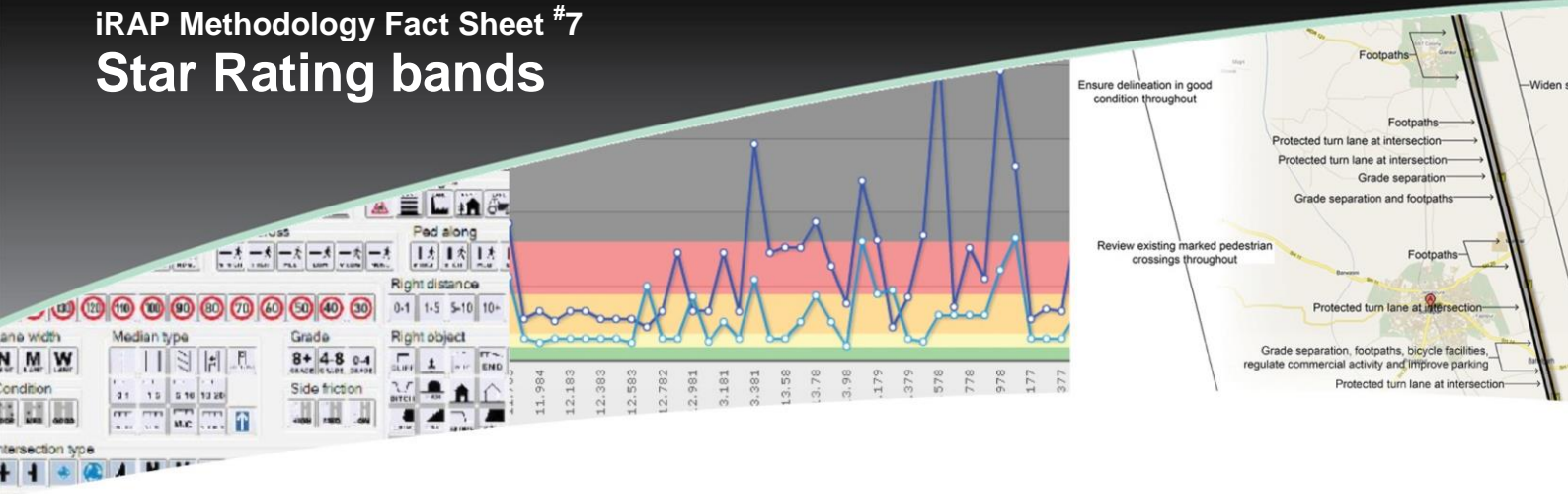


iRAP Methodology Fact Sheet #7

Star Rating bands



This factsheet is part of a series that describes the iRAP methodology. It describes the Star Rating bands and how they were set.

Related documents

This factsheet should be read in conjunction with:

- Other factsheets in the [iRAP Methodology Fact Sheet](#) series.
- [iRAP Road Attribute Risk Factor Fact Sheets](#).
- [Road Safety Toolkit](#).

Star Rating bands

Star Ratings are determined by assigning Star Rating Scores (SRS) to the bands as shown in the table below. Separate bands are used for motorised road users (vehicle occupants and motorcyclists), bicyclists and pedestrians because their scores are calculated using different equations. That is, motorised road user scores are based on head-on, run-off road and intersection crashes; pedestrian scores are based on walking along and across the road crashes; and bicyclist scores are based on riding along the road and intersections crashes.

Star Rating bands and colours

Star Rating	Star Rating Score				
	Vehicle occupants and motorcyclists	Bicyclists	Pedestrians		
			Total	Along	Crossing
5	0 to < 2.5	0 to < 5	0 to < 5	0 to < 0.2	0 to < 4.8
4	2.5 to < 5	5 to < 10	5 to < 15	0.2 to < 1	4.8 to < 14
3	5 to < 12.5	10 to < 30	15 to < 40	1 to < 7.5	14 to < 32.5
2	12.5 to < 22.5	30 to < 60	40 to < 90	7.5 to < 15	32.5 to < 75
1	22.5 +	60+	90 +	15 +	75 +

How the bands were set

The Star Rating bands were set after sensitivity testing was performed, with a particular focus on five inter-related issues:

1. The Safe System context and the role of speed.
2. The expected injury severity.
3. The role of Star Ratings in setting targets.

4. The relationship between Star Ratings and crash rates.
5. The distribution of Star Ratings across a typical road network.

This testing was iterative, involving adjustments to the Star Rating bands in conjunction with review and research of both the likelihood and severity components of crash risk. Each of the issues considered is discussed below.

The Safe System Context

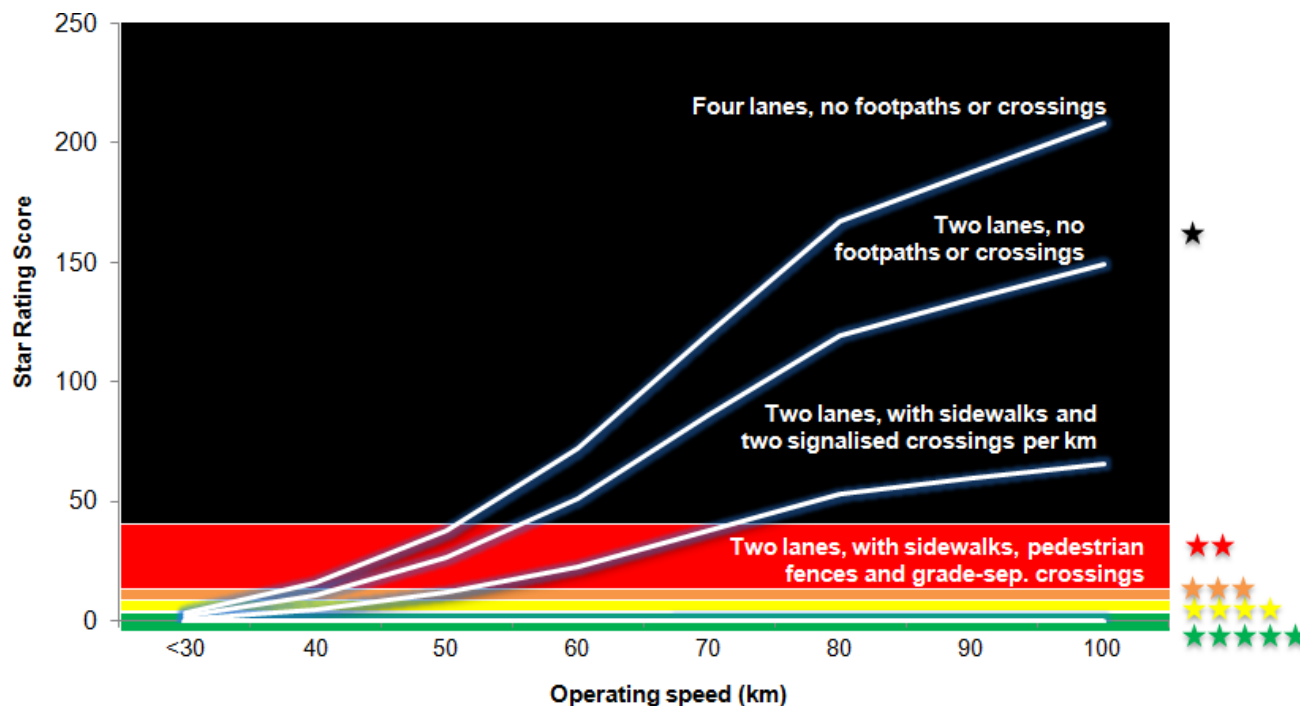
The following principles broadly underpin the safe system approach and informed the development of iRAP's approach:

- Mistakes, errors of judgment and poor decisions are intrinsic to humans. The road system needs to be designed and operated to account for this.
- The role of vehicle speed is critical. The safety of infrastructure cannot be understood without an understanding of the speed of vehicles using the road.
- Humans are fragile. Unprotected, we cannot survive impacts that occur at greater than around 30km/h.
- People who behave with disregard for the safety of themselves and others should expect tough policing and tough penalties.
- Safety can be built into the road system comprehensively and systematically, involving more than just 'patching up' apparent problem areas.
- The 'engineered' elements of the system—vehicles and roads—can be designed to be compatible with the human element, recognising that, while crashes might occur, the total system can be designed to minimise harm.

These principles particularly come to the fore when considering the road attributes of a 5-star road – where infrastructure-related risk of death or serious injury ought to be extremely low. Death or serious injury is still possible on a 5-star road (for example, end-of-queue crashes between vehicles of different mass on freeways), although it is highly unlikely to be as a result of an engineering design shortcoming.

As an example, the chart below shows the way in which the SRS and Star Ratings for pedestrians vary with changes in design and speed, and is illustrative of the type of tests that were used in this stage of setting the Star Rating bands. It shows the degree to which the SRS increase as speed does, which results in the Star Ratings declining. It also shows that the increase in risk associated with an increase in speed can be offset by road attributes. For example, a road is rated 5-stars at all speeds when pedestrian movements are fully managed through the use of footpaths, pedestrian fences and grade-separated crossings. At the other end of the spectrum, a four-lane road (two lanes in each direction) with no footpaths or crossings will be rated 1-star at speeds above 50km/h. However, if the road has only one lane in each direction, footpaths and well-spaced signalised crossings, it will be rated 3-stars. Further, if the speed reduces to 40km/h, then the road would be rated 4-stars. When speeds are 30km/h or less, all roads are rated 5-stars for pedestrians.

Star Rating Scores (SRS), Star Rating and selected pedestrian facility options *



* Assumes: traffic volume = 10,000 vpd; there are pedestrian flows along and across the entire road; no vehicle parking; sight distance good; grade is flat; delineation good; no shoulder rumble strips; road condition good; skid resistance good; street lighting not present; and no curves.

Expected injury severity

The iRAP methodology was developed with a focus on reducing deaths and serious injuries. As such, crash severity was an important consideration in setting the Star Rating bands. As discussed in the previous section vehicle speed, and vehicle mass, plays a significant role in determining crash severity.

The IRTAD report: *Reporting on Serious Road Traffic Casualties* (OECD, 2010) provides a useful discussion on the definition of road injury crashes and includes a recommendation that a seriously injured road casualty be defined “as a person with injuries assessed at level 3 or more on the Maximum Abbreviated Injury Scale (MAIS) i.e. MAIS3+”. Further details on the Abbreviated Injury Scale (AIS) is available from the Association for the Advancement of Automotive Medicine (<http://www.aaam1.org>).

The exact outcome of a crash is dependent on a complex interaction of numerous human, physical and environmental factors and at this stage the direct prediction of likely MAIS outcomes from the Star Rating of the road is not possible. Nevertheless, while setting the Star Rating bands, efforts were made to subjectively assess the likely severity outcome of different crash scenarios on different road designs and, where possible, relate it to an expected probability of death using the MAIS structure as a guide.

In principle, the approach was to define the Star Rating extremities and then work within those boundaries for the remaining Star Ratings. That is, where the probability of MAIS3+ is very high and the frequency of exposure to the risk was also high then a 1-star rating was considered appropriate. Likewise, where the probability of MAIS3+ is very low and the frequency of exposure to the risk is low, a 5-star rating was considered appropriate.

Abbreviated Injury Scale (AIS)

AIS-Code	Injury	Example	AIS percentage probability of death
1	Minor	Superficial laceration	0
2	Moderate	Fractured sternum	1 – 2
3	Serious	Open fracture of humerus	8 – 10
4	Severe	Perforated trachea	5 – 50

AIS-Code	Injury	Example	AIS percentage probability of death
5	Critical	Ruptured liver with tissue loss	5 - 50
6	Maximum	Total severance of aorta	100

The role of Star Ratings in setting targets

The establishment of the Star Rating bands also took account of the trend towards setting Star Rating-based performance targets for road designs. For example, the Commission for Global Road Safety has recommended “desired design speeds for new roads should be subject to achieving minimum safety ratings” (CGS, 2011). There has been a particular focus on achieving *at least* 3-stars for roads being upgraded in low- and middle-income countries. Hence, the 3-star band was set to represent a reasonable balance between providing a safe environment and requiring a standard of design that, while challenging, is also achievable and represents a positive return of investment in the majority of cases.

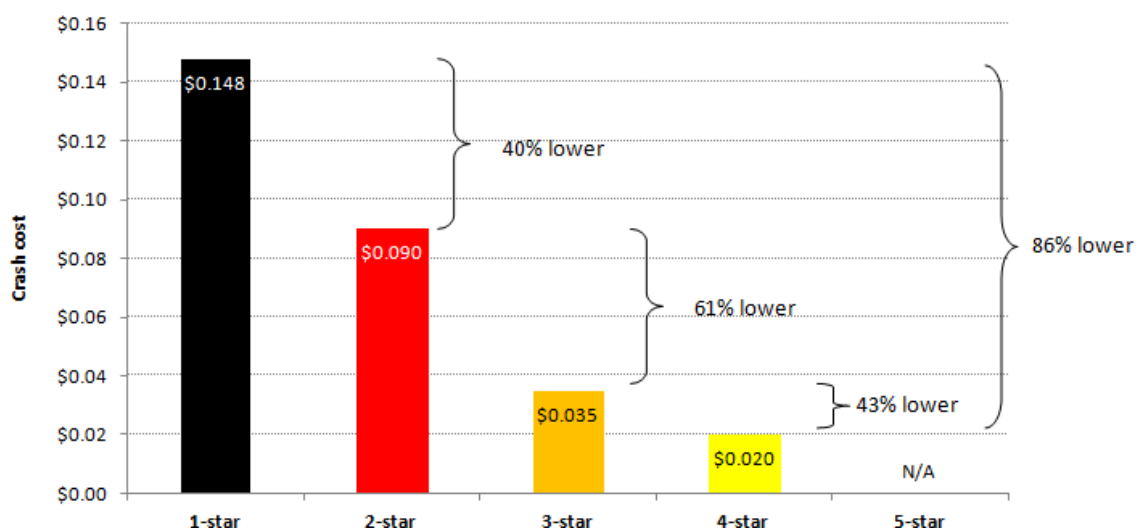
The relationship between Star Ratings and crash rates

Star Ratings relate to risk for an individual road user, with the relationship between the Star Ratings and crash costs per distance travelled the primary focus. This approach takes into account both the likelihood and severity outcome of any crash risk. During the development of the Star Rating methodology, tests were undertaken to examine this relationship. It is expected that as Star Ratings improve (increase) crash costs per distance travelled will decrease. Research studies undertaken on earlier versions of the iRAP model in the US, Europe, Australia and New Zealand have been previously summarised (Lawson, 2011).

Results of testing of the ‘version 3’ vehicle occupant model were published by McInerney and Fletcher (2013). That paper describes testing conducted with Transport and Main Roads (TMR), Queensland, Australia. The testing focussed on the relationship between Star Ratings and fatal and serious injury crash costs per vehicle kilometre travelled, thus taking into account both the likelihood and severity of crashes. The results of the testing are summarised in the chart below, and show that:

- crash costs on 2-star roads are 40% lower than on 1-star roads
- crash costs on 3-star roads are 61% lower than on 2-star roads
- crash costs on 4-star roads are 43% lower than on 3-star roads (and 86% lower than on 1-star roads).

Smoothed vehicle occupant Star Ratings and fatal and serious injury crash costs per vehicle kilometre travelled



The completion of further studies of this kind is actively encouraged to build a larger dataset of comparison studies and understanding of the relationship between Star Ratings, SRS, risk factors and crash costs per distance travelled.

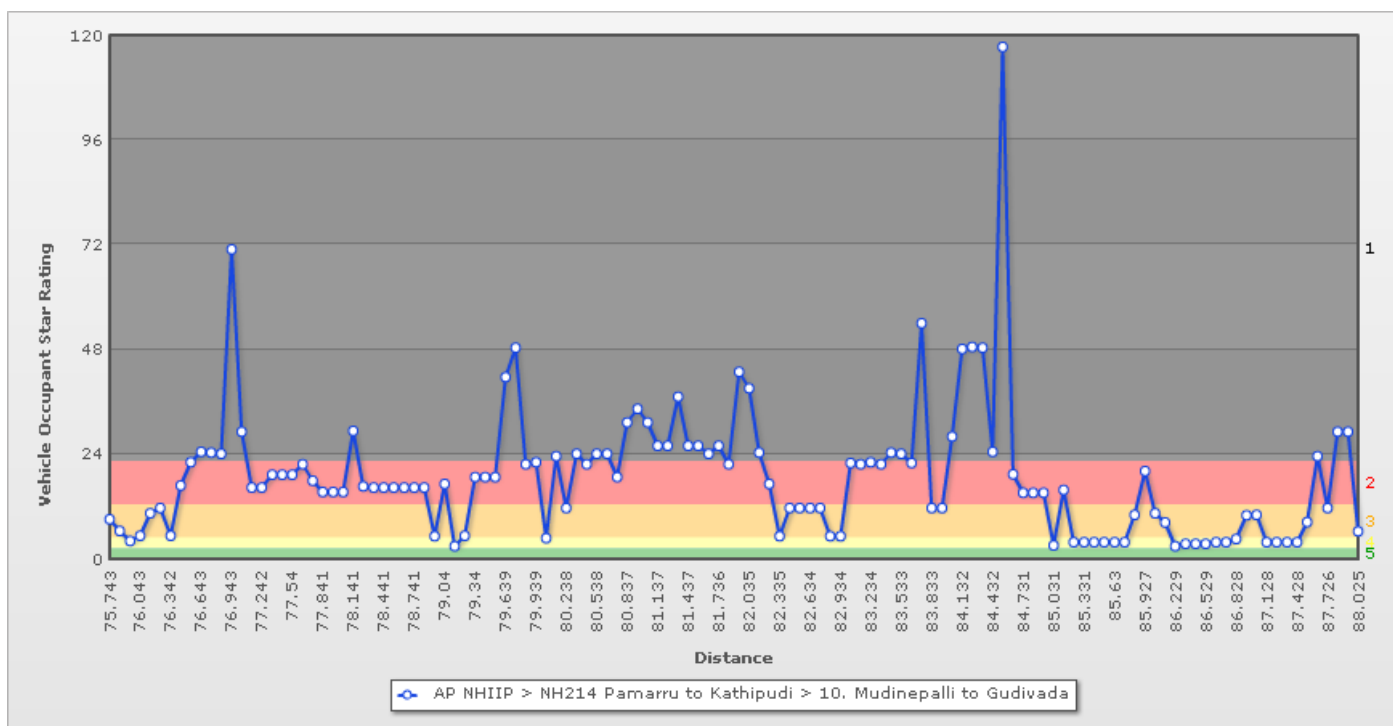
Accurate underlying crash location data is an important pre-requisite for any studies of this nature.

The distribution of Star Ratings across a typical road network

In order to produce results that are meaningful and, in particular, can be used to help guide investments to higher-risk sections of road, it was considered important that the bands were set so that there would often be a reasonable distribution of Star Ratings on a typical road network. This process was conducted by reviewing aggregated Star Rating tables, Star Rating maps and 'risk worms' such as the one shown below. In this chart, SRS and Star Ratings are plotted on the vertical axis and the distance along a road is plotted on the horizontal axis. The figure illustrates that as a vehicle occupant moves along the road, the risk they face varies between the Star Rating bands.

In addition to the road specific reviews, more than 50,000km of roads were assessed using the 'version 3' model during 2012, and this data was progressively used to validate that the 2-, 3- and 4-star rating bands (having assigned the 1- and 5-star bands from the safe system and injury severity approach discussed above).

Star Rating Scores (SRS), Star Ratings and distance along road



References

Commission for Global Road Safety (2011). *Make roads safe: time for action*.

Lawson, S (2011). *Crash rate - Star Rating comparisons: review of available evidence*. Available at:

<http://www.irap.org>.

McInerney, R and Fletcher, M (2013). *Relationship between Star Ratings and crash cost per kilometre travelled: the Bruce Highway, Australia*. Available at: <http://www.irap.org>.

OECD (2010), *Reporting on Serious Road Traffic Casualties*, OECD, Paris, France.

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