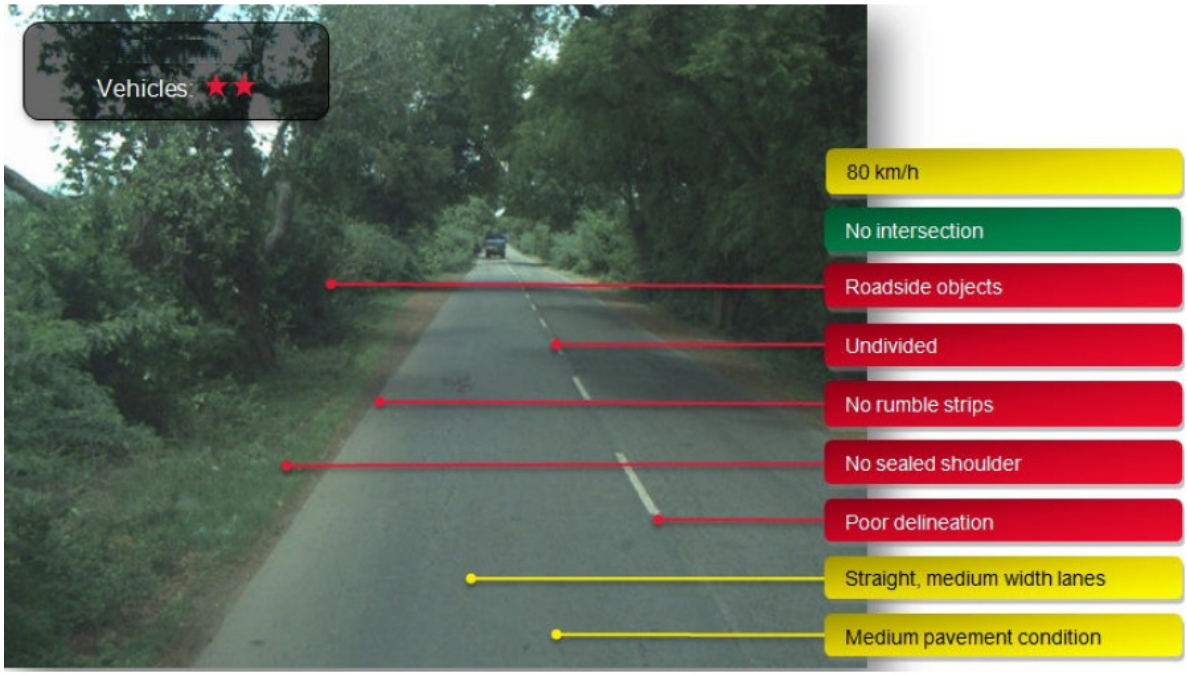


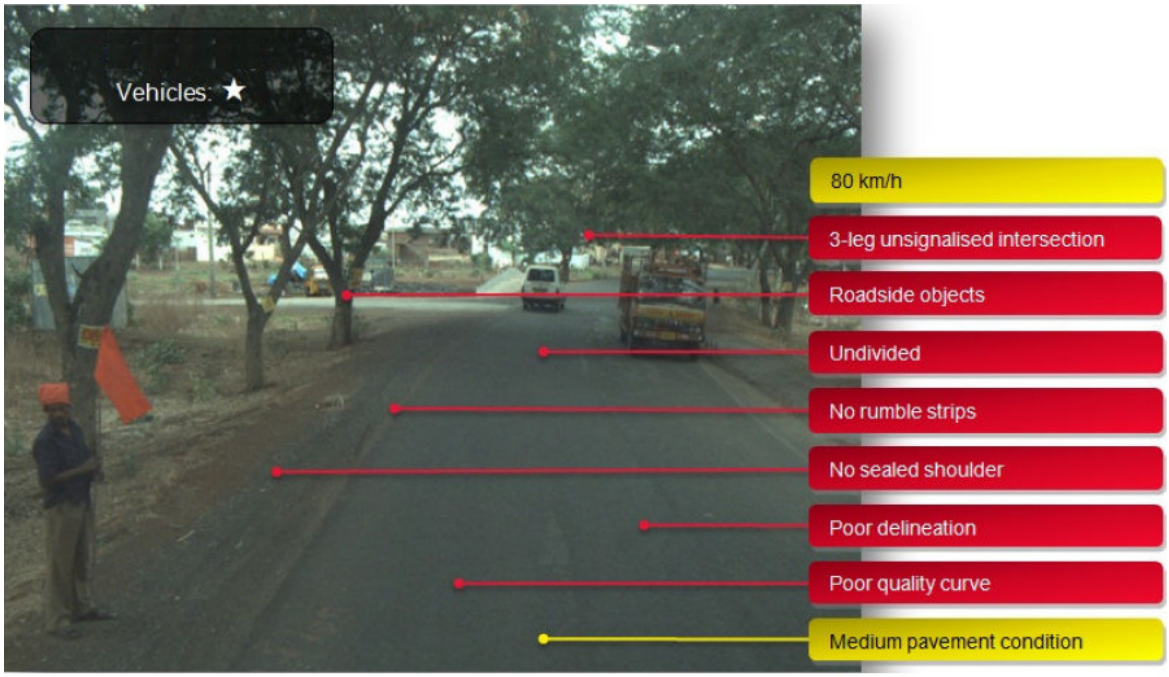
Figure 3.5 Examples of Star Ratings for Vehicle Occupants




Vehicles: ★★★★
60 km/h
No intersection
Roadside objects
Undivided
No rumble strips
Sealed shoulder
Adequate delineation
Straight, wide lanes
Medium pavement condition


Vehicles: ★★★
80 km/h
No intersection
Roadside objects
Undivided
No rumble strips
Sealed shoulder
Adequate delineation
Straight, wide lanes
Good pavement condition





3.3.3 Smoothened Star Rating

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 road map, 100 metres is too much detail. Hence, Star Ratings are smoothed (or averaged) over longer lengths in order to produce more meaningful results

3.4 Safer Road Investment Plan Methodology

IRAP considers more than 70 proven road improvement options to generate affordable and economically sound Safer Road Investment Plans that will save lives. Road improvement options range from lower cost items such as road markings and pedestrian refuges to higher cost items such as intersection upgrades and full roadway duplication.

Plans are developed in three key steps:

1. Drawing on the Star Ratings and traffic volume data, estimated numbers of deaths and serious injuries are distributed throughout the road network.

2. For each 100-m section of road, countermeasure options are tested for their potential to reduce deaths and injuries. For example, a section of road that has a poor pedestrian Star Rating and high pedestrian activity might be a candidate for the application of pedestrian refuge, pedestrian crossing, or signalised pedestrian crossing countermeasures.

3. Each countermeasure option is assessed against affordability and economic effectiveness criteria. The economic benefit of a countermeasure (measured in terms of the economic benefit of the deaths and serious injuries prevented) must, at a minimum, exceed the cost of its construction and maintenance (that is, it must have a benefit cost ratio (BCR) greater than one). In many circumstances, the “threshold" BCR for a plan is lifted above one, which has the effect of reducing the overall cost of the plan. This ensures that a plan that is affordable for a country while still representing a positive investment return and responsible use of public money can be generated.

The methodology underpinning this process is available in Star Ratings and Investment Plans: (http://www.IRAP.org/en/about-IRAP-3/specifications).

3.4.1 SRIP Support Data

Although the IRAP Star Ratings and Safer Roads Investment Plans use a standardised global methodology, the models are calibrated with local data to ensure that the results reflect local conditions. In this section of this report, the key data and methodology that relates specifically to the roads being assessed in this project are described.

- **Traffic volumes**

Traffic volume data for vehicle occupants and motorcycles is used by the IRAP model in the generation of estimates of the number of deaths and serious injuries that could be prevented on the roads. For this project, AADT data for vehicle occupants was obtained from local PWD office.

- **Pedestrian and Bicyclist volumes**

Data on observed pedestrian and bicycle usage of the roadways were recorded during the coding of road features. Pedestrian and bicycle flows were estimated from those observations using algorithms developed by iRAP.

3.4.2 Engineering Criteria: countermeasure triggers

For each countermeasure, a series of triggers (or prerequisite conditions) have been defined. A trigger must be satisfied before that countermeasure is considered suitable for a section of road. The triggers are applied for each 100-m section of road throughout the network, and are typically a function of:

1. Star Ratings, which are based on Road Protection Scores

2. Road condition, such as lane width or adequacy of delineation.

3. Traffic volume.

An example of the triggers for improving delineation is provided in Table below. Trigger 1 requires that delineation be improved on any section of road that has a traffic flow greater than 0, has poor delineation and is not rated 5-stars (the safest level) for car occupants. However, trigger 2 requires that even if a section of road is rated 5-stars good delineation should be provided at moderate curves and where there are severe roadsides present. Trigger 3 requires that good delineation be provided on all sections of road where there is a sharp or very sharp curve.

Trigger	Variable	Requirement
1	Traffic flow	Greater than 0
	Delineation	Poor
	Vehicle occupant Star Rating	1 to 4-stars
2	Traffic flow	Greater than 0
	Curvature	Moderate
	Delineation	Poor
	Roadside severity	Deep drainage ditches, steep fill embankment, distance to object 0-5m, distance to object 5-10m
	Vehicle occupant Star Rating	5-stars
3	Traffic flow	Greater than 0
	Curvature	Sharp curve or very sharp curve
	Delineation	Poor
	Vehicle occupant Star Rating	5-stars

A sample of triggers for the delineation countermeasure

The IRAP model includes more 300 different triggers for the assessment of potential countermeasures across the road network.

3.4.3 Engineering Criteria: application rules-1

In addition to the triggers, the IRAP model applies a series of application rules for certain countermeasures. These ensure that the countermeasure recommendations align with good engineering practice.

For example:

- grade-separated pedestrian crossings must be at least 1-km apart
- new signalised pedestrian crossings (non-intersection facilities) must be at least 600 m apart

- additional lanes (such as overtaking lanes or 2+1 cross section) must be required for a minimum length of 1 km before they are considered viable.

3.4.4 Engineering Criteria: application rules-2

The countermeasures are also subject to a hierarchy, with the most comprehensive countermeasures taking precedence. This ensures that there is no duplication of treatments that impact the same road feature. For example:

- if a grade separated pedestrian facility is feasible then that treatment will take precedence over all other pedestrian measures (such as a pedestrian refuge or signalised crossing)
- if a horizontal realignment is feasible then any treatments that are no longer relevant can be removed (for example, curve delineation and shoulder widening)
- if a segregated motorcycle lane is feasible then any lower standard motorcycle lanes (such as an on-road motorcycle lane) can be removed from the plan.

This approach assumes that comprehensive countermeasures are designed with safety as a key criterion, and the new treatment reflects best practice in safety design (for example, motorcycle lanes must manage conflicts at intersections).

3.5 Countermeasure costs

The IRAP model requires the input of local construction and maintenance costs for the 94 countermeasures that are considered in the development of the Safer Roads Investment Plans. The costs are categorised by area type (urban and rural) and upper and lower costs (low, medium and high). The countermeasure costs were based on estimates provided by iRAP team thanks to their experience in previous IRAP projects carried out in India. The countermeasure costs were used to represent the typical costs of countermeasure construction or installation in rural areas where no major physical constraints are present. Higher costs were assumed in urban and in rural areas with greater constraints. A sample of the data is shown **Annexure 2**.

3.5.1 Economic cost of a death and serious injury

The document Safer Roads Investment Plans: The IRAP Methodology used to estimate the economic cost of a road death and a serious injury in for IRAP projects. This approach is applied globally by IRAP and is based on research undertaken by McMahon and Dahdah (2008). It is noted that this approach may result in estimates that differ from those undertaken in the past using a different methodology.

The key equations used are:

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

On this basis:

- the economic cost of a death is estimated to be: **7,436,259.6 ₹**

- the economic cost of a serious injury is estimated to be: **1,859,064.9 ₹**

3.5.2 Discount rate

To calculate Net Present Costs and Benefits, a discount rate of 7% was used.

3.5.3 Economic Criteria: Benefit-Cost ratio

Following these steps, the countermeasures are subject to a benefit-cost analysis, comparing the cost of the countermeasure (life-cycle cost) with the economic benefits in terms of crash costs avoided.

3.6 IRAP Assessment and Accident Analysis

Detailed Accident Analysis (AA) for project corridors was conducted and about 34 Accident Black Spots were identified along project corridors (Reports Submitted as part of earlier submissions). The iRAP assessments and AA are highly complementary. They (and Road Safety Audits) are both necessary elements of a comprehensive approach to infrastructure safety.

iRAP assessments can:

- Provide a means of identifying the scale of investment and work necessary to reduce risk across an entire road corridor or a network.
- Improvement recommendations help target AA to locations that present the highest risk for vehicle occupants, motorcyclists, pedestrians and/or bicyclists.
- Help focus the AA on key road attributes, such as a lack of footpath provision in areas of high pedestrian activity, and countermeasures that are likely to generate the largest economic returns.

The iRAP Road Protection Score and Star Rating Score also provides a means of quantifying the potential reduction in risk associated with recommendations made in the AA.

Accident Analysis (AA) can:

- Improve upon the iRAP recommendations at specific locations by investigating detailed, site-specific issues
- Transform the generalised iRAP recommendations into detailed design recommendations, ready for implementation.

3.7 Implementation

This section of the report presents the criteria used for identifying appropriate countermeasures and in interpreting the results of this report, it is important to recognise that IRAP is designed to provide a network-level assessment of risk and cost-effective countermeasures. For this reason, implementation of the proposals in this report will ideally include the following steps:

- local examination of proposed countermeasures (including a “value engineering“ type workshop including all relevant stakeholders)
- preliminary scheme investigation studies
- detailed design and costing of each proposal, final evaluation and then construction.

The detailed results of the project and online software that enabled the iRAP analyses to be undertaken will be made available to stakeholders for further exploration and use. The Road Safety Toolkit (http://toolkit.IRAP.org) also provides guidance on the implementation of road safety countermeasures. While this report and the online software include recommendations for consideration, the ultimate decision on an appropriate investment level to improve safety and the specific countermeasures to be implemented rests with road authorities in Rajasthan (India).

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

3.7.1 Safe System

In order to improve road safety in Rajasthan, efforts that go beyond traditional engineering improvements will be necessary. For example, research has demonstrated that it is crucial to ensure that local communities have the opportunity to both contribute to road designs but also understand the intended use of various road design features.

In addition to taking a more comprehensive approach to road safety engineering, significant benefits could be realised through coordinated targeting risk factors for road users (such as speeding, seat belt wearing, drugs and alcohol) and vehicles. This would be consistent with taking a Safe System approach to the programme. The Road Safety Toolkit (http://toolkit.IRAP.org) and United Nations Road Safety Collaboration Good Practice Manuals provide further information on this issue.

3.7.2 Speed Management

The issue of speed management is particularly important in road safety. Traffic speeds also have a significant bearing on the IRAP Star Ratings. As such, it warrants special attention in this report.

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.

An issue that has emerged during iRAP’s assessments in some countries is a discrepancy between permitted (posted) speeds and the speeds at which vehicles actually travel. In some locations posted speed limits are set at very low speeds, and are unlikely to be complied with without continuous enforcement or robust traffic calming measures.

The results of this study have been based on estimates of the real speed, rather than on posted speed limits, because the real traffic speed is a better estimator of the safety performance of a roadway than the posted speed limit. The real traffic speeds (85^{th} percentile and 50^{th} percentile) were based on field measurements.

In the IRAP results, roads on which traffic operates at very low speeds may achieve a relatively high Star Rating (4- or 5-star), even though the engineering features may be of a lower standard.

In terms of speed management more broadly, 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 lower 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.

The IRAP results therefore should help enable a professional discussion between police and highway authorities about their goals and respective roles in enforcement and engineering so each can contribute best to ensuring safe speeds. It is for local stakeholders to decide if and when a nationwide debate which educates the public about the importance of speed limits should occur. Clearly such a debate is likely to make more sense if launched alongside a major programme of safety engineering improvements with emphasis on safe driving, safe vehicles and safe roads.

SECTION 2: CORRIDOR-WISE STAR RATINGS & SRIP

Corridor 1: Nasirabad - Deoli

Corridor number 1 connects Nasirabad to Deoli. State Highway – SH 26 between Nasirabad and Deoli is a Two-Lane Carriageway. The project road starts from Km.0.000 and ends at Km. 99.000 of SH-26, thus making a total length of 99 km. The project corridor passes through major towns Sarwar, kekru, Sabar & Hanuman Nagar. The project corridor generally passes through plains terrain. Two toll plazas are in operation on the project corridor Road condition

A. Road Condition (Corridor 1)

The following is a summary of the condition of the inspected road (Naseerabad to Deoli) included in the IRAP models. More detailed reports on the road condition are available in the IRAP online software (https://vida.IRAP.org/es/results/star_rating/map) and in the Annexure 1.

Key elements for all transport modes of corridor 1 are listed in the following snapshots.

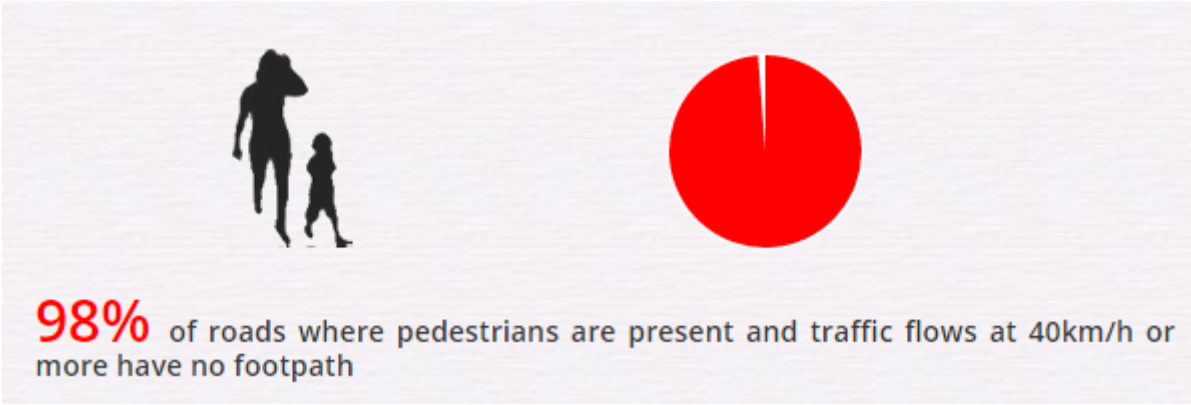


Figure A.1 Combination of pedestrians and real traffic speed > 40km/h

Figure A.2 Combination of bicyclists and real traffic speed > 40km/h

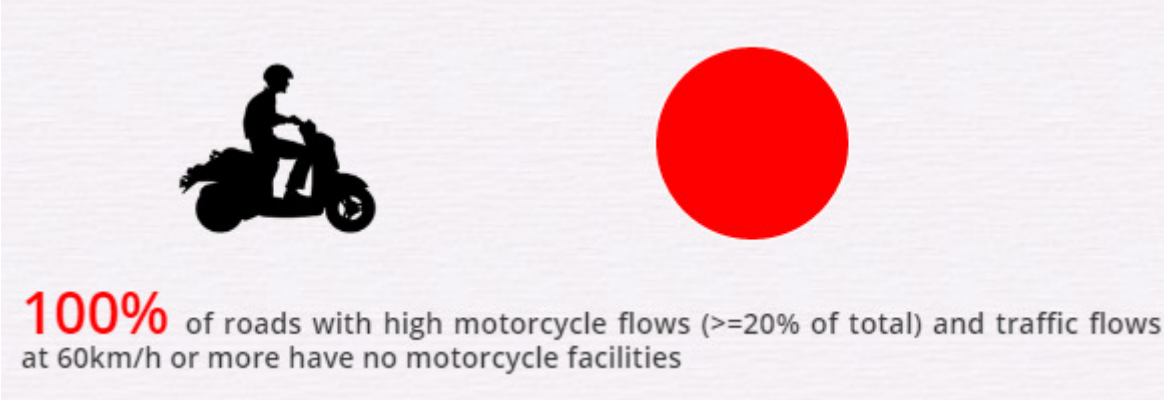


Figure A.3 Combination of motorcyclists and real traffic speed > 60km/h

Figure A.4 Combination of type of road and real traffic speed > 80km/h

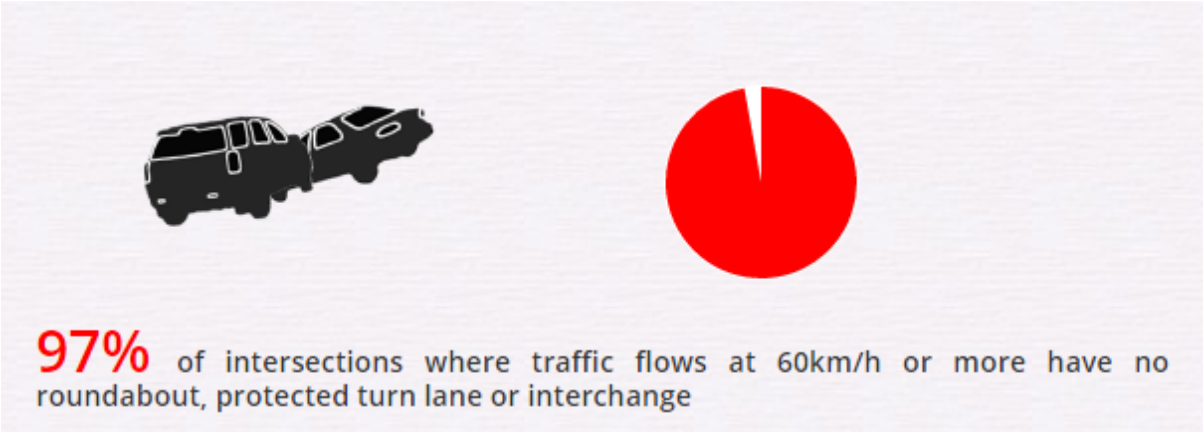


Figure A.5 Combination of type of intersection and real traffic speed > 60km/h

Figure A.6 Combination of hazardous roadsides and real traffic speed > 80km/h

The project evaluates 50 road infrastructure features included in the iRAP models. However, real traffic speed is a key attribute for measuring the likelihood of a road crash occurring and its severity. The data collected on site is used in estimating the 85th percentile and mean speed adjustment factors for that corridor:

Real traffic speed

Operating Speed (85th percentile)	km	%
60km/h	8.30	8
70km/h	90.90	92

Operating Speed (mean)	km	%
50km/h	8.30	8
60km/h	90.90	92

Figure A.7 Real traffic speed in corridor 1.

B. Star Ratings (Corridor 1)

The overall Star Ratings for the roads assessed is shown in Table B.1 and B.2:

	Vehicle Occupant		Motorcyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.10	0%	0.00	0%
4 Stars	1.70	2%	1.10	1%
3 Stars	87.70	88%	82.50	83%
2 Stars	9.20	9%	15.10	15%
1 Star	0.50	1%	0.50	1%
Not applicable	0.00	0%	0.00	0%
Totals	99.20	100%	99.20	100%

Table B.1: Overall Star Ratings for vehicle occupants and motorcyclist in Corridor 1.

	Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.10	0%	0.00	0%
3 Stars	4.40	4%	12.60	13%
2 Stars	94.10	95%	84.30	85%
1 Star	0.60	1%	2.30	2%
Not applicable	0.00	0%	0.00	0%
Totals	99.20	100%	99.20	100%

Table B.2: Overall Star Ratings for bicyclists and pedestrians in Corridor 1.

The same information about Star Ratings for vehicle occupants, motorcyclists, pedestrians and bicyclists together in the following chart provided by ViDA software:

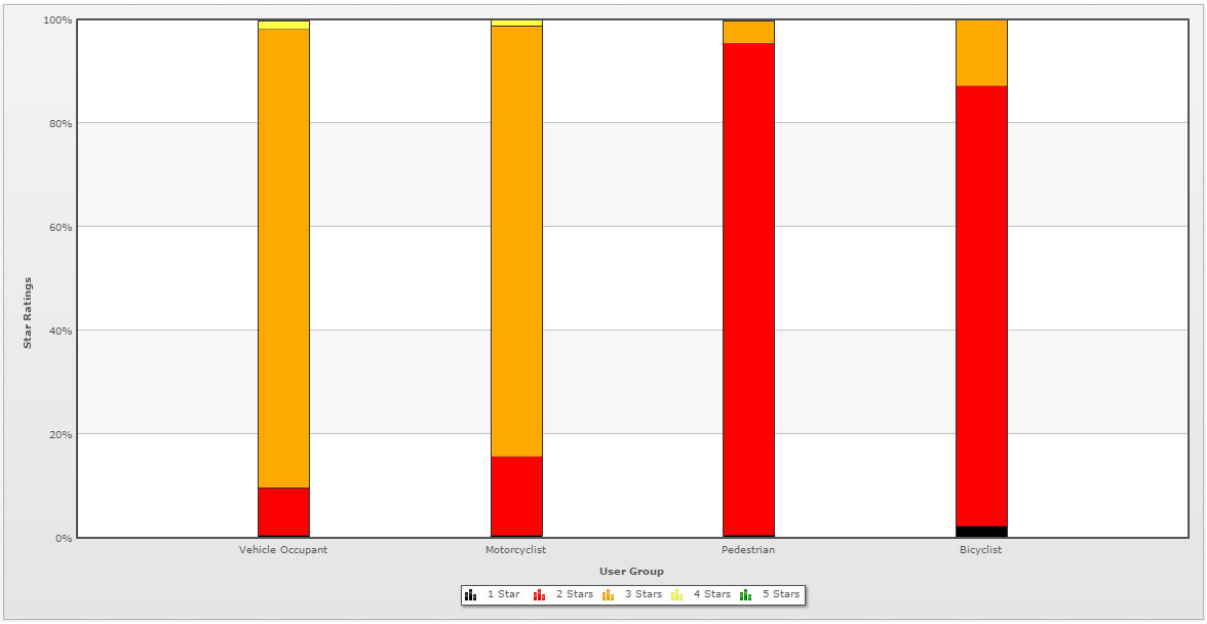


Figure B.3: Chart of smoothed Star Ratings for each transport mode in corridor 1.

Figures B.4 and B.5 illustrate the Star Ratings for Corridor 1 in map for vehicle occupants, motorcyclists bicyclists and pedestrians. More detailed information on the star ratings is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/map).

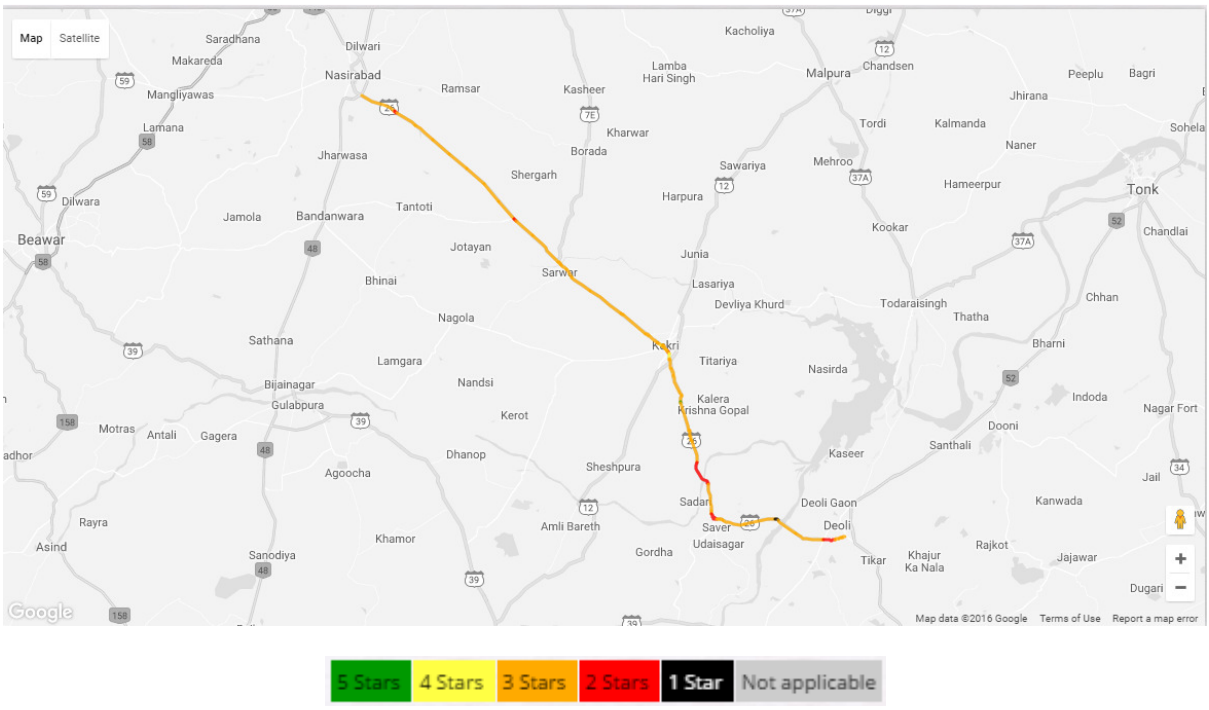


Figure B.4: Star Ratings for vehicle occupants.

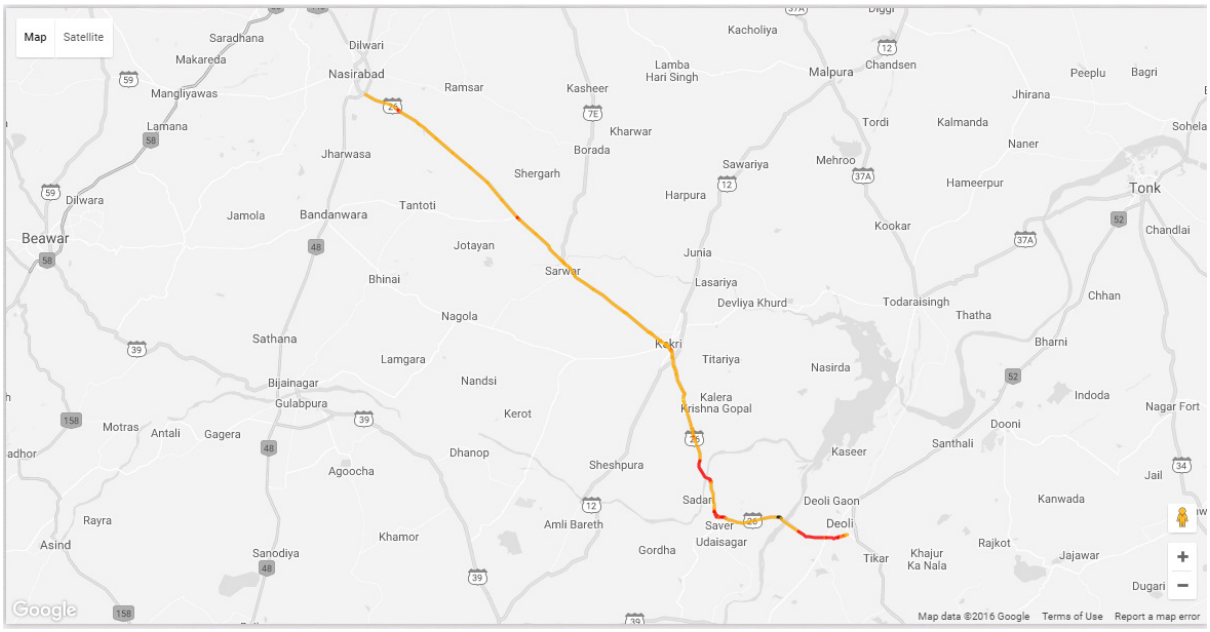
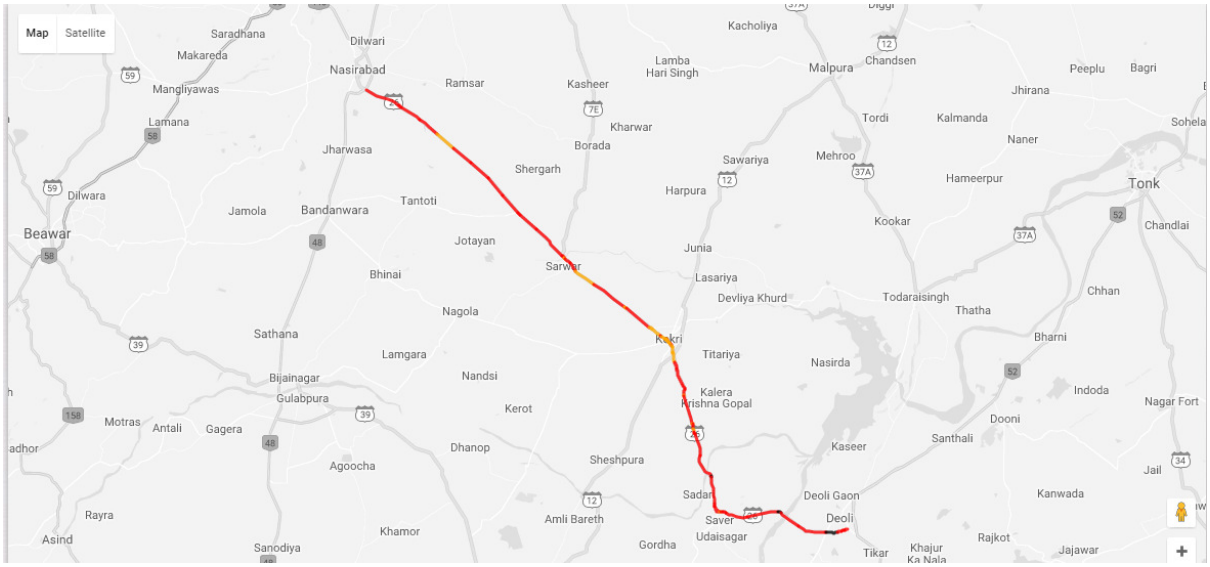


Figure B.5: Star Ratings for motorcyclists.



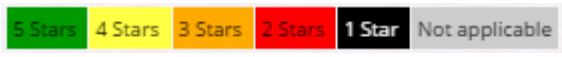


Figure B.6: Star Ratings for bicyclists.

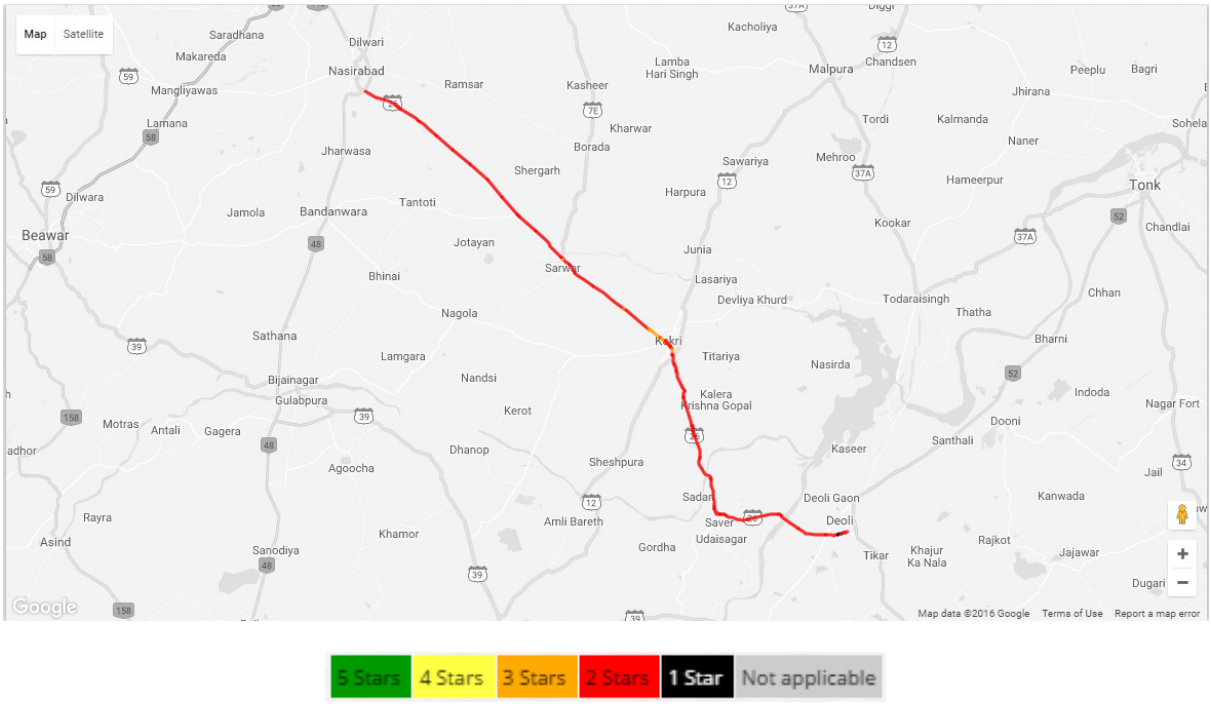


Figure B.7: Star Ratings for pedestrians.

C. Road Protection Scores – RPS (Corridor 1)

Figures C.1 and C.2 provide an example of how the RPS varies along one particular road section (in this case from Kekri to Deoli). They illustrate the RPS for each transport mode on a selected roadway section. The following figures show raw and smoothed version to visualise Star Rating for each 100m in the section of 49km from Kekri to Deoli:

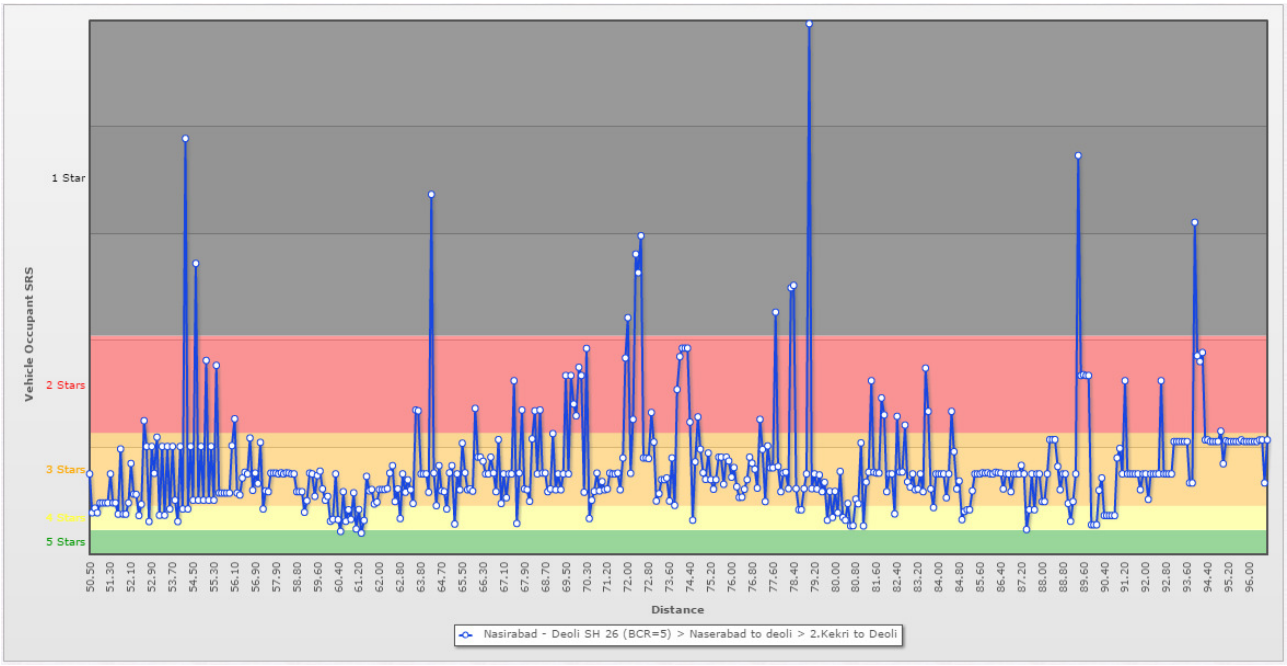


Figure C.1: RPS for vehicle occupants (Kekri to Deoli) - Raw version

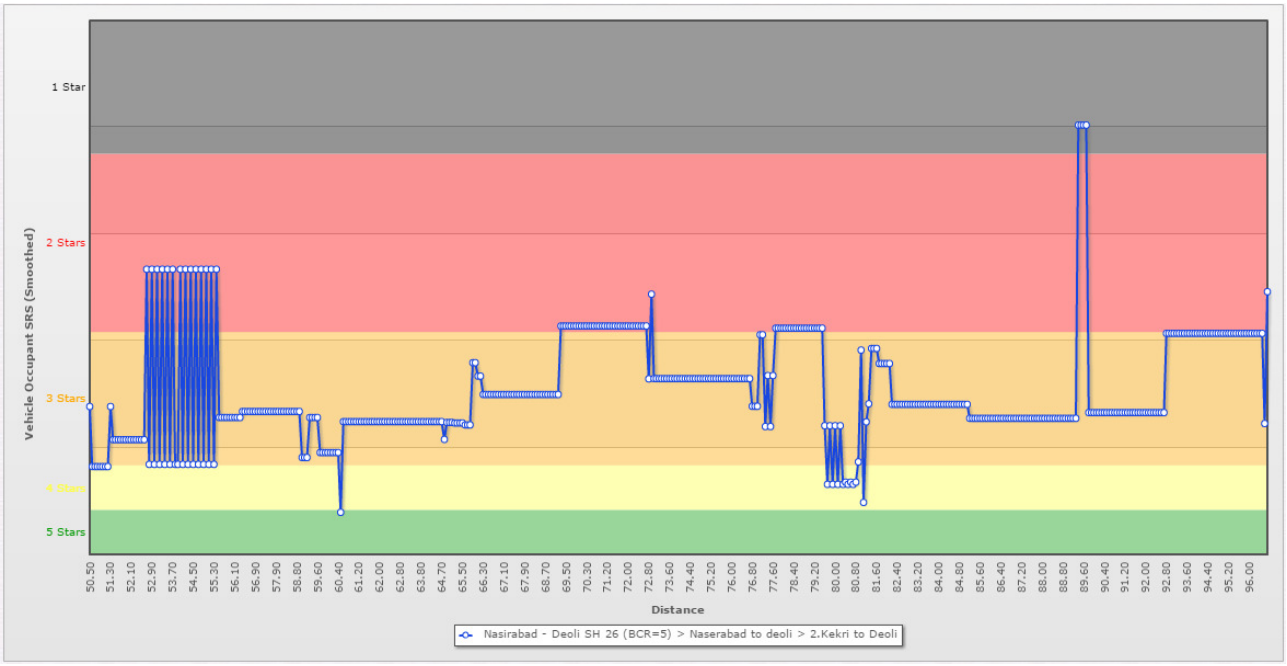


Figure C.2: RPS for vehicle occupants (Kekri to Deoli) – Smoothed version

More detailed information on the risk worm (raw and smoothed) is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/risk_worm).

Road sections

Each record has a section code. Section codes are used to group together 100-m segments for both processing and reporting purposes. Road sections are typically aligned with road authority inventory data, obvious changes in road condition or with obvious landmarks such as towns. For the purposes of this project, roads have been split into sections roughly according to important towns, traffic volumes and changes in road features.

Section number	Name of section	Length
1	Nasirabad to Kekri	51km
2	Kekri to Deoli	49km

Detailed road sections.

D. Safer Road Investment Plans (Corridor 1)

Using inspection and supporting data with the IRAP methodology, a series of investment plan options have been produced for the roads that make up the study network. Different assumptions about the benefit-cost ratio (BCR) thresholds for safety improvements were found to be applicable as an example for Rajasthan demo corridor. Smaller BCR thresholds must be considered to develop an investment program of meaningful size and greater BCR thresholds to maximize the efficiency of the investments.

Candidate investment plans with differing BCR thresholds and differing investment levels have been developed. While a specific investment option is recommended, the ultimate decision on an appropriate investment level to improve safety rests with road authorities in Rajasthan. The table C.3 shows usual options for iRAP projects. Option C is optimal for an estimated cost around 50,000,000 ₹.

	Option A	Option B	Option C
Minimum benefit cost ratio	3	5	8
Investment (₹)	648,869,922	143,110,259	50,953,464
Economic benefit 20 years (₹)	3,053,482,146	1,193,149,962	719,182,286
Programme benefit cost ratio	5	8	14
Deaths (per year)			
Before countermeasures	29.3	29.3	29.3
After countermeasures	9.9	21.7	24.7
Prevented	19.4	7.6	4.6
Reduction	66.1%	25.8%	15.6%
Deaths and serious injuries (20 years)			
Before countermeasures	2,930	2,930	2,930
After countermeasures	992	2,173	2,474
Prevented	1,938	757	456
Reduction	66.1%	25.8%	15.6%
Cost per death and serious injury prevented	334,817 ₹	188,982 ₹	111,630 ₹

Investment plan options for Corridor 1.

Countermeasure	Length/Sites	FSIs saved	PV of safety benefit	Estimated cost	Cost per FSI saved	Program BCR
Central hatching	78.40km	249	392,718,496	23,650,917	94,888	17
Skid resistance (paved road)	2.20km	59	93,054,977	7,281,828	123,295	13
Street lighting (mid-block)	1.40km	43	68,037,860	5,373,000	124,426	13
Improve curve delineation	3.60km	35	55,641,668	1,747,788	49,492	32
Additional lane (2+1 with road barriers)	0.70km	22	34,057,020	3,962,700	183,328	9
Delineation and signing (intersection)	4 sites	19	29,361,241	3,944,959	211,696	7
Central median barrier (1+1)	0.40km	13	20,153,685	1,886,000	147,446	11
Improve delineation	1.90km	12	19,244,834	1,988,473	162,799	10
Footpath provision passenger side (adjacent to road)	0.60km	3	4,287,401	658,800	242,105	7
Clear roadside hazards – driver side	0.30km	2	2,625,104	459,000	275,493	6
	TOTAL	**456**	**719,182,286**	**50,953,464**	**111,630**	**14**

Countermeasures options for safer roads investment plan (Option C)

Corridor 2: Bharatpur - Narnaul

Corridor number 2 connects Bharatpur to Narnaul in a 172 kilometre road, with 90% of undivided road and 10% of divided carriageway road. The project road starts from Km. 0 000 and ends at Km. 163.000 of SH-14, thus making a Total Length of 163km. The project corridor passes through five major towns' viz., Deeg, Nagar, Alwar, Tatarpur and Behror. The project corridor generally passes through plains terrain. Two toll plazas are in operation on the project corridor.

A. Road Condition (Corridor 2)

The following is a summary of the condition of the inspected road (Bharatpur to Narnaul) included in the IRAP models. More detailed reports on the road condition are available in the IRAP online software (https://vida.IRAP.org/es/results/star_rating/map) and in the Annexure 1.

Key elements for all transport modes of corridor 2 are listed in the following snapshots.

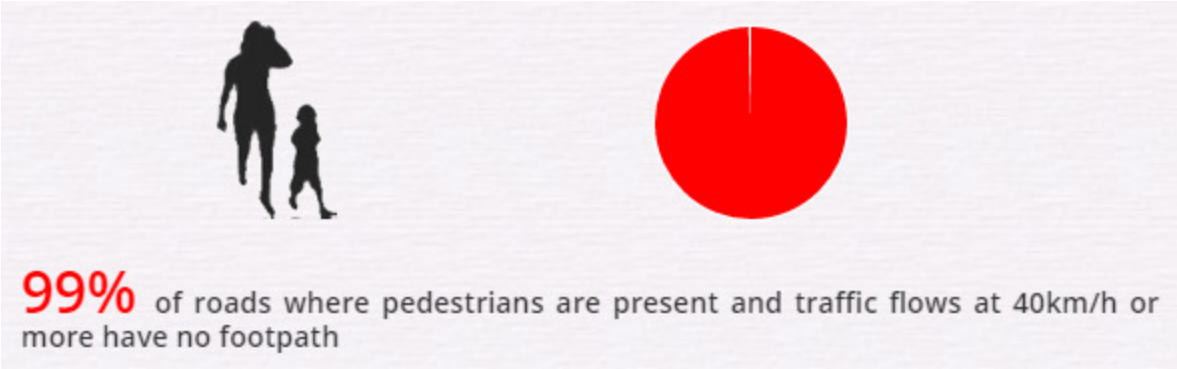


Figure A.1 Combination of pedestrians and real traffic speed > 40km/h

Figure A.2 Combination of bicyclists and real traffic speed > 40km/h

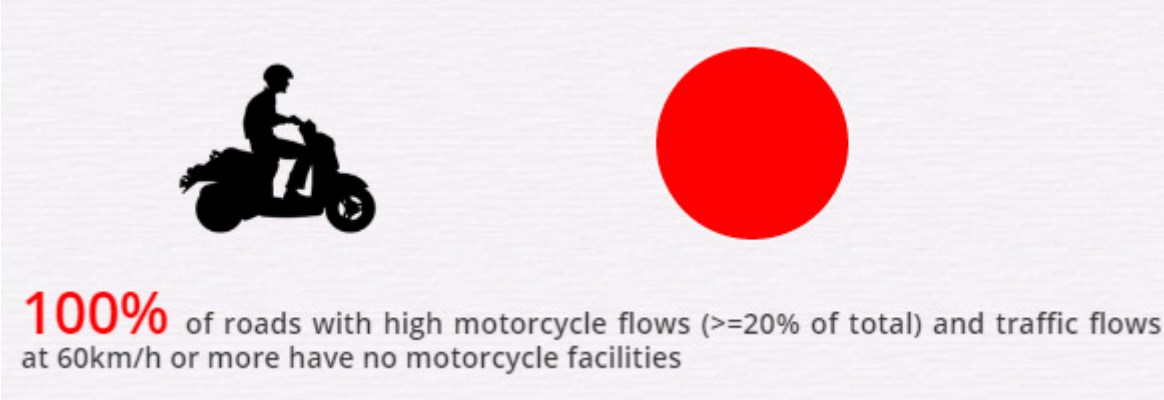


Figure A.3 Combination of motorcyclists and real traffic speed > 60km/h

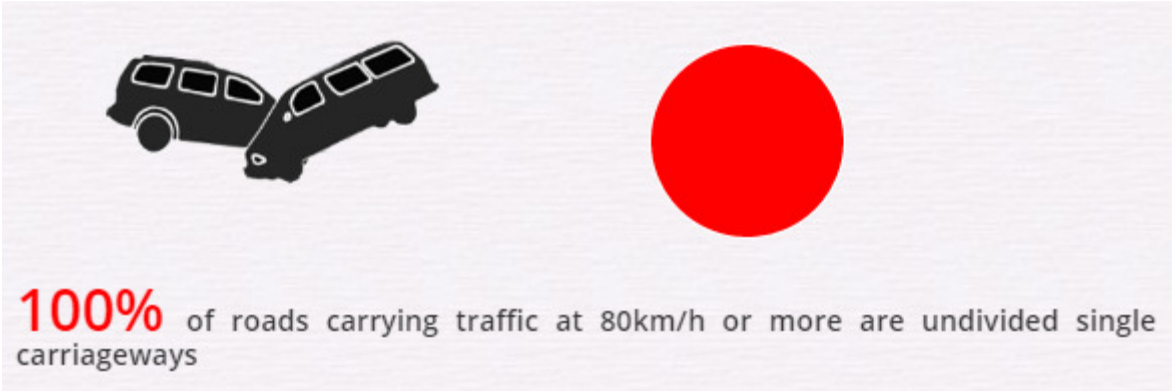


Figure A.4 Combination of type of road and real traffic speed > 80km/h

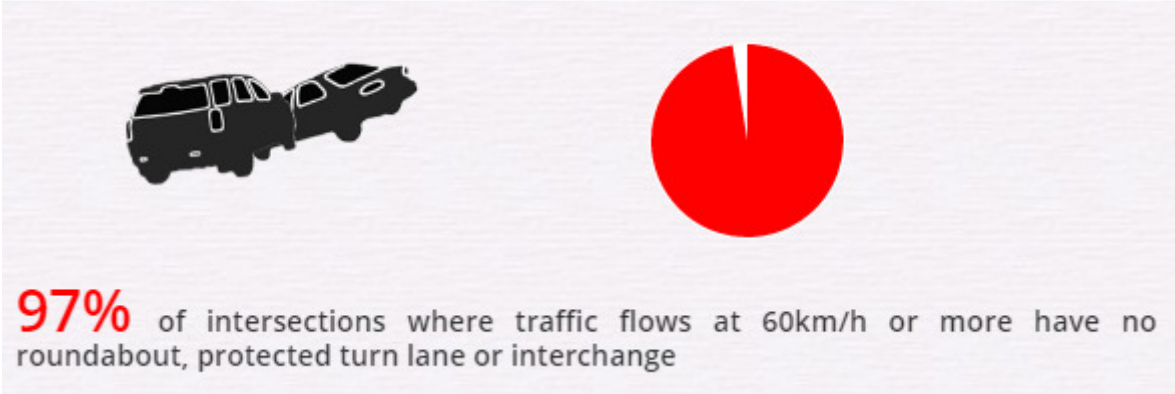


Figure A.5 Combination of type of intersection and real traffic speed > 60km/h

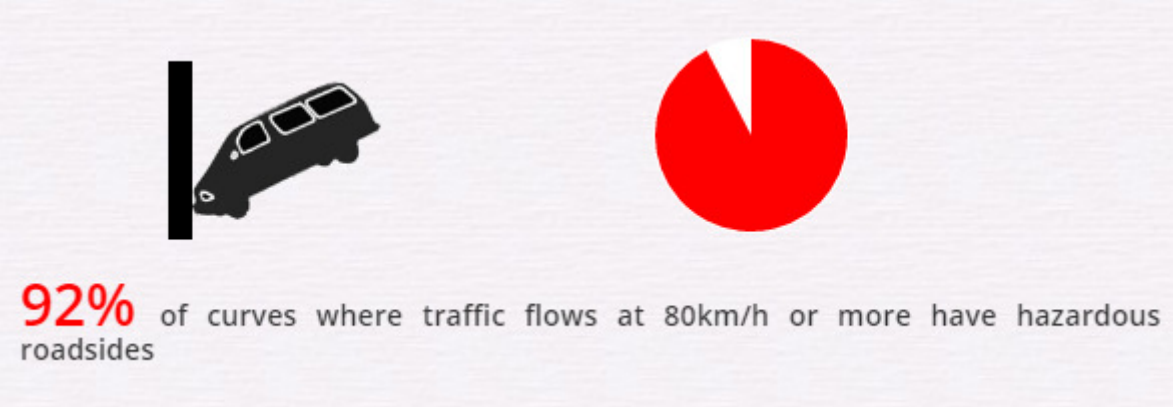


Figure A.6 Combination of hazardous roadsides and real traffic speed > 80km/h

The project evaluates 50 road infrastructure features included in the iRAP models. However, real traffic speed is a key attribute for measuring the likelihood of a road crash occurring and its severity. The data collected on site is used in estimating the 85th percentile and mean speed adjustment factors for that corridor:

Real traffic speed

Operating Speed (85th percentile)	km	%
60km/h	26.50	15
70km/h	130.80	76
80km/h	14.50	8

Operating Speed (mean)	km	%
50km/h	159.00	93
60km/h	12.80	7

Figure A.7 Real traffic speed in Corridor 2.

B. Star Ratings (Corridor 2)

The overall Star Ratings for the roads assessed is shown in Tables below:

	Vehicle Occupant		Motorcyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	3.00	2%	2.10	1%
3 Stars	155.40	90%	146.80	85%
2 Stars	12.40	7%	18.40	11%
1 Star	0.30	0%	3.80	2%
Not applicable	0.70	0%	0.70	0%
Totals	171.80	100%	171.80	100%

Table B.1: Overall Star Ratings for vehicle occupants and motorcyclist in Corridor 2.

	Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	5.20	3%	6.90	4%
3 Stars	123.50	72%	155.80	91%
2 Stars	40.80	24%	8.30	5%
1 Star	1.50	1%	0.10	0%
Not applicable	0.80	0%	0.70	0%
Totals	171.80	100%	171.80	100%

Table B.2: Overall Star Ratings for bicyclists and pedestrians in Corridor 2.

The same information about Star Ratings for vehicle occupants, motorcyclists, pedestrians and bicyclists together in the following chart provided by ViDA software:

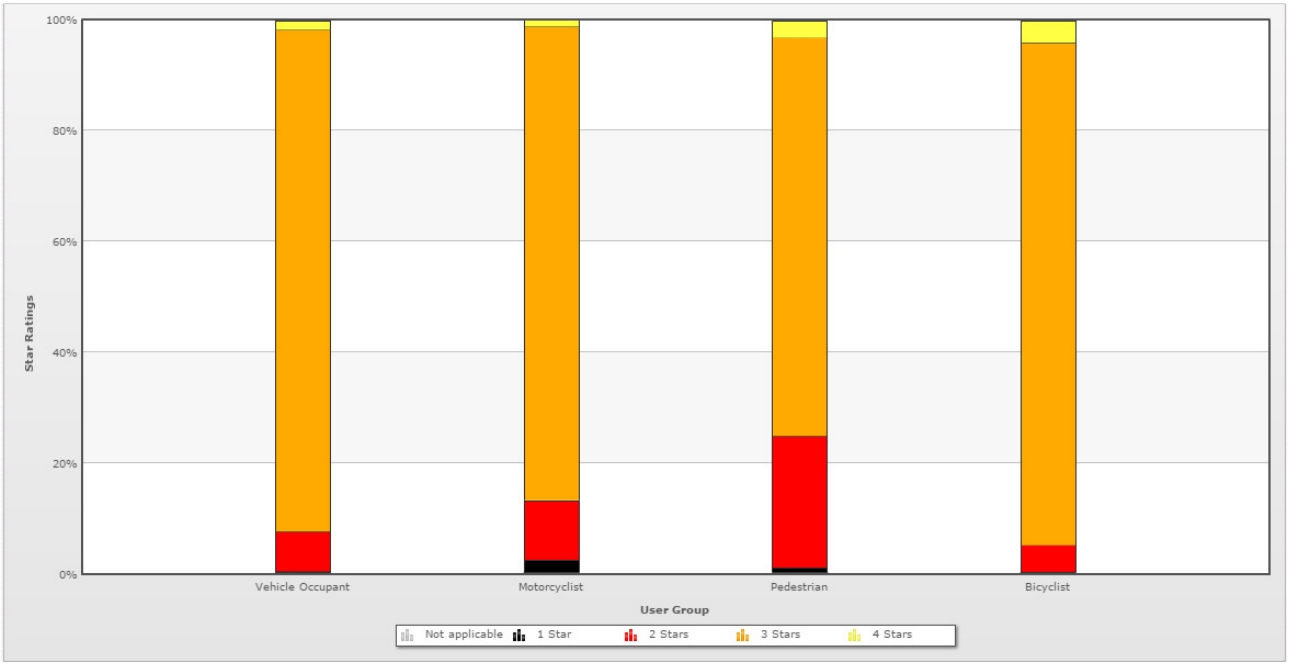


Figure B.3: Chart of smoothed Star Ratings for each transport mode in corridor 2.

Figures below illustrate the Star Ratings for Corridor 2 in map for vehicle occupants, motorcyclists bicyclists and pedestrians. More detailed information on the star ratings is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/map).

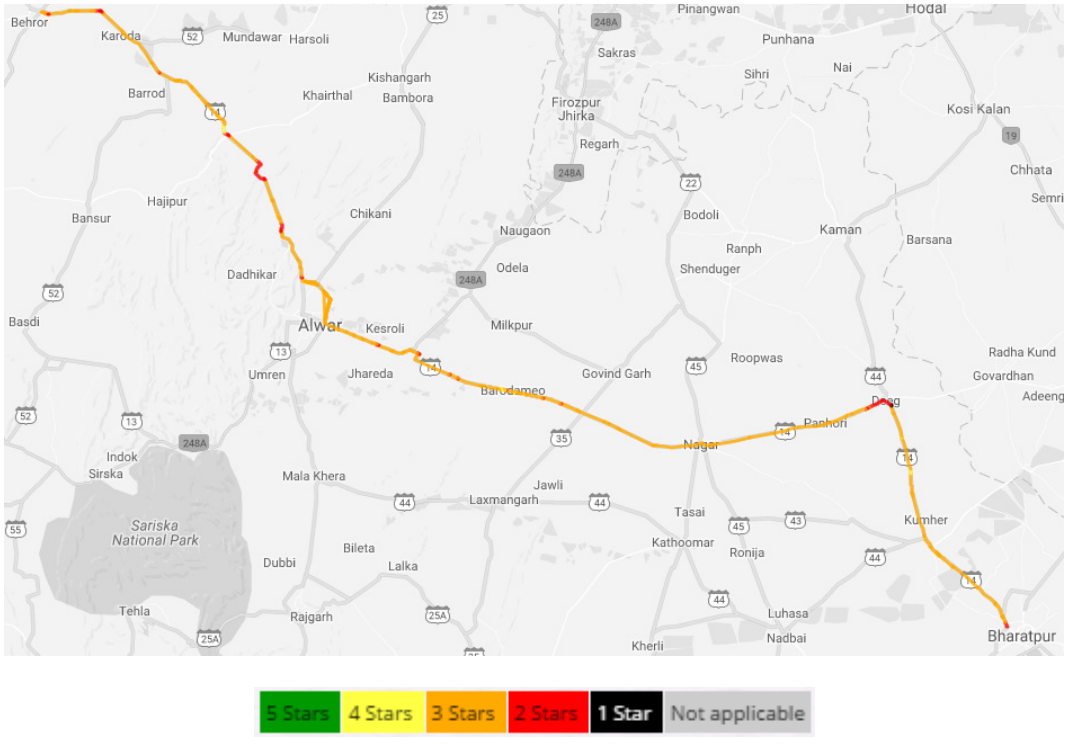


Figure B.4: Star Ratings for vehicle occupants.

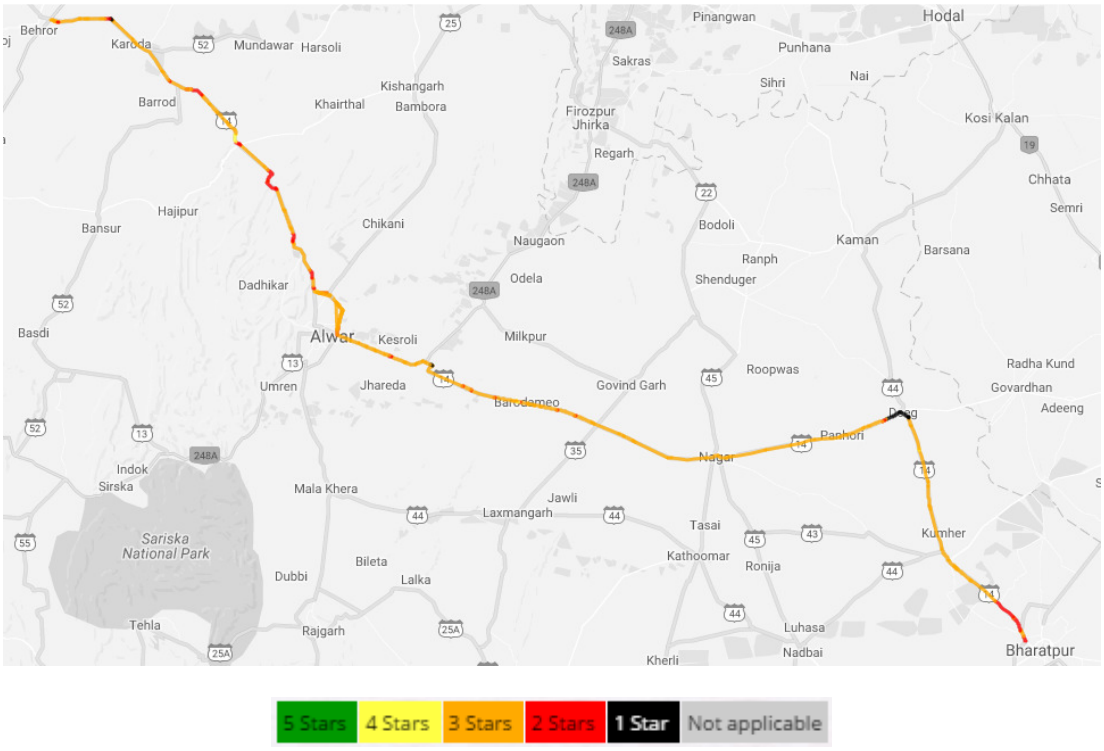


Figure B.5: Star Ratings for motorcyclists.

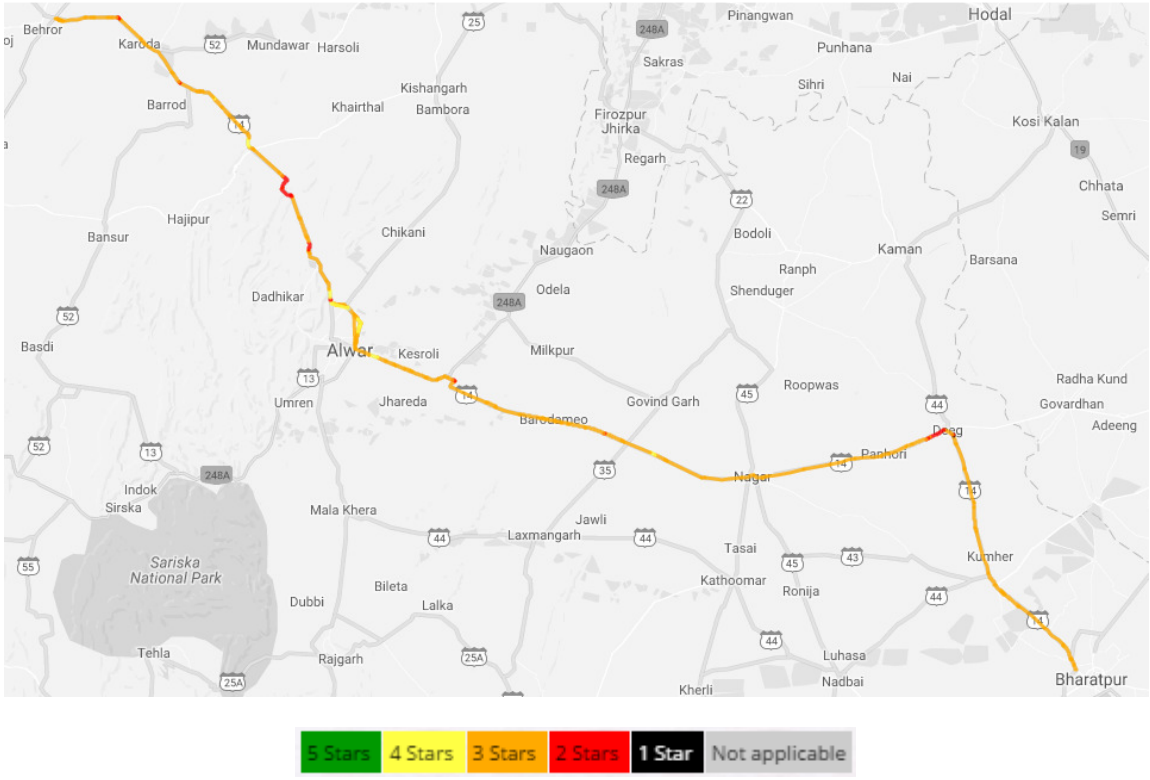


Figure B.6: Star Ratings for bicyclists.

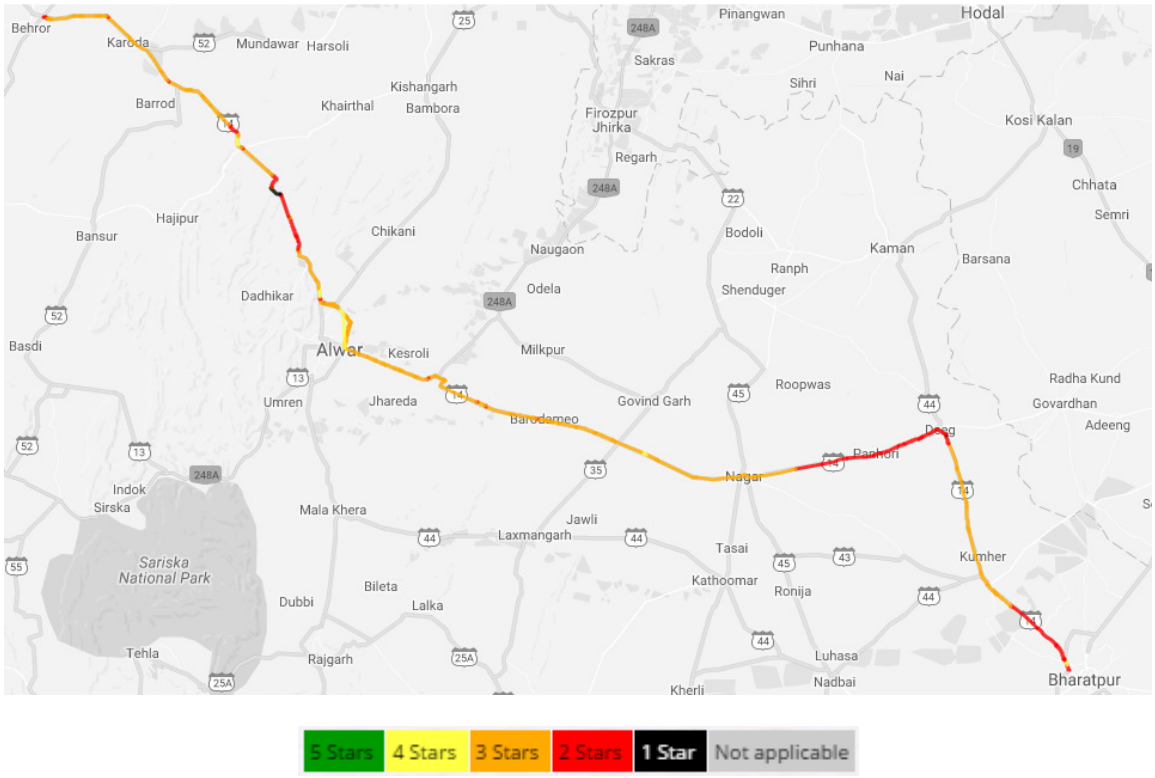


Figure B.7: Star Ratings for pedestrians.

C. Road Protection Scores – RPS (Corridor 2)

Figures C.1 and C.2 provide an example of how the RPS varies along one particular road section (in this case from Behror to Alwar). They illustrate the RPS for each transport mode on a selected roadway section. The following figures show raw and smoothed version to visualise Star Rating for each 100m in the section of 31km from Behror to Alwar:

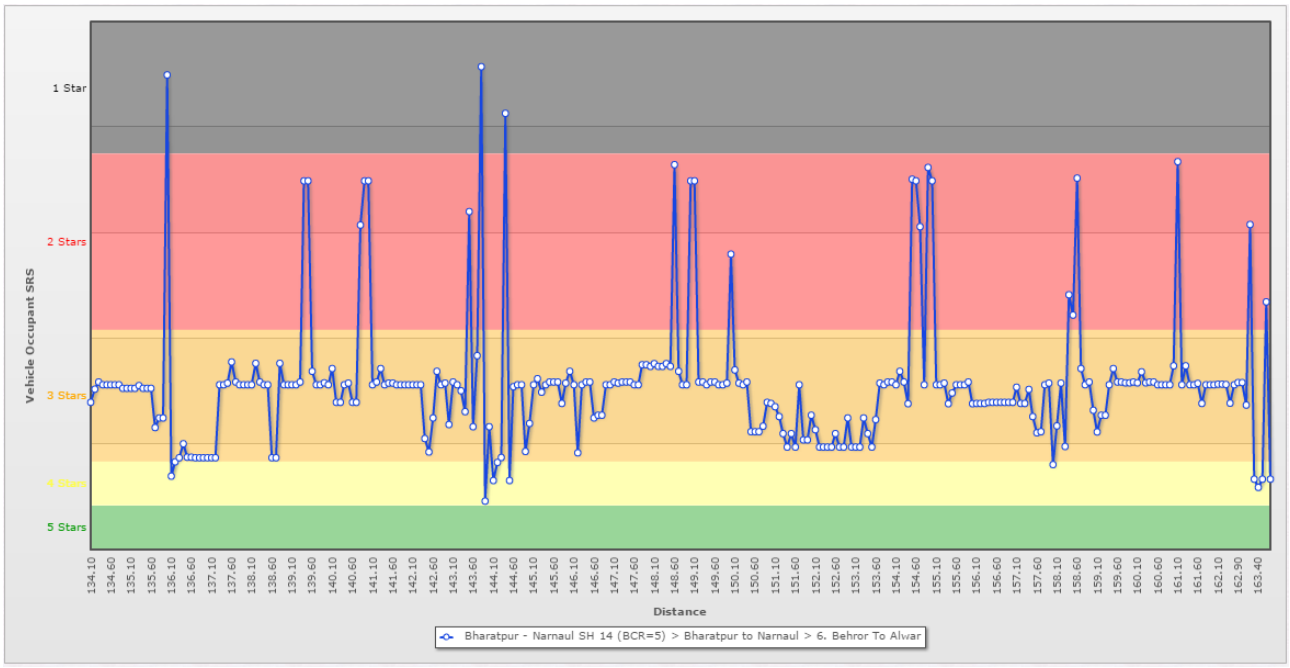


Figure C.1: RPS for vehicle occupants (Behror to Alwar) - Raw version

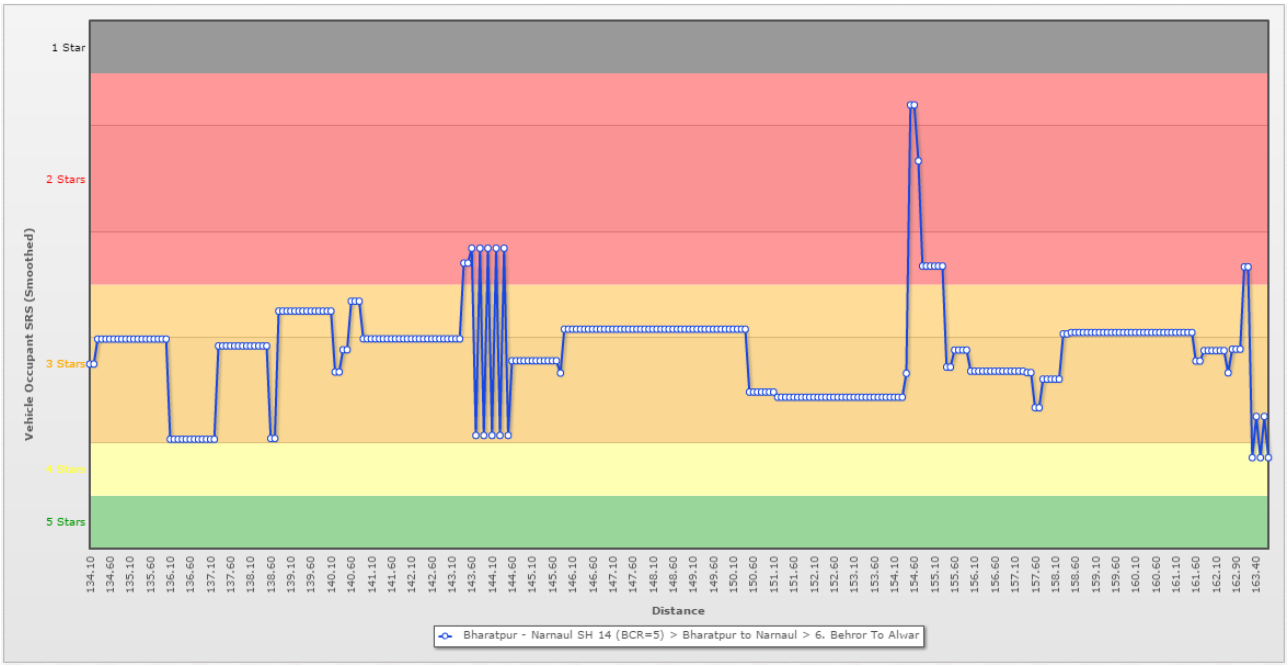


Figure C.2: RPS for vehicle occupants (Behror to Alwar) – Smoothed version

In these charts, a low RPS indicates a relatively low level of risk while a high RPS indicates a high level of risk. Star Rating bands are overlaid on the RPS charts, with the green band representing 5-stars (the locations with the most safety features) and the black band representing 1-star (the locations with the fewest safety features). More detailed information on the risk worm (raw and smoothed) is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/risk_worm).

D. Safer Road Investment Plans (Corridor 2)

• Number of deaths and serious injuries

Reported road deaths on surveyed road is 227 fatalities in the period from 2013 to 2015 (3 years), most of them motorcyclists (62%). Hence, the estimated number of fatalities on corridor SH-14Bharatpur to Narnaul per year is 75.7. According to First Information Reports (FIR) collected from police stations, the reported ratio of serious injuries to fatalities on that Rajasthan road is 4, thus it is estimated that a total of 378.3 fatalities and serious injuries per year occur on that corridor assessed in this project.

• Road Deaths on the Corridor 2 by Road User Type

In order to allocate deaths and serious injuries to the network, the IRAP model also requires the distribution of deaths by road user type. The proportion of deaths on the road by road user type was obtained following a review of data from First Information Reports (FIR).

Road user type	fatalities per year	Proportion of road deaths
Vehicle occupants	11,4	15%
Motorcyclists	46,9	62%
Pedestrians	16,6	22%
Bicyclists	0,8	1%
Total	**75,7**	**100%**

Table C.1: Road deaths on the corridor 2.

• Road sections

Each record has a section code. Section codes are used to group together 100-m segments for both processing and reporting purposes. Road sections are typically aligned with road authority inventory data, obvious changes in road condition or with obvious landmarks such as towns. For the purposes of this project, roads have been split into sections roughly according to important towns, traffic volumes and changes in road features.

Section number	Name of section	Length
1	Deeg to Bharatpur	32km
2	Alwar to Bharatpur	74km
3	Bypass Road	10km
4	Alwar By Pass road	2km
5	Towards Alwar	24km
6	Behror to Alwar	31km

Detailed road sections.

- ## Safer Road Investment Plans (Corridor 2)

Using inspection and supporting data with the IRAP methodology, a series of investment plan options have been produced for the roads that make up the study network. Different assumptions about the benefit-cost ratio (BCR) thresholds for safety improvements were found to be applicable as an example for Rajasthan demo corridor. Smaller BCR thresholds must be considered to develop an investment program of meaningful size and greater BCR thresholds to maximize the efficiency of the investments.

Candidate investment plans with differing BCR thresholds and differing investment levels have been developed. While a specific investment option is recommended, the ultimate decision on an appropriate investment level to improve safety rests with road authorities in Rajasthan. The table C.3 shows usual options for iRAP projects with an additional Option D for with an estimated cost lower than 50,000,000 ₹.

	Option A	Option B	Option C	Option D
Minimum benefit cost ratio	3	5	8	15
Investment (₹)	1,109,768,552	522,138,679	278,717,162	49,180,146
Economic benefit 20 years (₹)	5,878,574,227	4,246,166,964	3,239,854,612	1,180,279,986
Programme benefit cost ratio	5	8	12	24
Deaths (per year)				
Before countermeasures	75.7	75.7	75.7	75.7
After countermeasures	38.4	48.7	55.2	68.2
Prevented	37.3	26	20.5	7.5
Reduction	49.3%	35.6%	27.1%	9.9%
Deaths and serious injuries (20 years)				
Before countermeasures	7,566	7,566	7,566	7,566
After countermeasures	3,835	4,871	5,510	6817
Prevented	3,731	2,695	2,056	749
Reduction	49.3%	35.6%	27.1%	9.9%
Cost per death and serious injury prevented	75,927 ₹	53,254 ₹	135,545 ₹	65,652 ₹

Table C.3: Investment plan options for Corridor 2.

Countermeasure	Length/Sites	FSIs saved	PV of safety benefit	Estimated cost	Cost per FSI saved	Program BCR
Roadside barriers driver side	8.90km	224	353,570574	19,715,371	87,857	18
Central hatching	40.60km	199	313,991,899	12,247,796	61,459	26
Improve curve delineation	8.80km	154	242,954,759	4,575,894	29,675	53
Shoulder rumble strips	21.20km	86	134,937,925	5,116,321	59,740	26
Clear roadside hazards – drivers side	2.40km	45	71,410,484	4,493,000	99,133	16
Sight distance (obstruction removal)	0.80km	28	44,708,483	1,840,000	64,844	24
Pedestrian fencing	0,10km	5	8,293,898	500,000	94,985	17
Street lighting (mid-block)	0.10km	4	5,584,257	365,364	103,087	15
Footpath provision passenger side (adjacent to road)	0.30km	3	4,827,706	326,400	106,526	15
	TOTAL	**749**	**1,180,279,986**	**49,180,146**	**65,652**	**24**

TableC.4: Countermeasures options for safer roads investment plan (Option D)

Corridor 3: Jaipur – Nagaur

State Highway – SH-90 between Jaipur and Nagaur is a two-lane carriageway. The project road starts from Km.64 000 and ends at Km. 189.600 of SH-90, thus making a total length of 125.600kms. The project corridor passes through four major town's viz., Jobner, Kuchaman, Khatu, Tarnau. The project corridor generally passes through plains terrain. Three toll plazas are in operation on the project corridor.

A. Road Condition (Corridor 3)

The following is a summary of the condition of the inspected road (Jaipur-Nagaur) included in the IRAP models. More detailed reports on the road condition are available in the IRAP online software (https://vida.IRAP.org/es/results/star_rating/map) and in the Annexure 1.

Key elements for all transport modes of corridor 3 are listed in the following snapshots.

Figure A.1 Combination of pedestrians and real traffic speed > 40km/h

Figure A.2 Combination of bicyclists and real traffic speed > 40km/h

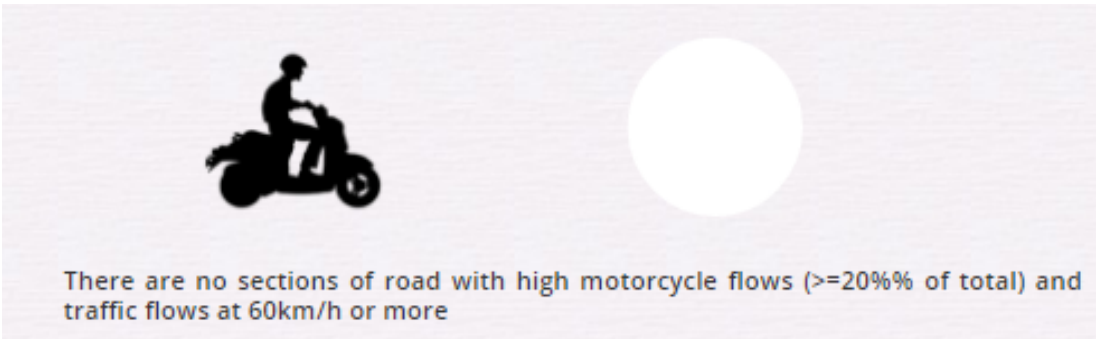


Figure A.3 Combination of motorcyclists and real traffic speed > 60km/h

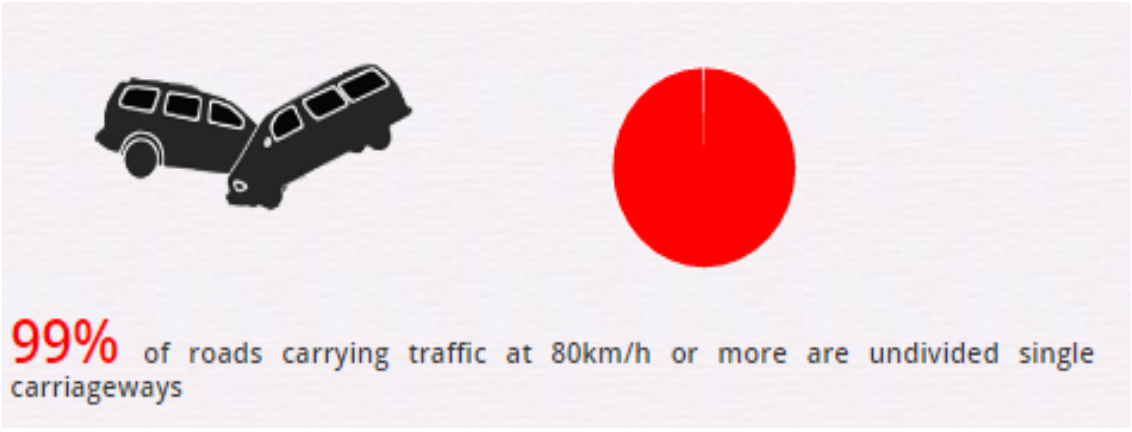


Figure A.4 Combination of type of road and real traffic speed > 80km/h

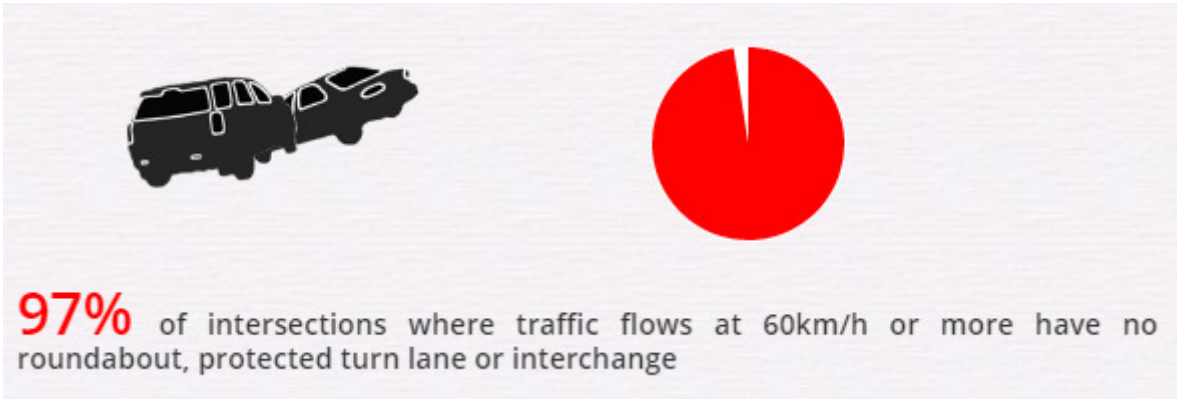


Figure A.5 Combination of type of intersection and real traffic speed > 60km/h

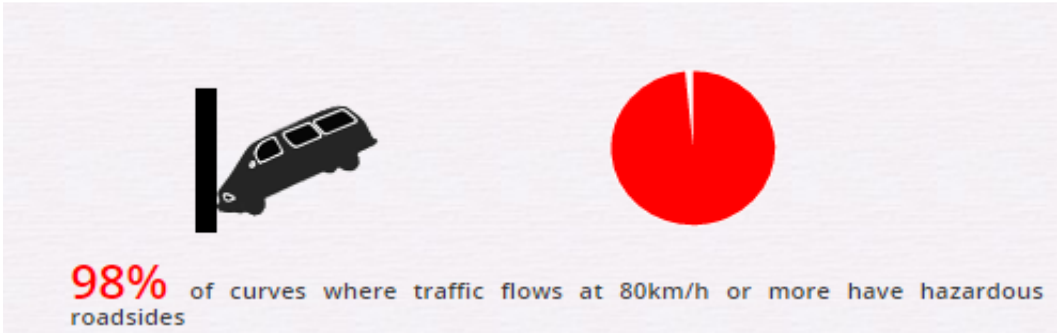


Figure A.6 Combination of hazardous roadsides and real traffic speed > 80km/h

Real traffic speed

Operating Speed (85th percentile)	km	%
80km/h	126.10	100

Operating Speed (mean)	km	%
60km/h	126.10	100

Figure A.7 Real traffic speed in corridor 3.

The project evaluates 50 road infrastructure features included in the iRAP models. However, real traffic speed is a key attribute for measuring the likelihood of a road crash occurring and its severity. The data collected on site is used in estimating the 85th percentile and mean speed adjustment factors for that corridor:

B. Star Ratings (Corridor 3)

The overall Star Ratings for the roads assessed is shown in Table B.1 and B.2:

	Vehicle Occupant		Motorcyclist		Pedestrian	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%	0.00	0%
4 Stars	0.00	0%	0.00	0%	0.20	0%
3 Stars	105.60	84%	86.30	68%	86.50	69%
2 Stars	19.30	15%	31.50	25%	39.40	31%
1 Star	1.20	1%	8.30	7%	0.00	0%
Not applicable	0.00	0%	0.00	0%	0.00	0%
Totals	126.10	100%	126.10	100%	126.10	100%

Table B.1: Overall Star Ratings for vehicle occupants and motorcyclist in Corridor 3.

	Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.20	0%	0.00	0%
3 Stars	86.50	69%	104.40	83%
2 Stars	39.40	31%	21.10	17%
1 Star	0.00	0%	0.60	0%
Not applicable	0.00	0%	0.00	0%
Totals	126.10	100%	126.10	100%

Table B.2: Overall Star Ratings for bicyclists and pedestrians in Corridor 3.

The same information about Star Ratings for vehicle occupants, motorcyclists, pedestrians and bicyclists together in the following chart provided by ViDA software:

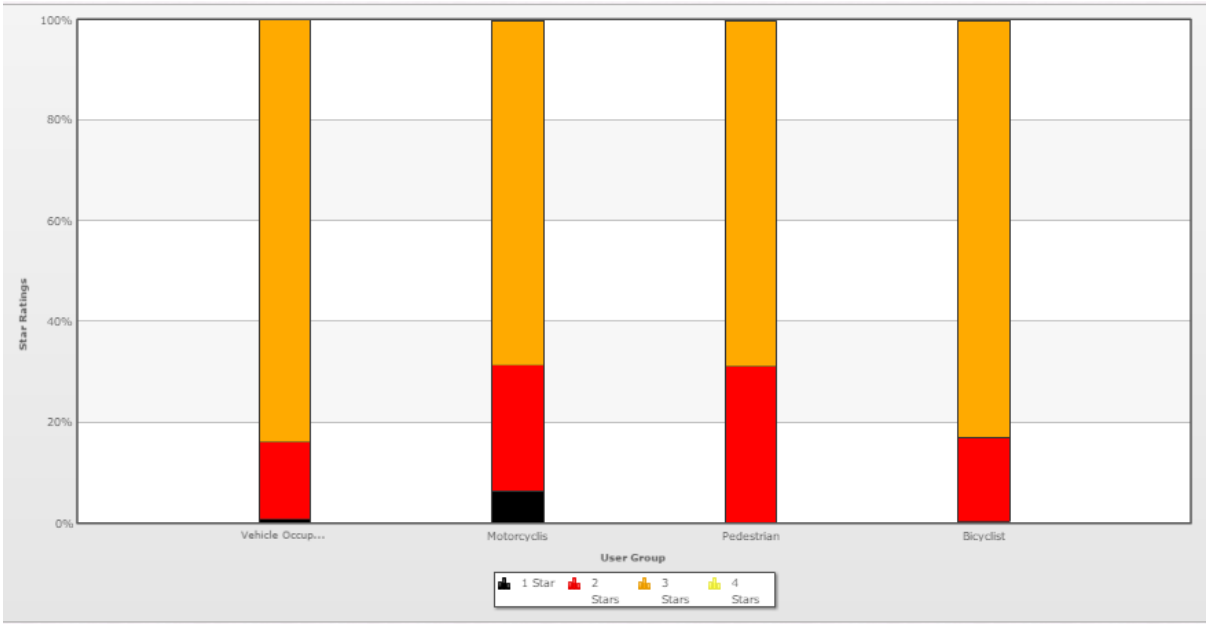


Figure B.3: Chart of smoothed Star Ratings for each transport mode in corridor 3.

Figures B.4 and B.5 illustrate the Star Ratings for Corridor 3 in map for vehicle occupants, motorcyclists bicyclists and pedestrians. More detailed information on the star ratings is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/map).

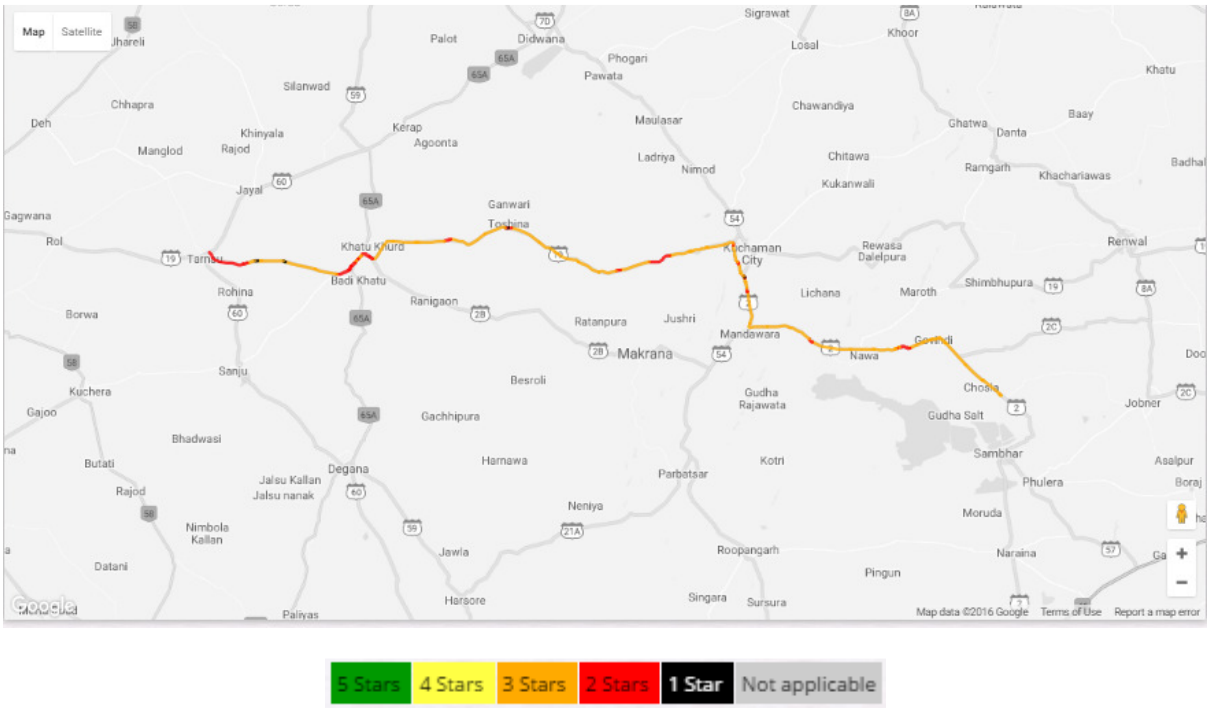
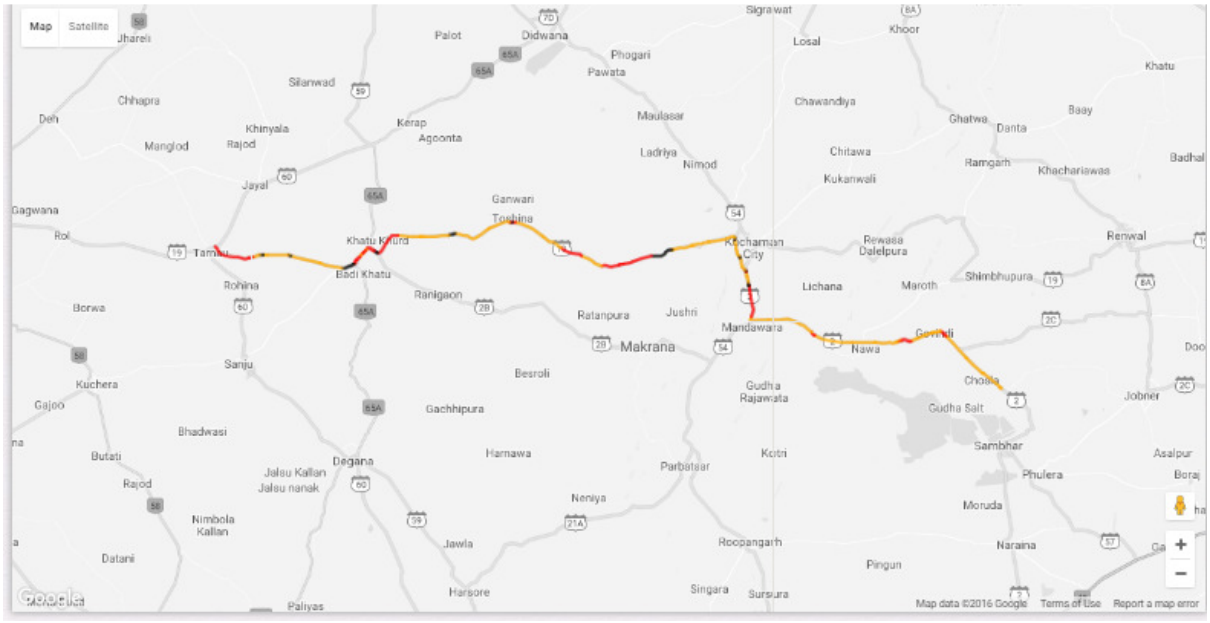
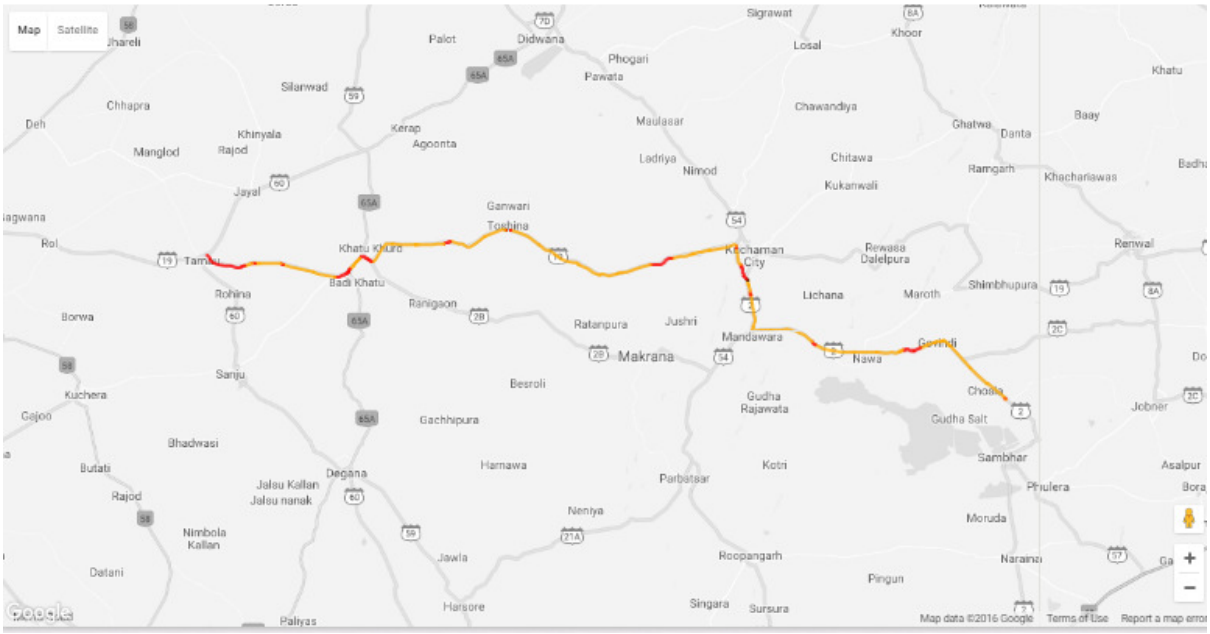


Figure B.4: Star Ratings for vehicle occupants.



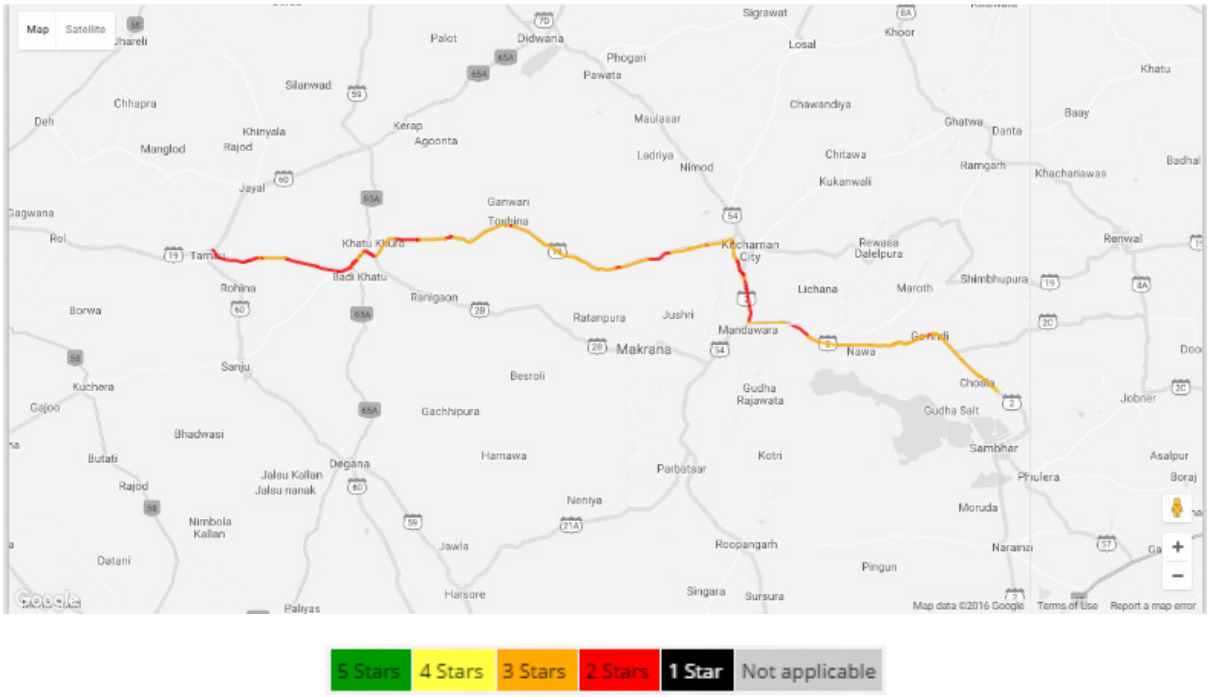
5 Stars | 4 Stars | 3 Stars | 2 Stars | 1 Star | Not applicable

Figure B.5: Star Ratings for motorcyclists.



5 Stars | 4 Stars | 3 Stars | 2 Stars | 1 Star | Not applicable

Figure B.6: Star Ratings for bicyclists.



5 Stars | 4 Stars | 3 Stars | 2 Stars | 1 Star | Not applicable

Figure B.7: Star Ratings for pedestrians.

C. Road Protection Scores – RPS (Corridor 3)

Figures C.1 and C.2 provide an example of how the RPS varies along one particular road section (in this case from Jobner to Nagaur). They illustrate the RPS for each transport mode on a selected roadway section. The following figures show raw and smoothed version to visualise Star Rating for each 100m in the section of 68km from Jobner to Nagaur:

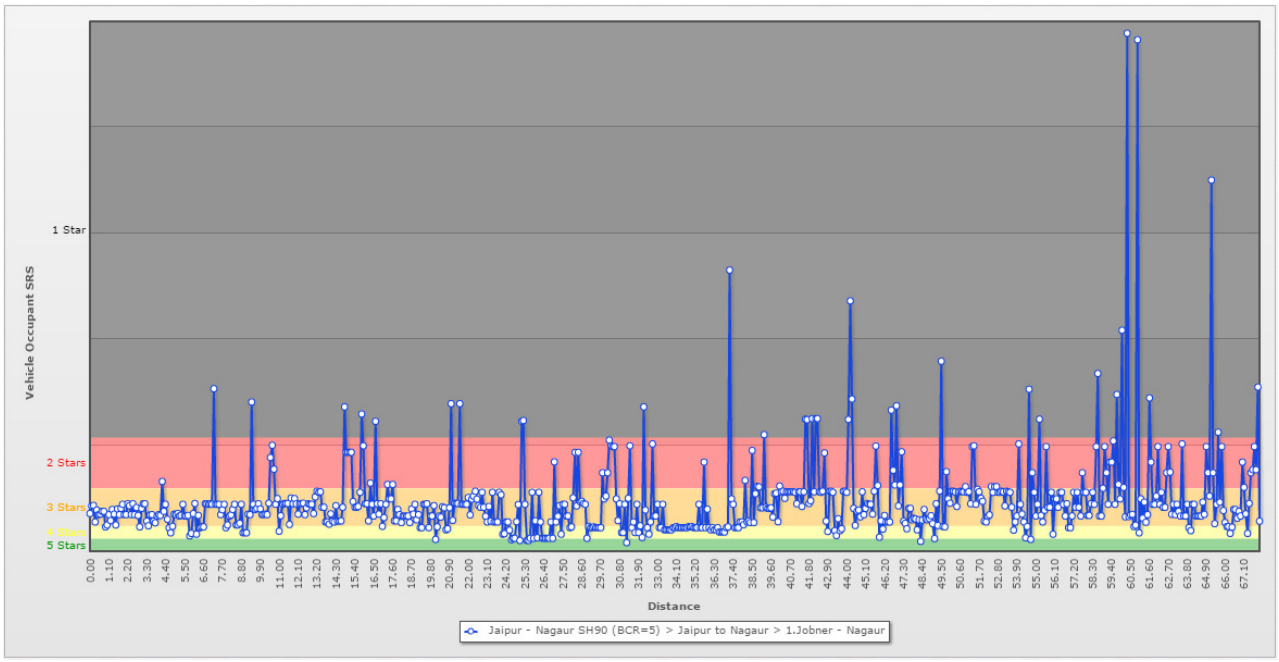


Figure C.1: RPS for vehicle occupants (Jobner to Nagaur) - Raw version

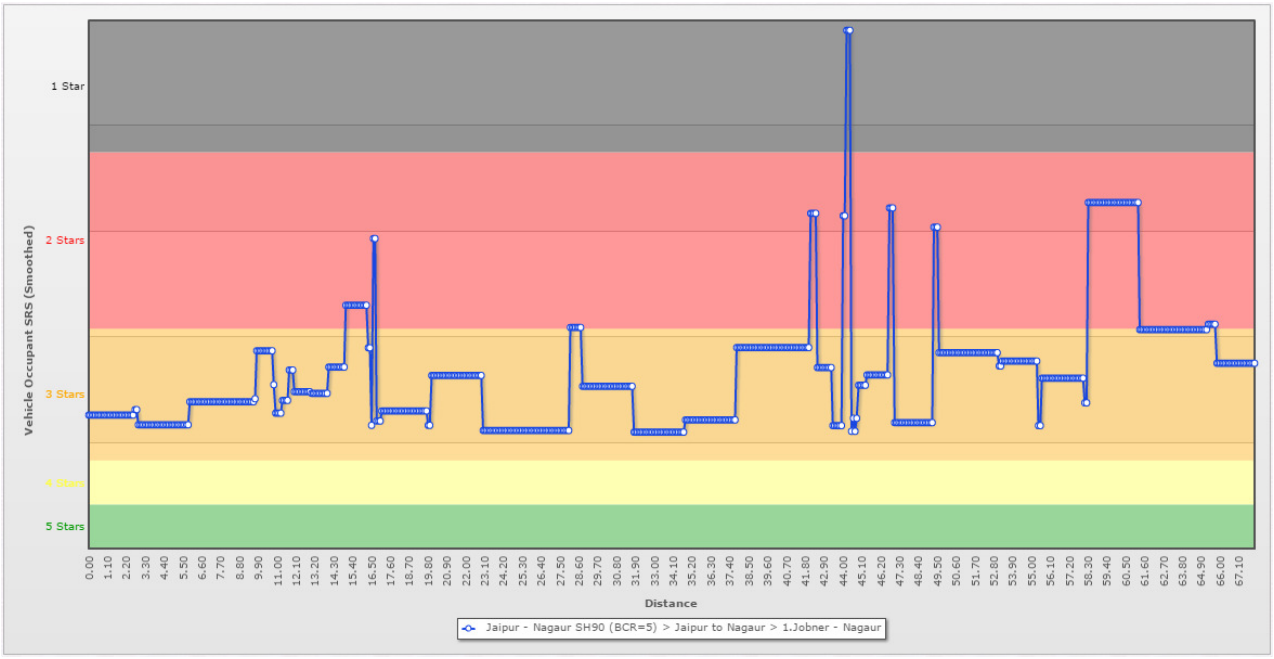


Figure C.2: RPS for vehicle occupants (Jobner to Nagaur) – Smoothed version

In these charts, a low RPS indicates a relatively low level of risk while a high RPS indicates a high level of risk. Star Rating bands are overlaid on the RPS charts, with the green band representing 5-stars (the locations with the most safety features) and the black band representing 1-star (the locations with the fewest safety features). More detailed information on the risk worm (raw and smoothed) is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/risk_worm).

D. Safer Road Investment Plans (Corridor 3)

• Number of deaths and serious injuries

Reported road deaths on surveyed road is 49 fatalities in the period from 2013 to 2015 (3 years), most of them motorcyclists (63%). Hence, the estimated number of fatalities on corridor SH-90 Jaipur to Nagaur per year is 16.3. According to First Information Reports (FIR) collected from police stations, the reported ratio of serious injuries to fatalities on that Rajasthan road is 4, thus it is estimated that a total of 81.5 fatalities and serious injuries per year occur on that corridor assessed in this project.

• Road deaths on the corridor 3 by road user type

In order to allocate deaths and serious injuries to the network, the IRAP model also requires the distribution of deaths by road user type. The proportion of deaths on the road by road user type was obtained following a review of data from First Information Reports (FIR).

Road user type	Estimated fatalities per year	Proportion of road deaths
Vehicle occupants	3.7	23%
Motorcyclists	10.3	63%

Road user type	Estimated fatalities per year	Proportion of road deaths
Pedestrians	2.3	14%
Bicyclists	0.0	0%
Total	**16.3**	**100%**

Table D.1: Road deaths on the Corridor 3.

• Road sections

Each record has a section code. Section codes are used to group together 100-m segments for both processing and reporting purposes. Road sections are typically aligned with road authority inventory data, obvious changes in road condition or with obvious landmarks such as towns. For the purposes of this project, roads have been split into sections roughly according to important towns, traffic volumes and changes in road features.

Section number	Name of section	Length
1	Jobner to Nagaur	68km
2	Budsu to Nagaur	58km

Table D.2: Detailed road sections.

• Investment Plans (Corridor 3)

Using inspection and supporting data with the IRAP methodology, a series of investment plan options have been produced for the roads that make up the study network. Different assumptions about the benefit-cost ratio (BCR) thresholds for safety improvements were found to be applicable as an example for Rajasthan demo corridor. Smaller BCR thresholds must be considered to develop an investment program of meaningful size and greater BCR thresholds to maximize the efficiency of the investments.

Candidate investment plans with differing BCR thresholds and differing investment levels have been developed. While a specific investment option is recommended, the ultimate decision on an appropriate investment level to improve safety rests with road authorities in Rajasthan. The table C.3 shows usual options for iRAP projects with additional column with minimum BCR = 6 because meet the objective of an economic investment lower than 50,000,000 ₹.

	Option A	Option B	Option C	Option D
Minimum benefit cost ratio	3	5	6	8
Investment (₹)	90,132,329	65,672,094	46,097,598	16,100,173
Economic benefit 20 years (₹)	540,046,019	495,097,039	388,712,080	223,819,260
Programme benefit cost ratio	6	8	8	14
Deaths (per year)				
Before countermeasures	16.3	16.3	16.3	16.3
After countermeasures	12.9	13.2	13.9	14.9
Prevented	3.4	3.1	2.4	1.4
Reduction	21.0%	19.2%	15.1%	8.7%
Deaths and serious injuries (20 years)				
Before countermeasures	1,630	1,630	1,630	1,630
After countermeasures	1,287	1,316	1,383	1,488
Prevented	343	314	247	142
Reduction	21.0%	19.2%	15.1%	8.7%
Cost per death and serious injury prevented	262,963 ₹	208,995 ₹	186,851 ₹	113,339 ₹

Investment plan options for Corridor 3.

Countermeasure	Length/Sites	FSIs saved	PV of safety benefit	Estimated cost	Cost per FSI saved	Program BCR
Improve curve delineation	19.30km	96	151,264,602	8,981,274	93,550	17
Central median barrier (1+1)	6.40km	76	120,047,716	20,509,225	269,179	6
Central hatching	43.90km	57	89,477,538	13,243,307	233,199	7
Roadside barriers – passenger side	0.60km	7	10,837,158	1,245,267	181,047	9
Shoulder rumble strips	4.50km	6	9,537,800	1,086,011	179,404	9
Skid resistance (paved road)	0.10km	2	3,165,979	421,682	209,856	8
Improve delineation	0.30km	1	2,302,165	219,831	150,452	10
Clear roadside hazards – passenger side	0.20km	1	2,079,123	391,000	296,307	5
	TOTAL	**247**	**388,712,080**	**46,097,598**	**186,851**	**8**

Countermeasures options for safer roads investment plan (Option C)

Corridor 4: Deoli to Triveni

Major District Road – MDR 7 between Triveni Chowraya to Deoli is a Two-Lane Carriageway. The project road starts from Km 0.000 and ends at Km 75.000 of MDR-7, thus making a Total Length of 75km. The project corridor passes through five major towns' viz., Bilod, Mandalgarh, Kachola, Sakkargarhand, and Jahazpur. The project corridor generally passes through plains terrain.

A. Road Condition (Corridor 4)

The following is a summary of the condition of the inspected road (Deoli to Triveni) included in the IRAP models. More detailed reports on the road condition are available in the IRAP online software (https://vida.IRAP.org/es/results/star_rating/map) and in the Annexure 1.

Key elements for all transport modes of corridor 4 are listed in the following snapshots.

Figure A.1 Combination of pedestrians and real traffic speed > 40km/h

Figure A.2 Combination of bicyclists and real traffic speed > 40km/h

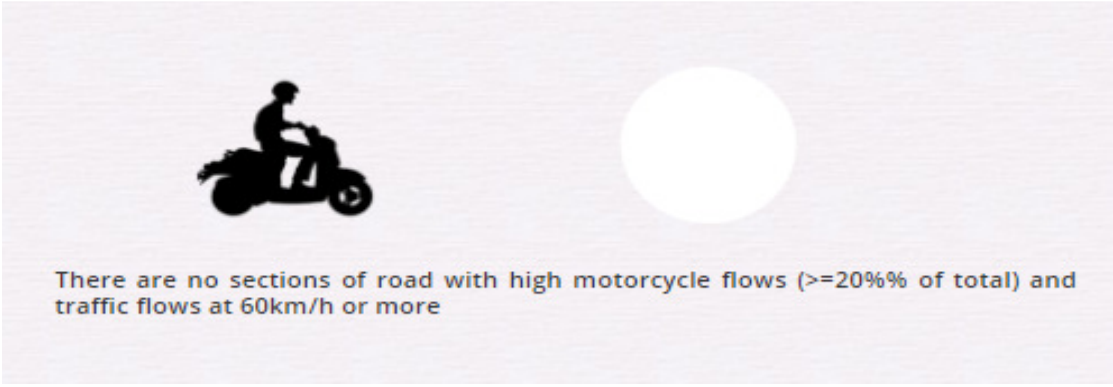


Figure A.3 Combination of motorcyclists and real traffic speed > 60km/h

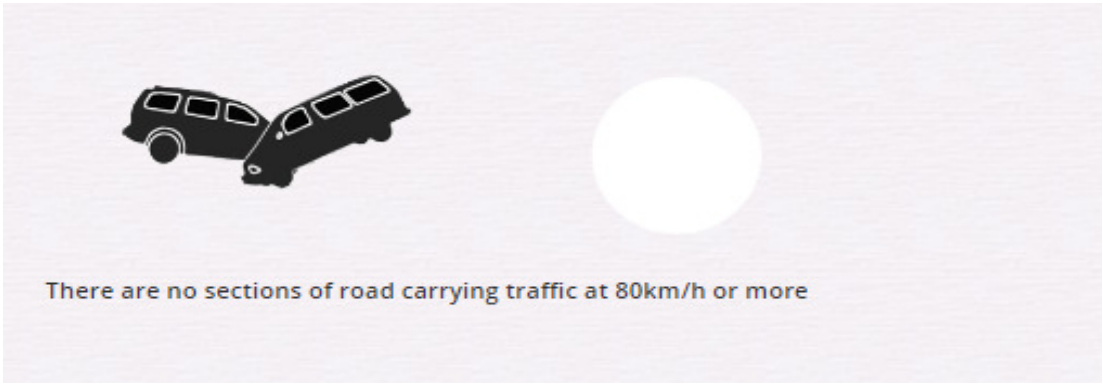


Figure A.4 Combination of type of road and real traffic speed > 80km/h

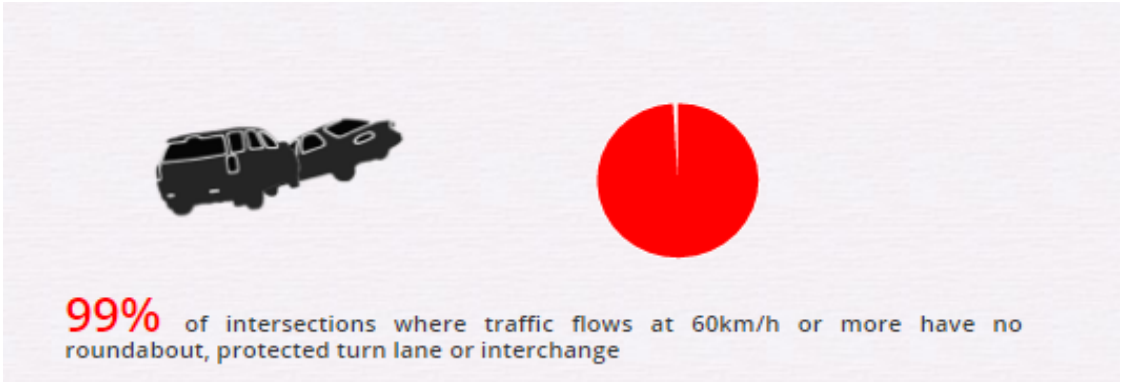


Figure A.5 Combination of type of intersection and real traffic speed > 60km/h

Figure A.6 Combination of hazardous roadsides and real traffic speed > 80km/h

The project evaluates 50 road infrastructure features included in the iRAP models. However, real traffic speed is a key attribute for measuring the likelihood of a road crash occurring and its severity. The data collected on site is used in estimating the 85th percentile and mean speed adjustment factors for that corridor:

Real traffic speed

Operating Speed (85th percentile)	km	%
70km/h	75.00	100

Operating Speed (mean)	km	%
45km/h	25.10	33
50km/h	49.90	67

Figure A.7 Real traffic speed in corridor 4.

B. Star Ratings (Corridor 4)

The overall Star Ratings for the roads assessed is shown in Table B.1 and B.2:

	Vehicle Occupant		Motorcyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.70	1%	0.40	1%
3 Stars	67.80	90%	64.10	85%
2 Stars	6.50	9%	9.60	13%
1 Star	0.00	0%	0.90	1%
Not applicable	0.00	0%	0.00	0%
Totals	75.00	100%	75.00	100%

Table B.1: Overall Star Ratings for vehicle occupants and motorcyclist in Corridor 4.

	Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.00	0%	0.00	0%
3 Stars	70.70	94%	71.60	95%
2 Stars	4.30	6%	3.40	5%
1 Star	0.00	0%	0.00	0%
Not applicable	0.00	0%	0.00	0%
Totals	75.00	100%	75.00	100%

Table B.2: Overall Star Ratings for bicyclists and pedestrians in Corridor 4.

The same information about Star Ratings for vehicle occupants, motorcyclists, pedestrians and bicyclists together in the following chart provided by ViDA software:

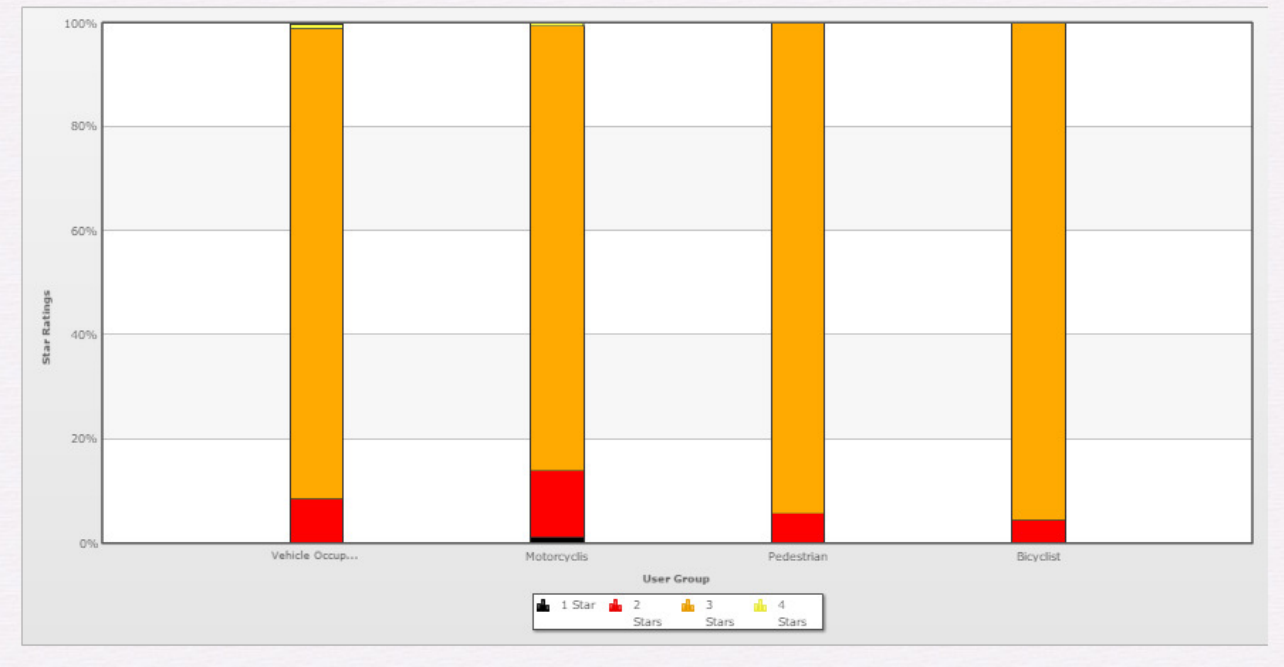
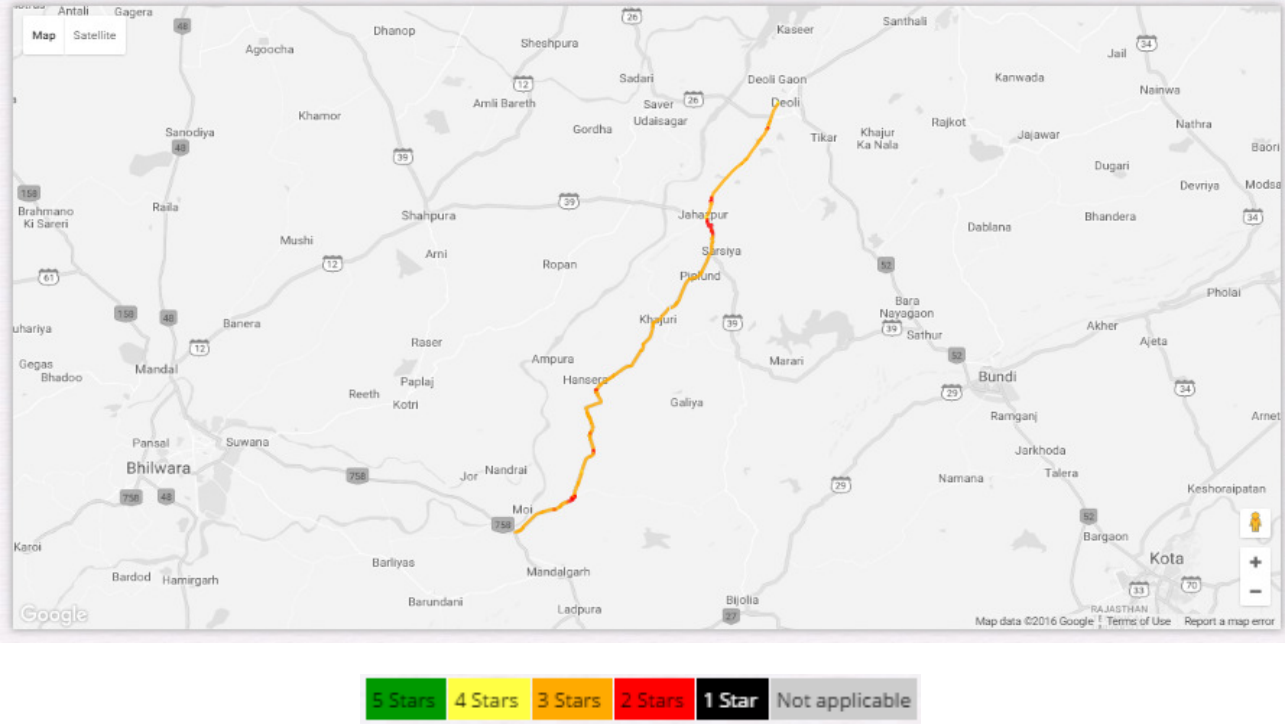


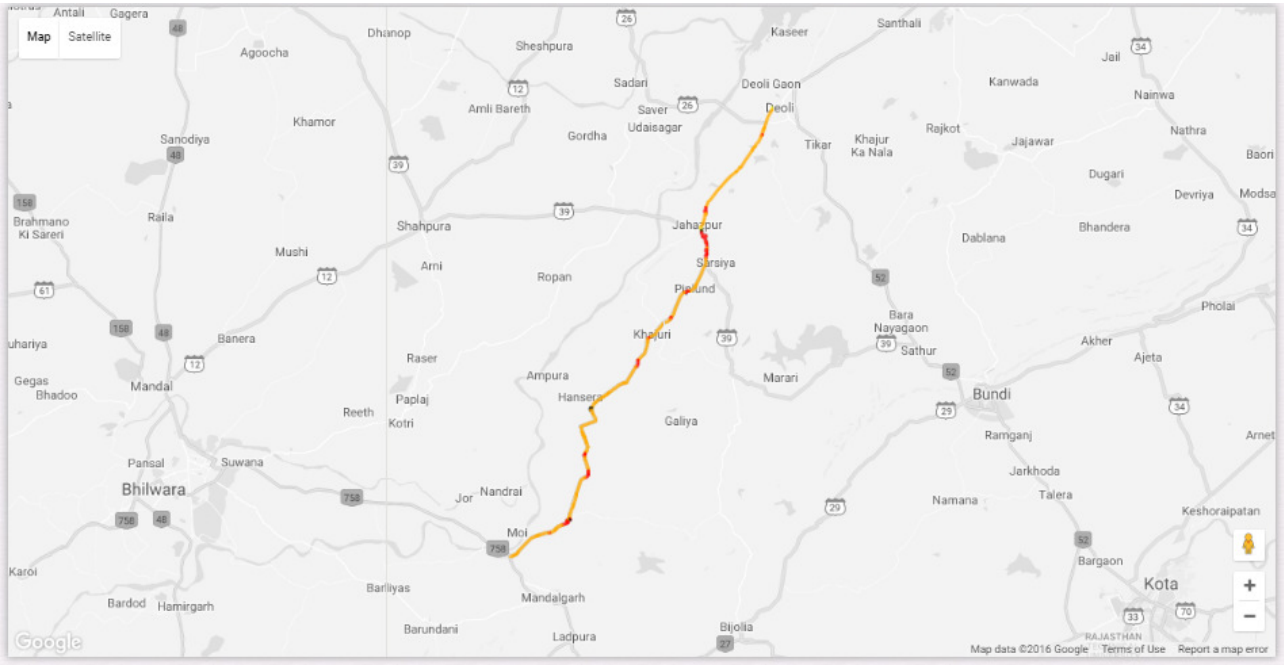
Figure B.3: Chart of smoothed Star Ratings for each transport mode in corridor 4.

Figures B.4 and B.5 illustrate the Star Ratings for Corridor 4 in map for vehicle occupants, motorcyclists bicyclists and pedestrians. More detailed information on the star ratings is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/map).



5 Stars | 4 Stars | 3 Stars | 2 Stars | 1 Star | Not applicable

Figure B.4: Star Ratings for vehicle occupants.



5 Stars | 4 Stars | 3 Stars | 2 Stars | 1 Star | Not applicable

Figure B.5: Star Ratings for motorcyclists.

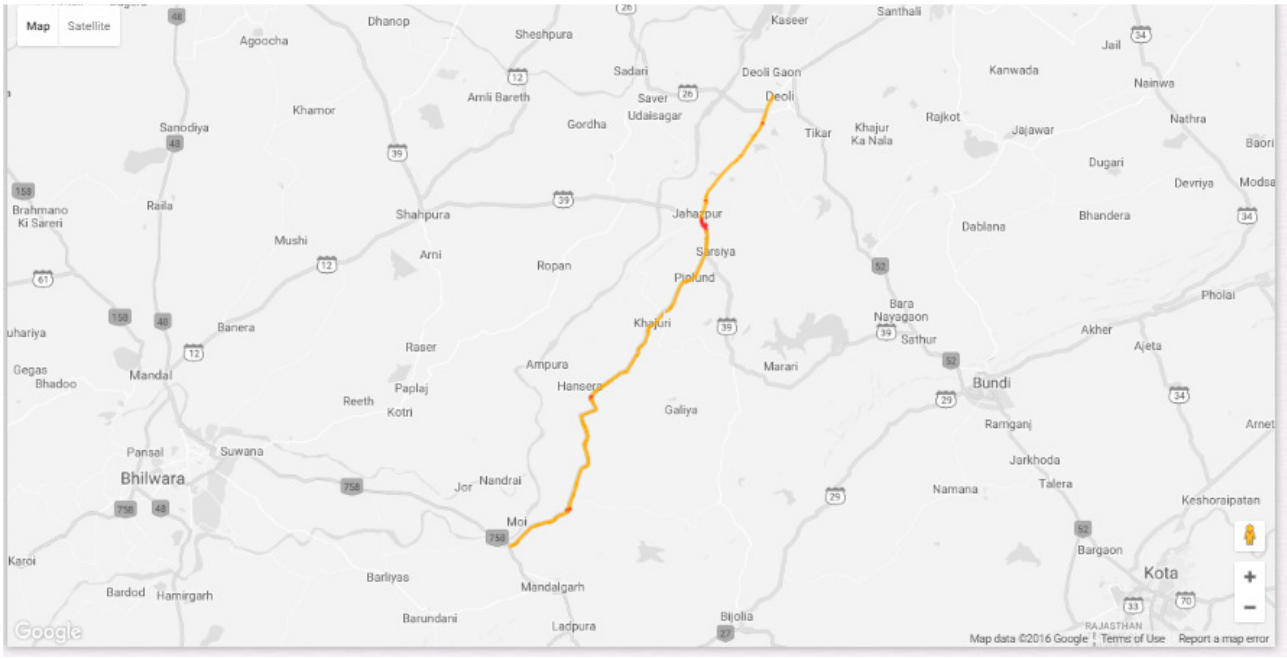


Figure B.6: Star Ratings for bicyclists.

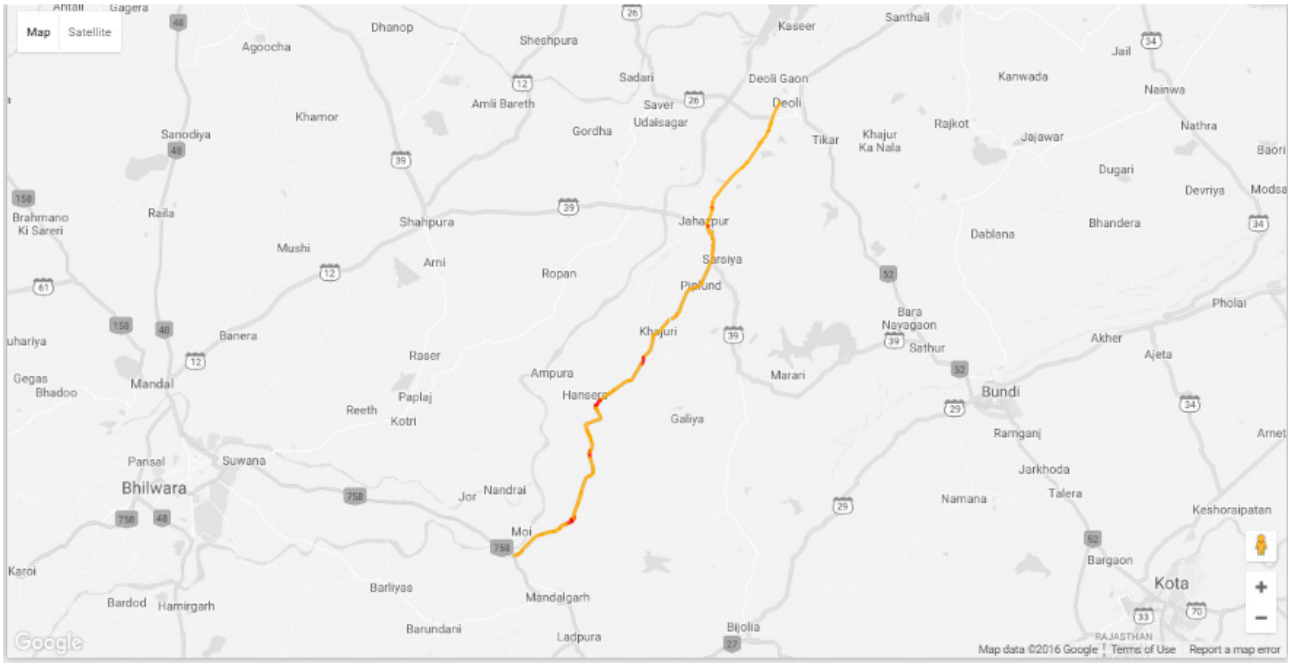


Figure B.7: Star Ratings for pedestrians.

C. Road Protection Scores – RPS (Corridor 4)

Figures C.1 and C.2 provide an example of how the RPS varies along one particular road section (in this case from Jahazpur to Mandalgarh). They illustrate the RPS for each transport mode on a selected roadway section. The following figures show raw and smoothed version to visualise Star Rating for each 100m in the section of 38km from Jahazpur to Mandalgarh:

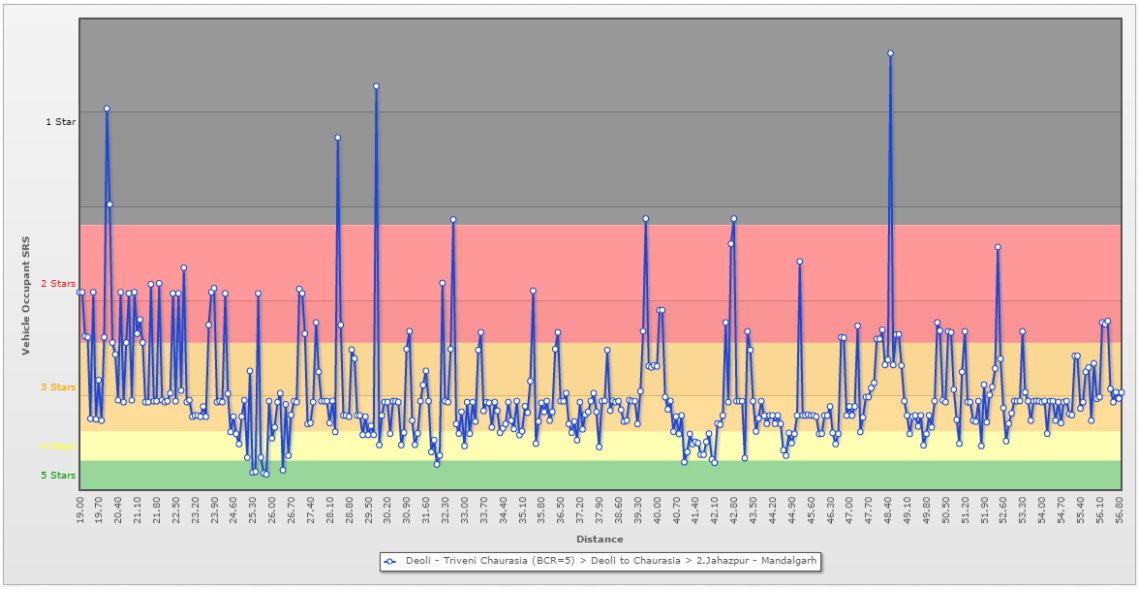


Figure C.1: RPS for vehicle occupants (Jahazpur to Mandalgarh) - Raw version

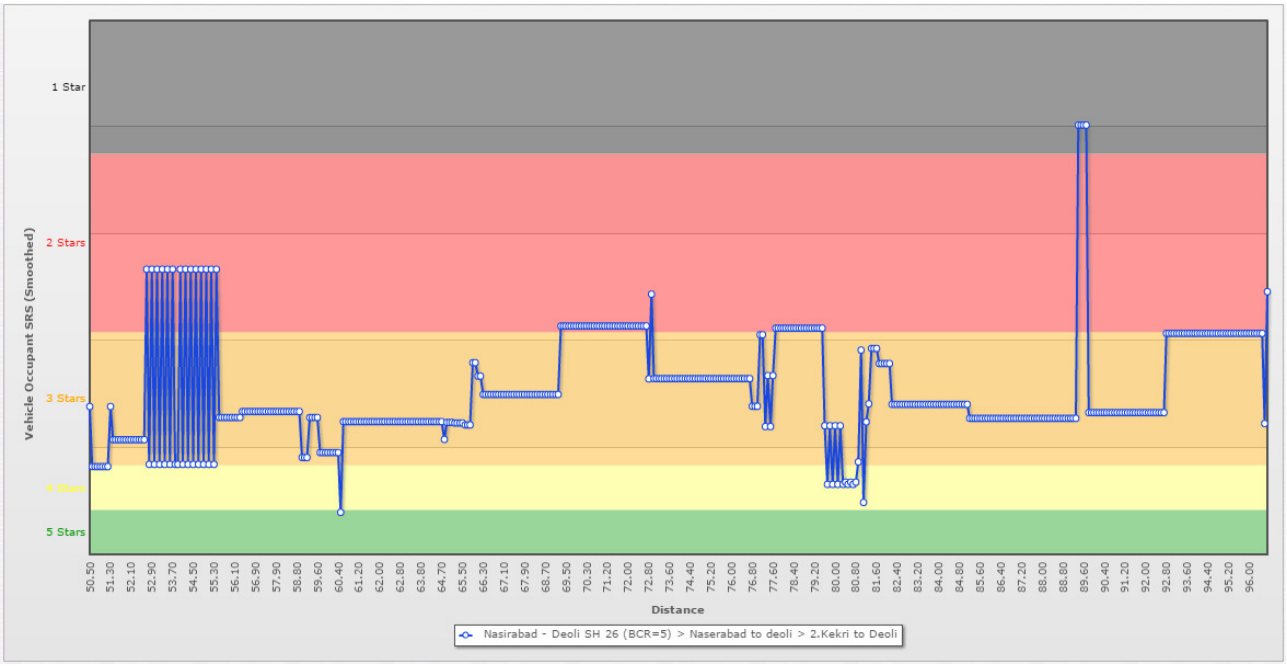


Figure C.2: RPS for vehicle occupants (Jahazpur to Mandalgarh) – Smoothed version

In these charts, a low RPS indicates a relatively low level of risk while a high RPS indicates a high level of risk. Star Rating bands are overlaid on the RPS charts, with the green band representing 5-stars (the locations with the most safety features) and the black band representing 1-star (the locations with the fewest safety features). More detailed information on the risk worm (raw and smoothed) is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/risk_worm).

D. Safer Road Investment Plans (Corridor 4)

• Number of deaths and serious injuries

Reported road deaths on surveyed road is 53 fatalities in the period from 2013 to 2015 (3 years), most of them motorcyclists (62%). Hence, the estimated number of fatalities on corridor MDR-7 Deoli to Triveni Chaurasia per year is 17.7. According to First Information Reports (FIR) collected from police stations, the reported ratio of serious injuries to fatalities on that Rajasthan road is 4, thus it is estimated that a total of 88.5 fatalities and serious injuries per year occur on that corridor assessed in this project.

• Road deaths on the corridor 4 by road user type

In order to allocate deaths and serious injuries to the network, the IRAP model also requires the distribution of deaths by road user type. The proportion of deaths on the road by road user type was obtained following a review of data from First Information Reports (FIR).

Road user type	Estimated fatalities per year	Proportion of road deaths
Vehicle occupants	3.5	20%
Motorcyclists	11.0	62%
Pedestrians	3.2	18%
Bicyclists	0.0	0%
Total	**17.8**	**100%**

Table C.1: Road deaths on the Corridor 4.

• Road sections

Each record has a section code. Section codes are used to group together 100-m segments for both processing and reporting purposes. Road sections are typically aligned with road authority inventory data, obvious changes in road condition or with obvious landmarks such as towns. For the purposes of this project, roads have been split into sections roughly according to important towns, traffic volumes and changes in road features.

Section number	Name of section	Length
1	Towards Mandalgarh	19km
2	Jahazpur – Mandalgarh	38km
3	Deoli – Mandalgarh	18km

Detailed road sections.

• Safer Road Investment Plans (Corridor 4)

Using inspection and supporting data with the IRAP methodology, a series of investment plan options have been produced for the roads that make up the study network. Different assumptions about the benefit-cost ratio (BCR) thresholds for safety improvements were found to be applicable as an example for Rajasthan demo corridor. Smaller BCR thresholds must be considered to develop an investment program of meaningful size and greater BCR thresholds to maximize the efficiency of the investments.

Candidate investment plans with differing BCR thresholds and differing investment levels have been developed. While a specific investment option is recommended, the ultimate decision on an appropriate investment level to improve safety rests with road authorities in Rajasthan. The table C.3 shows usual options for iRAP projects. Option C is optimal for an estimated cost around 50,000,000 ₹, because a minimum BCR = 7 has an investment plan of 53.000.000₹ with an estimated FSIs prevented of 390.

	Option A	Option B	Option C
Minimum benefit cost ratio	3	5	8
Investment (₹)	336,473,440	87,099,988	38,163,387
Economic benefit 20 years (₹)	1,667,899,802	824,502,210	528,331,552
Programme benefit cost ratio	5	9	14
Deaths (per year)			
Before countermeasures	17.7	17.7	17.7
After countermeasures	7.1	12.5	14.3
Prevented	10.6	5.2	3.4
Reduction	59.8%	29.5%	18.9%
Deaths and serious injuries (20 years)			
Before countermeasures	1,770	1,770	1,770
After countermeasures	711	1,247	1,435
Prevented	1,059	523	335
Reduction	59.8%	29.5%	18.9%
Cost per death and serious injury prevented	317,853 ₹	166,445 ₹	113,811 ₹

Investment plan options for Corridor 4.

Countermeasure	Length/Sites	FSIs saved	PV of safety benefit	Estimated cost	Cost per FSI saved	Program BCR
Central hatching	59.80km	139	219,565,723	18,039,858	129,453	12
Improve curve delineation	6.00km	67	106,083,288	2,845,820	42,267	37
Shoulder rumble strips	27.50km	55	87,288,195	6,636,737	119,797	13
Central median barrier (1+1)	1.50km	35	54,944,527	4,704,750	134,914	12
Clear roadside hazards – driver side	1.70km	14	22,388,767	2,628,000	184,944	9
Pedestrian fencing	0.20km	8	12,468,660	1,000,000	126,365	12
Skid resistance (paved road)	0.10km	5	8,118,428	388,249	75,350	21
Improve delineation	0.40km	3	4,026,282	479,631	187,693	8
Roadside barriers – drivers side	0.20km	3	4,226,026	415,089	177,404	9
Roadside barriers – passenger side	0.20km	2	3,686,573	415,089	177,404	9
Street lighting (mid – block)	0.10km	1	1,336,211	153,000	180,410	8
	TOTAL	**335**	**719,182,286**	**50,953,464**	**111,630**	**14**

Countermeasures options for safer roads investment plan (Option C)

Corridor 5: Salamber to Keer Ki Chouki

State Highway – SH 53 between Keer Ki Chowki to Salamber is a Two-Lane Carriageway. The project road starts from Km 12.000 and ends at Km 85.000 of SH 53, thus making a Total Length of 73km. The project corridor passes through two major towns' viz., Bhindar and Khurabad. The project corridor generally passes through plains terrain. Two toll plazas are in operation on the project corridor.

A. Road Condition (Corridor 5)

The following is a summary of the condition of the inspected road (Keer Ki Chowki to Salamber) included in the IRAP models. More detailed reports on the road condition are available in the IRAP online software (https://vida.IRAP.org/es/results/star_rating/map) and in the Annexure 1.

Key elements for all transport modes of Corridor 5 are listed in the following snapshots.

Figure A.1 Combination of pedestrians and real traffic speed > 40km/h

Figure A.2 Combination of bicyclists and real traffic speed > 40km/h

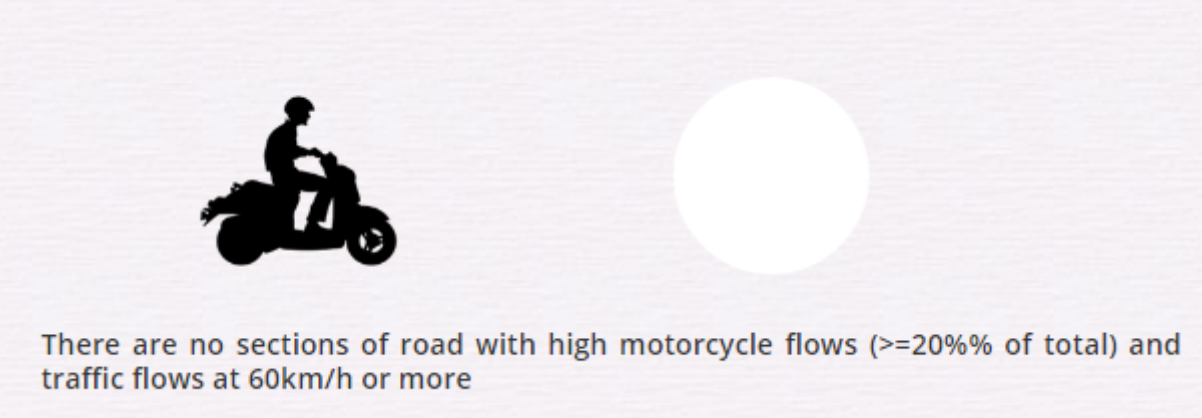


Figure A.3 Combination of motorcyclists (flow>%20%) and real traffic speed > 60km/h

Figure A.4 Combination of type of road and real traffic speed > 80km/h

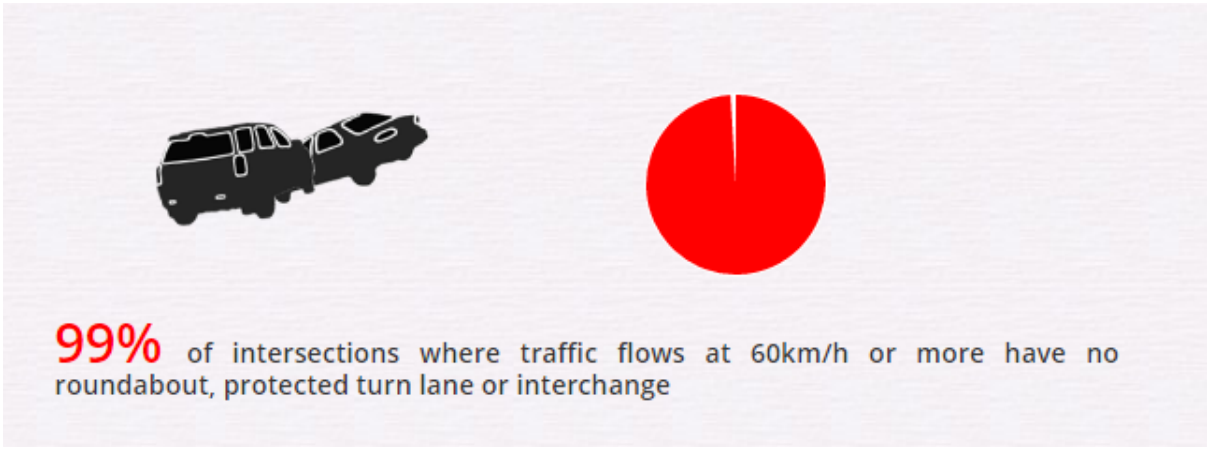


Figure A.5 Combination of type of intersection and real traffic speed > 60km/h

Figure A.6 Combination of hazardous roadsides and real traffic speed > 80km/h

The project evaluates 50 road infrastructure features included in the iRAP models. However, real traffic speed is a key attribute for measuring the likelihood of a road crash occurring and its severity. The data collected on site is used in estimating the 85th percentile and mean speed adjustment factors for that corridor:

Real traffic speed

Operating Speed (85th percentile)	km	%
70km/h	73.10	100

Operating Speed (mean)	km	%
50km/h	73.10	100

Figure A.7 Real traffic speed in Corridor 5.

B. Star Ratings (Corridor 5)

The overall Star Ratings for the roads assessed is shown in Table B.1 and B.2:

	Vehicle Occupant		Motorcyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.00	0%	0.00	0%
3 Stars	57.90	79%	43.80	60%
2 Stars	13.50	18%	26.50	36%
1 Star	1.50	2%	2.60	4%
Not applicable	0.20	0%	0.20	0%
Totals	73.10	100%	73.10	100%

Table B.1: Overall Star Ratings for vehicle occupants and motorcyclist in Corridor 5.

	Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.00	0%	0.00	0%
3 Stars	53.90	74%	57.90	79%
2 Stars	16.80	23%	14.90	20%
1 Star	1.60	2%	0.10	0%
Not applicable	0.80	1%	0.20	0%
Totals	73.10	100%	73.10	100%

Table B.2: Overall Star Ratings for bicyclists and pedestrians in Corridor 5.

The same information about Star Ratings for vehicle occupants, motorcyclists, pedestrians and bicyclists together in the following chart provided by ViDA software:

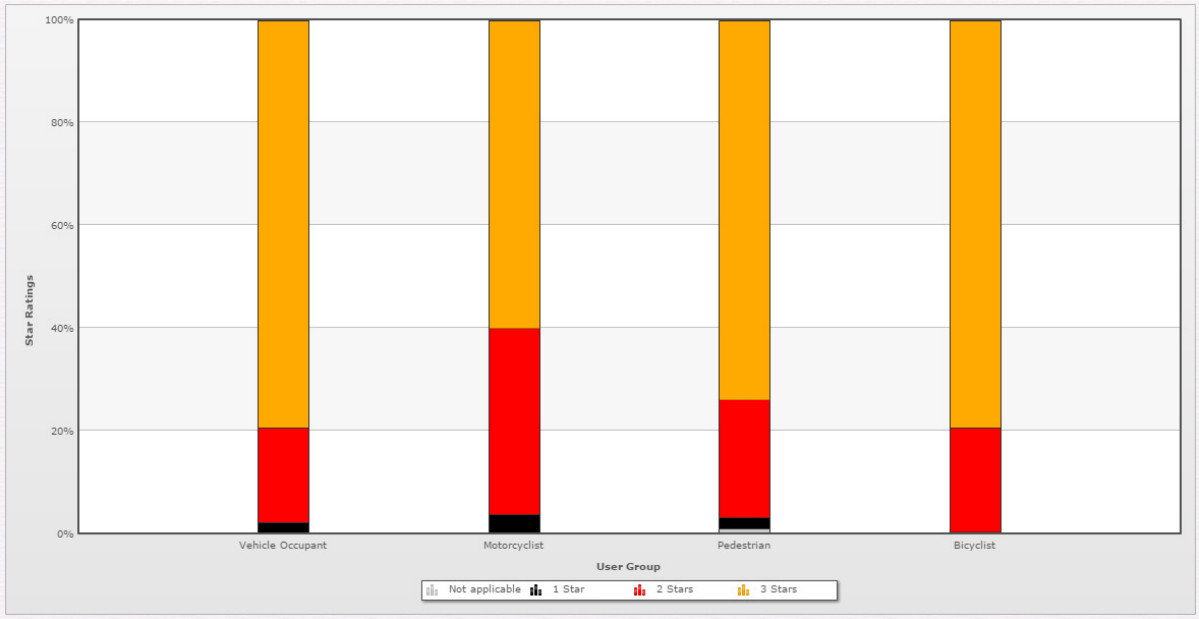


Figure B.3: Chart of smoothed Star Ratings for each transport mode in corridor 5.

Figures B.4 and B.5 illustrate the Star Ratings for Corridor 5 in map for vehicle occupants, motorcyclists bicyclists and pedestrians. More detailed information on the star ratings is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/map).

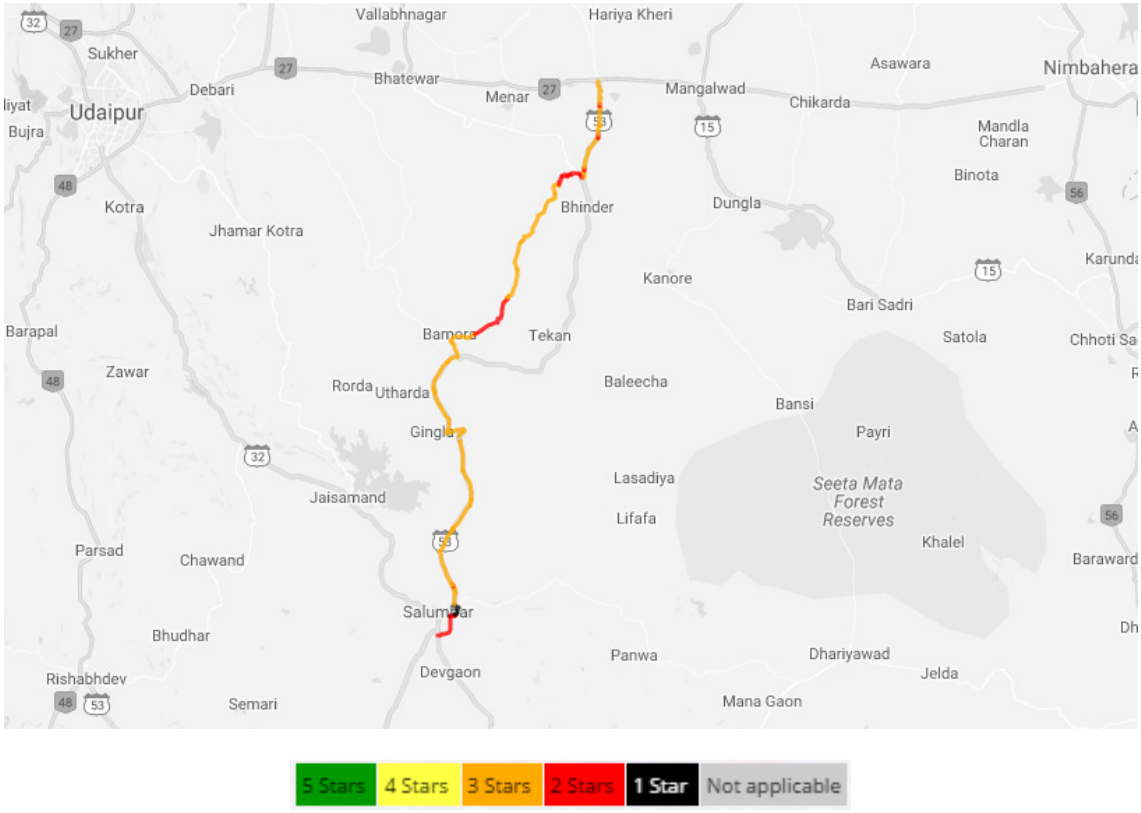


Figure B.4: Star Ratings for vehicle occupants.

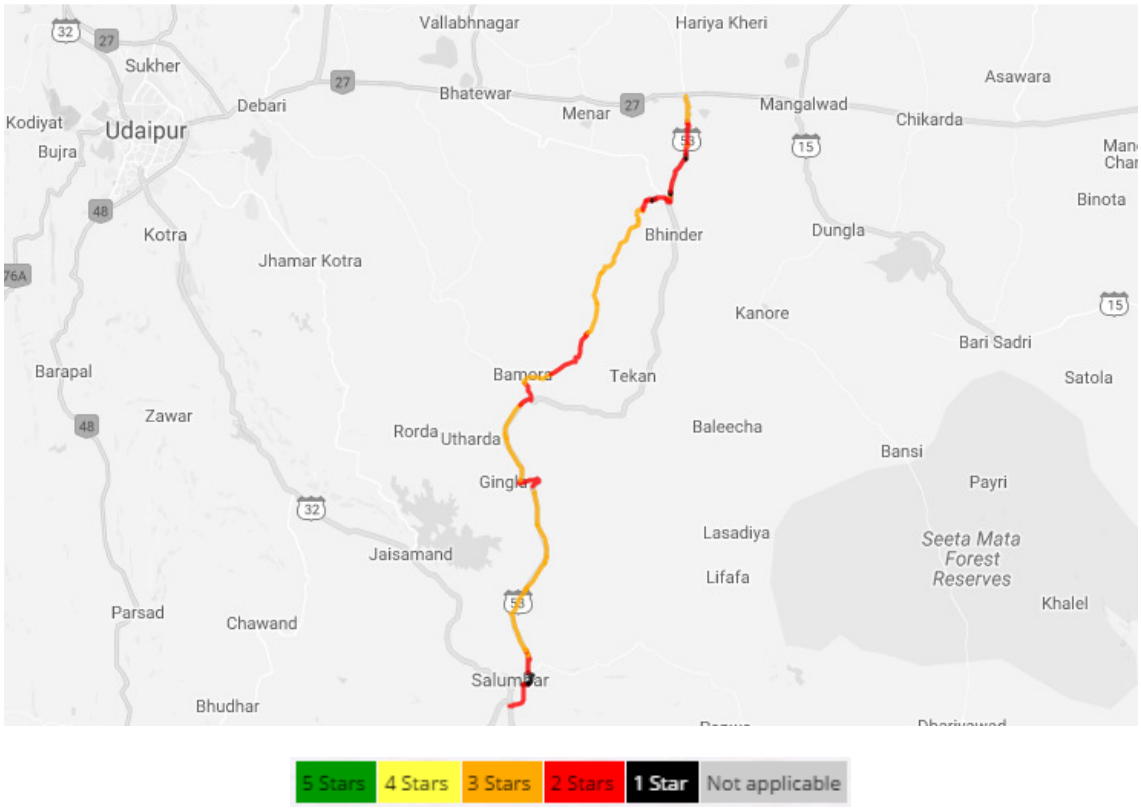


Figure B.5: Star Ratings for motorcyclists.

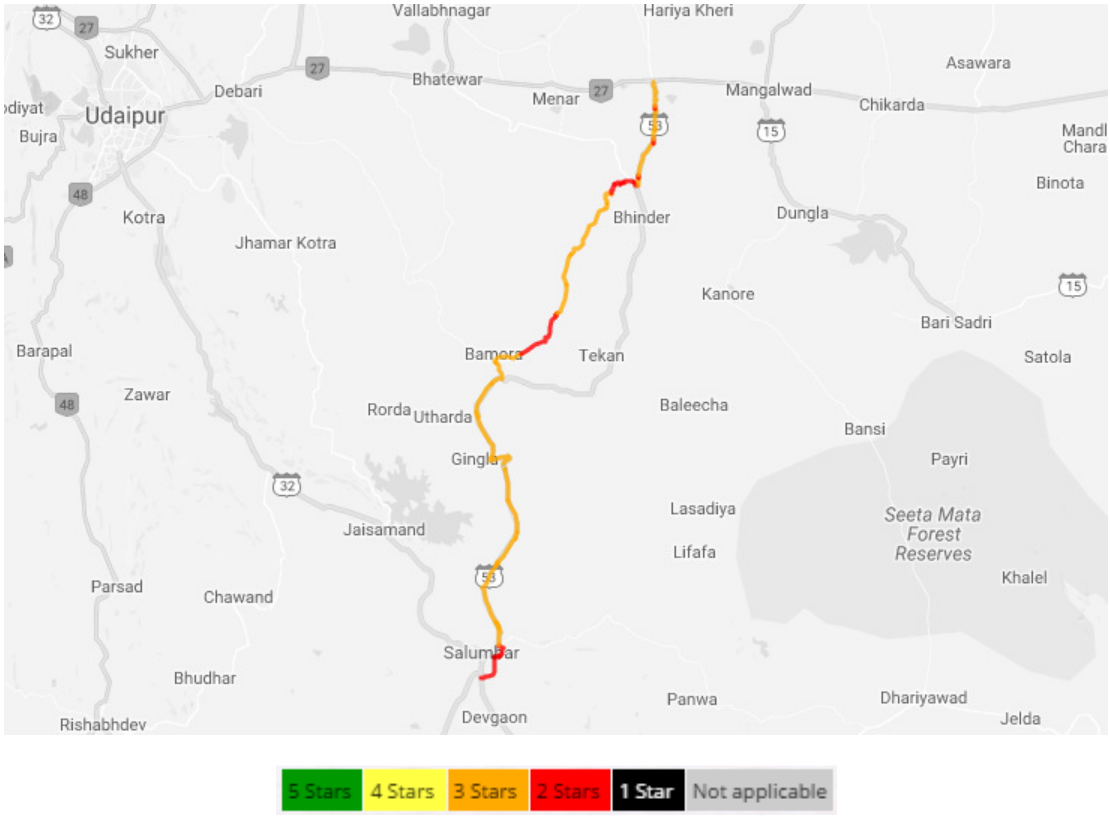


Figure B.6: Star Ratings for bicyclists.

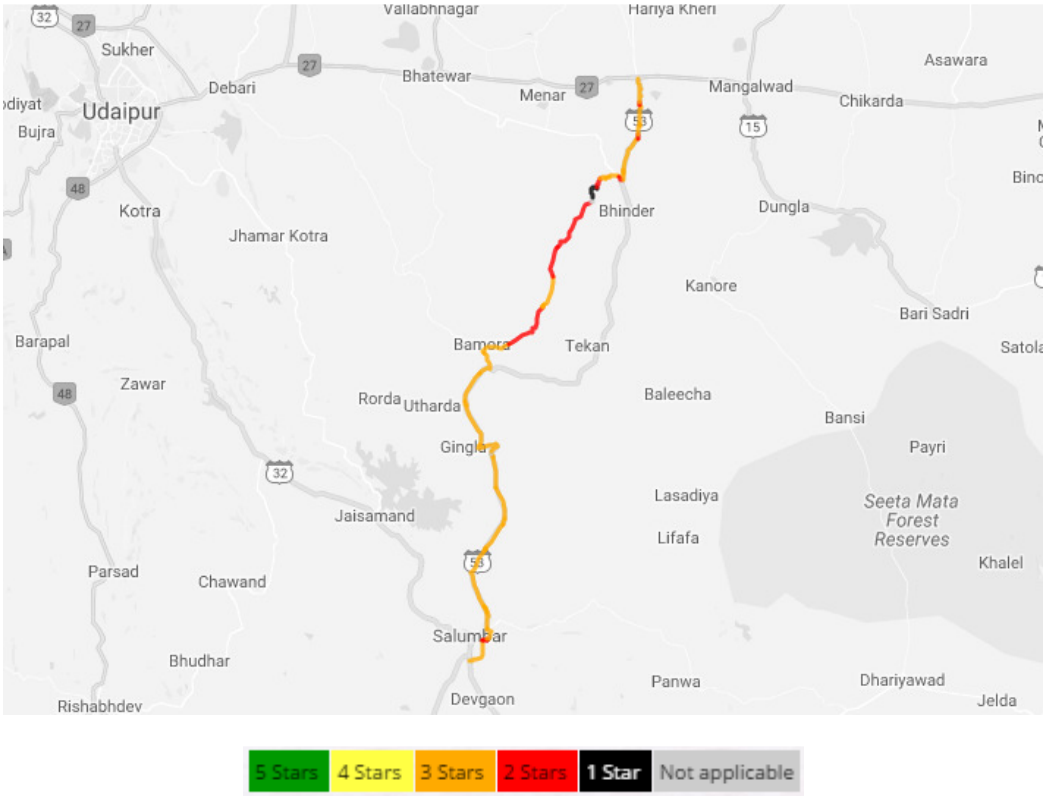


Figure B.7: Star Ratings for pedestrians.

C. Road Protection Scores – RPS (Corridor 5)

Figures C.1 and C.2 provide an example of how the RPS varies along one particular road section (in this case from Salamber to Kirki choki). They illustrate the RPS for each transport mode on a selected roadway section. The following figures show raw and smoothed version to visualise Star Rating for each 100m in the section of 52km Towards Salamber:

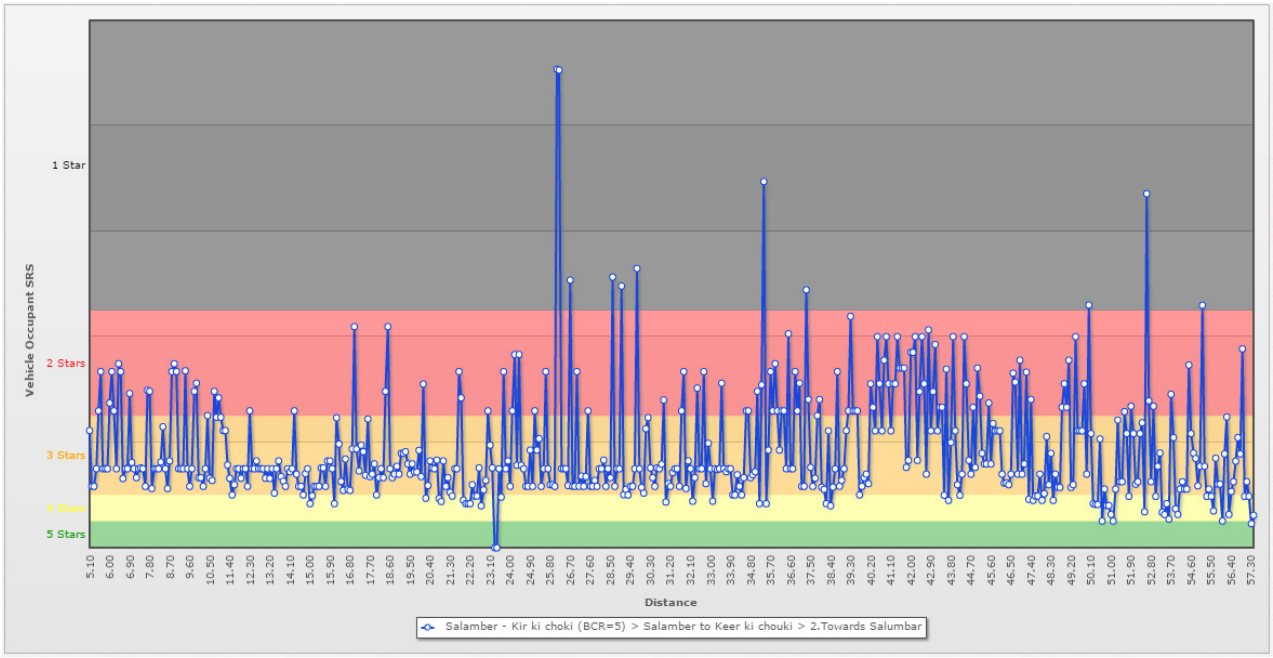


Figure C.1: RPS for vehicle occupants (Towards Salamber) - Raw version

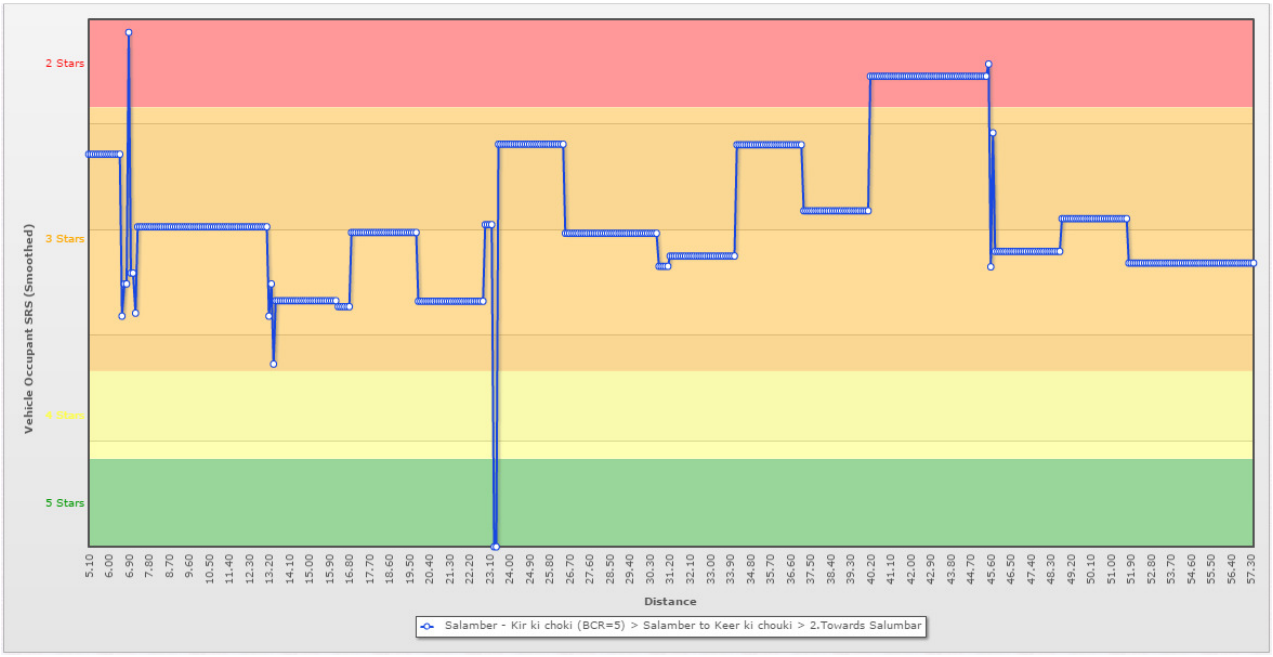


Figure C.2: RPS for vehicle occupants (Towards Salamber) – Smoothed version

In these charts, a low RPS indicates a relatively low level of risk while a high RPS indicates a high level of risk. Star Rating bands are overlaid on the RPS charts, with the green band representing 5-stars (the locations with the most safety features) and the black band representing 1-star (the locations with the fewest safety features). More detailed information on the risk worm (raw and smoothed) is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/risk_worm).

D. Safer Road Investment Plans (Corridor 5)

• Number of deaths and serious injuries

Reported road deaths on surveyed road is 21 fatalities in the period from 2013 to 2015 (3 years), most of them vehicle occupants (62%). Hence, the estimated number of fatalities on corridor SH-53 Salamber to Kirki choki per year is 7.0. According to First Information Reports (FIR) collected from police stations, the reported ratio of serious injuries to fatalities on that Rajasthan road is 4, thus it is estimated that a total of 35 fatalities and serious injuries per year occur on that corridor assessed in this project.

• Road deaths on the corridor 5 by road user type

In order to allocate deaths and serious injuries to the network, the IRAP model also requires the distribution of deaths by road user type. The proportion of deaths on the road by road user type was obtained following a review of data from First Information Reports (FIR).

Road user type	Estimated fatalities per year	Proportion of road deaths
Vehicle occupants	4.3	62%
Motorcyclists	2.3	33%
Pedestrians	0.4	5%
Bicyclists	0.0	0%
Total	**7.0**	**100%**

Table C.1: Road deaths on the Corridor 5.

• Road sections

Each record has a section code. Section codes are used to group together 100-m segments for both processing and reporting purposes. Road sections are typically aligned with road authority inventory data, obvious changes in road condition or with obvious landmarks such as towns. For the purposes of this project, roads have been split into sections roughly according to important towns, traffic volumes and changes in road features.

Section number	Name of section	Length
1	Actually road	5km
2	Towards Salumbar	52km
3	Bhindar Railway Salumbar	6km
4	Kir ki choki	10km

Detailed road sections.

• Safer Road Investment Plans (Corridor 5)

Using inspection and supporting data with the IRAP methodology, a series of investment plan options have been produced for the roads that make up the study network. Different assumptions about the benefit-cost ratio (BCR) thresholds for safety improvements were found to be applicable as an example for Rajasthan demo corridor. Smaller BCR thresholds must be considered to develop an investment program of meaningful size and greater BCR thresholds to maximize the efficiency of the investments.

Candidate investment plans with differing BCR thresholds and differing investment levels have been developed. While a specific investment option is recommended, the ultimate decision on an appropriate investment level to improve safety rests with road authorities in Rajasthan. The table C.3 shows usual options for iRAP projects. Option A is optimal for an estimated cost around 50,000,000 ₹. Due to the low number of fatalities, a minimum BCR=8 do not make sense for achieving the objective of reducing fatalities and serious injuries in that corridor:

	Option A	Option B	Option C
Minimum benefit cost ratio	3	5	8
Investment (M ₹)	48,498,852	6,625,421	369,949
Economic benefit 20 years (M ₹)	166,185,078	39,600,632	3,238,409
Programme benefit cost ratio	3	6	9
Deaths (per year)			
Before countermeasures	7.0	7.0	7.0
After countermeasures	4.9	6.5	6.9
Prevented	2.1	0.5	0.1
Reduction	30.1%	7.1%	0.6%
Deaths and serious injuries (20 years)			
Before countermeasures	700	700	700
After countermeasures	489	650	696
Prevented	211	50	4
Reduction	30.1%	7.1%	0.6%
Cost per death and serious injury prevented	229,908₹	131,803₹	89,996₹

Investment plan options for Corridor 5.

Countermeasure	Length/Sites	FSIs saved	PV of safety benefit	Estimated cost	Cost per FSI saved	Program BCR
Central median barrier (1+1)	10.60km	135	106,081,032	33,721,475	250,429	3
Improve curve delineation	27.60km	67	52,627,126	12,665,688	189,598	4
Central hatching	7.00km	9	7,476,920	2,111,689	222,496	3
	TOTAL	**211**	**166,185,078**	**48,498,852**	**229,908**	**3**

Countermeasures options for safer roads investment plan (Option A)

Corridor 6: Suket to Dug

State Highway-19A & Major District Road - MDR 109 between Suket to Dug is a Two-Lane Carriageway. The project road starts from Km 0.000 to Km 19.000 of MDR-109 & Km 19.900 and ends at Km 105.600 of SH-19A, thus making a Total Length of 101.7km. The project corridor passes through three major towns' viz., Bhawani Mandi, Mishroli and Pagariya. The project corridor generally passes through plains terrain. Four toll plazas are in operation on the project corridor.

A. Road Condition (Corridor 6)

The following is a summary of the condition of the inspected road (Suket to Dug) included in the IRAP models. More detailed reports on the road condition are available in the IRAP online software (https://vida.IRAP.org/es/results/star_rating/map) and in the Annexure 1.

Key elements for all transport modes of corridor 6 are listed in the following snapshots.

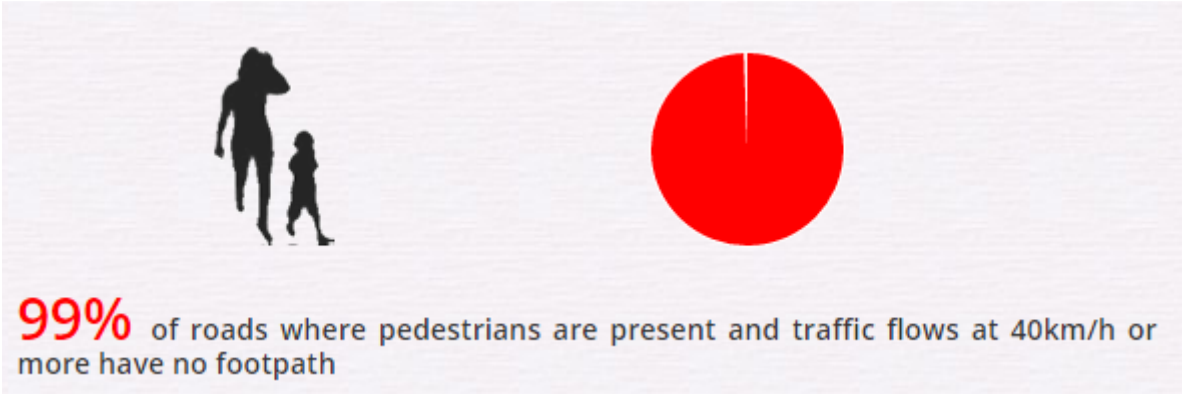


Figure A.1 Combination of pedestrians and real traffic speed > 40km/h

Figure A.2 Combination of bicyclists and real traffic speed > 40km/h

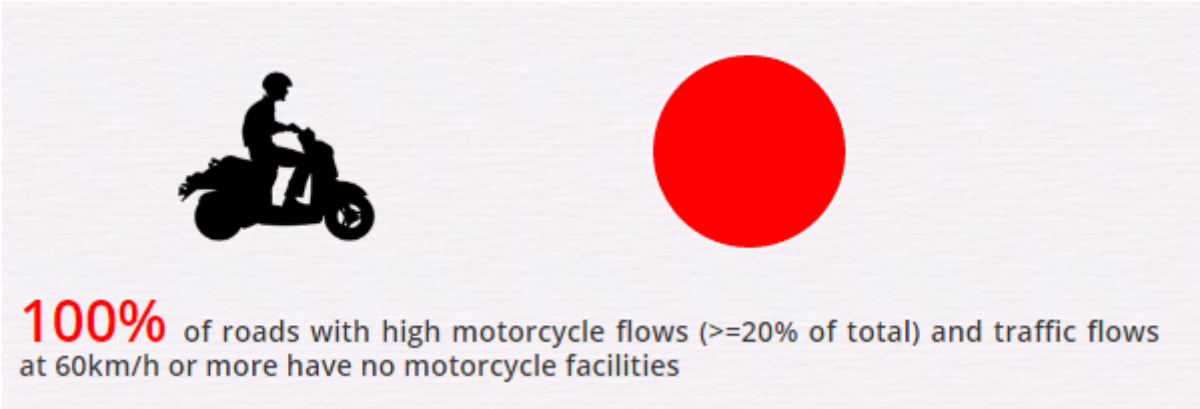


Figure A.3 Combination of motorcyclists and real traffic speed > 60km/h

Figure A.4 Combination of type of road and real traffic speed > 80km/h

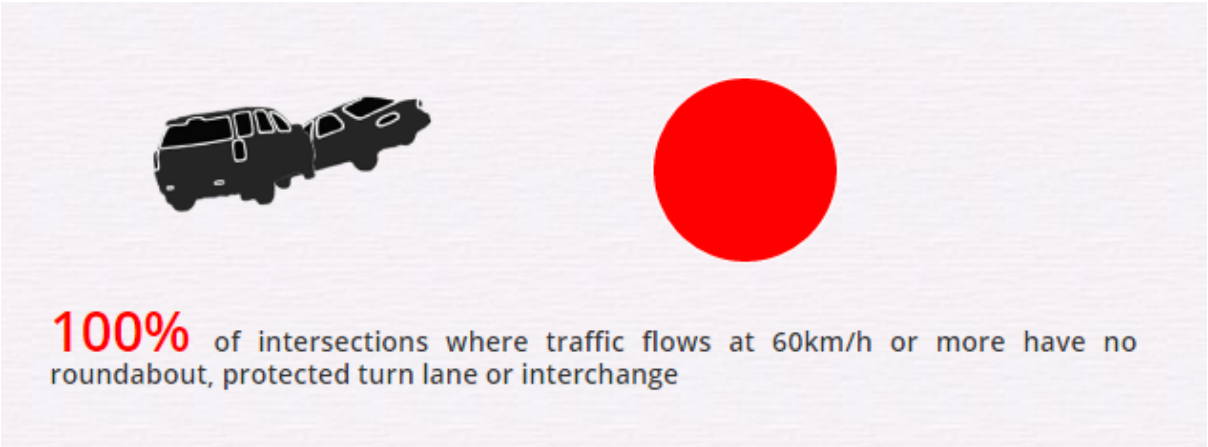


Figure A.5 Combination of type of intersection and real traffic speed > 60km/h

Figure A.6 Combination of hazardous roadsides and real traffic speed > 80km/h

The project evaluates 50 road infrastructure features included in the iRAP models. However, real traffic speed is a key attribute for measuring the likelihood of a road crash occurring and its severity. The data collected on site is used in estimating the 85th percentile and mean speed adjustment factors for that corridor:

Real traffic speed

Operating Speed (85th percentile)	km	%
65km/h	103.00	100

Operating Speed (mean)	km	%
45km/h	73.90	72
50km/h	29.10	28

Figure A.7 Real traffic speed in corridor 6.

B. Star Ratings (Corridor 6)

The overall Star Ratings for the roads assessed is shown in Table B.1 and B.2:

	Vehicle Occupant		Motorcyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.30	0%	0.00	0%
4 Stars	7.20	7%	3.60	3%
3 Stars	93.90	91%	95.00	92%
2 Stars	1.60	2%	4.40	4%
1 Star	0.00	0%	0.00	0%
Not applicable	0.00	0%	0.00	0%
Totals	103.00	100%	103.00	100%

Table B.1: Overall Star Ratings for vehicle occupants and motorcyclist in Corridor 6.

	Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.30	0%	3.20	3%
3 Stars	101.30	98%	98.00	95%
2 Stars	1.40	1%	1.80	2%
1 Star	0.00	0%	0.00	0%
Not applicable	0.00	0%	0.00	0%
Totals	103.00	100%	103.00	100%

Table B.2: Overall Star Ratings for bicyclists and pedestrians in Corridor 6.

The same information about Star Ratings for vehicle occupants, motorcyclists, pedestrians and bicyclists together in the following chart provided by ViDA software:

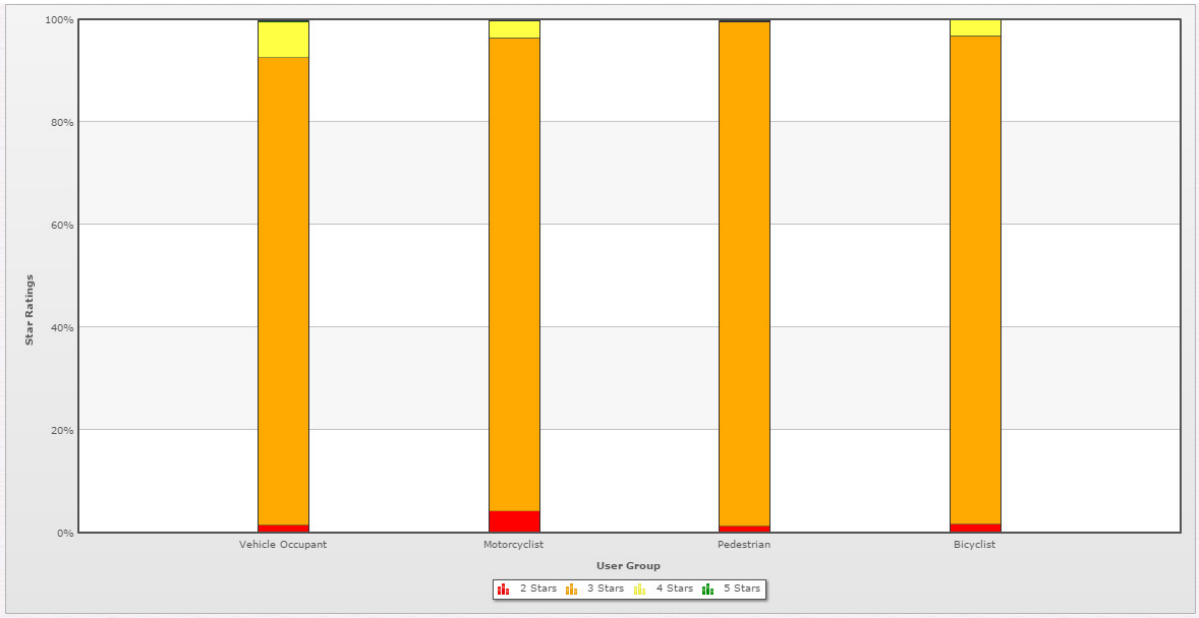


Figure B.3: Chart of smoothed Star Ratings for each transport mode in corridor 6.

Figures B.4 and B.5 illustrate the Star Ratings for Corridor 6 in map for vehicle occupants, motorcyclists bicyclists and pedestrians. More detailed information on the star ratings is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/map).

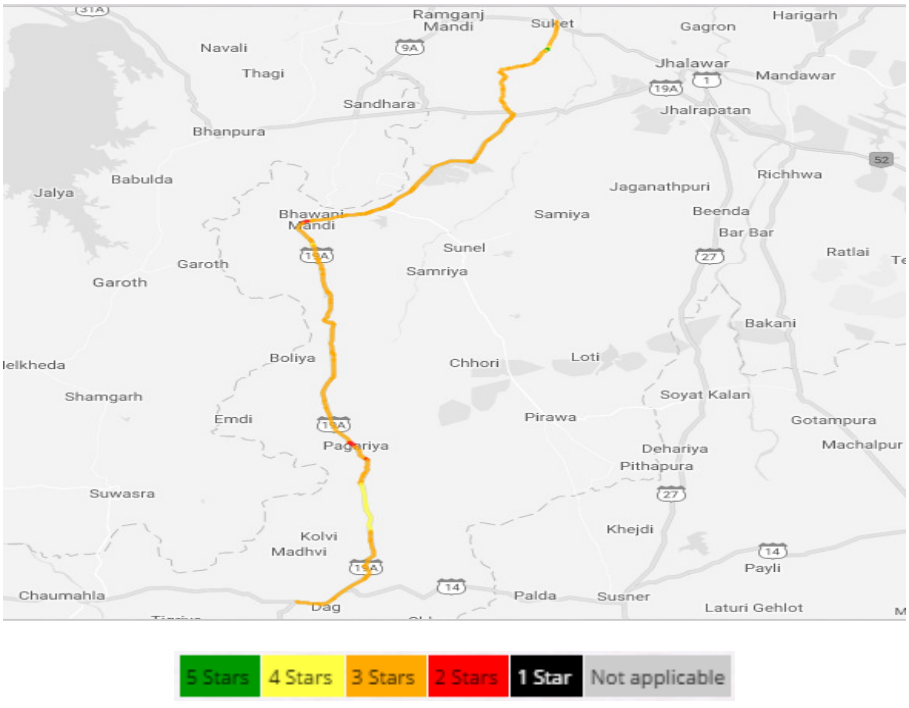


Figure B.4: Star Ratings for vehicle occupants.

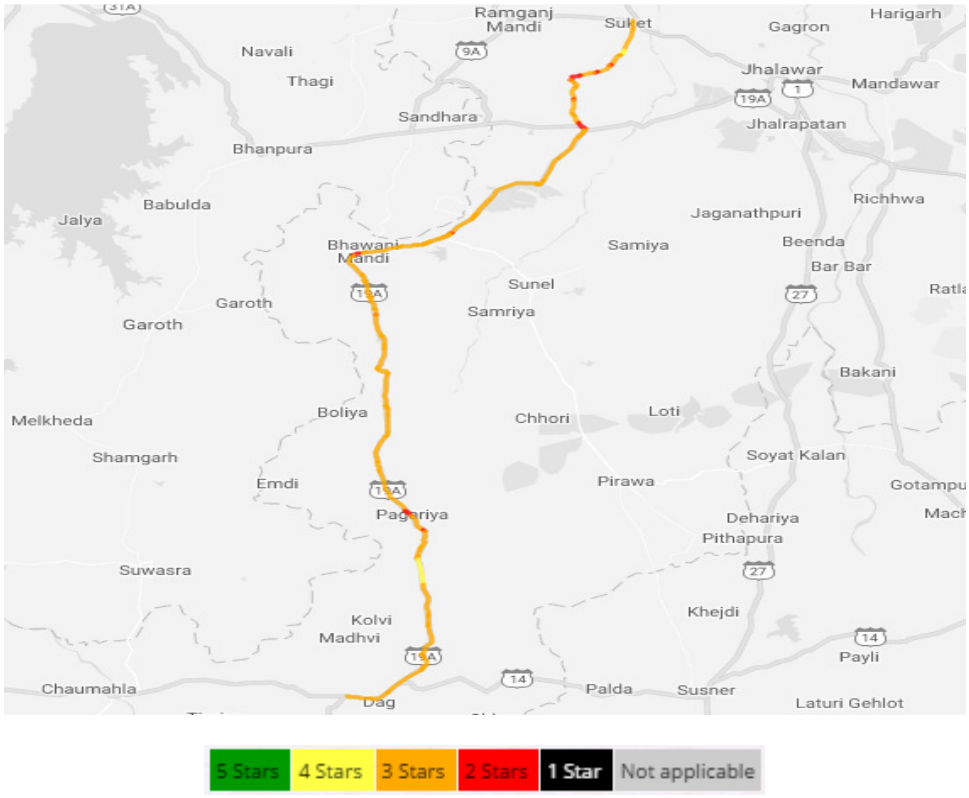


Figure B.5: Star Ratings for motorcyclists.

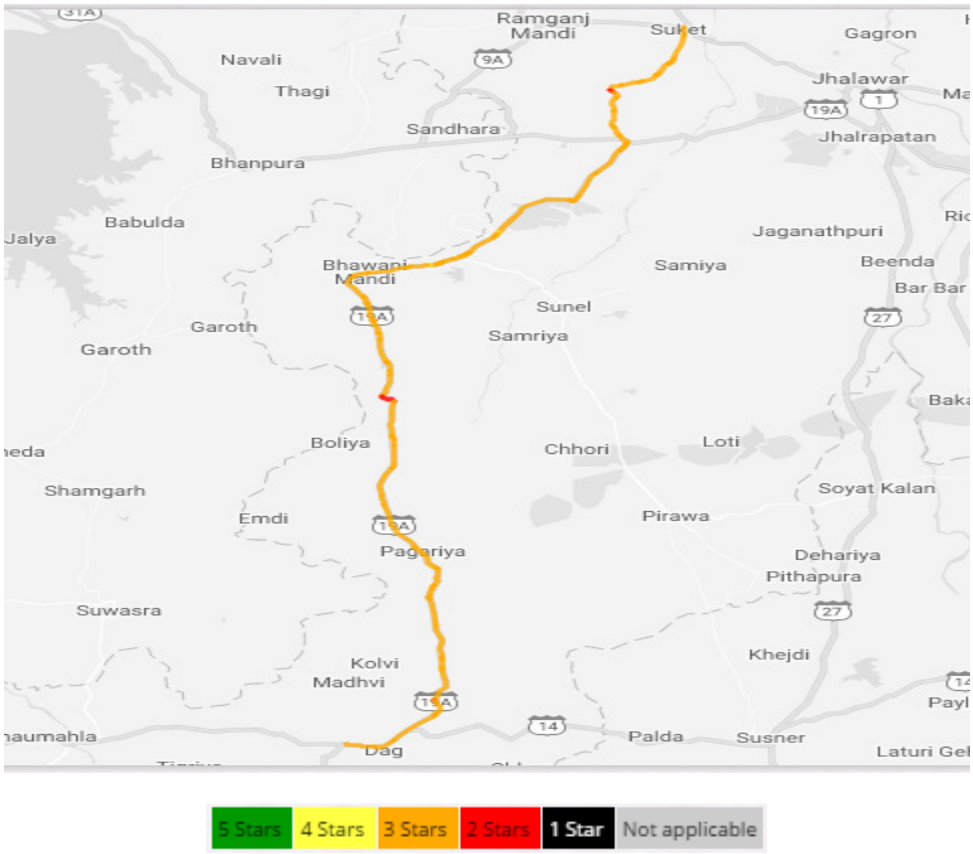


Figure B.6: Star Ratings for bicyclists.

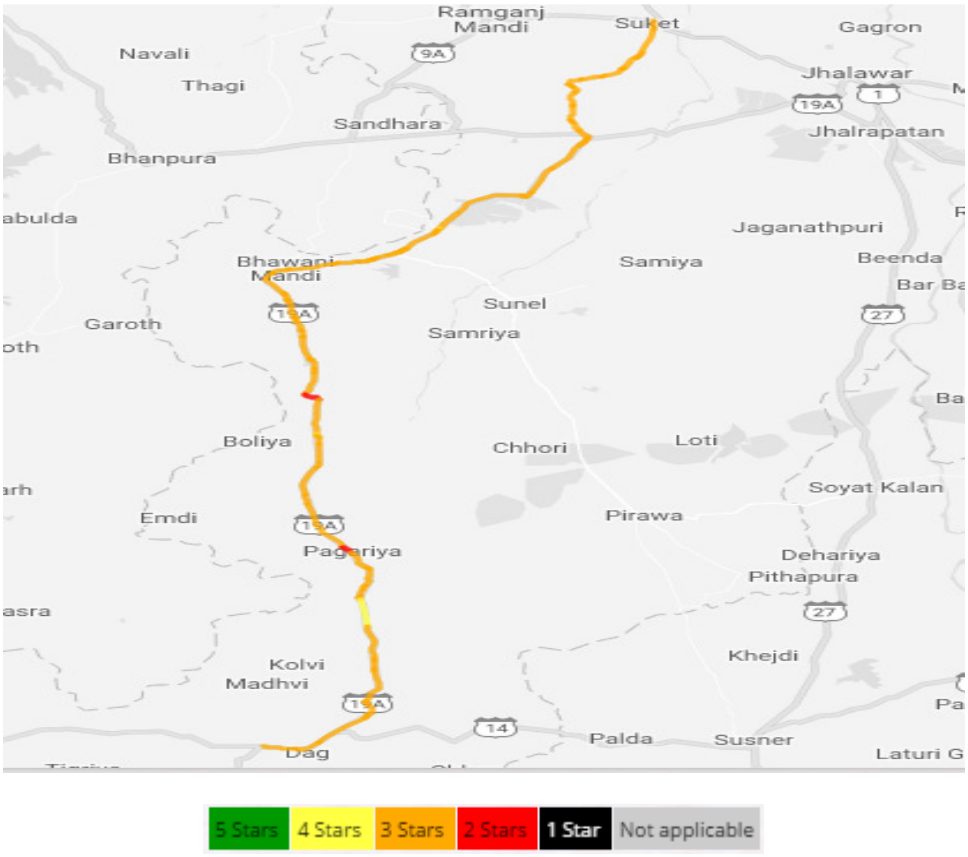


Figure B.7: Star Ratings for pedestrians.

C. Road Protection Scores – RPS (Corridor 6)

Figures C.1 and C.2 provide an example of how the RPS varies along one particular road section (in this case from Dag to Suket). They illustrate the RPS for each transport mode on a selected roadway section. The following figures show raw and smoothed version to visualise Star Rating for each 100m in the section of 38km from Dag to Suket:

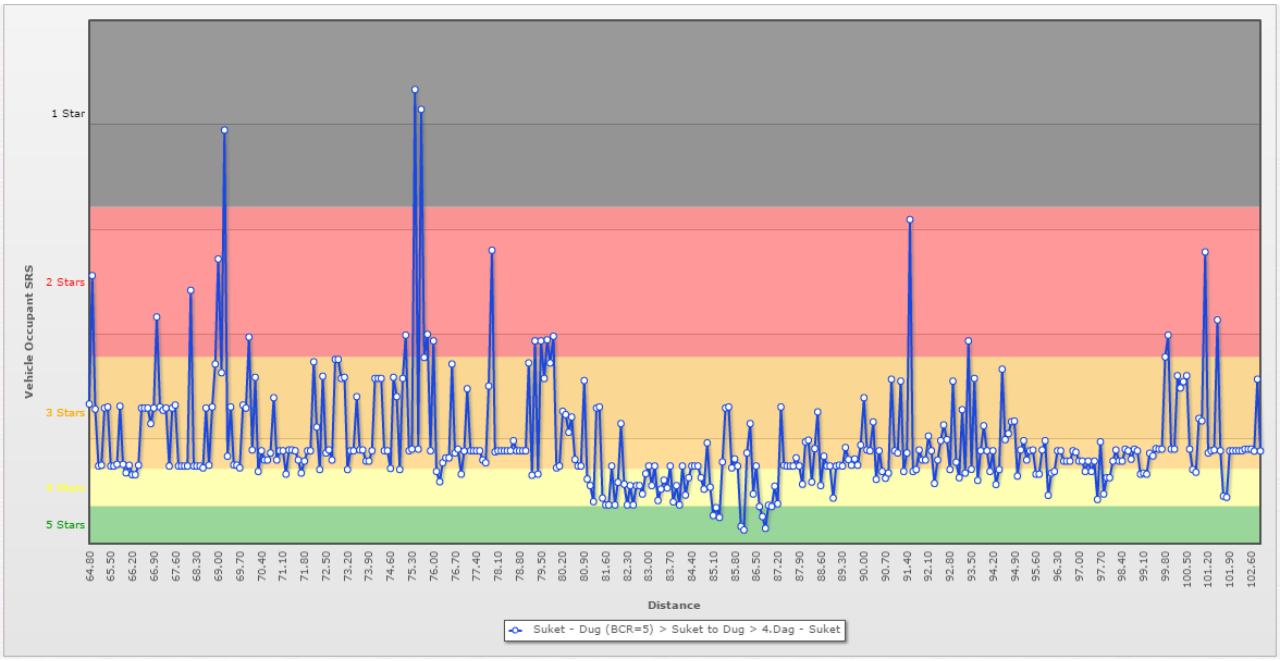


Figure C.1: RPS for vehicle occupants (Dag to Suket) - Raw version

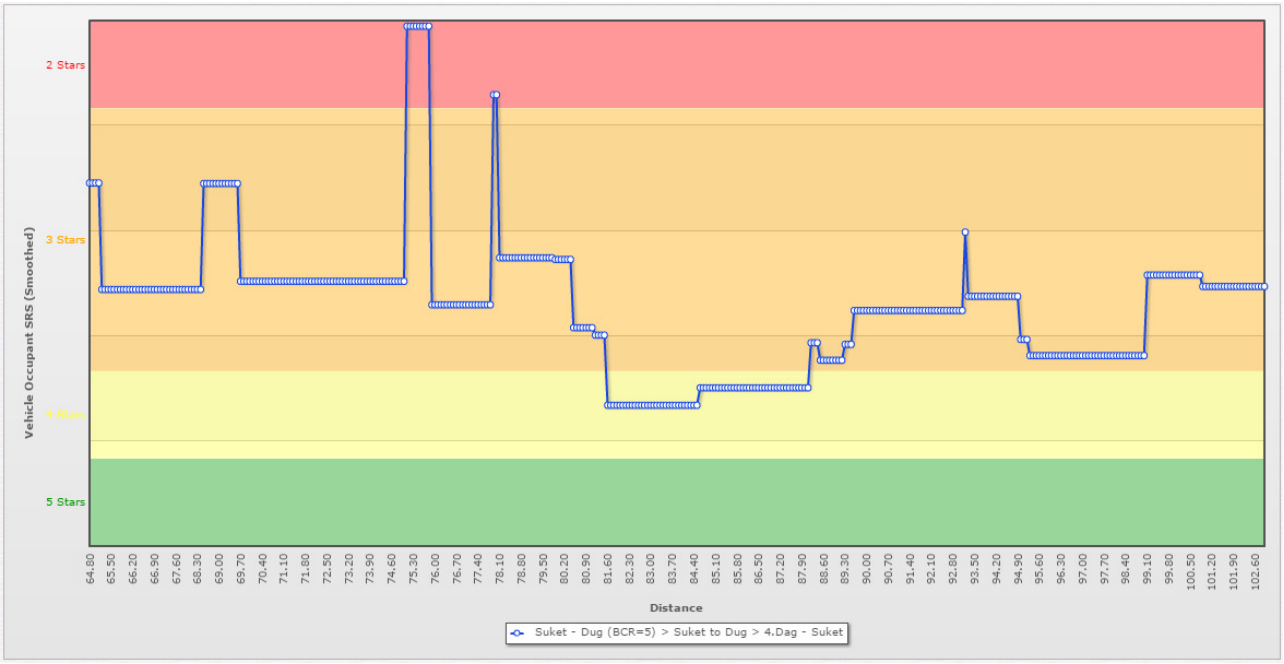


Figure C.2: RPS for vehicle occupants (Dag to Suket) – Smoothed version

In these charts, a low RPS indicates a relatively low level of risk while a high RPS indicates a high level of risk. Star Rating bands are overlaid on the RPS charts, with the green band representing 5-stars (the locations with the most safety features) and the black band representing 1-star (the locations with the fewest safety features). More detailed information on the risk worm (raw and smoothed) is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/risk_worm).

D. Safer Road Investment Plans (Corridor 6)

• Number of deaths and serious injuries

Reported road deaths on surveyed road is 31 fatalities in the period from 2013 to 2015 (3 years), most of them motorcyclists (65%). Hence, the estimated number of fatalities on corridor SH-19A and MDR-109 Suket to Dug per year is 10.3. According to First Information Reports (FIR) collected from police stations, the reported ratio of serious injuries to fatalities on that Rajasthan road is 4, thus it is estimated that a total of 51.5 fatalities and serious injuries per year occur on that corridor assessed in this project.

• Road deaths on the corridor 6 by road user type

In order to allocate deaths and serious injuries to the network, the IRAP model also requires the distribution of deaths by road user type. The proportion of deaths on the road by road user type was obtained following a review of data from First Information Reports (FIR).

Road user type	Estimated fatalities per year	Proportion of road deaths
Vehicle occupants	3.0	29%
Motorcyclists	6.7	65%
Pedestrians	0.6	6%
Bicyclists	0.0	0%
Total	**10.3**	**100%**

Table C.1: Road deaths on the Corridor 6.

• Road sections

Each record has a section code. Section codes are used to group together 100-m segments for both processing and reporting purposes. Road sections are typically aligned with road authority inventory data, obvious changes in road condition or with obvious landmarks such as towns. For the purposes of this project, roads have been split into sections roughly according to important towns, traffic volumes and changes in road features.

Section number	Name of section	Length
1	Pipalya to Suket	16km
2	Bahwani Mandi to Suket	26km
3	Towards Bahwani Mandi	23km
4	Dag to Suket	38km

Detailed road sections.

• Safer Road Investment Plans (Corridor 6)

Using inspection and supporting data with the IRAP methodology, a series of investment plan options have been produced for the roads that make up the study network. Different assumptions about the benefit-cost ratio (BCR) thresholds for safety improvements were found to be applicable as an example for Rajasthan demo corridor. Smaller BCR thresholds must be considered to develop an investment program of meaningful size and greater BCR thresholds to maximize the efficiency of the investments.

Candidate investment plans with differing BCR thresholds and differing investment levels have been developed. While a specific investment option is recommended, the ultimate decision on an appropriate investment level to improve safety rests with road authorities in Rajasthan. The table C.3 shows usual options for iRAP projects. Option A is optimal for an estimated cost around 50,000,000 ₹.

	Option A	Option B	Option C
Minimum benefit cost ratio	3	5	8
Investment (₹)	52,539,169	14,600,667	4,041,450
Economic benefit 20 years (₹)	261,660,633	115,009,582	46,501,638
Programme benefit cost ratio	5	8	12
Deaths (per year)			
Before countermeasures	10.3	10.3	10.3
After countermeasures	8.6	9.6	10.0
Prevented	1.7	0.7	0.3
Reduction	16.1%	7.1%	2.9%
Deaths and serious injuries (20 years)			
Before countermeasures	1,030	1,030	1,030
After countermeasures	864	957	1,000
Prevented	166	73	30
Reduction	16.1%	7.1%	2.9%
Cost per death and serious injury prevented	316,366 ₹	200,025 ₹	136,935 ₹

Investment plan options for Corridor 6.

Countermeasure	Length/Sites	FSIs saved	PV of safety benefit	Estimated cost	Cost per FSI saved	Program BCR
Central hatching	99.40km	98	154,800,070	29,985,984	305,205	5
Improve delineation	8.70km	22	34,215,882	9,762,504	449,551	4
Improve curve delineation	5.30km	21	32,521,447	2,588,043	125,385	13
Clear roadside hazards – driver side	3.20km	10	16,273,915	5,316,500	514,729	3
Sight distance (obstruction removal)	0.70km	8	12,599,399	1,610,000	201,336	8
Roadside barriers – driver side	0.50km	3	4,405,905	1,246,624	445,805	4
Street lighting (ped crossing)	3 sites	3	4,233,267	1,370,115	509,949	3
Footpath provision passenger side	0.60km	2	2,610,748	659,400	397,950	4
	TOTAL	**166**	**261,660,633**	**52,539,169**	**316,366**	**5**

Countermeasures options for safer roads investment plan (Option A)

Corridor 7: Mahuwa to Karauli

Corridor number 7 connects Mahuwa to Karauli in a 65 kilometre road. State Highway – SH 22 between Mahuwa to Karauli is a Two Lane Carriageway. The project road starts from Km 42.000 and ends at Km 107.000 of SH 22, thus making a Total Length of 65 km. The project corridor passes through major towns Hindaun city. The project corridor generally passes through both Steep and plains terrain. Two toll plazas are in operation on the project corridor.

A. Road Condition (Corridor 7)

The following is a summary of the condition of the inspected road (Mahuwa to Karauli) included in the IRAP models. More detailed reports on the road condition are available in the IRAP online software (https://vida.IRAP.org/es/results/star_rating/map) and in the Annexure 1.

Key elements for all transport modes of corridor 7 are listed in the following snapshots.

Figure A.1 Combination of pedestrians and real traffic speed > 40km/h

Figure A.2 Combination of bicyclists and real traffic speed > 40km/h

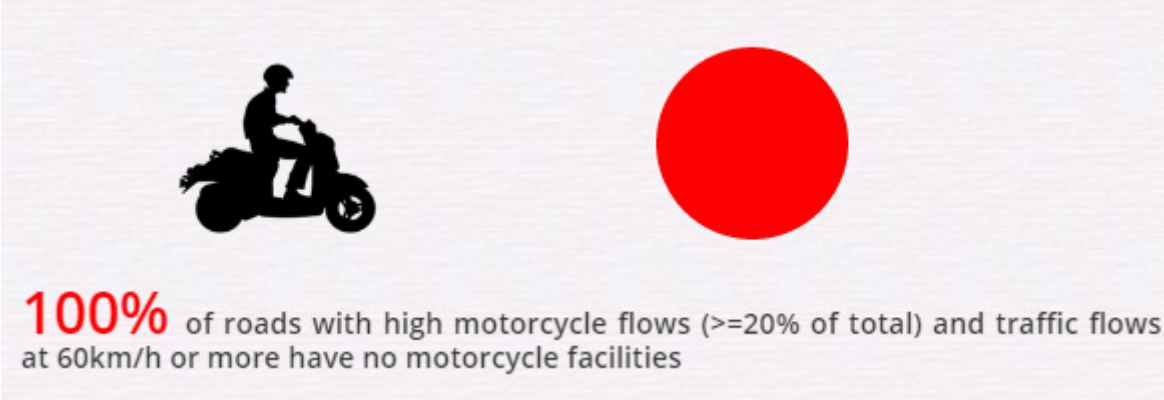


Figure A.3 Combination of motorcyclists and real traffic speed > 60km/h

Figure A.4 Combination of type of road and real traffic speed > 80km/h

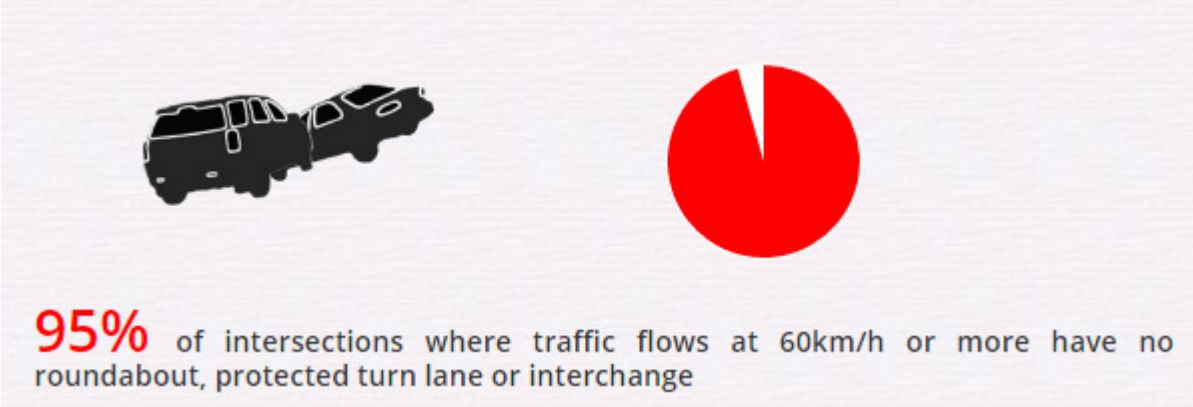


Figure A.5 Combination of type of intersection and real traffic speed > 60km/h

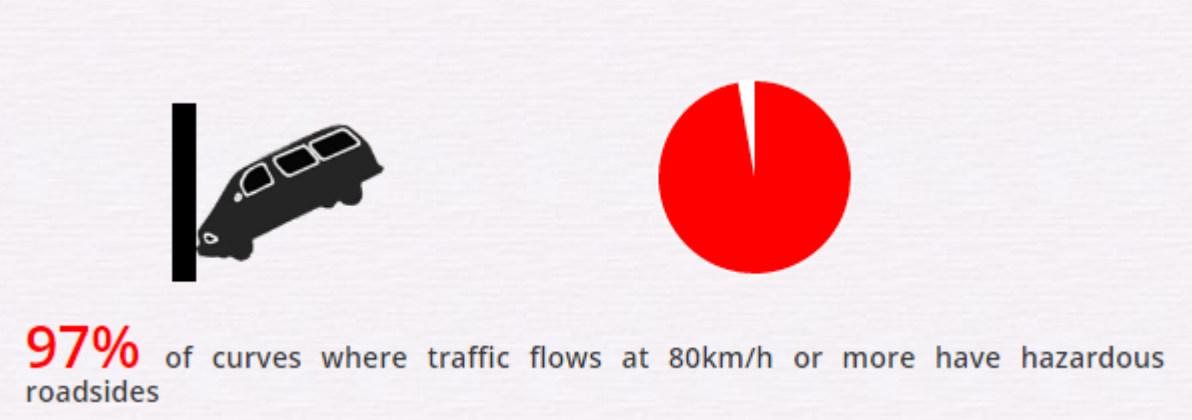


Figure A.6 Combination of hazardous roadsides and real traffic speed > 80km/h

The project evaluates 50 road infrastructure features included in the iRAP models. However, real traffic speed is a key attribute for measuring the likelihood of a road crash occurring and its severity. The data collected on site is used in estimating the 85th percentile and mean speed adjustment factors for that corridor:

Real traffic speed

Operating Speed (85th percentile)	km	%
75km/h	15.10	21
80km/h	55.50	79

Operating Speed (mean)	km	%
55km/h	70.60	100

Figure A.7 Real traffic speed in corridor 7.

B. Star Ratings (Corridor 7)

The overall Star Ratings for the roads assessed is shown in Table B.1 and B.2:

	Vehicle Occupant		Motorcyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.30	0%	0.30	0%
3 Stars	34.30	49%	12.60	18%
2 Stars	33.90	48%	49.10	70%
1 Star	2.10	3%	8.60	12%
Not applicable	0.00	0%	0.00	0%
Totals	**70.60**	**100%**	**70.60**	**100%**

Table B.1: Overall Star Ratings for vehicle occupants and motorcyclist in Corridor 7.

	Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%
4 Stars	0.60	1%	0.00	0%
3 Stars	0.00	0%	0.00	0%
2 Stars	0.10	0%	3.90	6%
1 Star	18.30	26%	0.60	1%
Not applicable	51.60	73%	66.10	94%
Totals	**70.60**	**100%**	**70.60**	**100%**

Table B.2: Overall Star Ratings for bicyclists and pedestrians in Corridor 7.

The same information about Star Ratings for vehicle occupants, motorcyclists, pedestrians and bicyclists together in the following chart provided by ViDA software:

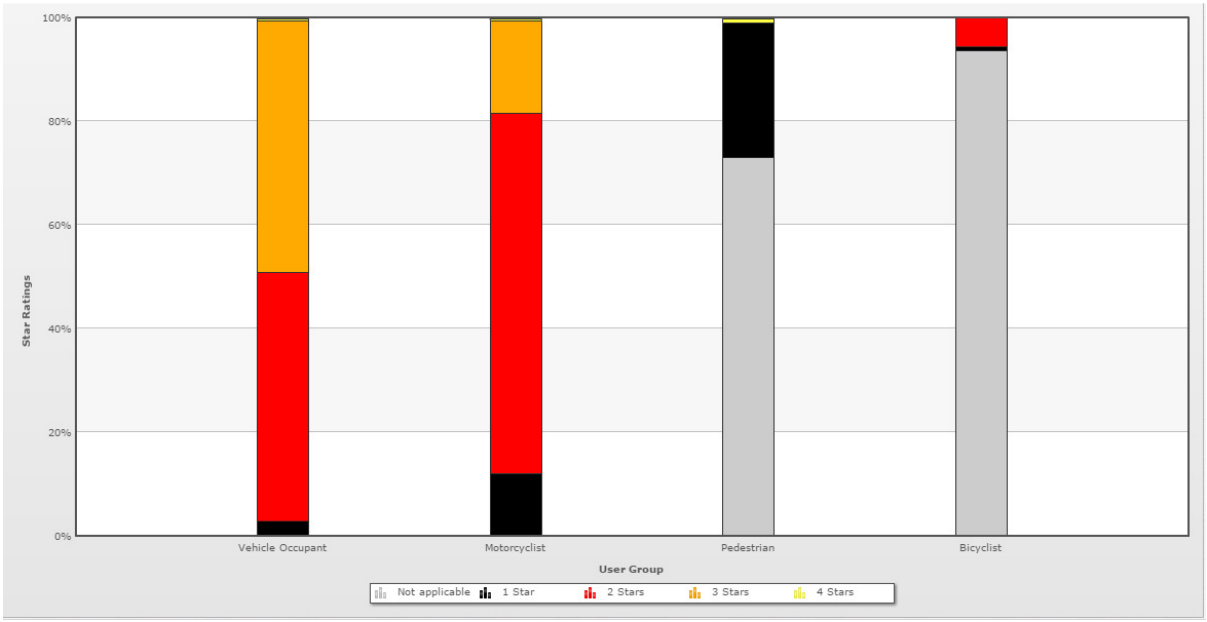


Figure B.3: Chart of smoothed Star Ratings for each transport mode in corridor 7.

Figures B.4 and B.5 illustrate the Star Ratings for Corridor 7 in map for vehicle occupants, motorcyclists bicyclists and pedestrians. More detailed information on the star ratings is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/map).

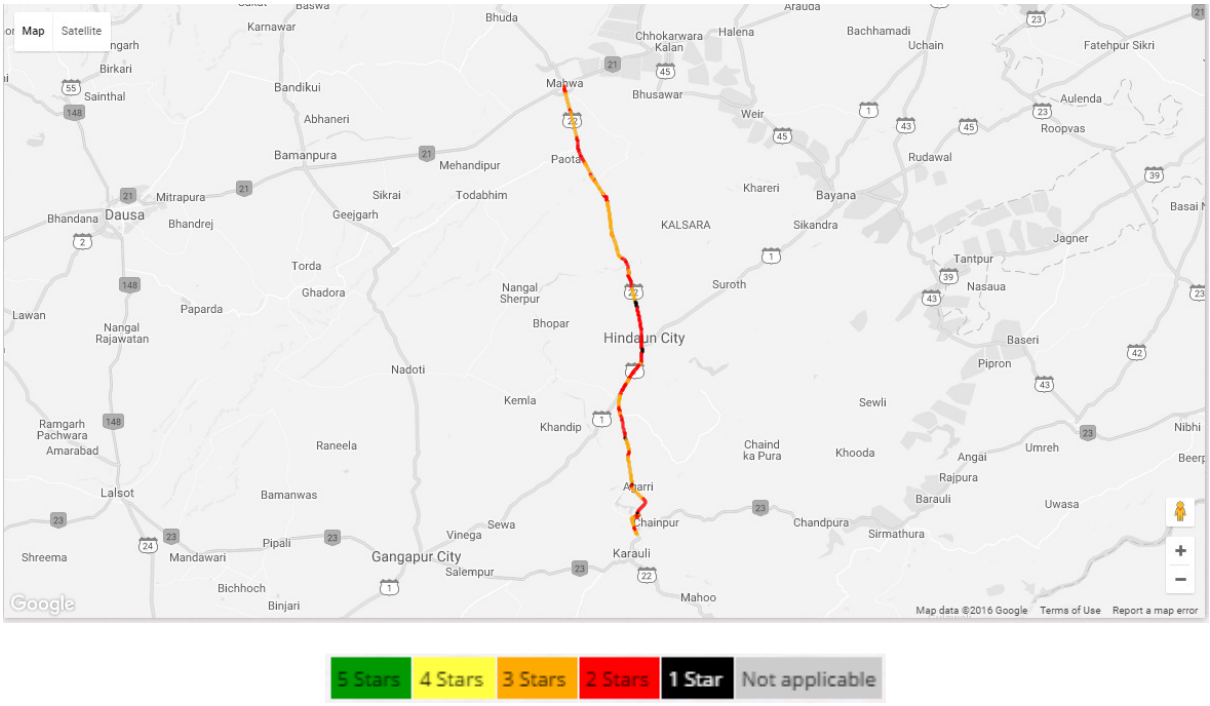
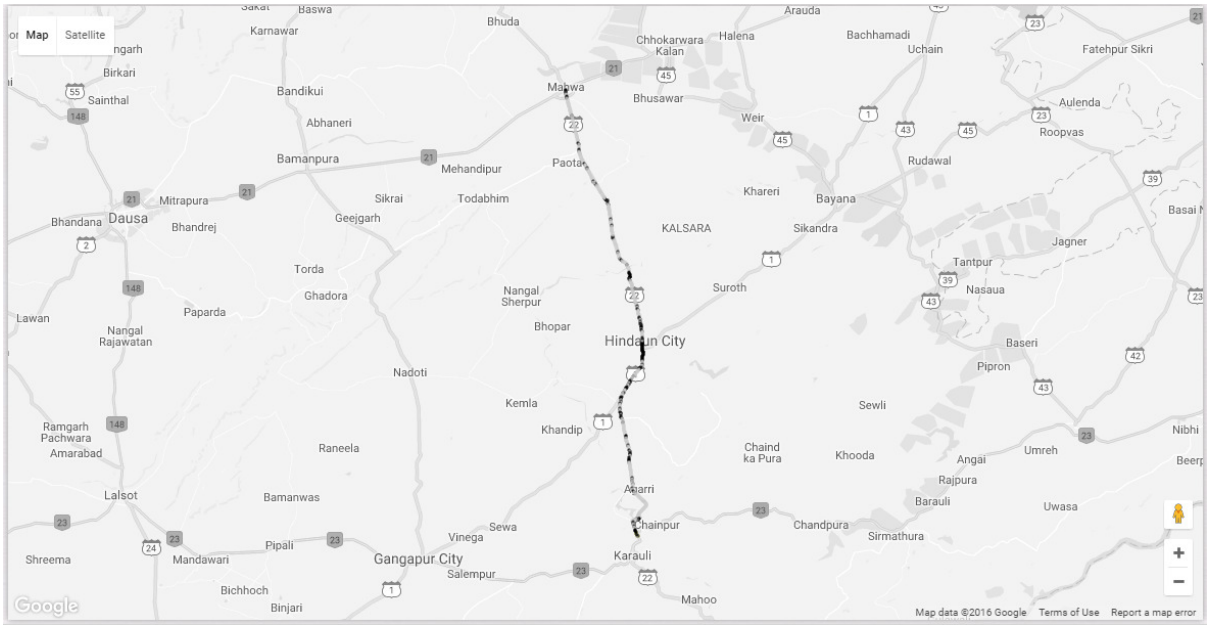


Figure B.4: Star Ratings for vehicle occupants.

5 Stars | 4 Stars | 3 Stars | 2 Stars | 1 Star | Not applicable

Figure B.5: Star Ratings for motorcyclists.



5 Stars | 4 Stars | 3 Stars | 2 Stars | 1 Star | Not applicable

Figure B.6: Star Ratings for bicyclists.

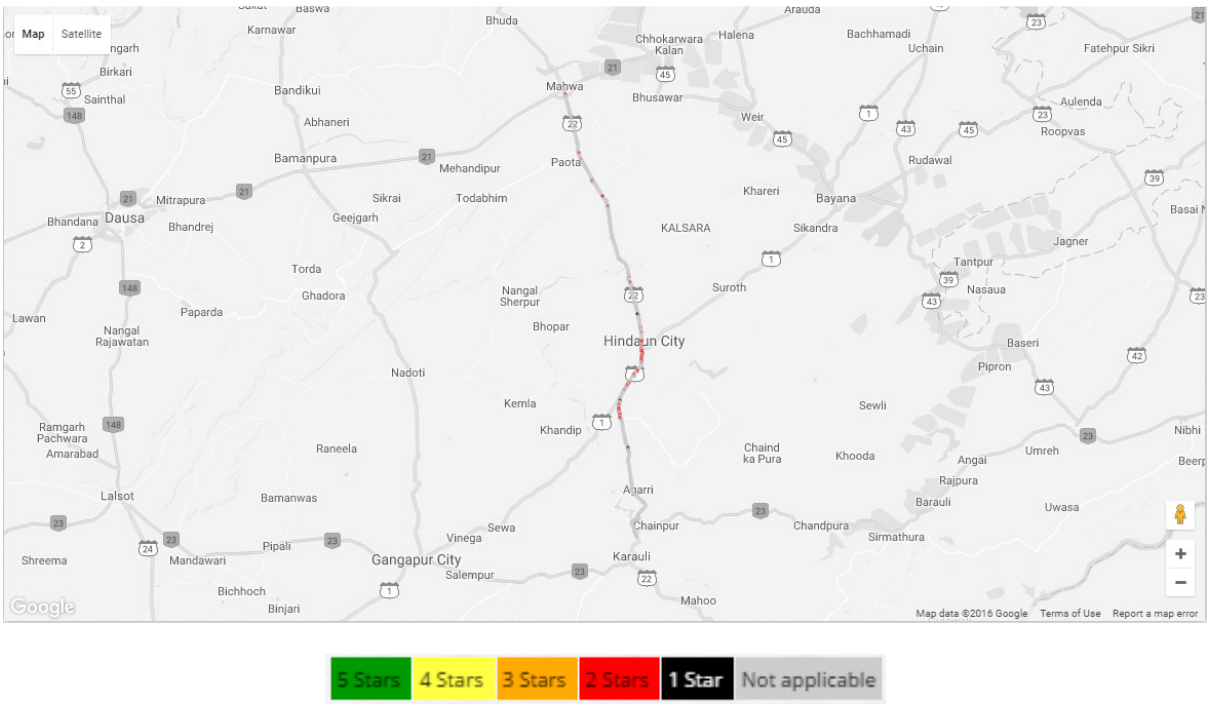


Figure B.7: Star Ratings for pedestrians.

C. Road Protection Scores – RPS (Corridor 7)

Figures C.1 and C.2 provide an example of how the RPS varies along one particular road section (in this case from Hindaun City to Karauli). They illustrate the RPS for each transport mode on a selected roadway section. The following figures show raw and smoothed version to visualise Star Rating for each 100m in the section of 34km from Hindaun City to Karauli:

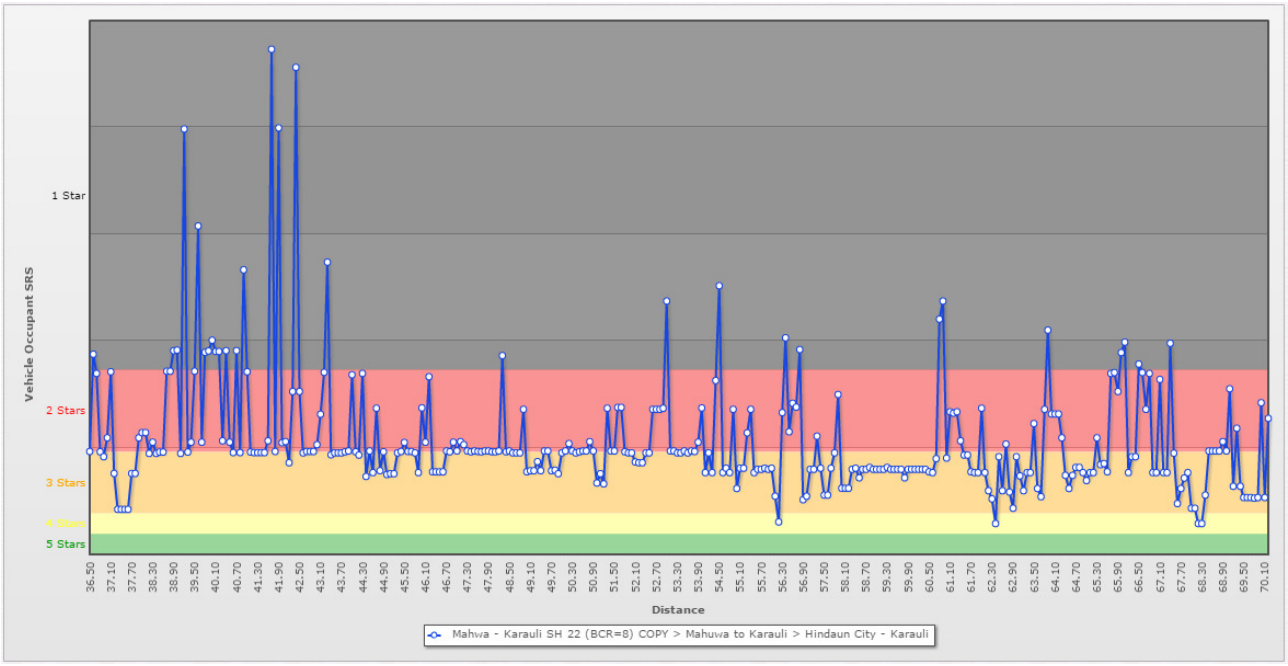


Figure C.1: RPS for vehicle occupants (Hindaun City to Karauli) - Raw version

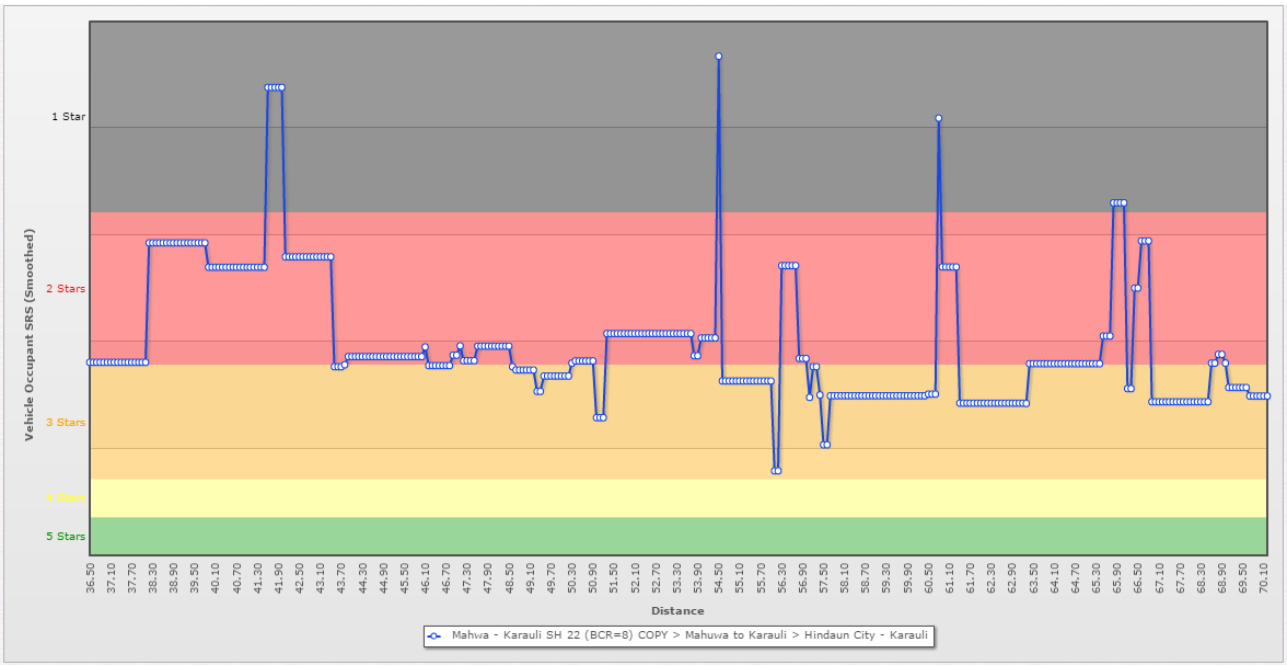


Figure C.2: RPS for vehicle occupants (Hindaun City to Karauli) – Smoothed version

In these charts, a low RPS indicates a relatively low level of risk while a high RPS indicates a high level of risk. Star Rating bands are overlaid on the RPS charts, with the green band representing 5-stars (the locations with the most safety features) and the black band representing 1-star (the locations with the fewest safety features). More detailed information on the risk worm (raw and smoothed) is available in the IRAP online software (https://vida.iRAP.org/en-gb/results/star_rating/risk_worm).

D. Safer Road Investment Plans (Corridor 7)

• Number of deaths and serious injuries

Reported road deaths on surveyed road is 121 fatalities in the period from 2013 to 2015 (3 years), most of them motorcyclists (47%). Hence, the estimated number of fatalities on corridor SH-22 Mahuwa to Karauli per year is 40.3. According to First Information Reports (FIR) collected from police stations, the reported ratio of serious injuries to fatalities on that Rajasthan road is 4, thus it is estimated that a total of 201 fatalities and serious injuries per year occur on that corridor assessed in this project.

• Road deaths on the corridor 7 by road user type

In order to allocate deaths and serious injuries to the network, the IRAP model also requires the distribution of deaths by road user type. The proportion of deaths on the road by road user type was obtained following a review of data from First Information Reports (FIR).

Road user type	Estimated fatalities per year	Proportion of road deaths
Vehicle occupants	14.9	37%
Motorcyclists	19.0	47%
Pedestrians	6.5	16%
Bicyclists	0.0	0%
Total	**40.3**	**100%**

Table C.1: Road deaths on the Corridor 7.

Road sections

Each record has a section code. Section codes are used to group together 100-m segments for both processing and reporting purposes. Road sections are typically aligned with road authority inventory data, obvious changes in road condition or with obvious landmarks such as towns. For the purposes of this project, roads have been split into sections roughly according to important towns, traffic volumes and changes in road features.

Section number	Name of section	Length
1	Hindaun City to Karauli	34km
2	Mahuwa to Hindaun City	37km

Detailed road sections.

- ## Safer Road Investment Plans (Corridor 7)

Using inspection and supporting data with the IRAP methodology, a series of investment plan options have been produced for the roads that make up the study network. Different assumptions about the benefit-cost ratio (BCR) thresholds for safety improvements were found to be applicable as an example for Rajasthan demo corridor. Smaller BCR thresholds must be considered to develop an investment program of meaningful size and greater BCR thresholds to maximize the efficiency of the investments.

Candidate investment plans with differing BCR thresholds and differing investment levels have been developed. While a specific investment option is recommended, the ultimate decision on an appropriate investment level to improve safety rests with road authorities in Rajasthan. The table C.3 shows usual options for iRAP projects with additional option with a minimum BCR=18 in order to obtain an investment plan lower than 50,000,000₹.

	Option A	Option B	Option C	Option D
Minimum benefit cost ratio	3	5	8	18
Investment (₹)	510,265,966	443,796,727	175,196,479	46,442,898
Economic benefit 20 years (₹)	3,933,683,713	3,773,024,296	2,083,895,614	1,053,033,080
Programme benefit cost ratio	8	9	12	23
Deaths (per year)				
Before countermeasures	40.3	40.3	40.3	40.3
After countermeasures	15.3	16.3	27.1	33.6
Prevented	25	24	13.2	6.7
Reduction	62.0%	59.4%	15.6%	16.6%
Deaths and serious injuries (20 years)				
Before countermeasures	4,030	4,030	4,030	4,030
After countermeasures	1,533	1,635	2.707	3,362
Prevented	2,497	2,395	1,323	668
Reduction	62.0%	59.4%	32.8%	16.6%
Cost per death and serious injury prevented	204,38 2₹	185,327 ₹	132,463 ₹	69,490 ₹

Investment plan options for Corridor 7.

Countermeasure	Length/Sites	FSIs saved	PV of safety benefit	Estimated cost	Cost per FSI saved	Program BCR
Central median barrier (1+1)	3.30km	155	243,443,664	11,744,450	76,011	21
Central hatching	33.20km	147	231,166,087	10,015,439	10,015,439	23
Improve curve delineation	5.10km	89	139,696,068	2,559,302	28,866	55
Shoulder rumble strips	17.00km	65	101,827,911	4,102,710	63,482	25
Improve delineation	3.30km	40	63,051,436	3,302,464	82,526	19
Refuge island	5 sites	40	63,204,136	2,884,718	71,912	22
Roadside barriers – driver side	1.70km	34	53,522,091	3,690,358	108,638	15
Clear roadside hazards – driver side	2.00km	33	52,583,347	3,307,000	99,090	16
Street lighting (mid – block)	0.50km	28	44,629,929	1,740,852	61,358	26
Footpath provision passenger side	1.40km	25	40,023,861	1,736,100	68,344	23
Street lighting (intersection)	1 site	10	15,018,602	913,410	95,826	16
Footpath provision driver side	0.20km	3	4,865,947	446,094	144,446	11
	TOTAL	**668**	**1,053,033,080**	**46,442,898**	**69,490**	**23**

Countermeasures options for safer roads investment plan (Option D)

SECTION 3: CONCLUSIONS & RECOMMENDATIONS

4 Conclusions & Recommendations

4.1 Corridor wise Recommendations

1. **Corridor 1:** To achieve 25% reduction in Fatalities, combination of SRIP BCR 5 and blackspot elimination recommendations may be adopted. However, major cost associated road widening/shoulder addition could be taken up under capital program and remaining countermeasures could be taken up as part of Safety enhancements.
2. **Corridor 2:** To achieve 30% reduction in Fatalities, combination of SRIP BCR 8 and blackspot elimination recommendations may be adopted. However, major cost associated median and road widening/shoulder could be taken up under capital program and remaining countermeasures could be taken up as part of Safety enhancements.
3. **Corridor 3:** To achieve 20% reduction in Fatalities, combination of SRIP BCR 5 and blackspot elimination recommendations may be adopted.
4. **Corridor 4:** To achieve 30% reduction in Fatalities, combination of SRIP BCR 5 and blackspot elimination recommendations may be adopted.
5. **Corridor 5:** To achieve 30% reduction in Fatalities, combination of SRIP BCR 3 and blackspot elimination recommendations may be adopted.
6. **Corridor 6:** To achieve 16% reduction in Fatalities, combination of SRIP BCR 3 and blackspot elimination recommendations may be adopted.
7. **Corridor 7:** To achieve 30% reduction in Fatalities, combination of SRIP BCR 8 and blackspot elimination recommendations may be adopted. However, major cost associated roadside barriers, median and road widening/shoulder could be taken up under capital program and remaining countermeasures could be taken up as part of Safety enhancements.

4.2 General Recommendations

The following are initial recommendations for consideration by Rajasthan road authorities. It is envisaged that these advice will be refined following the consultation with stakeholders.

- The Government of Rajasthan should review the countermeasures proposed in this report, with a view to improving road safety as a part of Rajasthan Road Sector Modernization Project (RRSMP).
- Within the Government of Rajasthan, a project implementation team should be established to ensure IRAP recommendations are included in existing and future Government and development bank-funded corridor upgrades.
- Consider IRAP methodology as a useful tool to carry out comparative analysis among different roads in Rajasthan and to define road safety objectives for its road network.
- Local and regional authorities should ensure that all future road infrastructure upgrades are accompanied by information and awareness campaigns to ensure local communities are knowledgeable about the way in which de infrastructure is intended to be used.
- Monitoring and collecting of key data required for IRAP analysis. Apart from traffic volume data, crash type data and countermeasure cost data should be obtained according IRAP methodology.
- “Before and after” studies should be undertaken to assess the road safety impact of various road infrastructure upgrades after they are implemented.

4.3 Demo Corridor Selection Matrix

Scoring matrix for selection of a "Demo Corridor" is given below. Project Corridors are assigned with comparative scores (see column – "scoring criteria') with a maximum limit of 100 points.

Corridor 2: Bharathpur – Narnaul, scored the highest (75.37 out of 100) and it is recommended that this corridor to be considered for Safety Demonstration Program under RRSMP.

S. No.	Description	Scoring Criteria	Top Score Counted	Nasirabad - Deoli (0 to 99)		Bharatpur - Narnaul (0 to 163)		Jaipur - Nagaur (64 to 189)		Deoli - Triveni Chaurasia (0 to 75)		Salamber - Keer Ki Chouki (12 to 85)		Suket – Dug (19 to 105, SH19A) (0 to 16, MDR109)		Mahuwa – Karauli (42 to 107)	
				Corridor 1	Scoring	Corridor 2	Scoring	Corridor 3	Scoring	Corridor 4	Scoring	Corridor 5	Scoring	Corridor 6	Scoring	Corridor 7	Scoring
	Length	-		99.00		163.00		125.00		75.00		73.00		103.00		65.00	
1	AADT	Highest Scoring 5	10	3865.00	8.92	3995.00	9.22	1101.00	2.54	3312.00	7.65	854.00	1.97	1788.00	4.13	4331.00	10.00
2	Total Number of Accidents in last 3 years (Jan-2014 to Dec-2015)	Highest Scoring 5	5	180.00	2.03	444.00	5.00	78.00	0.88	160.00	1.80	48.00	0.54	90.00	1.01	219.00	2.47
3	Total Number of Fatal Accidents in last 3 years (Jan-2014 to Dec-2015)	Highest Scoring 5	5	77.00	1.85	208.00	5.00	47.00	1.13	44.00	1.06	16.00	0.38	26.00	0.63	111.00	2.67
4	Accident Severity	Highest Scoring 5	10	48.89	7.78	51.12	8.14	62.82	10.00	36.88	5.87	43.75	6.96	34.44	5.48	55.25	8.80
5	Accidents Density	Highest Scoring 5	5	0.61	2.70	0.91	4.04	0.21	0.93	0.74	3.30	0.22	0.98	0.29	1.30	1.12	5.00
6	Roadway Crash Rate	Highest Scoring 5	5	42.96	3.46	62.00	5.00	51.76	4.17	61.27	4.94	70.31	5.67	44.63	3.60	71.04	5.73
7	Threshold Severity Value	Highest Scoring 5	5	28.05	3.81	34.38	4.67	30.03	4.08	36.84	5.00	13.69	1.86	13.76	1.87	30.13	4.09
8	Number of Black Spots	Highest Scoring 5	10	6	8.57	7	10.00	3	4.29	4	5.71	3	4.29	4	5.71	7	10.00
9	Star Rating (Car Occupants)	Highest Score 2 if: Rating </= 3	2	98%	1.96	98%	1.96	100%	2.00	99%	1.98	100%	2.00	93%	1.86	100.0%	2.00
10	Star Rating (Motorcyclists)	Highest Score 2 if: Rating </= 3	2	100%	2.00	99%	1.98	100%	2.00	100%	2.00	100%	2.00	96%	1.92	100%	2.00
11	Star Rating (Pedestrians)	Highest Score 2 if: Rating </= 3	2	100%	2.00	97%	1.94	100%	2.00	100%	2.00	100%	2.00	99%	1.98	99%	1.98
12	Star Rating (Bicyclists)	Highest Score 2 if: Rating </= 3	2	100%	2.00	96%	1.92	100%	2.00	100%	2.00	100%	2.00	97%	1.94	100%	2.00
13	Total FSIs Saved	Highest Scoring 7	7	456	1.55	2056	7.00	314	1.07	523	1.78	211	0.72	166	0.57	668	2.27
14	Cost per FSI saved	Highest Scoring 10	10	11,630	0.37	1,35,545	4.28	2,08,995	6.61	1,66,445	5.26	2,29,908	7.27	3,16,366	10.00	69,490.00	2.20
15	The benefit cost ratio (BCR): It is the Economic Benefit divided by the Cost. The BCR provides an indication of the value of money for the program.	Highest Scoring 10	10	14	6.09	12	5.22	8	3.48	9	3.91	3	1.30	5	2.17	23	10.00
16	Trauma Care Center Availability near Corridor	Score 5 if: Trauma Care Center available near the project corridor within Golden Hour	10	Available	0.00	Available	0.00	Not Available	10.00	Available	0.00	Not Available	10.00	Not Available	10.00	Available	0.00
	Final Scoring for Demo Corridor Selection		**100**		**55.09**		**75.37**		**57.17**		**54.27**		**49.94**		**54.17**		**71.20**

SECTION 4: ANNEXURES

Annexure 1: Road condition

Corridor 1

Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	5.30	5
1 to <5m	81.60	82
5 to <10m	8.10	8
>= 10m	4.20	4

Roadside severity - driver-side object	km	%
Safety barrier - metal	0.70	1
Safety barrier - concrete	0.60	1
Upwards slope - rollover gradient	0.60	1
Deep drainage ditch	0.40	0
Downwards slope	1.00	1
Tree >=10cm dia.	51.50	52
Sign, post or pole >= 10cm dia.	19.90	20
Rigid structure/bridge or building	11.00	11
Semi-rigid structure or building	4.10	4
Unprotected safety barrier end	3.50	4
Large boulders >=20cm high	3.00	3
None	2.90	3

Roadside severity - passenger-side distance	km	%
0 to <1m	4.70	5
1 to <5m	80.90	82
5 to <10m	11.00	11
>=10m	2.60	3

Roadside severity - passenger-side object	km	%
Safety barrier - metal	1.10	1
Safety barrier - concrete	0.60	1
Upwards slope - rollover gradient	1.70	2
Deep drainage ditch	0.60	1
Downwards slope	0.40	0
Tree >= 10cm dia.	47.70	48
Sign, post or pole >=10cm dia.	21.80	22
Rigid structure/bridge or building	12.10	12
Semi-rigid structure or building	4.70	5
Unprotected safety barrier end	3.20	3
Large boulders >= 20cm high	4.00	4
None	1.30	1

Shoulder rumble strips	km	%
Not present	99.20	100

Paved shoulder - driver-side	km	%
Narrow (>= 0m to < 1.0m)	10.80	11
None	88.40	89

Paved shoulder - passenger-side	km	%
Narrow (>= 0m to < 1.0m)	11.10	11
None	88.10	89

Mid-block

Carriageway label	km	%
Carriageway A of a divided carriageway road	2.50	3
Carriageway B of a divided carriageway road	2.40	2
Undivided road	94.30	95

Upgrade cost	km	%
Low	91.30	92
Medium	7.20	7
High	0.70	1

Median type	km	%
Physical median width >= 1.0m to < 5.0m	4.50	5
Physical median width >= 0m to < 1.0m	0.40	0
Centre line	94.30	95

Centreline rumble strips	km	%
Not present	99.20	100

Number of lanes	km	%
One	94.30	95
Two	4.90	5

Lane width	km	%
Wide (>= 3.25m)	99.20	100

Curvature	km	%
Straight or gently curving	88.20	89
Moderate	10.80	11
Sharp	0.20	0

Quality of curve	km	%
Adequate	7.40	7
Poor	3.60	4
Not applicable	88.20	89

Grade	km	%
>= 0% to <7.5%	99.20	100

Road condition	km	%
Good	85.70	86
Medium	13.50	14

Skid resistance / grip	km	%
Sealed - adequate	89.60	90
Sealed - medium	8.20	8
Sealed - poor	1.40	1

Delineation	km	%
Adequate	7.50	8
Poor	91.70	92

Street lighting	km	%
Not present	98.90	100
Present	0.30	0

Vehicle parking	km	%
Low	83.50	84
Medium	11.30	11
High	4.40	4

Service road	km	%
Not present	99.20	100

Roadworks	km	%
No road works	99.20	100

Sight distance	km	%
Adequate	99.10	100
Poor	0.10	0

Intersections

Intersection type	Points	%
3-leg (unsignalised) with no protected turn lane	85	9
4-leg (unsignalised) with protected turn lane	3	0
4-leg (unsignalised) with no protected turn lane	14	1
None	886	89
Median crossing point - formal	4	0

Intersection channelisation	Points	%
Not present	989	100
Present	3	0

Intersecting road volume	Points	%
1,000 to 5,000 vehicles	10	1
100 to 1,000 vehicles	25	3
1 to 100 vehicles	71	7
None	886	89

Intersection quality	Points	%
Adequate	8	1
Poor	98	10
Not applicable	886	89

Property access points	km	%
Commercial Access 1+	18.20	18
Residential Access 3+	7.70	8
Residential Access 1 or 2	15.50	16
None	57.80	58

Flow

Vehicle flow (AADT)	km	%
1000 - 5000	99.20	100

Motorcyclist observed flow	km	%
None	50.40	51
1 motorcycle observed	31.00	31
2 to 3 motorcycles observed	15.20	15
4 to 5 motorcycles observed	1.70	2
6 to 7 motorcycles observed	0.40	0
8+ motorcycles observed	0.50	1

Bicyclist observed flow	km	%
None	98.10	99
1 bicycle observed	1.10	1

Pedestrian observed flow across the road	km	%
None	98.20	99
1 pedestrian crossing observed	0.90	1
2 to 3 pedestrians crossing observed	0.10	0

Pedestrian observed flow along the road driver-side	km	%
None	93.10	94
1 pedestrian along driver-side observed	3.50	4
2 to 3 pedestrians along driver-side observed	2.10	2
4 to 5 pedestrians along driver-side observed	0.10	0
6 to 7 pedestrians along driver-side observed	0.20	0
8+ pedestrians along driver-side observed	0.20	0

Pedestrian observed flow along the road passenger-side	km	%
None	91.30	92
1 pedestrian along passenger-side observed	3.90	4
2 to 3 pedestrians along passenger-side observed	2.40	2
4 to 5 pedestrians along passenger-side observed	0.70	1
6 to 7 pedestrians along passenger-side observed	0.40	0
8+ pedestrians along passenger-side observed	0.50	1

Motorcyclist %	km	%
21% - 40%	99.20	100

Pedestrian peak hour flow across the road	km	%
0	3.90	4
1 to 5	79.50	80
6 to 25	15.80	16

Pedestrian peak hour flow along the road driver-side	km	%
0	4.90	5
6 to 25	94.30	95

Pedestrian peak hour flow along the road passenger-side	km	%
6 to 25	99.20	100

Bicyclist peak hour flow	km	%
1 to 5	99.20	100

Vulnerable road users facilities and land use

Land use - driver-side	km	%
Undeveloped areas	8.40	8
Farming and agricultural	77.00	78
Residential	1.90	2
Commercial	11.30	11
Not Recorded	0.10	0
Educational	0.40	0
Industrial and manufacturing	0.10	0

Land use - passenger-side	km	%
Undeveloped areas	6.90	7
Farming and agricultural	78.40	79
Residential	2.70	3
Commercial	10.80	11
Not Recorded	0.10	0
Educational	0.30	0

Area type	km	%
Rural / open area	85.50	86
Urban / rural town or village	13.70	14

Pedestrian crossing facilities - inspected road	Points	%
Unsignalised marked crossing without a refuge	13	1
No facility	979	99

Pedestrian crossing quality	Points	%
Poor	13	1
Not applicable	979	99

Pedestrian crossing facilities - intersecting road	Points	%
Unsignalised marked crossing without a refuge	1	0
No facility	991	100

Pedestrian fencing	km	%
Not present	99.20	100

Sidewalk - driver-side	km	%
Non-physical separation 1.0m to <3.0m	0.20	0
Non-physical separation 0m to <1.0m	0.30	0
None	5.20	5
Informal path 0m to <1.0m	93.50	94

Sidewalk - passenger-side	km	%
Non-physical separation 1.0m to <3.0m	1.00	1
Non-physical separation 0m to <1.0m	0.20	0
None	0.50	1
Informal path 0m to <1.0m	97.50	98

Facilities for motorised two wheelers	km	%
None	99.20	100

Facilities for bicycles	km	%
None	99.20	100

School zone warning	Points	%
School zone static signs or road markings	5	1
No school zone warning	8	1
Not applicable (no school at the location)	979	99

School zone crossing supervisor	Points	%
School zone crossing supervisor not present	13	1
Not applicable (no school at the location)	979	99

Corridor 2

Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	17.20	10
1 to <5m	144.10	84
5 to <10m	5.70	3
>= 10m	4.80	3

Roadside severity - driver-side object	km	%
Safety barrier - concrete	1.00	1
Upwards slope - no rollover gradient	0.20	0
Deep drainage ditch	0.30	0
Downwards slope	2.20	1
Cliff	0.20	0
Tree >=10cm dia.	96.90	56
Sign, post or pole >= 10cm dia.	47.30	28
Rigid structure/bridge or building	12.60	7
Semi-rigid structure or building	7.40	4
Unprotected safety barrier end	1.00	1
Large boulders >=20cm high	0.10	0
None	2.60	2

Roadside severity - passenger-side distance	km	%
0 to <1m	10.20	6
1 to <5m	151.60	88
5 to <10m	5.30	3
>=10m	4.70	3

Roadside severity - passenger-side object	km	%
Safety barrier - metal	0.20	0
Safety barrier - concrete	1.50	1
Upwards slope - rollover gradient	0.20	0
Deep drainage ditch	1.20	1
Downwards slope	1.90	1
Tree >= 10cm dia.	96.60	56
Sign, post or pole >=10cm dia.	44.80	26
Rigid structure/bridge or building	14.50	8
Semi-rigid structure or building	6.90	4
Unprotected safety barrier end	0.80	0
Large boulders >= 20cm high	0.20	0
None	3.00	2

Shoulder rumble strips	km	%
Not present	171.80	100

Paved shoulder - driver-side	km	%
Medium (>= 1.0m to < 2.4m)	26.60	15
Narrow (>= 0m to < 1.0m)	15.80	9
None	129.40	75

Paved shoulder - passenger-side	km	%
Medium (>= 1.0m to < 2.4m)	26.60	15
Narrow (>= 0m to < 1.0m)	19.10	11
None	126.10	73

Mid-block

Carriageway label	km	%
Carriageway A of a divided carriageway road	8.30	5
Carriageway B of a divided carriageway road	8.30	5
Undivided road	155.20	90

Upgrade cost	km	%
Low	148.80	87
Medium	19.00	11
High	4.00	2

Median type	km	%
Safety barrier - concrete	0.20	0
Physical median width >= 1.0m to < 5.0m	15.80	9
Physical median width >= 0m to < 1.0m	0.60	0
Centre line	155.20	90

Centreline rumble strips	km	%
Not present	171.80	100

Number of lanes	km	%
One	136.00	79
Two	35.80	21

Lane width	km	%
Wide (>= 3.25m)	24.60	14
Medium (>= 2.75m to < 3.25m)	146.50	85
Narrow (>= 0m to < 2.75m)	0.70	0

Curvature	km	%
Straight or gently curving	154.00	90
Moderate	16.90	10
Sharp	0.90	1

Quality of curve	km	%
Adequate	9.00	5
Poor	8.80	5
Not applicable	154.00	90

Grade	km	%
>= 0% to <7.5%	150.00	87
Not applicable	21.80	13

Road condition	km	%
Good	166.90	97
Medium	3.40	2
Poor	1.50	1

Skid resistance / grip	km	%
Sealed - adequate	170.70	99
Sealed - medium	0.40	0
Sealed - poor	0.20	0
Unsealed - poor	0.50	0

Delineation	km	%
Adequate	40.70	24
Poor	131.10	76

Street lighting	km	%
Not present	149.50	87
Present	22.30	13

Vehicle parking	km	%
Low	146.20	85
Medium	16.80	10
High	8.80	5

Service road	km	%
Not present	171.80	100

Roadworks	km	%
No road works	171.10	100
Major road works in progress	0.70	0

Sight distance	km	%
Adequate	158.60	92
Poor	13.20	8

Intersections

Intersection type	Points	%
Merge lane	1	0
Roundabout	6	0
3-leg (unsignalised) with no protected turn lane	227	13
4-leg (unsignalised) with no protected turn lane	39	2
None	1433	83
Railway Crossing - active (flashing lights / boom gates)	4	0
Median crossing point - formal	8	0

Intersection channelisation	Points	%
Not present	1707	99
Present	11	1

Intersecting road volume	Points	%
5,000 to 10,000 vehicles	1	0
1,000 to 5,000 vehicles	17	1
100 to 1,000 vehicles	109	6
1 to 100 vehicles	158	9
None	1433	83

Intersection quality	Points	%
Adequate	13	1
Poor	272	16
Not applicable	1433	83

Property access points	km	%
Commercial Access 1+	29.40	17
Residential Access 3+	20.30	12
Residential Access 1 or 2	11.90	7
None	110.20	64

Flow

Vehicle flow (AADT)	km	%
1000 - 5000	171.80	100

Motorcyclist observed flow	km	%
None	64.90	38
1 motorcycle observed	48.80	28
2 to 3 motorcycles observed	40.10	23
4 to 5 motorcycles observed	11.40	7
6 to 7 motorcycles observed	3.60	2
8+ motorcycles observed	3.00	2

Bicyclist observed flow	km	%
None	164.10	96
1 bicycle observed	6.20	4
2 to 3 bicycles observed	1.40	1
4 to 5 bicycles observed	0.10	0

Pedestrian observed flow across the road	km	%
None	167.70	98
1 pedestrian crossing observed	3.00	2
2 to 3 pedestrians crossing observed	0.90	1
4 to 5 pedestrians crossing observed	0.20	0

Pedestrian observed flow along the road driver-side	km	%
None	154.20	90
1 pedestrian along driver-side observed	7.90	5
2 to 3 pedestrians along driver-side observed	7.00	4
4 to 5 pedestrians along driver-side observed	1.10	1
6 to 7 pedestrians along driver-side observed	0.50	0
8+ pedestrians along driver-side observed	1.10	1

Pedestrian observed flow along the road passenger-side	km	%
None	150.10	87
1 pedestrian along passenger-side observed	9.20	5
2 to 3 pedestrians along passenger-side observed	7.90	5
4 to 5 pedestrians along passenger-side observed	2.20	1
6 to 7 pedestrians along passenger-side observed	1.00	1
8+ pedestrians along passenger-side observed	1.40	1

Motorcyclist %	km	%
21% - 40%	171.80	100

Pedestrian peak hour flow across the road	km	%
0	3.20	2
1 to 5	114.20	66
6 to 25	54.40	32

Pedestrian peak hour flow along the road driver-side	km	%
0	16.60	10
6 to 25	155.20	90

Pedestrian peak hour flow along the road passenger-side	km	%
0	0.10	0
1 to 5	1.90	1
6 to 25	169.80	99

Bicyclist peak hour flow	km	%
1 to 5	171.80	100

Vulnerable road users facilities and land use

Land use - driver-side	km	%
Undeveloped areas	6.00	3
Farming and agricultural	116.80	68
Residential	15.10	9
Commercial	32.00	19
Industrial and manufacturing	1.90	1

Land use - passenger-side	km	%
Undeveloped areas	7.00	4
Farming and agricultural	117.00	68
Residential	13.60	8
Commercial	33.20	19
Educational	0.10	0
Industrial and manufacturing	0.90	1

Area type	km	%
Rural / open area	124.30	72
Urban / rural town or village	47.50	28

Pedestrian crossing facilities - inspected road	Points	%
Unsignalised marked crossing without a refuge	138	8
No facility	1571	91
Unsignalised raised marked crossing without refuge	9	1

Pedestrian crossing quality	Points	%
Adequate	34	2
Poor	113	7
Not applicable	1571	91

Pedestrian crossing facilities - intersecting road	Points	%
Unsignalised marked crossing without a refuge	8	0
No facility	1710	100

Pedestrian fencing	km	%
Not present	171.60	100
Present	0.20	0

Sidewalk - driver-side	km	%
Physical barrier	0.20	0
Non-physical separation 1.0m to <3.0m	0.10	0
Non-physical separation 0m to <1.0m	0.40	0
None	15.90	9
Informal path 0m to <1.0m	155.20	90

Sidewalk - passenger-side	km	%
Physical barrier	0.20	0
Non-physical separation 0m to <1.0m	0.40	0
None	7.60	4
Informal path 0m to <1.0m	163.60	95

Facilities for motorised two wheelers	km	%
None	171.80	100

Facilities for bicycles	km	%
None	171.80	100

School zone warning	Points	%
School zone static signs or road markings	3	0
No school zone warning	114	7
Not applicable (no school at the location)	1601	93

School zone crossing supervisor	Points	%
School zone crossing supervisor not present	17	1
Not applicable (no school at the location)	1701	99

Corridor 3

Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	2.10	2
1 to <5m	87.50	69
5 to <10m	31.50	25
>= 10m	5.00	4

Roadside severity - driver-side object	km	%
Safety barrier - metal	1.60	1
Safety barrier - concrete	0.60	0
Aggressive vertical face	0.30	0
Upwards slope - rollover gradient	6.80	5
Upwards slope - no rollover gradient	1.40	1
Deep drainage ditch	1.20	1
Downwards slope	5.60	4
Tree >=10cm dia.	62.60	50
Sign, post or pole >= 10cm dia.	30.30	24
Rigid structure/bridge or building	7.20	6
Semi-rigid structure or building	5.50	4
Unprotected safety barrier end	0.30	0
Large boulders >=20cm high	1.60	1
None	1.10	1

Roadside severity - passenger-side distance	km	%
0 to <1m	1.20	1
1 to <5m	78.40	62
5 to <10m	41.00	33
>=10m	5.50	4

Roadside severity - passenger-side object	km	%
Safety barrier - metal	1.20	1
Safety barrier - concrete	0.50	0
Aggressive vertical face	0.20	0
Upwards slope - rollover gradient	9.90	8
Upwards slope - no rollover gradient	1.40	1
Deep drainage ditch	1.00	1
Downwards slope	3.90	3
Cliff	0.40	0
Tree >= 10cm dia.	62.30	49
Sign, post or pole >=10cm dia.	27.20	22
Rigid structure/bridge or building	9.30	7
Semi-rigid structure or building	6.60	5
Large boulders >= 20cm high	1.70	1
None	0.50	0

Shoulder rumble strips	km	%
Not present	126.10	100

Paved shoulder - passenger-side	km	%
Medium (>= 1.0m to < 2.4m)	2.70	2
Narrow (>= 0m to < 1.0m)	56.40	45
None	67.00	53

Paved shoulder - driver-side	km	%
Medium (>= 1.0m to < 2.4m)	2.70	2
Narrow (>= 0m to < 1.0m)	55.10	44
None	68.30	54

Mid-block

Carriageway label	km	%
Carriageway A of a divided carriageway road	0.20	0
Carriageway B of a divided carriageway road	0.20	0
Undivided road	125.70	100

Upgrade cost	km	%
Low	122.70	97
Medium	3.40	3

Median type	km	%
Safety barrier - metal	0.20	0
Centre line	125.90	100

Centreline rumble strips	km	%
Not present	126.10	100

Number of lanes	km	%
One	126.10	100

Lane width	km	%
Wide (>= 3.25m)	126.10	100

Curvature	km	%
Straight or gently curving	106.80	85
Moderate	18.80	15
Sharp	0.50	0

Quality of curve	km	%
Poor	19.30	15
Not applicable	106.80	85

Grade	km	%
>= 0% to <7.5%	126.10	100

Road condition	km	%
Good	126.00	100
Poor	0.10	0

Skid resistance / grip	km	%
Sealed - adequate	126.00	100
Sealed - poor	0.10	0

Street lighting	km	%
Not present	124.60	99
Present	1.50	1

Vehicle parking	km	%
Low	116.00	92
Medium	7.50	6
High	2.60	2

Service road	km	%
Not present	125.90	100
Present	0.20	0

Roadworks	km	%
No road works	126.10	100

Sight distance	km	%
Adequate	126.10	100

Intersections

Intersection type	Points	%
Merge lane	2	0
3-leg (unsignalised) with protected turn lane	1	0
3-leg (unsignalised) with no protected turn lane	98	8
4-leg (unsignalised) with no protected turn lane	30	2
None	1129	90
Railway Crossing - active (flashing lights / boom gates)	1	0

Intersection channelisation	Points	%
Not present	1252	99
Present	9	1

Intersecting road volume	Points	%
5,000 to 10,000 vehicles	6	0
1,000 to 5,000 vehicles	4	0
100 to 1,000 vehicles	58	5
1 to 100 vehicles	64	5
None	1129	90

Intersection quality	Points	%
Poor	132	10
Not applicable	1129	90

Property access points	km	%
Commercial Access 1+	12.30	10
Residential Access 3+	5.70	5
Residential Access 1 or 2	21.30	17
None	86.80	69

Flow

Vehicle flow (AADT)	km	%
1000 - 5000	126.10	100

Motorcyclist observed flow	km	%
None	89.50	71
1 motorcycle observed	28.80	23
2 to 3 motorcycles observed	6.90	5
4 to 5 motorcycles observed	0.80	1
8+ motorcycles observed	0.10	0

Pedestrian observed flow across the road	km	%
None	125.60	100
1 pedestrian crossing observed	0.50	0

Bicyclist observed flow	km	%
None	125.80	100
1 bicycle observed	0.30	0

Pedestrian observed flow across the road	km	%
None	125.60	100
1 pedestrian crossing observed	0.50	0

Pedestrian observed flow along the road driver-side	km	%
None	120.30	95
1 pedestrian along driver-side observed	3.50	3
2 to 3 pedestrians along driver-side observed	1.40	1
4 to 5 pedestrians along driver-side observed	0.70	1
6 to 7 pedestrians along driver-side observed	0.20	0

Pedestrian observed flow along the road passenger-side	km	%
None	120.00	95
1 pedestrian along passenger-side observed	3.40	3
2 to 3 pedestrians along passenger-side observed	1.90	2
4 to 5 pedestrians along passenger-side observed	0.40	0
6 to 7 pedestrians along passenger-side observed	0.10	0
8+ pedestrians along passenger-side observed	0.30	0

Motorcyclist %	km	%
11% - 20%	126.10	100

Pedestrian peak hour flow along the road passenger-side	km	%
1 to 5	6.10	5
6 to 25	120.00	95

Pedestrian peak hour flow across the road	km	%
0	2.40	2
1 to 5	101.90	81
6 to 25	21.80	17

Bicyclist peak hour flow	km	%
1 to 5	126.10	100

Vulnerable road users facilities and land use

Land use - driver-side	km	%
Undeveloped areas	4.20	3
Farming and agricultural	104.90	83
Residential	6.30	5
Commercial	6.30	5
Educational	0.60	0
Industrial and manufacturing	3.80	3

Land use - passenger-side	km	%
Undeveloped areas	4.30	3
Farming and agricultural	105.10	83
Residential	6.70	5
Commercial	5.90	5
Educational	0.80	1
Industrial and manufacturing	3.30	3

Area type	km	%
Rural / open area	109.50	87
Urban / rural town or village	16.60	13

Pedestrian crossing facilities - inspected road	Points	%
Unsignalised marked crossing without a refuge	122	10
No facility	1137	90
Unsignalised raised marked crossing without refuge	2	0

Pedestrian crossing quality	Points	%
Adequate	116	9
Poor	8	1
Not applicable	1137	90

Pedestrian crossing facilities - intersecting road	Points	%
No facility	1261	100

Pedestrian fencing	km	%
Not present	126.10	100

Sidewalk - driver-side	km	%
Non-physical separation 1.0m to <3.0m	0.50	0
Non-physical separation 0m to <1.0m	2.30	2
None	6.60	5
Informal path >= 1.0m	0.10	0
Informal path 0m to <1.0m	116.60	92

Sidewalk - passenger-side	km	%
Non-physical separation 1.0m to <3.0m	0.50	0
Non-physical separation 0m to <1.0m	2.30	2
None	6.20	5
Informal path 0m to <1.0m	117.10	93

Facilities for motorised two wheelers	km	%
None	126.10	100

Facilities for bicycles	km	%
None	126.10	100

School zone warning	Points	%
School zone static signs or road markings	10	1
No school zone warning	5	0
Not applicable (no school at the location)	1246	99

School zone crossing supervisor	Points	%
School zone crossing supervisor not present	15	1
Not applicable (no school at the location)	1246	99

Corridor 4

Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	1.40	2
1 to <5m	58.10	77
5 to <10m	13.40	18
>= 10m	2.10	3

Roadside severity - driver-side object	km	%
Safety barrier - metal	0.50	1
Aggressive vertical face	0.40	1
Upwards slope - rollover gradient	5.40	7
Upwards slope - no rollover gradient	0.20	0
Deep drainage ditch	1.20	2
Downwards slope	1.10	1
Tree >=10cm dia.	27.70	37
Sign, post or pole >= 10cm dia.	18.30	24
Rigid structure/bridge or building	13.70	18
Semi-rigid structure or building	4.30	6
Large boulders >=20cm high	1.40	2
None	0.80	1

Roadside severity - passenger-side distance	km	%
0 to <1m	1.60	2
1 to <5m	57.60	77
5 to <10m	13.90	19
>=10m	1.90	3

Roadside severity - passenger-side object	km	%
Safety barrier - metal	0.50	1
Aggressive vertical face	1.00	1
Upwards slope - rollover gradient	2.10	3
Upwards slope - no rollover gradient	0.50	1
Deep drainage ditch	0.80	1
Downwards slope	1.30	2
Tree >= 10cm dia.	27.20	36
Sign, post or pole >=10cm dia.	21.10	28
Rigid structure/bridge or building	12.00	16
Semi-rigid structure or building	5.60	7
Large boulders >= 20cm high	2.10	3
None	0.80	1

Shoulder rumble strips	km	%
Not present	75.00	100

Paved shoulder - driver-side	km	%
Narrow (>= 0m to < 1.0m)	72.10	96
None	2.90	4

Paved shoulder - passenger-side	km	%
Narrow (>= 0m to < 1.0m)	72.20	96
None	2.80	4

Mid-block

Carriageway label	km	%
Undivided road	75.00	100

Upgrade cost	km	%
Low	63.50	85
Medium	9.80	13
High	1.70	2

Median type	km	%
Centre line	75.00	100

Centreline rumble strips	km	%
Not present	75.00	100

Number of lanes	km	%
One	75.00	100

Lane width	km	%
Wide (>= 3.25m)	73.40	98
Medium (>= 2.75m to < 3.25m)	1.60	2

Curvature	km	%
Straight or gently curving	59.30	79
Moderate	15.10	20
Sharp	0.60	1

Quality of curve	km	%
Adequate	9.70	13
Poor	6.00	8
Not applicable	59.30	79

Grade	km	%
>= 0% to <7.5%	75.00	100

Road condition	km	%
Good	73.60	98
Medium	0.70	1
Poor	0.70	1

Skid resistance / grip	km	%
Sealed - adequate	74.30	99
Sealed - medium	0.70	1

Delineation	km	%
Adequate	10.00	13
Poor	65.00	87

Street lighting	km	%
Not present	74.80	100
Present	0.20	0

Vehicle parking	km	%
Low	64.20	86
Medium	6.00	8
High	4.80	6

Service road	km	%
Not present	74.70	100
Present	0.30	0

Roadworks	km	%
No road works	75.00	100

Sight distance	km	%
Adequate	75.00	100

Intersections

Intersection type	Points	%
Roundabout	1	0
3-leg (unsignalised) with no protected turn lane	99	13
4-leg (unsignalised) with no protected turn lane	6	1
None	644	86

Intersection channelisation	Points	%
Not present	749	100
Present	1	0

Intersecting road volume	Points	%
1,000 to 5,000 vehicles	4	1
100 to 1,000 vehicles	37	5
1 to 100 vehicles	65	9
None	644	86

Intersection quality	Points	%
Adequate	5	1
Poor	101	13
Not applicable	644	86

Property access points	km	%
Commercial Access 1+	4.70	6
Residential Access 3+	9.20	12
Residential Access 1 or 2	31.10	41
None	30.00	40

Flow

Vehicle flow (AADT)	km	%
1000 - 5000	75.00	100

Motorcyclist observed flow	km	%
None	38.40	51
1 motorcycle observed	23.30	31
2 to 3 motorcycles observed	10.80	14
4 to 5 motorcycles observed	2.30	3
6 to 7 motorcycles observed	0.20	0

Bicyclist observed flow	km	%
None	73.70	98
1 bicycle observed	1.20	2
2 to 3 bicycles observed	0.10	0

Pedestrian observed flow across the road	km	%
None	73.40	98
1 pedestrian crossing observed	1.30	2
2 to 3 pedestrians crossing observed	0.20	0
6 to 7 pedestrians crossing observed	0.10	0

Pedestrian observed flow along the road driver-side	km	%
None	68.40	91
1 pedestrian along driver-side observed	4.20	6
2 to 3 pedestrians along driver-side observed	1.40	2
4 to 5 pedestrians along driver-side observed	0.90	1
8+ pedestrians along driver-side observed	0.10	0

Pedestrian observed flow along the road passenger-side	km	%
None	68.00	91
1 pedestrian along passenger-side observed	3.60	5
2 to 3 pedestrians along passenger-side observed	2.60	3
4 to 5 pedestrians along passenger-side observed	0.70	1
6 to 7 pedestrians along passenger-side observed	0.10	0

Motorcyclist %	km	%
1% - 5%	75.00	100

Pedestrian peak hour flow across the road	km	%
0	0.90	1
1 to 5	54.10	72
6 to 25	20.00	27

Pedestrian peak hour flow along the road driver-side	km	%
6 to 25	75.00	100

Pedestrian peak hour flow along the road passenger-side	km	%
6 to 25	75.00	100

Bicyclist peak hour flow	km	%
1 to 5	75.00	100

Vulnerable road users facilities and land use

Land use - driver-side	km	%
Undeveloped areas	1.20	2
Farming and agricultural	58.30	78
Residential	10.90	15
Commercial	3.50	5
Educational	0.40	1
Industrial and manufacturing	0.70	1

Land use - passenger-side	km	%
Undeveloped areas	1.20	2
Farming and agricultural	58.60	78
Residential	10.90	15
Commercial	3.30	4
Educational	0.50	1
Industrial and manufacturing	0.50	1

Area type	km	%
Rural / open area	60.30	80
Urban / rural town or village	14.70	20

Pedestrian crossing facilities - inspected road	Points	%
Unsignalised marked crossing without a refuge	67	9
No facility	683	91

Pedestrian crossing quality	Points	%
Adequate	13	2
Poor	54	7
Not applicable	683	91

Pedestrian crossing facilities - intersecting road	Points	%
No facility	750	100

Pedestrian fencing	km	%
Not present	75.00	100

Sidewalk - driver-side	km	%
None	3.00	4
Informal path 0m to <1.0m	72.00	96

Sidewalk - passenger-side	km	%
None	2.80	4
Informal path 0m to <1.0m	72.20	96

Facilities for motorised two wheelers	km	%
None	75.00	100

Facilities for bicycles	km	%
None	75.00	100

School zone warning	Points	%
School zone static signs or road markings	4	1
No school zone warning	2	0
Not applicable (no school at the location)	744	99

School zone crossing supervisor	Points	%
School zone crossing supervisor not present	5	1
Not applicable (no school at the location)	745	99

Corridor 5

Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	3.30	5
1 to <5m	64.70	89
5 to <10m	4.20	6
>= 10m	0.90	1

Roadside severity - driver-side object	km	%
Safety barrier - metal	0.50	1
Aggressive vertical face	3.80	5
Upwards slope - rollover gradient	7.90	11
Upwards slope - no rollover gradient	0.60	1
Deep drainage ditch	0.20	0
Downwards slope	0.80	1
Cliff	0.10	0
Tree >=10cm dia.	24.60	34
Sign, post or pole >= 10cm dia.	5.70	8
Rigid structure/bridge or building	9.30	13
Semi-rigid structure or building	16.90	23
Unprotected safety barrier end	0.30	0
Large boulders >=20cm high	2.00	3
None	0.40	1

Roadside severity - passenger-side distance	km	%
0 to <1m	1.60	2
1 to <5m	65.70	90
5 to <10m	5.00	7
>=10m	0.80	1

Roadside severity - passenger-side object	km	%
Safety barrier - metal	0.20	0
Aggressive vertical face	1.70	2
Upwards slope - rollover gradient	7.60	10
Upwards slope - no rollover gradient	0.20	0
Deep drainage ditch	0.20	0
Downwards slope	1.60	2
Cliff	0.10	0
Tree >= 10cm dia.	25.50	35
Sign, post or pole >=10cm dia.	5.90	8
Rigid structure/bridge or building	7.60	10
Semi-rigid structure or building	20.40	28
Unprotected safety barrier end	0.30	0
Large boulders >= 20cm high	1.50	2
None	0.30	0

Shoulder rumble strips	km	%
Not present	73.10	100

Paved shoulder - driver-side	km	%
Narrow (>= 0m to < 1.0m)	66.40	91
None	6.70	9

Paved shoulder - passenger-side	km	%
Narrow (>= 0m to < 1.0m)	66.60	91
None	6.50	9

Mid-block

Carriageway label	km	%
Undivided road	73.10	100

Upgrade cost	km	%
Low	67.20	92
Medium	4.70	6
High	1.20	2

Median type	km	%
Centre line	73.10	100

Centreline rumble strips	km	%
Not present	73.10	100

Number of lanes	km	%
One	73.10	100

Lane width	km	%
Wide (>= 3.25m)	40.00	55
Medium (>= 2.75m to < 3.25m)	33.10	45

Curvature	km	%
Straight or gently curving	43.20	59
Moderate	28.70	39
Sharp	1.20	2

Quality of curve	km	%
Poor	29.90	41
Not applicable	43.20	59

Grade	km	%
>= 0% to <7.5%	73.10	100

Road condition	km	%
Good	72.40	99
Medium	0.70	1

Skid resistance / grip	km	%
Sealed - adequate	73.10	100

Delineation	km	%
Adequate	23.50	32
Poor	49.60	68

Street lighting	km	%
Not present	72.20	99
Present	0.90	1

Vehicle parking	km	%
Low	67.90	93
Medium	4.00	5
High	1.20	2

Service road	km	%
Not present	73.10	100

Roadworks	km	%
No road works	72.70	99
Minor road works in progress	0.20	0
Major road works in progress	0.20	0

Sight distance	km	%
Adequate	73.10	100

Intersections

Intersection type	Points	%
3-leg (unsignalised) with protected turn lane	1	0
3-leg (unsignalised) with no protected turn lane	97	13
4-leg (unsignalised) with no protected turn lane	5	1
None	627	86
Railway Crossing - passive (signs only)	1	0

Intersection channelisation	Points	%
Not present	730	100
Present	1	0

Intersecting road volume	Points	%
1,000 to 5,000 vehicles	8	1
100 to 1,000 vehicles	31	4
1 to 100 vehicles	65	9
None	627	86

Intersection quality	Points	%
Adequate	1	0
Poor	103	14
Not applicable	627	86

Property access points	km	%
Commercial Access 1+	3.90	5
Residential Access 3+	2.40	3
Residential Access 1 or 2	4.90	7
None	61.90	85

Flow

Vehicle flow (AADT)	km	%
0 - 1000	24.80	34
1000 - 5000	48.30	66

Motorcyclist observed flow	km	%
None	45.30	62
1 motorcycle observed	19.40	27
2 to 3 motorcycles observed	7.90	11
4 to 5 motorcycles observed	0.50	1

Bicyclist observed flow	km	%
None	72.50	99
1 bicycle observed	0.60	1

Pedestrian observed flow across the road	km	%
None	72.40	99
1 pedestrian crossing observed	0.60	1
2 to 3 pedestrians crossing observed	0.10	0

Pedestrian observed flow along the road driver-side	km	%
None	67.50	92
1 pedestrian along driver-side observed	2.40	3
2 to 3 pedestrians along driver-side observed	2.20	3
4 to 5 pedestrians along driver-side observed	0.50	1
6 to 7 pedestrians along driver-side observed	0.30	0
8+ pedestrians along driver-side observed	0.20	0

Pedestrian observed flow along the road passenger-side	km	%
None	67.70	93
1 pedestrian along passenger-side observed	2.40	3
2 to 3 pedestrians along passenger-side observed	1.90	3
4 to 5 pedestrians along passenger-side observed	1.00	1
8+ pedestrians along passenger-side observed	0.10	0

Motorcyclist %	km	%
11% - 20%	73.10	100

Pedestrian peak hour flow across the road	km	%
0	11.10	15
1 to 5	52.90	72
6 to 25	9.10	12

Pedestrian peak hour flow along the road driver-side	km	%
0	0.60	1
1 to 5	3.30	5
6 to 25	69.20	95

Pedestrian peak hour flow along the road passenger-side	km	%
0	0.60	1
1 to 5	3.30	5
6 to 25	69.20	95

Bicyclist peak hour flow	km	%
1 to 5	73.10	100

Vulnerable road users facilities and land use

Land use - driver-side	km	%
Undeveloped areas	13.00	18
Farming and agricultural	50.00	68
Residential	6.30	9
Commercial	2.80	4
Educational	0.80	1
Industrial and manufacturing	0.20	0

Land use - passenger-side	km	%
Undeveloped areas	13.10	18
Farming and agricultural	50.50	69
Residential	6.40	9
Commercial	2.80	4
Industrial and manufacturing	0.30	0

Area type	km	%
Rural / open area	68.40	94
Urban / rural town or village	4.70	6

Pedestrian crossing facilities - inspected road	Points	%
Unsignalised marked crossing without a refuge	7	1
No facility	723	99
Unsignalised raised marked crossing without refuge	1	0

Pedestrian crossing quality	Points	%
Poor	8	1
Not applicable	723	99

Pedestrian crossing facilities - intersecting road	Points	%
No facility	731	100

Pedestrian fencing	km	%
Not present	73.10	100

Sidewalk - driver-side	km	%
None	11.20	15
Informal path 0m to <1.0m	61.90	85

Sidewalk - passenger-side	km	%
None	11.00	15
Informal path 0m to <1.0m	62.10	85

Facilities for motorised two wheelers	km	%
None	73.10	100

Facilities for bicycles	km	%
None	73.10	100

School zone warning	Points	%
School zone static signs or road markings	4	1
No school zone warning	1	0
Not applicable (no school at the location)	726	99

School zone crossing supervisor	Points	%
School zone crossing supervisor not present	5	1
Not applicable (no school at the location)	726	99

Corridor 6

Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	2.70	3
1 to <5m	90.90	88
5 to <10m	7.30	7
>= 10m	2.10	2

Roadside severity - driver-side object	km	%
Safety barrier - metal	1.10	1
Safety barrier - concrete	0.40	0
Aggressive vertical face	0.90	1
Upwards slope - rollover gradient	2.60	3
Upwards slope - no rollover gradient	1.10	1
Deep drainage ditch	1.00	1
Downwards slope	11.50	11
Tree >=10cm dia.	48.00	47
Sign, post or pole >= 10cm dia.	16.00	16
Rigid structure/bridge or building	14.90	14
Semi-rigid structure or building	2.50	2
Unprotected safety barrier end	1.00	1
Large boulders >=20cm high	0.50	0
None	1.50	1

Roadside severity - passenger-side distance	km	%
0 to <1m	3.50	3
1 to <5m	92.20	90
5 to <10m	5.10	5
>=10m	2.20	2

Roadside severity - passenger-side object	km	%
Safety barrier - metal	1.40	1
Safety barrier - concrete	0.40	0
Aggressive vertical face	1.00	1
Upwards slope - rollover gradient	2.30	2
Upwards slope - no rollover gradient	1.00	1
Deep drainage ditch	0.50	0
Downwards slope	12.40	12
Tree >= 10cm dia.	46.60	45
Sign, post or pole >=10cm dia.	17.00	17
Rigid structure/bridge or building	14.70	14
Semi-rigid structure or building	2.40	2
Unprotected safety barrier end	1.40	1
Large boulders >= 20cm high	0.30	0
None	1.60	2

Shoulder rumble strips	km	%
Not present	103.00	100

Paved shoulder - driver-side	km	%
Narrow (>= 0m to < 1.0m)	17.60	17
None	85.40	83

Paved shoulder - passenger-side	km	%
Narrow (>= 0m to < 1.0m)	15.50	15
None	87.50	85

Mid-block

Carriageway label	km	%
Undivided road	103.00	100

Upgrade cost	km	%
Low	92.00	89
Medium	10.60	10
High	0.40	0

Median type	km	%
Centre line	103.00	100

Centreline rumble strips	km	%
Not present	103.00	100

Number of lanes	km	%
One	103.00	100

Lane width	km	%
Wide (>= 3.25m)	103.00	100

Curvature	km	%
Straight or gently curving	75.80	74
Moderate	26.40	26
Sharp	0.80	1

Quality of curve	km	%
Adequate	21.90	21
Poor	5.30	5
Not applicable	75.80	74

Grade	km	%
>= 0% to <7.5%	103.00	100

Road condition	km	%
Good	102.50	100
Medium	0.30	0
Poor	0.20	0

Skid resistance / grip	km	%
Sealed - adequate	103.00	100

Delineation	km	%
Adequate	36.30	35
Poor	66.70	65

Street lighting	km	%
Not present	102.30	99
Present	0.70	1

Vehicle parking	km	%
Low	91.20	89
Medium	6.90	7
High	4.90	5

Service road	km	%
Not present	103.00	100

Roadworks	km	%
No road works	103.00	100

Sight distance	km	%
Adequate	90.00	87
Poor	13.00	13

Intersections

Intersection type	Points	%
3-leg (unsignalised) with no protected turn lane	79	8
4-leg (unsignalised) with no protected turn lane	5	0
None	945	92
Railway Crossing - active (flashing lights / boom gates)	1	0

Intersection channelisation	Points	%
Not present	1030	100

Intersecting road volume	Points	%
1,000 to 5,000 vehicles	8	1
100 to 1,000 vehicles	31	3
1 to 100 vehicles	46	4
None	945	92

Intersection quality	Points	%
Poor	85	8
Not applicable	945	92

Property access points	km	%
Commercial Access 1+	8.60	8
Residential Access 3+	4.40	4
Residential Access 1 or 2	22.20	22
None	67.80	66

Flow

Vehicle flow (AADT)	km	%
1000 - 5000	103.00	100

Motorcyclist observed flow	km	%
None	53.40	52
1 motorcycle observed	31.40	30
2 to 3 motorcycles observed	14.90	14
4 to 5 motorcycles observed	2.60	3
6 to 7 motorcycles observed	0.60	1
8+ motorcycles observed	0.10	0

Bicyclist observed flow	km	%
None	99.00	96
1 bicycle observed	3.60	3
2 to 3 bicycles observed	0.40	0

Pedestrian observed flow across the road	km	%
None	101.50	99
1 pedestrian crossing observed	1.00	1
2 to 3 pedestrians crossing observed	0.10	0
4 to 5 pedestrians crossing observed	0.20	0
6 to 7 pedestrians crossing observed	0.10	0
8+ pedestrians crossing observed	0.10	0

Pedestrian observed flow along the road driver-side	km	%
None	92.10	89
1 pedestrian along driver-side observed	4.60	4
2 to 3 pedestrians along driver-side observed	3.10	3
4 to 5 pedestrians along driver-side observed	1.80	2
6 to 7 pedestrians along driver-side observed	0.50	0
8+ pedestrians along driver-side observed	0.90	1

Pedestrian observed flow along the road passenger-side	km	%
None	91.20	89
1 pedestrian along passenger-side observed	5.30	5
2 to 3 pedestrians along passenger-side observed	3.60	3
4 to 5 pedestrians along passenger-side observed	1.10	1
6 to 7 pedestrians along passenger-side observed	0.40	0
8+ pedestrians along passenger-side observed	1.40	1

Motorcyclist %	km	%
41% - 60%	103.00	100

Pedestrian peak hour flow across the road	km	%
0	1.80	2
1 to 5	73.10	71
6 to 25	28.10	27

Pedestrian peak hour flow along the road driver-side	km	%
6 to 25	103.00	100

Pedestrian peak hour flow along the road passenger-side	km	%
6 to 25	103.00	100

Bicyclist peak hour flow	km	%
1 to 5	103.00	100

Vulnerable road users facilities and land use

Land use - driver-side	km	%
Undeveloped areas	3.30	3
Farming and agricultural	79.20	77
Residential	10.00	10
Commercial	9.10	9
Industrial and manufacturing	1.40	1

Land use - passenger-side	km	%
Undeveloped areas	4.40	4
Farming and agricultural	78.60	76
Residential	9.70	9
Commercial	8.80	9
Industrial and manufacturing	1.50	1

Area type	km	%
Rural / open area	82.90	80
Urban / rural town or village	20.10	20

Pedestrian crossing facilities - inspected road	Points	%
Unsignalised marked crossing without a refuge	109	11
No facility	921	89

Pedestrian crossing quality	Points	%
Adequate	96	9
Poor	13	1
Not applicable	921	89

Pedestrian crossing facilities - intersecting road	Points	%
Unsignalised marked crossing without a refuge	12	1
No facility	1018	99

Pedestrian fencing	km	%
Not present	103.00	100

Sidewalk - driver-side	km	%
Non-physical separation 1.0m to <3.0m	0.60	1
None	2.70	3
Informal path 0m to <1.0m	99.70	97

Sidewalk - passenger-side	km	%
Non-physical separation 1.0m to <3.0m	0.20	0
Non-physical separation 0m to <1.0m	0.30	0
None	3.20	3
Informal path >= 1.0m	9.60	9
Informal path 0m to <1.0m	89.70	87

Facilities for motorised two wheelers	km	%
None	103.00	100

Facilities for bicycles	km	%
None	103.00	100

School zone warning	Points	%
Not applicable (no school at the location)	1030	100

School zone crossing supervisor	Points	%
Not applicable (no school at the location)	1030	100

Corridor 7

Roadside

Roadside severity - driver-side distance	km	%
0 to <1m	7.60	11
1 to <5m	57.00	81
5 to <10m	3.30	5
>= 10m	2.70	4

Roadside severity - driver-side object	km	%
Safety barrier - metal	2.80	4
Safety barrier - concrete	0.60	1
Aggressive vertical face	1.20	2
Upwards slope - rollover gradient	0.50	1
Deep drainage ditch	0.60	1
Downwards slope	1.20	2
Tree >=10cm dia.	35.30	50
Sign, post or pole >= 10cm dia.	19.10	27
Rigid structure/bridge or building	6.10	9
Semi-rigid structure or building	2.20	3
Unprotected safety barrier end	0.80	1
None	0.20	0

Roadside severity - passenger-side distance	km	%
0 to <1m	7.10	10
1 to <5m	60.80	86
5 to <10m	2.50	4
>=10m	0.20	0

Roadside severity - passenger-side object	km	%
Safety barrier - metal	0.90	1
Safety barrier - concrete	1.00	1
Aggressive vertical face	0.80	1
Upwards slope - rollover gradient	1.60	2
Deep drainage ditch	0.90	1
Downwards slope	0.50	1
Tree >= 10cm dia.	39.10	55
Sign, post or pole >=10cm dia.	15.00	21
Rigid structure/bridge or building	8.50	12
Semi-rigid structure or building	0.80	1
Unprotected safety barrier end	1.10	2
Large boulders >= 20cm high	0.30	0
None	0.10	0

Shoulder rumble strips	km	%
Not present	70.60	100

Paved shoulder - driver-side	km	%
Medium (>= 1.0m to < 2.4m)	7.70	11
Narrow (>= 0m to < 1.0m)	33.00	47
None	29.90	42

Paved shoulder - passenger-side	km	%
Medium (>= 1.0m to < 2.4m)	7.80	11
Narrow (>= 0m to < 1.0m)	31.80	45
None	31.00	44

Mid-block

Carriageway label	km	%
Carriageway A of a divided carriageway road	5.30	8
Carriageway B of a divided carriageway road	5.30	8
Undivided road	60.00	85

Upgrade cost	km	%
Low	59.00	84
Medium	8.70	12
High	2.90	4

Median type	km	%
Safety barrier - metal	1.20	2
Physical median width >= 1.0m to < 5.0m	5.40	8
Physical median width >= 0m to < 1.0m	4.10	6
Centre line	59.90	85

Centreline rumble strips	km	%
Not present	70.60	100

Number of lanes	km	%
One	64.60	92
Two	6.00	8

Lane width	km	%
Wide (>= 3.25m)	70.60	100

Curvature	km	%
Straight or gently curving	57.20	81
Moderate	13.30	19
Sharp	0.10	0

Quality of curve	km	%
Adequate	7.90	11
Poor	5.50	8
Not applicable	57.20	81

Grade	km	%
>= 0% to <7.5%	70.60	100

Road condition	km	%
Good	69.00	98
Medium	0.60	1
Poor	1.00	1

Skid resistance / grip	km	%
Sealed - adequate	70.60	100

Delineation	km	%
Adequate	30.20	43
Poor	40.40	57

Street lighting	km	%
Not present	62.50	89
Present	8.10	11

Vehicle parking	km	%
Low	63.50	90
Medium	6.30	9
High	0.80	1

Service road	km	%
Not present	70.60	100

Roadworks	km	%
No road works	70.60	100

Sight distance	km	%
Adequate	70.60	100

Intersections

Intersection type	Points	%
Roundabout	1	0
3-leg (unsignalised) with protected turn lane	3	0
3-leg (unsignalised) with no protected turn lane	74	10
4-leg (unsignalised) with no protected turn lane	9	1
4-leg (signalised) with protected turn lane	1	0
None	591	84
Median crossing point - informal	27	4

Intersection channelisation	Points	%
Not present	697	99
Present	9	1

Intersecting road volume	Points	%
5,000 to 10,000 vehicles	1	0
1,000 to 5,000 vehicles	16	2
100 to 1,000 vehicles	44	6
1 to 100 vehicles	54	8
None	591	84

Intersection quality	Points	%
Adequate	11	2
Poor	104	15
Not applicable	591	84

Property access points	km	%
Commercial Access 1+	9.80	14
Residential Access 3+	13.80	20
Residential Access 1 or 2	15.30	22
None	31.70	45

Flow

Vehicle flow (AADT)	km	%
1000 - 5000	70.60	100

Motorcyclist observed flow	km	%
None	21.80	31
1 motorcycle observed	20.60	29
2 to 3 motorcycles observed	20.40	29
4 to 5 motorcycles observed	6.30	9
6 to 7 motorcycles observed	1.10	2
8+ motorcycles observed	0.40	1

Bicyclist observed flow	km	%
None	66.10	94
1 bicycle observed	3.90	6
2 to 3 bicycles observed	0.60	1

Pedestrian observed flow across the road	km	%
None	68.90	98
1 pedestrian crossing observed	0.80	1
2 to 3 pedestrians crossing observed	0.80	1
4 to 5 pedestrians crossing observed	0.10	0

Pedestrian observed flow along the road driver-side	km	%
None	63.10	89
1 pedestrian along driver-side observed	2.80	4
2 to 3 pedestrians along driver-side observed	2.60	4
4 to 5 pedestrians along driver-side observed	1.10	2
6 to 7 pedestrians along driver-side observed	0.60	1
8+ pedestrians along driver-side observed	0.40	1

Pedestrian observed flow along the road passenger-side	km	%
None	56.30	80
1 pedestrian along passenger-side observed	5.00	7
2 to 3 pedestrians along passenger-side observed	4.50	6
4 to 5 pedestrians along passenger-side observed	1.80	3
6 to 7 pedestrians along passenger-side observed	0.80	1
8+ pedestrians along passenger-side observed	2.20	3

Motorcyclist %	km	%
21% - 40%	70.60	100

Pedestrian peak hour flow across the road	km	%
0	68.90	98
1 to 5	1.70	2

Pedestrian peak hour flow along the road driver-side	km	%
0	63.10	89
1 to 5	6.50	9
6 to 25	1.00	1

Pedestrian peak hour flow along the road passenger-side	km	%
0	56.30	80
1 to 5	11.30	16
6 to 25	3.00	4

Bicyclist peak hour flow	km	%
None	66.10	94
1 to 5	4.50	6

Vulnerable road users facilities and land use

Land use - driver-side	km	%
Undeveloped areas	5.10	7
Farming and agricultural	38.20	54
Residential	10.20	14
Commercial	15.90	23
Educational	0.10	0
Industrial and manufacturing	1.10	2

Land use - passenger-side	km	%
Undeveloped areas	5.00	7
Farming and agricultural	38.60	55
Residential	9.20	13
Commercial	16.40	23
Educational	0.50	1
Industrial and manufacturing	0.90	1

Area type	km	%
Rural / open area	44.50	63
Urban / rural town or village	26.10	37

Pedestrian crossing facilities - inspected road	Points	%
Unsignalised marked crossing without a refuge	61	9
No facility	644	91
Unsignalised raised marked crossing without refuge	1	0

Pedestrian crossing quality	Points	%
Adequate	25	4
Poor	38	5
Not applicable	643	91

Pedestrian crossing facilities - intersecting road	Points	%
Unsignalised marked crossing without a refuge	4	1
No facility	702	99

Pedestrian fencing	km	%
Not present	70.50	100
Present	0.10	0

Sidewalk - driver-side	km	%
None	11.40	16
Informal path 0m to <1.0m	59.20	84

Sidewalk - passenger-side	km	%
Non-physical separation 1.0m to <3.0m	0.60	1
None	8.10	11
Informal path 0m to <1.0m	61.90	88

Facilities for motorised two wheelers	km	%
None	70.60	100

Facilities for bicycles	km	%
None	70.60	100

School zone warning	Points	%
School zone static signs or road markings	4	1
No school zone warning	3	0
Not applicable (no school at the location)	699	99

Annexure 2: Countermeasure costs

Countermeasure	Unit of Cost	Service Life	Urban-Medium Upgrade Cost
Improve Delineation	lane km	5	251.376,00
Bicycle Lane (on-road)	per km	20	180.000,00
Bicycle Lane (off-road)	per km	20	2.587.500,00
Motorcycle Lane (Painted logos only on-road)	per km	5	207.000,00
Motorcycle Lane (Construct on-road)	per km	20	3.115.350,00
Motorcycle Lane (Segregated)	per km	20	4.673.025,00
Horizontal Realignment	lane km	20	8.682.500,00
Improve curve delineation	per carriageway km	5	233.725,00
Lane widening (up to 0.5m)	lane km	10	3.809.388,00
Lane widening (>0.5m)	lane km	10	4.362.699,00
Protected turn lane (unsignalised 3 leg)	intersection	10	2.300.000,00
Protected turn lane (unsignalised 4 leg)	intersection	10	3.450.000,00
Delineation and signing (intersection)	intersection	5	573.804,00
Protected turn provision at existing signalised site (3-leg)	intersection	10	2.300.000,00
Protected turn provision at existing signalised site (4-leg)	intersection	10	3.450.000,00
Signalise intersection (3-leg)	intersection	20	2.373.698,00
Signalise intersection (4-leg)	intersection	20	5.215.375,00
Grade separation	intersection	20	230.000.000,00
Rail crossing upgrade	unit	20	5.750.000,00
Roundabout	intersection	20	13.376.354,00
Central hatching	per km	10	200.000,00
Centreline rumble strip / flexi-post	per km	10	265.938,00
Central turning lane full length	per km	10	8.510.000,00
Central median barrier (no duplication)	per km	10	4.715.000,00
Duplication with median barrier	per carriageway km	20	35.920.000,00
Duplicate - <1m median	per carriageway km	20	26.196.800,00
Duplicate - 1-5 m median	per carriageway km	20	28.196.800,00
Duplicate - 5-10m median	per carriageway km	20	36.120.000,00
Duplicate - 10-20m median	per carriageway km	20	57.960.000,00
Duplicate - >20m median	per carriageway km	20	86.940.000,00
Service road	per km	20	7.475.000,00
Additional lane (2 + 1 road with barrier)	per km	20	8.510.000,00
Implement one way network	per carriageway km	20	2.070.000,00
Upgrade pedestrian facility quality	unit	10	388.125,00
Refuge Island	unit	10	382.500,00
Unsignalised crossing	unit	10	344.250,00
Signalised crossing	unit	20	877.236,00
Grade separated pedestrian facility	unit	20	17.250.000,00
Road surface rehabilitation	lane km	10	5.750.000,00
Clear roadside hazards - passenger side	per linear km	20	2.300.000,00
Clear roadside hazards - driver side	per linear km	20	2.300.000,00
Sideslope improvement - passenger side	per linear km	20	2.530.000,00
Sideslope improvement - driver side	per linear km	20	2.530.000,00
Roadside barriers - passenger side	per linear km	20	3.119.950,00
Roadside barriers - driver side	per linear km	20	3.119.950,00
Shoulder sealing passenger side (<1m)	per linear km	20	3.450.000,00
Shoulder sealing passenger side (>1m)	per linear km	20	4.025.000,00
Restrict/combine direct access points	per km	10	4.600.000,00
Footpath provision passenger side (adjacent to road)	per linear km	20	1.380.000,00
Footpath provision passenger side (>3m from road)	per linear km	20	4.312.500,00
Speed management reviews	per carriageway km	5	100.000,00
Traffic calming	per carriageway km	10	2.300.000,00
Vertical realignment (major)	lane km	20	2.875.000,00
Overtaking lane	per linear km	20	8.510.000,00
Median crossing upgrade	intersection	10	2.875.000,00
Clear roadside hazards (bike lane)	per km	20	2.300.000,00
Sideslope improvement (bike lane)	per km	20	2.530.000,00
Roadside barriers (bike lane)	per km	20	3.119.950,00

Clear roadside hazards (seg MC lane) passenger side	per km	20	2.300.000,00
Sideslope improvement (seg MC lane) passenger side	per km	20	2.530.000,00
Roadside barriers (seg MC lane) passenger side	per km	20	3.119.950,00
Speed management reviews (MC Lane)	per carriageway km	5	100.000,00
Central median barrier (MC lane)	per km	10	4.715.000,00
Skid Resistance (paved road)	lane km	10	1.644.500,00
Skid Resistance (unpaved road)	per carriageway km	10	299.000,00
Pave road surface	lane km	10	5.750.000,00
Street lighting (mid-block)	lane km	20	2.149.200,00
Street lighting (intersection)	intersection	20	1.074.600,00
Street lighting (ped crossing)	unit	20	537.300,00
Shoulder rumble strips	per carriageway km	10	160.000,00
Parking improvements	per carriageway km	20	2.070.000,00
Sight distance (obstruction removal)	per linear km	20	2.300.000,00
Pedestrian fencing	per carriageway km	20	5.000.000,00
Side road grade separated pedestrian facility	intersection	20	12.937.500,00
Side road signalised pedestrian crossing	intersection	20	5.750.000,00
Side road unsignalised pedestrian crossing	intersection	10	517.500,00
Footpath provision passenger side (with barrier)	per linear km	20	4.367.930,00
Footpath provision passenger side (informal path >1m)	per linear km	10	2.587.500,00
Shoulder sealing driver side (<1m)	per linear km	20	3.450.000,00
Shoulder sealing driver side (>1m)	per linear km	20	4.025.000,00
Footpath provision driver side (adjacent to road)	per linear km	20	3.365.982,00
Footpath provision driver side (>3m from road)	per linear km	20	7.195.602,00
Footpath provision driver side (with barrier)	per linear km	20	4.367.930,00
Footpath provision driver side (informal path >1m)	per linear km	10	2.587.500,00
Realignment (sight distance improvement)	lane km	20	4.025.000,00
Central median barrier (1+1)	per km	20	4.715.000,00
Clear roadside hazards (seg MC lane) driver side	per km	20	2.300.000,00
Sideslope improvement (seg MC lane) driver side	per km	20	2.530.000,00
Roadside barriers (seg MC lane) driver side	per km	20	3.119.950,00
Wide centreline	per linear km	10	124.200,00
School zone warning - signs and markings	lane km	5	103.500,00
School zone warning - flashing beacon	unit	20	161.190,00
School zone - crossing guard or supervisor	unit	1	207.000,00
Unsignalised raised crossing	unit	10	481.950,00