SAFETY MANAGEMENT ON THE MRN

Introduction and scope

All users of a 'fit for purpose' Major Road Network (MRN) – whether in motorised vehicles, on motorcycles or cycles, or on foot – should expect the road infrastructure to be designed, managed and maintained to minimise the risk of crashes, particularly those causing fatal and serious injuries. The network operator should have a safety strategy that sets out how this objective is to be pursued, and increasingly we see this driven by a "Vision Zero" aspiration – the eventual elimination of serious crashes which result in death.

The widely used 'Safe System' approach recognises that in any situation it is the interaction between the infrastructure, vehicle characteristics and the behaviour of drivers that determines the risk of crashes. There are many ways to influence driver behaviour to be safer, some of which the network operator can act upon - through signage, road design and markings, speed limits and their enforcement. But the network operator needs to match this by approaches which make the infrastructure itself as 'forgiving' as possible to driver error.

For many years developments in automotive technology have made vehicles progressively safer to drive and less damaging in crashes to humans inside and outside the vehicle, manifested in part by the NCAP rating scheme. Network operators will be well aware of this, but they need also to be aware of the rapid progress in degrees of automation which provide a growing range of 'driver assist' features, the most immediate consequences of which will be the reduction in crashes caused by driver misjudgement or error. This technology is covered in more depth in Supporting Document 10; it is interesting to note that in our investigations we were unable to track down any forecasts of the reduction in crashes and in people killed and seriously injured (KSI) that these developments are expected to give rise to.

In this Supporting Document we focus on the 8,000 mile Major Road Network (motorways, trunk roads and the important local authority 'A' roads included in the MRN) and the pattern and experience of killed and serious injury crashes on this network. We commissioned the Road Safety Foundation – who have developed the well-known methodology for analysing road collision data – to carry out more detailed analysis of collisions on the MRN, including by road type and user type. We explore the impact of interventions to reduce collision risk on the most dangerous roads in the MRN. We then look in greater depth at the risks faced by vulnerable road users, and consider the experience of interventions to reduce those risks.

We turn to the question of predictive risk assessment, and review the experience of the methodology developed by the Road Safety Foundation's international sister organisation iRAP. This is then put in the context of a review carried out by TRL for the DfT of over 20 road safety management and risk assessment methodologies. Having touched on the contribution that fast changing vehicle technologies can make to collision risk, conclusions are drawn.

Overview of collision risk on the Major Road Network

The MRN represents some 8,000 miles of motorways and the more important A roads in England, but only 4% of all roads in England. It accounts for 43% of all traffic, but (according to analysis we commissioned from the Road Safety Foundation) only 16% of all those killed and serious injured in road crashes. The crash risk facing road users overall (28 KSI per billion vehicle miles) is thus significantly lower on the MRN than on other A roads and minor roads (averaging over 100 KSI per bn vehicle miles).

We recognise, therefore, that tackling safety on the MRN has a relatively limited contribution to make to overall road safety experience, although it should be noted that the proportion of KSI crashes that involve a death is higher on the MRN than for the rest of the network. And the worsening crash risk once you leave the Strategic Road Network in particular – even to travel on the local authority MRN roads - can in part be explained by the different mix of road types but there is a residual difference that bears further examination.

Table SD8 - 1

	MRN		MRN			
	SRN	LHA	Total	Other LHA A roads	Minor roads	**TOTAL**
Mileage	4,200	3,800	8,000	13,600	166,000	186,000
% of total	2.2%	2.1%	4.3%	7.2%	88.3%	100%
Vehicle miles bn	86	27	113	60	93	266
% of total	32%	10%	43%	23%	35%	100%
KSI	1,460	1,737	3,197	6,760	9,730	19,600
KSI/bn veh-mls	17	64	28	113	105	74
% of total KSIs	7.4%	8.9%	16.3%	34.5%	49.5%	100%

source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

These variations reflect the fact that the KSI risk rate varies considerably by road type – safest on motorways and most risky on urban single carriageway A roads, reflecting more risk on single vs dual carriageway roads, and more risk in urban areas vs rural areas. The next section describes the RSF's work to illustrate and explain these variations by road type on the MRN.

Collision risk by road type on the MRN

The Road Safety Foundation has for many years carried out analysis of crashes and KSi statistics on Britain's motorways and 'A' roads as a whole, and produced 'risk ratings' for individual road sections across this network. The basis for this is an *ex post* analysis of actual crashes and KSI data (taken from STATS19 databases) by year or group of years; together with the vehicle traffic data from DfT, each road section has its risk assessed as the number of KSI's per billion vehicle miles. These are classified into five colour-coded risk bands (high, medium high, medium, low-medium and low risk).

Clearly, this method encompasses all contributory causes of collisions – whether driver behaviour, vehicle issues or infrastructure characteristics or in any combination. The Annual Reports by the Road Safety Foundation for Britain's motorways and A roads use this material to draw attention to 'worst roads', 'most improved roads' and 'persistently high risk roads' and so on, as well as identifying the costs of collisions and the value for money of interventions[1].

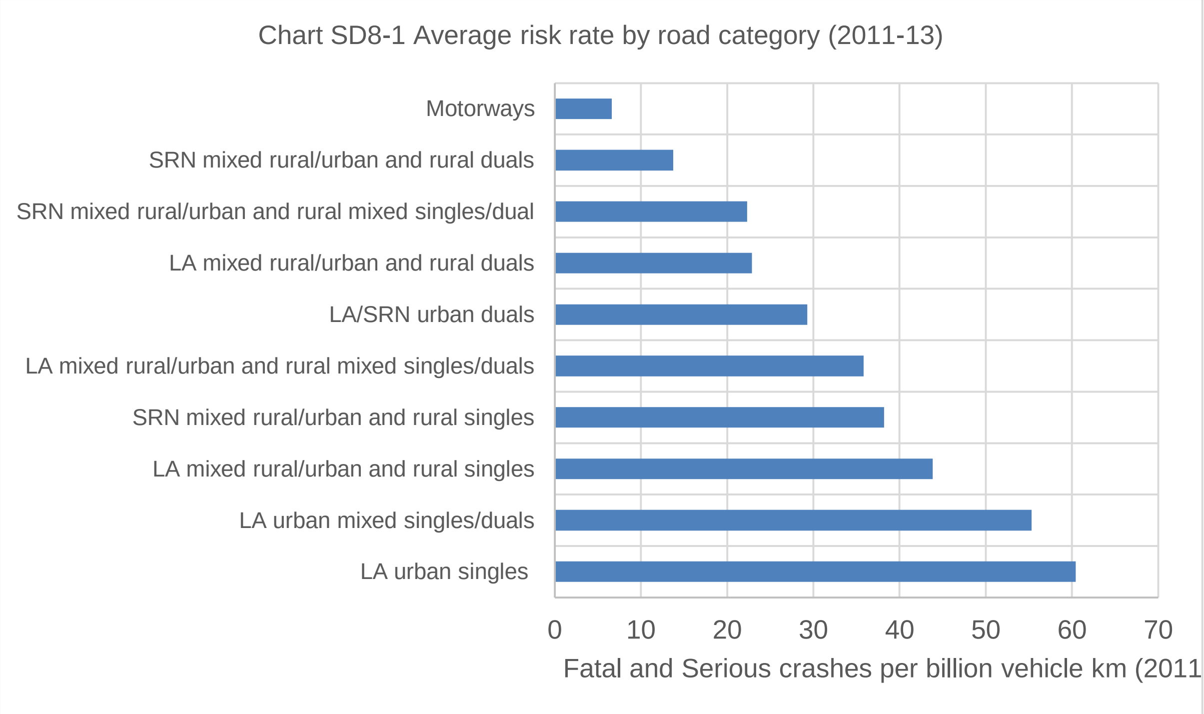
Reading the Annual Report is both sobering and encouraging. The list of 'persistently higher risk roads' features those where the collision risk is *15 to 20 times* that on a typically low risk road, and has been at that level for at least 6 years. They are on this list because little or nothing seems to have been done by the relevant local highway authority to mitigate risk on those roads. The list of 'most improved roads' is encouraging, however, because it shows how a combination of carefully tailored interventions (many of them relatively low cost) can dramatically improve collision risk, moving a road section from a high (black) rating to a low-medium (yellow) rating, or from a medium-high (red) rating to a low (green) rating.

Even those with a high motorcycle involvement (such as the notorious A537 Macclesfield – Buxton; not on the MRN) have been substantially improved with appropriate interventions such as motorcycle-friendly barriers and average speed cameras.

The RSF carried out a detailed analysis of risk ratings of road sections in the 8,000 mile MRN. As we would expect, the average collision risk varies considerably by type of road - as between limited access dual carriageways (motorways and major trunk roads) at one end, and urban single carriageway roads at the other. There is also variation for similar road types as between the SRN and LHA roads on the MRN.

In order to create sufficiently reliable statistical quantities, the EuroRAP methodology uses road section lengths which average 15 miles for the SRN and 10 miles for the LHA MRN roads. It also averages the statistics over three years (2011-2013 for this report). This means that some of the road sections are mixed urban/rural, or mixed single/dual carriageway (although we know the single/dual proportions).

[1] For example *How much do road crashes cost where you live*, British EuroRAP Results 2015, Road Safety Foundation, September 2015 http://www.roadsafetyfoundation.org/media/32684/british_eurorap_report_2015_final.pdf



source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

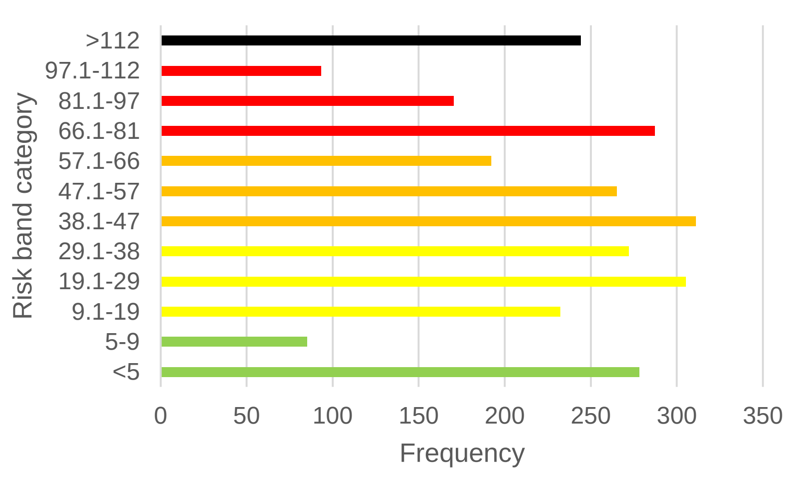
These are averages by road type. We see that where a comparison can be made

- For road sections which are mixed rural/urban, and where the rural is mixed single and dual carriageway, the SRN average (line 3) has a risk rating (KSI's per bn vehicle-kms) of 22 vs 36 for the LHA equivalent (line 6). Inevitably there are differences in the characteristics of SRN and LHA roads within this category, but it should be noted that the proportion of the rural which is dual carriageway (44%) is the same for each network.
- Similar comparisons are revealed between SRN and LHA equivalents where the rural sections are all dual (14 on line 2 vs 23 on line 4); and where the rural sections are all single (38 on line 7 and 44 on line 8).

We cannot draw any conclusions as to whether these differences between SRN and LHA are due to real differences between the physical characteristics of the roads in each category, or whether they reflect differences in the approach to safety management and available resources for making safety improvements as between the then Highways Agency and the relevant local authorities, particularly since the squeeze on local authority expenditure since 2010. For what it is worth, across all road types, SRN roads will tend to have higher traffic flows; it is not clear what effect that would have, if any, on the risk rating.

Of particular interest is the *distribution* of risk rating by individual road links on the MRN. To set the context, this next chart shows the risk rating for the whole EuroRAP network in Britain – ie all motorways and 'A' roads. The risk rating is calculated for each road length by dividing the KSI's over the period 2011-13 by the sum total of vehicle-kms (from DfT traffic counts) over the same three years. The y-axis sets out the colour-coded bands of risk rating, and the limits of risk rating which each band represents. So for example, the whole of the 'medium risk' band, represented in orange, runs from 38 – 66 KSI's per bn vehicle-kms. The word 'frequency' on the x-axis refers to the numbers of road sections in the RSF analysis for each colour band.

Chart SD8 - 2 Risk Rate distribution for the full EuroRAP network (2011-13)

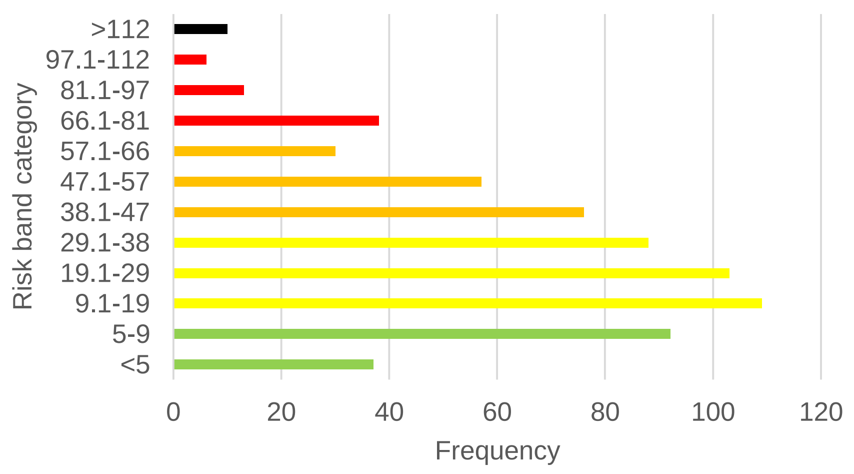


source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

It will be noted that 9% of road sections are high risk (black), and that high and medium-high (black and red) together account for 29% of all road sections – that is, more than 65 KSI's per billion vehicle-kms.

The risk distribution for the MRN shows a rather smaller percentage of high risk roads.

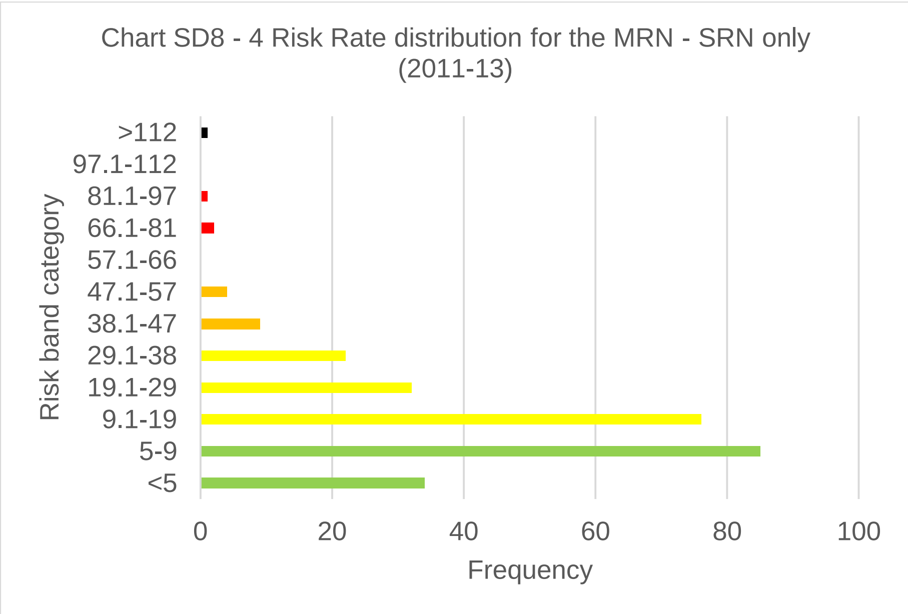
Chart SD8 - 3 Risk Rate distribution for the MRN (2011-13)



source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

As already noted on page 1, the MRN (for England) is generally safer than the 'A; road network as a whole, reflecting the fact that most 'other' roads are in urban areas or less well-engineered rural roads. Here we see that less than 2% are high risk (black), and 10% of road mileage is medium-high and high risk (red and black).

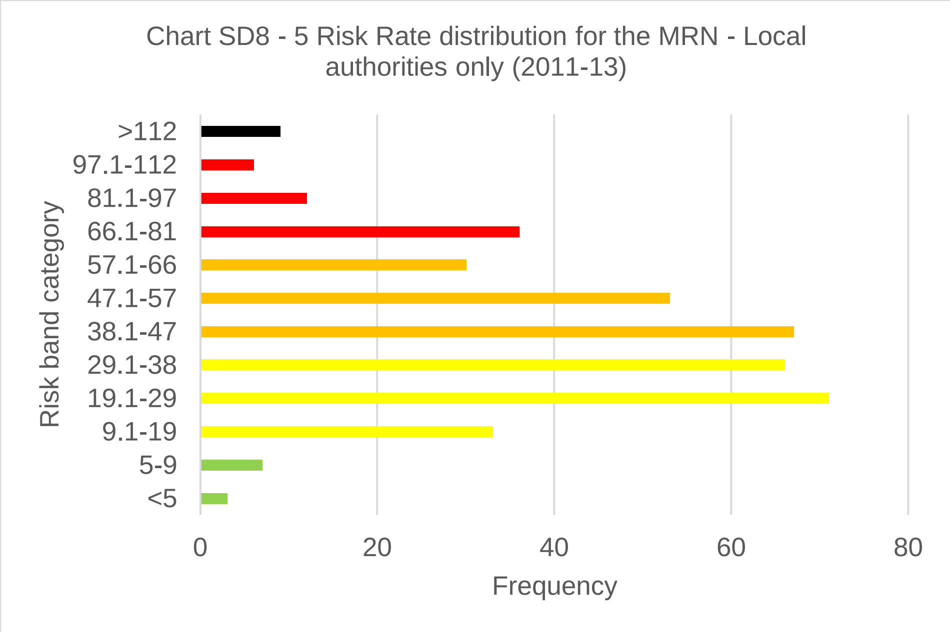
It is interesting to see how the distribution varies as between the two elements of the MRN – the Strategic Road Network and the LHA network: this is shown in the next two charts, SRN first.



source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

Here we see that 45% of the mileage of the SRN is 'low risk' (green), and a further 49% is low-medium risk (yellow). Only 6% of route mileage on the SRN (representing 17 sections) is medium, medium-high or high risk; 1.5% (only 4 sections) are black or red – these are i) ; ii) ; iii) ; iv) .

The picture for the local authority element of the MRN shows more roads with higher risk.



source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

Here we see a rather different picture from the SRN, with only 2.5% of the LHA mileage on the MRN with low risk-ratings (green); and 16% with high risk (black) or medium-high (red) ratings.

The different mix of road types in the SRN compared with the LHA mileage on the MRN will be the primary driver of the differences in risk rating, but as we have seen above, within similar road types there still are differences. Again we cannot judge the extent to which the fewer resources available to local highway authorities compared with Highways England – both to plan and analyse, and to design and deliver, interventions which act to mitigate collision risk – is also a factor.

This analysis suggests – but cannot prove – that there are likely to be relatively more opportunities to make effective and value-for-money interventions on the LHA network than on the SRN.

Targeting interventions on high risk sections of the MRN

Even where a programme of specific risk-mitigation interventions all achieve similar values for money, it could be argued that users – those who face the risks every day - would prefer to see a focus on dealing with the highest risk roads.

As an exercise, we have taken each of the ten road types shown in Chart SD8 – 1 above (the one with all blue bars), and the average risk ratings for each type. We have postulated a series of theoretical interventions which, for each road type, would reduce the KSIs of all those road sections where the risk rating exceeds the average such that the risk rating then equates to the average (it will then of course no longer be the average!). This table shows how this would work out for each of the ten road types.

Table SD8 – 2 Effects of hypothetical interventions to reduce KSIs where risk rating exceeds average for that road type, so the risk rating equals the (previous) average

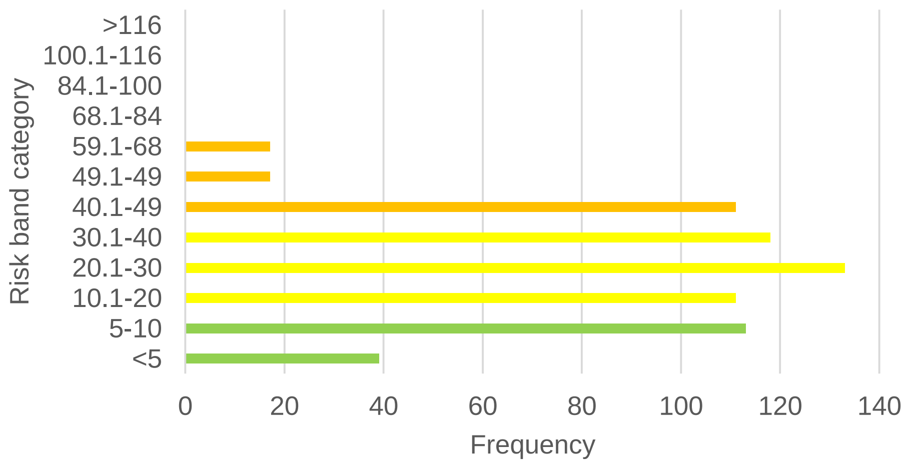
Road type	Average risk rate	KSIs 2011-2013 average per year	KSI savings 2011-2013 avg per year	% reduction	New average risk rate following improvements
LA urban singles	60	163	-26	16%	51
LA urban mixed singles/duals	55	68	-13	19%	45
LA mixed rural/urban and rural singles	44	856	-159	19%	35
SRN mixed rural/urban and rural singles	38	162	-28	17%	32
LA mixed rural/urban and rural mixed singles/duals	36	378	-65	17%	29
LA/SRN urban duals	29	73	-18	25%	22
LA mixed rural/urban and rural duals	23	205	-38	18%	19
SRN mixed rural/urban and rural mixed singles/dual	22	307	-57	19%	18
SRN mixed rural/urban and rural duals	14	419	-64	15%	12
Motorways	7	565	-81	14%	6
TOTAL KSI's per annum on MRN		**3197**	**-549**	**17%**	

source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

Such a strategy could achieve a 17% reduction in KSI's on the MRN overall.

The risk distribution would then look like this:

Chart SD8 - 6 Risk Rate distribution for the MRN if the 2011-13 risk rates did not exceed previous average risk rates for each road category



source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

We do not have the resource within this study to investigate which those roads would be, the kind of interventions that could deliver these reductions and the cost and value for money of those interventions. An exercise similar to this was conducted by the Road Safety Foundation for the RAC Foundation, with a report[2] published in 2011, which did explore the value of typical interventions. It demonstrated overall high value for money for a programme of interventions focussed on bringing risk ratings down to a low or low-medium level, specified uniquely for each road type.

Risks faced by vulnerable road users

The much higher risks faced by pedal cyclists, pedestrians and motorcyclists than car users are illustrated in this table from DfT Statistics

Table SD8 – 3 Casualty Rate per billion vehicle miles Great Britain 2015

	Killed	Killed or seriously injured
Car driver	2	24
Pedal cyclist	31	1,025
Pedestrian	35	460
Motorcycle rider	127	1,875

Note: 2014 National Travel Survey data used to calculate 2014 pedestrian rates; NTS data based on England-only resident sample.

Source Table RAS300070, Department for Transport Statistics, September 2016

There is a case for casting such risk rates on a per *hour of travel* basis rather than *per mile travelled*. For example, a risk to pedestrians expressed per mile walked is not comparable with risks to cyclists or motorcyclists per mile ridden, as their respective speeds are so different. Given that the time that people allocate to travel seems to show a remarkably similar average across different modes as well as across different incomes, demographics and employment status – about an hour a day, on average[3] - it is during this hour of travel that they are risk from a travel-related accident. So such risks would become comparable when expressed per hour of travel. On reasonable assumptions of speed[4], the risk *per hour walking* of a pedestrian being hit and killed or seriously injured by any vehicle is broadly similar to the risk per hour of travel faced by car/bus/coach occupants – less than 1 KSI per million hours. In contrast, the risk for a cyclist is about 10 KSI per million hours of travel, and that for a motorcyclist over 60 KSI per million hours of travel. On this basis, the contrast between cyclists, and particularly motorcyclists, and all other travellers (including pedestrians) is very stark.

[2] *Saving Lives, Saving Money: the costs and benefits of achieving safe roads*, Road Safety Foundation and RAC Foundation, April 2011 http://www.roadsafetyfoundation.org/media/11070/saving%20lives_saving%20money.pdf

[3] See for example *The Limits to Travel: How Far Will You Go?* David Metz, Earthscan, London, 2008

[4] 30 mph for cars, 35 mph for motorcycles, 10 mph for cyclists and 2 mph for pedestrians

The much higher rates of risk faced by pedal cyclists and motorcyclists, and indeed the risks faced by pedestrians on roads and in urban streets, are reflected in the proportions of collisions on the MRN in which there was a motorcyclist or pedal cyclist or pedestrian involvement.

Per annum (average 2011-13)	SRN	LHA (MRN)	TOTAL MRN
All KSI	1,460	1,737	3,197
All traffic: bn veh-kms	83	28	101
Overall risk rating (KSI/bn veh-kms)	18	62	32
KSI with m/c involvement	297	507	804
m/c traffic bn veh-kms	0.44	0.25	0.69
m/c risk rating (KSI/bn m/c veh-kms)	675	2,025	1,165
% of all KSIs with m/c involvement	20%	29%	25%
% of all KSIs with cyclist or pedestrian involvement	9%	25%	18%

source: unpublished working papers provided to the Study Team by the Road Safety Foundation as part of their commission

There is a significant difference in the risk ratings faced by motorcyclists on the SRN and the LHA component of the MRN, which reflects the differences between the overall risk ratings between the two networks, already discussed above. Nevertheless, the risk ratings per bn vehicle miles for motorcyclists average 40 times higher than for the average of traffic as a whole; this embraces collisions caused both by motorcyclists and by other road users.

Note also that collisions involving vulnerable road users account for nearly a third of all collisions on the SRN, and over a half of all collisions on the LHA component of the Major Road Network. This is a function of urbanisation – for example in London, vulnerable road users accounted for some 80% of those killed and seriously injured on the TLRN (the Transport for London Road Network – main roads in London, a proportion of which account for the MRN in Greater London)[5].

This picture clearly reinforces the actions by many local authorities to focus on measures to reduce cycle safety risk – including some modifying road infrastructure (cycle lanes, road signage, dedicated cycleways) to afford more protection to cyclists – and campaign action led by government to increase road users' awareness of

[5] *Collisions and Casualties on London's roads: Annual Report 2014,* Transport for London, 2015

motorcyclists and their vulnerability. Nevertheless, motorcyclists' own behaviour can be a critical factor: a TfL working paper[6] evidences that nearly three quarters of motorcycle fatalities in London in the five year period to 2010, were due to speeding, in some cases to very extreme levels.

In London, Transport for London have developed and adopted the Street Types Matrix (see main Study Report p31 section 5.5 and figure 5.2) as a toolkit for addressing and resolving the differing balances of conflict between the 'movement' and 'place' functions of each of London's streets and roads[7]. This technique – as applicable to the TLRN (and thus the MRN in London) as to local roads - also helps to design street and crossing features which not only mitigate risk for pedestrians but integrate with the nature and purpose of each road and street, making the whole more effective.

Predictive risk assessment

Predictive risk assessment is a core tool of safety management in other transport sectors – railways, aviation – and throughout the rest of industry, and is at the heart of safety systems as required under Health and Safety legislation. Road safety has never been part of such a regime, and until relatively recently has never embraced predictive risk assessment. As described above, safety management and decisions about interventions by local highway authorities have used *ex-post* data (for example from STATS19). This has been effective over many years – along with other factors – in helping steadily to reduce crashes and KSIs across Britain's road networks. Ironically, as the incidence of KSI crashes continues to reduce (and will do so even more rapidly as 'driver assist' systems become commonplace) so the data becomes more sparse with which to guide future interventions to make the infrastructure still safer and more 'forgiving'.

Perhaps the best-known (outside the UK at least) method of *ex ante* or predictive risk assessment is that developed over the last 15 years by iRAP (International Road Assessment Programme), the international sister organisation to the Road Safety Foundation (in the UK) and EuroRAP. iRAP has been developed into a scalable method which is licensed for third parties to use, to assess the risks that particular road infrastructure and its management generate for networks across the world, with the aim of guiding investment in programmes by national governments and highway authorities to achieve major – in some cases dramatic – improvements in road safety.

The core of the method is an assessment of the contribution that the physical, signage and traffic management characteristics of individual stretches of road make to the collision risk of each stretch of road. By its nature it does not take account of vehicle characteristics or driver behaviour, but it does seek to reflect different mixes of vehicle type, especially two wheelers. iRAP have developed a sophisticated software package

[6] *Road Risk and Vulnerable Road User Working Paper,* Transport for London
[7] See https://tfl.gov.uk/info-for/boroughs/street-types

called VIDA, which enables an *ex ante* assessment of infrastructure risk to be estimated, with a trained engineer working from a detailed video image of the road captured in a similar way to Google Street View, supplemented in some cases by physical measurements. The risks are captured in a 5-point star rating system, and expectations and targets are set that different types of road should aim to reach. Assessments have already been carried out by iRAP for a number of national road administrations in Europe and elsewhere in the world, which have guided large scale remedial work programmes, often funded by the World Bank.

The star rating methodology has seen relative little use in the UK. RSF with the cooperation of the Highways Agency carried out an assessment of the Strategic Road Network between 2006-08, and published it in 2010. More significantly, Highways England have in their current Delivery Plan committed to using the new VIDA methodology to assess the entire Strategic Road Network over the first RIS period, and to making risk-mitigating improvements to the network to achieve the goal of 90% of travel being on SRN roads with at least 3-star ratings by 2020.

There has been little interest in using this methodology by English local highway authorities. We sense this arises from a combination of local highway authorities a) already having access to STATS19 data and using this to evidence known 'blackspots'; b) making some use already of the *ex post* 'risk rating' material produced by RSF; c) suffering continuing squeeze on resources within local government; and d) in the light of the steadily improving road safety statistics and the lack of any targets from central government, not placing new remedial approaches high on their agenda.

Yet we understand the VIDA package approach developed by iRAP is unexpectedly inexpensive to apply. Proposed physical measures can then be evaluated for their risk mitigation potential, and a cost-benefit analysis carried out – initially on a desk basis by an experienced engineer.

A recent report by TRL[8], commissioned by DfT, examined and evaluated 21 safety management models for use on rural roads, both *ex post* and predictive (or proactive); It suggested an approach to set standards for safety levels for different road types, to help identify and priorities where interventions were needed; it recommended the use of proactive screening methods to help identify more effectively effective safety management measures, and a more systematic approach to the design and evaluation of such measures. DfT should take the lead in enabling these developments, so that the whole highway authorities community could benefit.

The scope for automotive technology to improve safety and reduce risk

Automotive technologies already widely available in new cars, such as autonomous emergency braking, and a range of other driver-assist features, are likely to achieve significant reductions in crashes; these beneficially effects should become more

[8] *Road Safety Models,* Report PPR 70, Transport Research Laboratory, 2015

significant as level of vehicle automation increase, although we have not seen any quantified predictions of these benefits. Supporting Document 10 on Technology has more on this subject.

How these developments will affect the balance of risk and causation of vehicle crashes on the road is not known and to our knowledge has not been studied. It is likely however that the need for road infrastructure itself to be made safer and more forgiving will still be necessary, and the case for standards and targets to be set - for example through the iRAP-style Star Ratings – to help guide safety management measures. But is does suggest that research should be commissioned – possibly by DfT – to ensure that the effects of increasing vehicle automation are studied and analysed carefully to promote the essential understanding of how risk and causation within the 'safe system' methodology (vehicle/driver/infrastructure) is going to evolve.

Conclusions

1. The MRN – and the SRN in particular – already offers less risk to its users than the generality of roads in England, although crashes that do occur seem to involve a higher proportion of deaths.
2. There is a wide range of risks (measured in KSI's per billion vehicle-miles) between different road types and between rural and urban areas in the MRN; and within specific road types there is a wide variation of risk. Existing methods of risk analysis (for example using the Road Safety Foundation's Risk Rating system using STATS19 data) can give clear guidance on priorities for intervention – but there still are many high risk local authority roads that go unattended from one year to the next, probably because of resource constraints..
3. There are significant differences between the SRN and local authority MRN roads, even for the same road-types. We cannot tell whether this is due to differences between actual roads and in user mix, or due to differences in approach and resource availability to identify and tackle the problems.
4. The conventionally expressed risks faced by vulnerable road users (cyclists, pedestrians and motorcyclists) are much higher than users in vehicles – and when the risks are expressed per hour of travel they are startling and stark for cyclists and particularly motorcyclists (but not for pedestrians). The case for concentrating interventions – especially in cities – to mitigate risks for vulnerable users is overwhelming,, even though TfL evidence suggests that much risk for motorcyclists – deaths due to speeding - is self-inflicted.   The Street Types Matrix developed by TfL and the Mayor's Roads Task Force for addressing movement/place conflicts on London's roads and streets provides a valuable framework for designing appropriate risk mitigation measures.
5. As safety continues to improve, so the crash data with which interventions are guided and developed becomes more sparse. We believe the road safety community

should join the rest of industry and learn about and start to use predictive risk assessment as a basis for continuing to reduce risk associated with infrastructure and its management. The recent TRL report evaluating 21 safety management models from round the world gives a clear set of recommendations about the adoption of predictive (or proactive) methods of assessment, and encouragement to the DfT to take the lead in making this happen.

6. Rapid development s in automotive technology are bringing major safety benefits by reducing the scope for driver error, though we know of no investigations to forecast the effects over the longer term. Meanwhile, these developments will in time alter the balance of risk and causation between the three 'safe system' pillars – vehicles, drivers, infrastructure – with implications for policy and value for money investment; we believe it is important that this too should be the subject of research and study at some stage over the next few years .