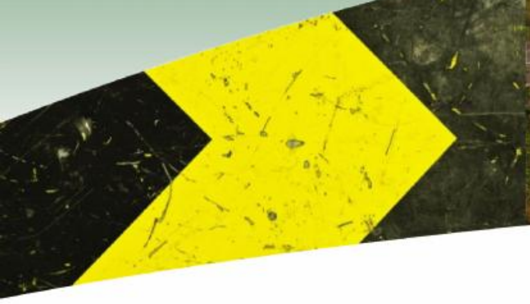
iRAP Road Attribute Risk Factors

Roadside Severity - Distance



This factsheet describes the road attribute risk factors used in the iRAP methodology for Roadside Severity - Distance. Roadside Severity – Distance is a measure of the distance between the edge of the road and the nearest roadside object that would result in death or serious injury to a vehicle occupant, motorcyclist or bicyclist if struck.

About risk factors

Risk factors, sometimes called crash modification factors (CMF), are used in the iRAP Star Rating methodology to relate road attributes and crash rates. Risk factors (or CMF) are described by the Crash Modification Factor Clearing House as follows:

> *A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site.*
>
> *For example, an intersection is experiencing 100 angle crashes and 500 rear-end crashes per year. If you apply a countermeasure that has a CMF of 0.80 for angle crashes, then you can expect to see 80 angle crashes per year following the implementation of the countermeasure (100 x 0.80 = 80). If the same countermeasure also has a CMF of 1.10 for rear-end crashes, then you would also expect to also see 550 rear-end crashes per year following the countermeasure (500 x 1.10 = 550).*

Related documents

This factsheet should be read in conjunction with:

- *Star Rating Roads for Safety: The iRAP Methodology.*
- *Safer Roads Investment Plans: The iRAP Methodology.*
- *Star Rating and Investment Plan Coding Manual.*
- *Road Safety Toolkit (http://toolkit.irap.org).*

Risk factors

Risk factors by road attribute category, road user type and crash type

Roadside Severity – Distance	Vehicle occupant run-off	Motorcyclist run-off	Bicyclist run-off
0m to <1m	1.0	1.0	1.0
1m to <5m	0.8	0.8	0.6
5m to <10m	0.35	0.35	0.1
>= 10m	0.1	0.1	0.01

Selection of risk factors

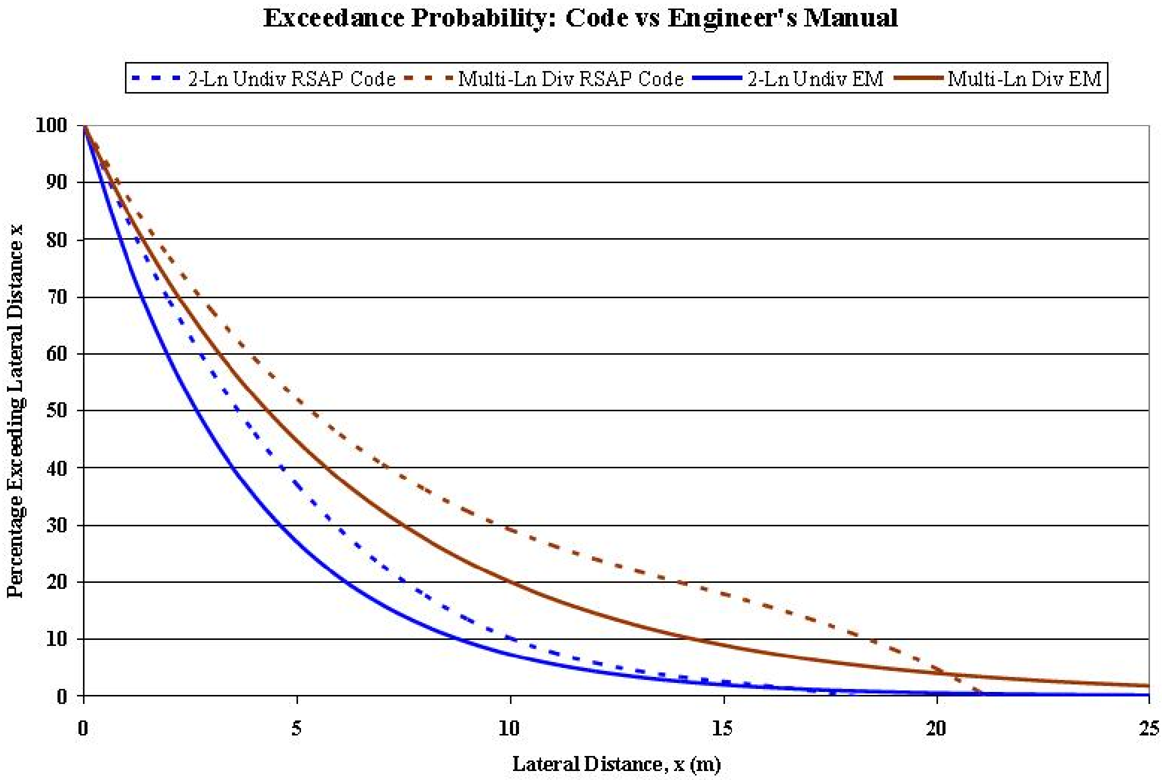
In the iRAP Methodology, Roadside Severity – Distance is treated as factor that influences the severity of a crash, as opposed to the likelihood of a crash occurring. It is acknowledged that this approach is different to approaches cited in the literature. The iRAP approach is taken because risk factors that influence likelihood are considered to be those that contribute to a vehicle, motorcycle or bicycle losing control (and in this case, subsequently crossing the edge line). At that point in time, Roadside Severity – Distance then relates to the probability that an object will be struck by the errant vehicle, motorcycle or bicycle. The severity of the impact is also affected by the type of object struck and the speed at which the object is struck (a separate factsheet on Roadside Severity – Object is available).

In the literature on this topic, the term ‘encroachment’ is often used to describe the degree to which a vehicle approaches a roadside object. Encroachment is often described in terms of:

- frequency of encroachment related to speed, or frequency per kilometre
- ‘how far’ the encroachment is (as a means to deciding how likely objects are to be struck when there is actually something in the path of an errant vehicle).

Much of the work in this area is based on or derived from the work of Cooper (1980), including the default encroachment rates used in the Roadside Safety Analysis Program (RSAP). It is noted that this is a tyre-track encroachment study and not an ‘object struck related to offset’.

Encroachment rates (Cooper, 1980)



iRAP has selected risk factors from the RSAP data that match the worst cast (top-end) for each distance category (note that feet and metres are used). In the encroachment rates chart above, the dotted blue line is for 2-lane roads. By eye, the value in the 0m to 1m approaches 100%; the high-risk end of the 1.0m to 5.0m range is about 90%; the high-risk end of the 5.0m to 10.0m band is about 38%; and at 10.0m the percentage is 10%.

Exceedance probability (%) by distance range

Roadside object - distance	Cooper range (by eye)	Cooper top-end	Cooper mid-point	Cooper mid-points rebased	iRAP v3	iRAP v2.2
0m to <1m	75% - 100%	100%	87%	100%	100%	5 (100%) for 0m-5m
1m to <5m	30% - 75%	75%	53%	53/87 = 61%	80%	
5m to <10m	7% - 30%	30%	19%	19/87 = 22%	35%	3.8 (76%)
>= 10m	0% - 7%	7%	4%	4/87 = 5%	10%	1 (20%)

Comparing iRAP with Cooper (top end) and RSAP (top end), both judged by eye, the results are similar although the RSAP accords higher risk in the region 1.0m to 2.0m (see table below).

Comparison of Cooper, RSAP and iRAP V3 values

Roadside object - distance	Cooper top-end (by eye)	RSAP top-end (by eye)	iRAP V3 (with1m to <5m 'rounded')
0m to <1m	100%	100%	100%
1m to <5m	75%	90%	80%
5m to <10m	30%	38%	35%
>= 10m	7%	10%	10%

The literature implies that the Cooper chart applies to both nearside and offside run-offs and that these are assumed to be equally likely (Ray et al., 2009):

> *The solid lines are the exponential functions described in Engineer's Manual and the dotted lines are the cubic polynomial curves used by the code. The differences between the two sets of distributions are obvious. The code is giving higher proportions of lateral extent of encroachment for lateral distances less than about 20 meters and does not allow lateral distance to exceed about 22 meters.*

Ray et al. (2009) also explain that the data and graphs presented in the Engineer's Manual appear to have been taken from a re-analysis of the Cooper data but that for some reason, however, the results of the study were not made available to those revising the RSAP code. This explains the discrepancy between the dotted and solid lines.

The values used in the bicyclist model are 1.0 (0m to <1m) 0.6 (1m to <5m), 0.1 (5m to <10m) and 0.01 (>=10m), reflecting the much lower likelihood of a bicyclist venturing far from the carriageway.

Background research and model development

Lynam (2010) explained the rationale behind the risk factor selection in the early EuroRAP and iRAP work. Many studies (Hutchinson and Kennedy, 1966; Sicking and Ross, 1986; Cooper, 1980; Calcote et al., 1985) have estimated distributions of encroachment angles, and most agree that the majority of encroachments occur between 5 and 20 degrees. These relatively shallow angles enable even safety zone widths of 5m or less to have an effect on crash outcome.

The research in the remainder of this review is from Lynam (2010) who cites several authors on this subject: Hautala (quoted in SAFESTAR, 1997) suggested that over half of the errant vehicles on rural roads in Finland hit objects less than 3m from the edge of the road, and 88% less than 7m from the road edge. Zegeer et al. (1988) investigated variation in crash rate by average roadside recovery distance (that is, distance from running lanes that is basically flat, unobstructed and smooth within which there is reasonable opportunity for safe recovery of an out-of-control vehicle). A recovery distance of 10 feet (3.3m) was associated with a reduction in related crashes of 25% and a distance of 20 feet (6.6m) with a reduction of 50%.

Knuiman et al. (1993) found that median crash rates and severity decline rapidly when the median width exceeds about 25 feet (7.6m). Meewes and Kuler (2001) compared run off crash rates for roads with different clearance distances on either side. This study suggested the following reductions in crash numbers might be obtained from varying the clear zone widths: 26% from adding a 3m clear zone; 30-48% from extending a 1.3m clear width to 5m clear width; and 60% from extending a 1m clear width to 8.6m.

Studies in the Netherlands in the 1980s (reported in Schoon, 1997) based on crashes on road sections lined with rows of trees at various distances from the edge of the vehicle running lane suggested acceptable obstacle free zones might be 3.5m (regional two lane road), 7m (federal two-way road, and 10m (motorway).

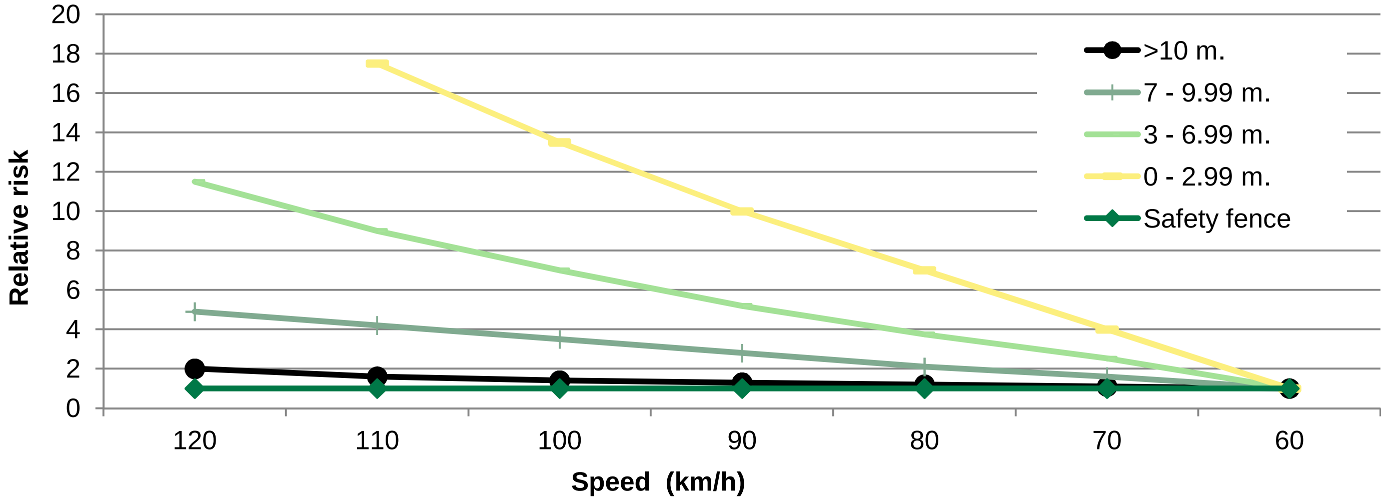
Elvik and Vaa (2004) conclude that increasing the safety zone from 1m to 5m reduces injury crashes by 22%, and increasing from 5m to 9m reduces injury crashes by 44%. They suggest that flattening the embankment slope from 1:3 to 1:4 reduces crashes by 42%, and from 1:4 to 1:6 by 22%. The same authors conclude that guardrails on embankments reduce run-off-road fatalities by 44%, but run-off crashes by only 7%.

These sources are discussed in more detail in Lynam and Kennedy (2005) in a review of the travel of errant vehicles after leaving the carriageway.

The cliff risk factor was introduced in the iRAP model to reflect high severity outcomes irrespective of speed travelled where vehicle recovery and/or crash survivability is expected to be rare.

In earlier versions of the iRAP model, a distinction was made between the relative risk of injury striking objects less than 3m from the edge line, from 3m to less than 7m, from 7m to less than 10m, and greater than 10m. This was compared with a baseline risk of striking a safety fence, as shown in the figure below.

Early iRAP model risk factors for run-off by speed



In earlier versions of the iRAP model, the elements of the model were applied as shown in table below, to the vehicle occupant, motorcyclist and bicyclist models. The model did not distinguish between the crash protection characteristics of different hazards other than as shown in the table. This measure therefore combined some element of severity with likelihood.

Risk factors in earlier versions of the iRAP model

Roadside condition	Vehicle occupant	Motorcyclist	Bicyclist
Safety barrier	1.75	2.5	1.0
Cut	1.75	1.75	1.0
Deep drainage ditches	5	5	5
Steep fill embankment slopes	5	5	5
Distance to object 0-5m	5	5	5
Distance to object 5-10m	3.8	3.8	3.8
Distance to object >10m	1	1	1
Motorcyclist friendly barrier	1.75	1.75	1.0
Not record (low speed area)	0	0	0
Cliff	10	10	10

Roadside condition	Vehicle occupant	Motorcyclist	Bicyclist
Safety barrier (concrete (CEN)) *	1.75	NA	NA
Roadside 0-3m *	6	NA	NA
Roadside 3-7m *	4	NA	NA
Roadside 7-10m *	2	NA	NA
Roadside > 10m *	1	NA	NA

** These attributes were present in the European application of the model and therefore only to the vehicle occupant element.*

Primary references

The following publications are the primary references used in the selection of the iRAP road attribute risk factors. A complete list of citations is available in: *iRAP Road Attribute Risk Factors: Full Reference List.*

Elvik, R, Hoye A, Vaa, T, and Sorensen, M. (2009). *The Handbook of Road Safety Measures, Second Edition (2009)* Emerald Group Publishing Limited. ISBN 978-1-84855-250-0.

Lynam, D (2012). Development of Risk Models for the Road Assessment Programme. RAP504.12 and TRL Report CPR1293, Published by iRAP and TRL and available at: http://www.trl.co.uk and at http://www.irap.org.

Mak, K. and Sicking, *D. (2003). Roadside Safety Analysis Program* – Engineer's Manual. Transportation Research Board (TRB) National Cooperative Highway Research Program (NCHRP) Report 492. ISBN 0-309-06812-6.

Turner, B. Steinmetz, L., Lim, A. and Walsh, K. (2012). Effectiveness of Road Safety Engineering Treatments. AP-R422-12. Austroads Project No: ST1571.

Turner, B., Affum, J., Tziotis, M. *and Jurewicz, C. (2009). Review of iRAP Risk Parameters*. ARRB Group Contract Report for iRAP.

Turner, B., Imberger, K., Roper, P., Pyta, V. and McLean, J. (2010). *Road Safety Engineering Risk Assessment Part 6: Crash Reduction Factors*. Austroads AP-T151/10. ISBN 978-1-921709-11-1.

University of North Carolina Highway Safety Research Center and U.S. Department of Transportation Federal *Highway Administration (2013). Crash Modification Factors* Clearing House: http://www.cmfclearinghouse.org/.

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