Maximising travel on 3-star or better roads: Safer roads and safer speeds to deliver the 2020 UN road safety targets

by Rob McInerney FACRS

Chief Executive Officer, iRAP

Introduction

Death is currently built into our road system and our road designs. Road crashes are the biggest killer of young people, and typically cost 3-5% of GDP in most countries worldwide. For reasons of historical road design standards, the lack of upkeep with the evolution of vehicle speeds over time, and increasing budget constraints, many existing roads are designed for the community in a way that tolerates crashes that kill and injure road users. The responsibility is passed onto road users to cope with and navigate the built-in risks in the road system.

The inconvenient truth of the global road safety crisis

Whether in Australia, New Zealand, Ethiopia, South Africa, Brazil or the UK the predominant response to the tragedy of road crashes by politicians and engineers alike is that the fault lies with the drivers or pedestrians. This common belief provides an excuse for inaction or a lack of understanding in the profession of how critical road design and maintenance are for preventing a crash occurring in the first place or managing the severity of the crash if one occurs. While road users must take a shared responsibility for road safety, the safe system approach being adopted worldwide now starts to place a high degree of accountability and opportunity on the system designers to save lives and reduce serious injuries.

Like their colleagues in the medical profession, engineering professionals around the world operate to a code of ethics that typically refer to valuing life and 'doing no harm'. For example:

- Australia – "Practise engineering to foster the health, safety and wellbeing of the community and the environment";
- UK – "Respect for life, law and the public good"; "Minimise and justify any adverse effect on society" and "hold paramount the health and safety of others"; and
- USA - "Hold paramount the safety, health and welfare of the public".

With these guiding principles for the engineering professional, the current management of road networks which results in the death and injury of an estimated 30-50 million people a year must be challenged on ethical grounds. The elevation of speed and travel time savings ahead of safety considerations must be challenged. The acceptance of the existing condition of road networks and under-investment in proven engineering measures must also be challenged.

In essence the road manager and engineer, in accordance with their respective code of ethics, must question why safe system principles should not be applied, and seek the resources to implement safe system engineering solutions.

With the United Nations Sustainable Development Goal (SDG) target to halve deaths and injuries from road traffic accidents by 2020, it is time to challenge the status quo and seek a large step-change in the response and attitude of the engineering profession to the global road safety crisis.

Road authorities and road engineers worldwide must take the lead, and challenge current road design standards, road maintenance standards, road budgets, project financing and prioritisation processes to elevate the protection of human life in line with the rail and air transport sectors. We must put the past behind us, accept where we are today and strive to create a world free of high-risk roads together.

The fundamentals of physics and road crashes

The forgotten formula of road design is $E_k = ½ m v^2$. The fundamentals of physics as they relate to road design safety are often absent from an engineering degree course and in many cases, road design standards. While detailed formulas exist for curve transitions, pavement strength or bridge design the interaction of humans in different vehicles and different speeds can be overlooked. The pavement strength of a road is well managed while the energy mismatch between road users on the road surface is not routinely measured or managed.

Table 1 provides a demonstration of the different philosophical approach to attributing the causes of crashes that kill and injure. One can look at crash causes from a behavioural and an engineering perspective.

That there is an engineering cause for every key crash type highlights that whether or not behaviour also played a role in causing the crash, engineering solutions exist. When taking into account the total social and economic costs to the community the engineering solutions are often cost effective. The causes of road death and injury can be

eliminated from the system and the benefits will be greater than the costs.

The safety gaps in the global road network

All of the road attributes in the international Road Assessment Programme (iRAP) star rating models impact the likelihood or severity of a crash. They provide partial or total contribution to safe system outcomes for that particular circumstance, speed, road user and crash type. As an indication of how the iRAP data can be used to explore the level of compliance of current road designs with safe system principles, an analysis of iRAP assessments on 170,807km of roads in 33 countries undertaken during 2013 and 2014 is provided in Figure 1.

These data highlight the built-in risk of the world's road networks and the underlying cause of major crashes that result in the death and injury of children and adults.

The potential for infrastructure to save lives

The potential for economically viable road infrastructure investment to eliminate death and injury is demonstrated in Figure 2. Rather than focussing on the road user error the analysis highlights the potential for cost effective

Table 1. The cause of road fatalities and injuries

Crash Type	Behavioural Cause	Engineering Cause
Head-on	Road user poor judgement or lane departure	Undivided high-speed road
Run-off road	Distraction, fatigue or speed on a curve	Road alignment and unprotected roadside hazards
Intersection crash	Incorrect yielding	Conflict speeds too high and insufficient time or space separation
Pedestrian crash	Poor crossing behaviour or walking on the road	No footpath, safe crossing point or speeds too high for function of road

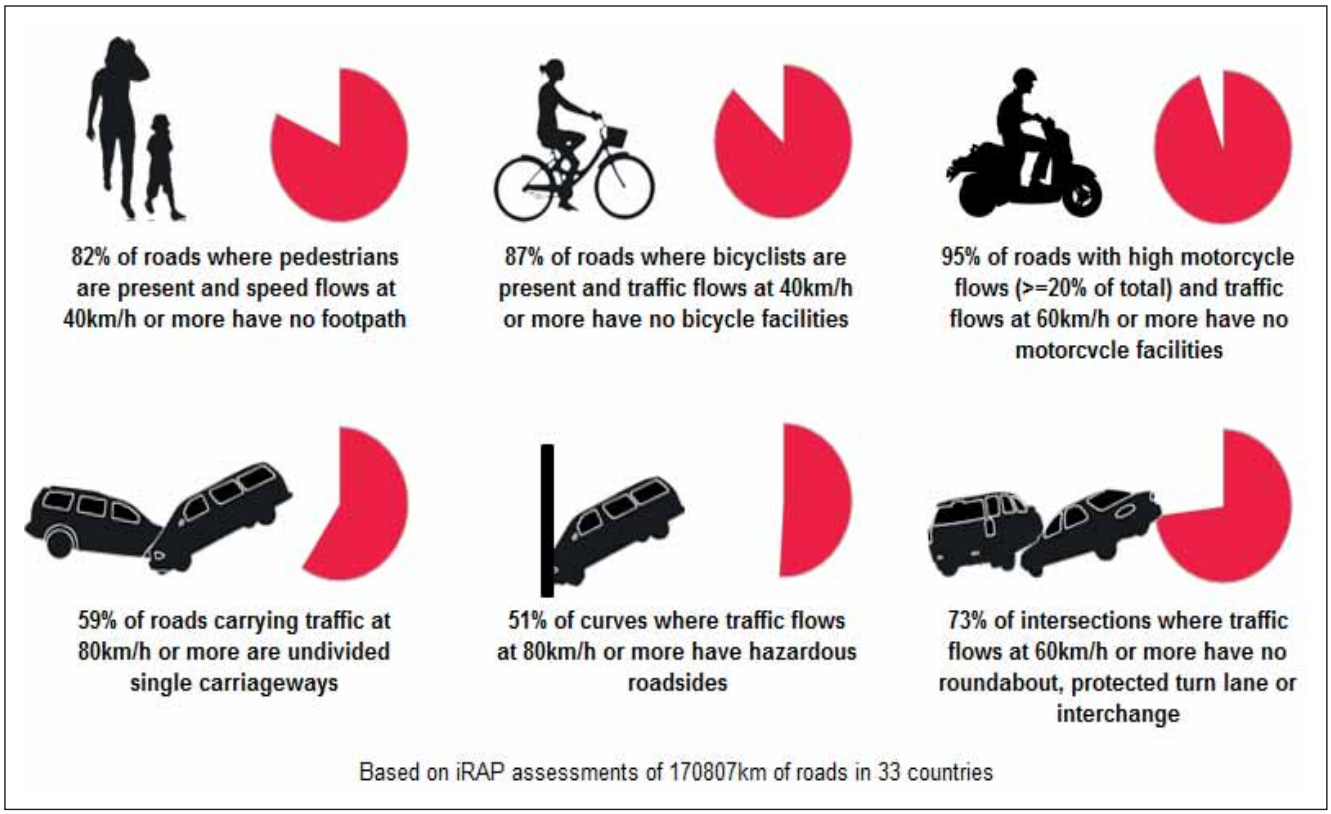

Figure 1. Safe System performance of the world's road networks

engineering treatments to eliminate fatalities and serious injuries associated with the major crash types. Proven engineering treatments can typically more than halve the death rate on targeted high risk roads.

The individual treatments to save lives are well-established and the evidence base is extensive. Examples of high return investment plans from iRAP assessments around the world are shown in Table 2.

Opportunities for policy and engineering leadership

Some immediate areas for policy and engineering leadership should include a revision of road design standards worldwide to standards that account for the safe system principles, the known limited tolerance of the

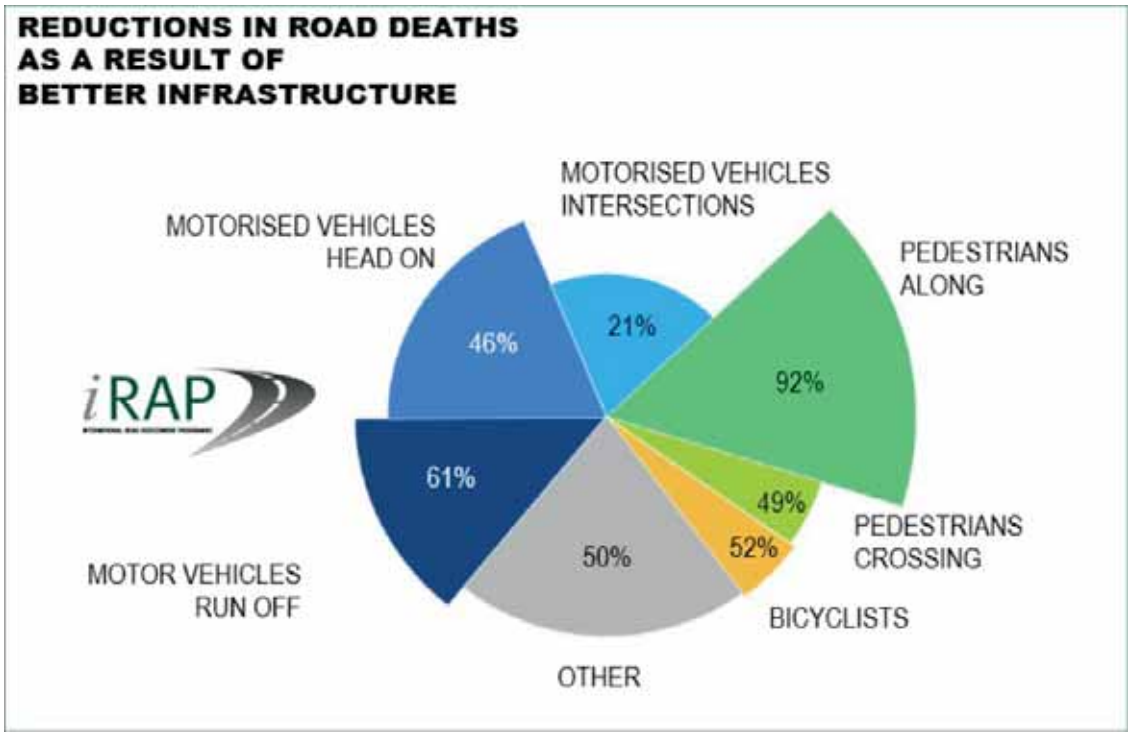

Figure 2. Fatality reduction potential of safer roads

Table 2. High return engineering countermeasures from around the world

Country	Treatment	Length	Deaths & Serious Injuries Saved (20yr)	Economic Benefit (US$)	BCR
Australia	Protected turning lanes	1,782 sites	1,340	$ 500 million	7
India	Footpaths	1,843 km	10,000	$135 million	4
Mexico	Roadside Barriers	14,500 km	155,000	$11,600 million	5
Egypt	2+1 design with median barrier	493 km	8,400	$210 million	6
Uganda	Shoulder widening	1,366 km	18,090	$340 million	24
Netherlands	Rumble strips	4,569 km	1,125	$400 million	7
Brazil	Pedestrian Fencing	108 km	3,590	$40 million	29

human body to injury, and the limited ability of vehicles to avoid and manage impact. In simple terms:

- Design standards should not allow an undivided high-speed road separated by a thin white line to be built. Central barriers or at a minimum wide centreline painted medians should be adopted.
- Design standards should not allow steep embankments or large rigid objects to remain unprotected along the roadsides of high-speed roads.
- Design standards must manage the interaction of road users at intersections and separate or manage the speed of conflicting travel paths wherever possible.
- Design standards should not allow high-speeds in urban areas and villages without footpaths, safe pedestrian crossings, cycle lanes and/or the management of vehicle speeds.

While Australian and New Zealand practice may capture these basic needs for safety they are often only applied on higher volume roads. Our historical road system retains many of these built-in risks. Furthermore, worldwide many brand new roads are still being built with these known, fundamental failures in road design. In addition, when faced with tight project budgets and timelines it is often the road safety elements that are omitted without consideration of the likely death and injury that will result. New roads are opened without line markings, without separation, without barriers and without footpaths or crossings. The tragic consequences of building such high risk roads are then left to the communities to suffer while the project teams move on to the next project.

Global support for policy leadership

The United Nations SDG target has provided the foundation for a global change in attitudes and actions for road safety.

The Ministerial Conference in Brazil in November 2015 united world leaders with a focus on action across all five pillars of the UN Decade of Action for Road Safety.

In the infrastructure area the World Bank and regional development banks reinforced their commitments to encouraging and financing safer road infrastructure. Ministers outlined their national actions to improve road safety from child safety in Sweden to urban transport infrastructure safety in Brazil. Zoleka Mandela provided a powerful and passionate call to action on all road safety priorities including infrastructure (Figure 3).

Organisations like the Fund for Global Health have established a 3-star coalition to build awareness, demand and support for minimum safety standards for all new road projects. With supporters including the Institute of Transportation Engineers, Insurance Institute for Highway Safety, American Academy for Pediatrics and the Association for Safe International Road Travel the coalition is building the support for the required change and commitment to stronger road safety action. With road deaths and injuries typically halved moving from 1-star to 2-star and halved again going from 2-star to 3-star, the potential to save lives with better specification of safety outcomes in road projects is clear (refer to the later section on the economics of 3-star or better roads).

The safe system work by leading countries around the world is providing a framework for engineers to challenge current practice and seek to eliminate death and injury from the world's roads. The OECD is leading an important global publication on safe system leadership and application that will be published in late 2016. This report will showcase safe system practice from leading countries like Sweden, Denmark, Netherlands and examples from Australia and New Zealand. The World Road Association (PIARC) has also consolidated global best practice into the PIARC Road Safety Manual that provides a living online resource for the world.

Figure 3. Zoleka Mandela speaking at the Ministerial Summit in Brazil in 2015

Many simple changes in road design exist for countries to immediately implement in order to fast-track results in saving lives for all road users.

High-income Country Policy Leadership

- The Dutch Government was the first to adopt a no one or two-star road by 2020 policy.
- The Swedish Government measure the percentage of vehicle mileage on roads that meet EuroRAP four-star standard. The Government expect that 75% of travel on the Swedish national road network will achieve 3-stars or better by 2020 and approaching 100% by 2025.
- Highways England has adopted a target for 90% of travel to be on 3-star or better roads by 2020. This is linked to broader goals for 4 and 5-star motorways.
- The New Zealand Government has a target for 4-star Roads of National Significance (RONS) and recently adopted a review of design standards that ensure Roads of National Significance will be implemented with a minimum 4-star rating.
- The Bureau of Infrastructure, Transport and Regional Economics in Australia has proposed that all new roads should be 4+ stars and no road user group less than 3-star. The Tasmanian Government has set a target for the Midlands Highway to be 3-star standard. The Queensland Government has a target for 85% of travel on national highways to be 3-star or better by 2020.
- Performance tracking using risk mapping is active across Europe (EuroRAP) and the US (usRAP) and New Zealand (kiwiRAP). Example reports include the 2014 UK results and the 2012 New Zealand results.
- Benchmarking of the European road system was undertaken as part of the 2011 European Road Safety Atlas project supported by the EU.
- Toll road concessionaires in New Zealand and Chile have set 3 and 4-star targets for their infrastructure as part of a focus on customer service.
- Mining companies have assessed their road networks and immediately invested to bring the roads to minimum 3-star standards from a health and safety perspective implementing both economically viable treatments and those that provide minimum safety standards.

Low and middle-income countries (LMIC) Policy Leadership

- The Malaysia Government is the first LMIC to set a star rating target with their commitment for 75% of travel on high volume roads to be 3-star or better by 2020.
- The Ministry of Transport in China is rolling out ChinaRAP assessments to an expected 350,000km of roads as part of their Highway Safety Enhancement Project titled “highway safety to cherish life” that is accompanied by billion dollar investments to upgrade roads.
- The road authority in Mexico (SCT) has assessed over 60,000km of roads and has implemented targeted maintenance spending to reduce 1 and 2-star road sections by close to 20%.
- The MDB Road Safety Guidelines have identified road safety rating as one of the issues to be considered in all stages of a road project (Figure 4).
- The SLoCaT Results Framework (p23) developed to support achieving the proposed SDG target to halve road deaths includes an implementation measure to eliminate one or two star roads by 2030.
- The World Bank SSATP programme has developed the Managing Road Safety in Africa publication (Figure 4) that provides a framework for national lead agencies that “can develop a prioritised program of works towards achieving at least 3 star safety ratings for all road users” (p46).
- The ADB Sustainable Transport Appraisal Rating (Figure 4) integrates the star rating performance targets into their Sustainable Transport Appraisal Rating including the recommendation for minimum 4-star standards for pedestrians in linear settlements and minimum 4-star standards on roads carrying 50,000 vehicles or more.
- The World Bank and relevant state governments have applied minimum star rating standards as part of road projects in Karnataka, Assam, Gujarat and Kerala in India. The Gujarat Results Report includes the monitoring of the length of the corridor meeting the star rating target.
- The ADB has also applied a similar star rating approach in Shaanxi and Anhui in China. These projects captured the economic benefits of minimum 3-star roads that have now been built into the economic modelling and internal rates of return for loan projects.

The economics of safer road infrastructure

One fundamental question to ask in relation to road safety is whether the level of investment, across all pillars of action, is commensurate with the scale and estimated 3-5% of GDP cost of the problem.

The inconvenient truth is that our ability to blame the road user allows us to spread the accountability sufficiently thin

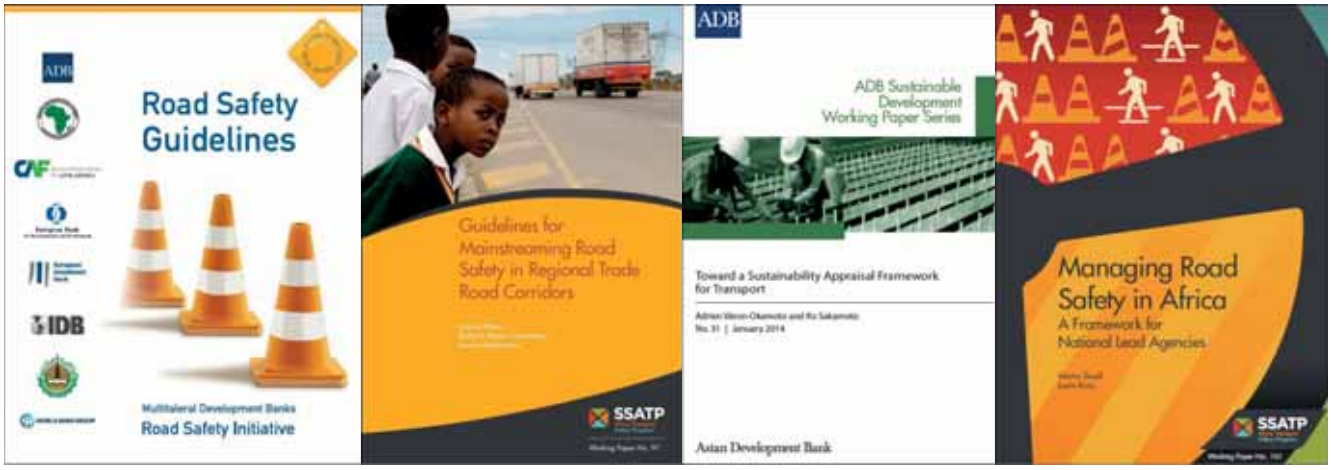

Figure 4. Example LMIC Road Safety Policy documents

that no one sector takes full accountability to eliminate death and injury from our roads. The airline industry would not tolerate such an approach, neither would the rail industry, the building industry, the mining industry and neither should the road industry.

The business case for safe system road infrastructure investment

Linked to the ethical, health and community benefits of road trauma reduction, the business case for investment in safe system outcomes is compelling. An analysis of iRAP assessments undertaken by road agencies worldwide was used to develop a global business case for road investment. The analysis suggests that a targeted investment of $681 billion (or less than 0.1% of GDP per year for ten years) could save an estimated 40,000,000 deaths and serious injuries over 20 years with a return on investment of $8 for every $1 invested (Table 3). (iRAP, 2014a)

The key to the appropriate level of investment in road trauma reduction is to bridge the gap between those who benefit from reductions in road trauma (emergency services, hospitals, health and welfare systems, insurers, business and Treasury) with those who hold the safe system solutions (road agencies, vehicle manufacturers, educators and police).

The potential for Social Impact Bonds, or Impact Investing products to provide the mechanism to close this gap are being actively explored worldwide. A pilot study is currently being undertaken by the FIA Foundation, iRAP, TAC, VicRoads, ARRB and the RACV in Victoria, Australia to develop a social impact bond calculator to measure the financial savings to all stakeholders from an investment in safer roads (McInerney et al, 2015). With success, the approach has the potential to mobilise the appropriate level of resources to address the road safety crisis and lift an enormous burden from health systems and individuals worldwide. This approach represents a win-win-win for all.

The economics of 3-star or better roads

The use of infrastructure star ratings is providing a positive

Table 3. The business case for safer roads

What could be achieved	Low Income	Lower-middle income	Upper-middle income	High Income	ALL
Improve highest risk 10% of roads	108,000 km	610,000 km	992,000 km	1,546,000 km	3,255,000 km
Build viable countermeasures	$8 billion	$61 billion	$149 billion	$464 billion	$681 billion
Reduction in fatalities	384,000	1,483,000	1,528,000	283,000	3,678,000
Reduction in fatalities and serious injuries	4,224,000	16,313,000	16,808,000	3,113,000	40,458,000
Economic benefit	$83 billion	$663 billion	$2,766 billion	$2,202 billion	$5,715 billion
Benefit cost ratio	11	11	19	5	8

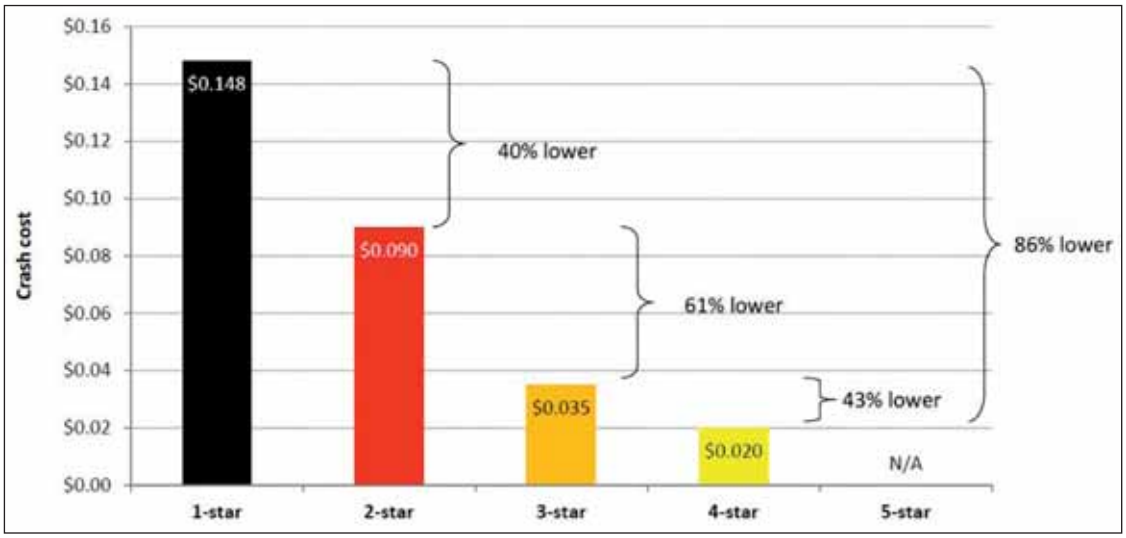

Figure 5: Relationship between star ratings and crash costs per kilometre travelled

stimulus for change in partnerships with government, development agencies and civil society worldwide as highlighted in the policy examples above. Understanding the economics of 3-star or better roads is also important to ensure investment is optimised.

Studies from around the world have consistently shown that fatal and serious injury crash costs are approximately halved for each incremental improvement in star rating (Figure 5). The investment focus of a road agency is then on maximising lives and serious injuries saved per dollar spent. This typically results in an investment plan that raises high volume roads to 4 or 5-star standard with engineering treatments and eliminating all other 1 and 2-star roads through a combination of speed management and lower-cost engineering improvements.

Targeting action on safer roads

The risk maps from New Zealand, Europe and the US highlight how actual deaths and injuries are concentrated on certain parts of the road network (Figure 6). Improving the safe system elements including infrastructure features and associated star ratings is a priority at these high risk locations.

Before and after star ratings

The before and after star ratings are now being increasingly used to help design teams (Figure 7), road funders and politicians measure and celebrate improvements in road infrastructure safety. Linked to the policy targets and specification of minimum star rating targets for new road

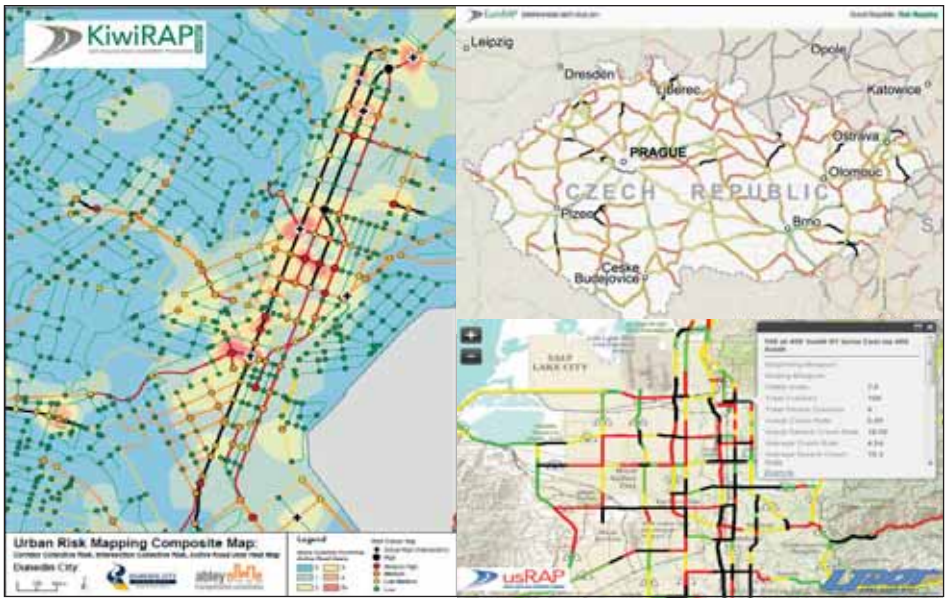

Figure 6: Urban and rural risk mapping examples from Europe, US and New Zealand

projects the design teams can immediately measure the performance of their design before construction. Politicians and project stakeholders can celebrate positive road safety improvements by ribbon-cutting the new 4 or 5-star roads.

Where crash data is available the monitoring of crashes before and after new safe system treatments are implemented is also important. This confirms the effectiveness of treatments and improves the evidence base upon which future investment decisions can be made.

Communicating success

The tragedy of road crashes will typically impact all members of the community at some stage in their life as they are either involved in a crash themselves or a friend or family member is directly impacted. Improvements to road safety should therefore be celebrated and shared with the public and demonstrate the positive contribution of a road agency, police agency, vehicle manufacturer or other safe system stakeholders to the well-being of a community.

The United Nations Sustainable Development Goal target to halve road deaths and injuries by 2020 has set the challenge for the world. Road engineers, policy makers and treasury officials must take stock of their role in achieving that target and trigger the scale and discipline of response needed. Linked with action across the full spectrum of road safety action, maximising travel on 3-star or better roads; safer roads can provide one of the silver bullets to deliver results and save lives.

Linked to the achievement of these targets, the communication of success to the general public should form an important part of any safe system policy framework. Automobile clubs, NGOs, business, community groups and government can all play a role in communicating success, and encouraging the next investment that will save further lives.

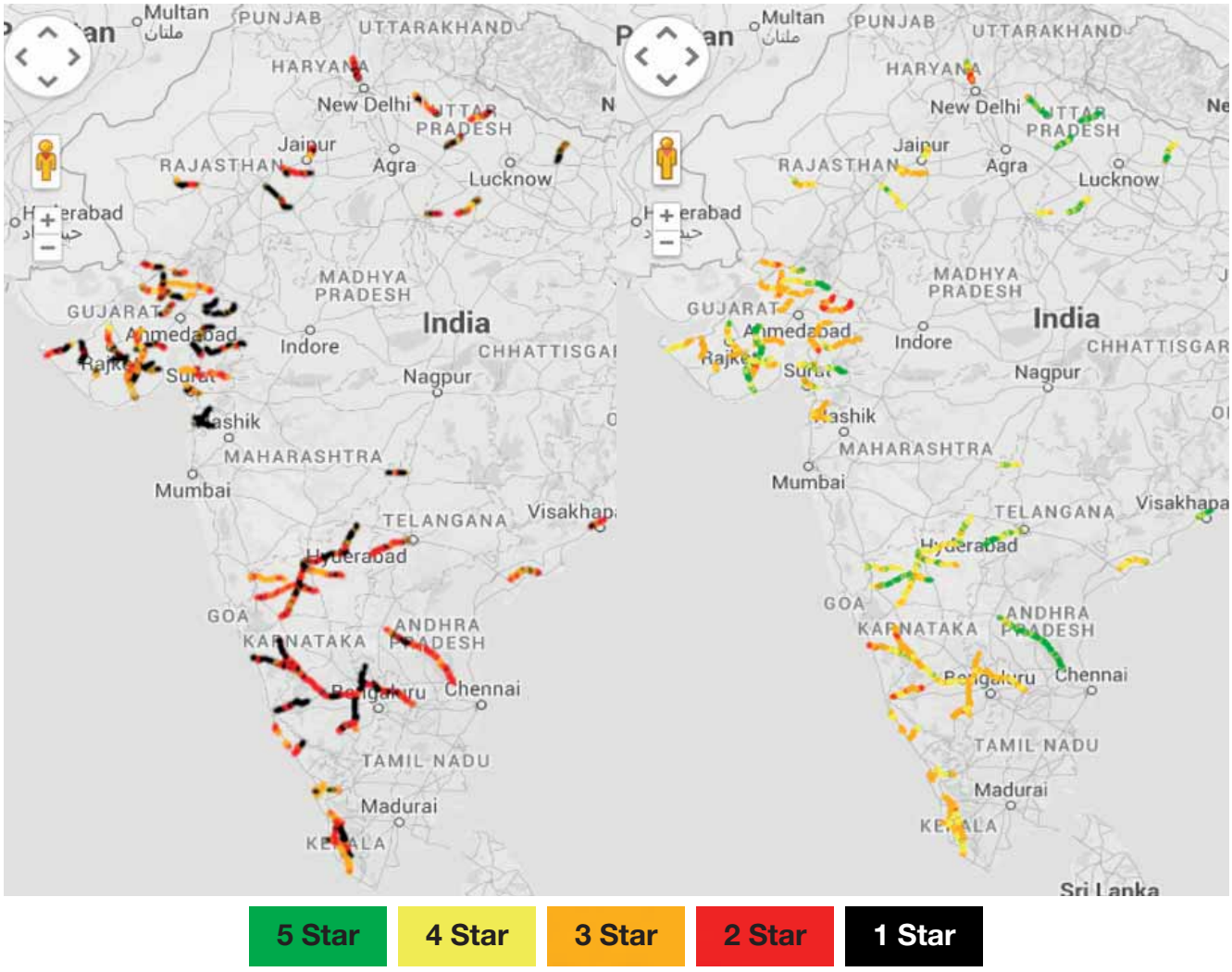

Figure 7: Predicted Before and After Star Ratings in India (World Bank, GRSF)

Saving lives is an achievement worth celebrating. Improving the star rating of a road will facilitate that achievement as politicians and stakeholders ribbon-cut brand new or upgraded 3, 4 and 5-star roads. With the SDG target to halve road deaths and injuries by 2020 we have many improvements to make and much success to celebrate now and into the future.

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