A EuroRAP case study: Potential for risk reductions on British inter-urban major roads

David Lynam
TRL

Stephen D Lawson
The AA Motoring Trust and EuroRAP AISBL

www.eurorap.org
Potential for risk reductions on British inter-urban major roads

David Lynam (TRL) and Stephen D Lawson (AA Motoring Trust and EuroRAP AISBL)

Just four types of collision account for about 80% of fatal crashes on inter-urban roads across Europe. The design and standard of these roads determines the extent to which the collisions occur and severity of resultant injuries. Mass action programmes provide the opportunity for systematic large-scale upgrading of sections of the road network with the widespread application of measures known to reduce injury. Investment priorities can be determined by analysing how the four collision types contribute to risk of severe injury on road sections of different types, and by assessing the number of severe collisions that could be reduced and thus the investment justified in upgrading. The biggest reductions in risk on British non-motorway inter-urban major roads will come from reducing collisions at junctions; risk can also be greatly reduced on some roads by using a median to divide single carriageway roads. The biggest changes in severe injury collision numbers can be obtained from improving those poor-quality dual carriageways that have many at-grade accesses to a grade-separated or improved merge design. There are likely to be particularly good investment returns in providing high-quality merge junctions on dual carriageways and junction improvements and median treatment on single carriageways.

CRASH PROTECTION AND MASS ACTION

Main inter-urban roads are already engineered to a relatively high standard, but, if infrastructure improvement on these roads is to contribute significantly to national casualty reduction targets, substantive changes in detailed design or in the management of traffic are required over large parts of the network. This paper uses collision and road layout data established through the European Road Assessment Programme (EuroRAP) for British trunk and primary routes. It explores the distribution of risk, assesses how far changes in access control, traffic separation and roadside edge treatment might achieve significant changes in casualty numbers, and calculates what investment is justified to achieve this.

Over a wide sample of European countries four main collision types lead to about 80% of all fatal collisions on rural main roads (OECD, 1999). These are head-on collisions between vehicles, single vehicles running off the road, collisions at junctions, and collisions involving pedestrians and cyclists. The relative proportions differ between countries and between road types, but the dominance of these four types is clear in most situations. They represent four different areas in which road design might be improved to reduce the total number of collisions. The remaining 20% of collisions are largely associated with shunt impacts, and are less directly influenced by changes in road design.

Table 1 summarises the extent to which roads are currently built to reduce the risk of serious injury in the four collisions described (or are designed, by segregation of road-users, to avoid collisions), and provides recent data reflecting their safety record. Motorways, for example, have median barriers to reduce head-on collisions, protected side areas to avoid severe run-off collisions, and merging junctions (where brutal side-impacts are minimised because collisions usually involve glancing blows as vehicles merge at acute angles). Motorways also prohibit vulnerable road-users. Figure 1 illustrates the extent to which elements of this protection also exist on single and dual carriageways.

Data presented in this paper are high-level indications

<table>
<thead>
<tr>
<th>Collision</th>
<th>Motorway</th>
<th>Dual carriageway, grade-separated junctions</th>
<th>Dual carriageway, at-grade junctions</th>
<th>Mixed dual and single carriageway</th>
<th>Single carriageway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-to-head Junctions</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Run-off</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Vulnerable road-users</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Risk of death and serious injury/billion vehkm (Britain)</td>
<td>18</td>
<td>28</td>
<td>43</td>
<td>53</td>
<td>80</td>
</tr>
</tbody>
</table>
showing which significant road features (e.g., the presence or absence of median protection) make a major difference to fatal and serious crash rates, indicating where major systematic potential exists to save lives. This work has the potential to generate powerful messages that will explain to the general public and decision-makers alike where the priorities are and whether Britain can afford to save lives.

The systematic upgrading of roads will reduce components of the risk on different types of road and mass action programmes (or ‘mass action plans’ - see, for example, the World Bank web link referenced) will provide a toolkit in this exercise as known remedies are applied to locations or routes with common collision problems. Plans are in hand for EuroRAP to document the opportunities available through mass action programmes by means of guidelines for practitioners. Indications of the likely direction of this work, however, may be judged from what has already been reported in Australia (AusRAP, 2004) and the United States (Federal Highway Administration, 2005), the latter containing research results such as calculated collision modification factors from ‘tried’ and ‘experimental’ strategies. The assignment of collision countermeasure priorities demonstrated by the Dutch transport research institute SWOV – outlined in Road Safety Explorer – may also have a role.

DISAGGREGATING RISK

The collisions on each route section on the British EuroRAP network (840 sections, 22,000 km) have been divided between the four collision types described. By comparing roads that differ primarily in the key design aspects affecting each collision type, it is possible to estimate potential differences in risk or collision numbers (see Table 2). This can be examined initially in terms of risk to the individual vehicle-user, and then extended to the potential reduction in the number of collisions, and the consequent benefits from such design changes.

The difference between the average distribution of risk for motorways, other dual carriageways and single carriageways in the British network assessed by EuroRAP is shown in Figure 2. This, and subsequent charts, is based on the combined total of fatal and serious (F&S) collisions for the years 1999-2001 which provides a sufficiently large sample (about 20,000) to investigate. For motorways, a large proportion of these collisions are ‘other’ or shunt collisions. For both single and dual carriageways (other than motorways), the largest contribution to risk comes from collisions at junctions. Risk from run-off collisions is not substantially different between motorways and dual carriageways.

Figure 3 shows that there are clear differences in junction risk between dual carriageways with mainly grade-separated junctions and those with mainly at-grade junctions.

RISK REDUCTION BY MASS ACTION UPGRADING

If the change in a specific road type is now considered – adding the effect of a median to existing high-flow single carriageways to include pedestrians and cyclists) also differs, probably because the overall accessibility and quality of the roads are different. Interestingly, the run-off risk is very consistent.

There are also clear differences in total risk between roads of each type with different traffic flow levels. Figure 4 compares single carriageways with different annual average daily traffic (AADT). Some of the components of risk follow the overall trends, while the differences in some, such as junction risk, are less pronounced. Figure 5 shows a similar variation in risk with flow for grade-separated dual carriageways.
Determining investment priorities

Figure 4: Variation of risk with flow (AADT) on single carriageway main roads
Figure 5: Variation in risk with flow (AADT) on grade-separated dual carriageways

Table 2: Areas of road design where changes produce the biggest potential for reducing risk
Table 3: Areas of road design where changes produce the biggest potential for reducing the number of fatal and serious collisions per kilometre

relevant measure - i.e., a median divide would reduce most head-on collisions. Fairly high reductions in risk can also be obtained from junction improvements on both single and dual carriageway roads.

COST EFFECTIVE INVESTMENT

To consider where it might be most cost effective to improve roads, however, it is necessary initially to combine these risk changes with the number of collisions on each stretch of road. The rank order then changes (Table 3). The biggest change in collision numbers per kilometre could be obtained from improving a poor-quality dual carriageway with many at-grade accesses to a grade-separated design. Substantial reductions could also be obtained from halving the junction risk or from adding median divides to single carriageways. Although the potential risk reduction was much higher on low-flow single carriageways, the potential reduction in number of collisions is similar for both high- and low-flow roads.

To decide on appropriate action to reduce the number of collisions it is necessary to assess the monetary value of the benefits that could be achieved, in relation to the cost of the measures required. Table 4 estimates the amount that it might be worth investing to achieve the benefits applied by the risk changes calculated. The challenge is to find solutions that can achieve this within these investment levels. The calculations are based on the average collision numbers for each group, so improvements to the worst roads in each group will justify higher investment per kilometre.

The Net Present Value in the right-hand column provides an estimate of the current value of the whole life benefits of the measures, assuming the life shown, using the current UK Treasury approved discount rate of 3.5 per cent. Improvement life and maintenance cost will depend on the type of measure, so the estimates are intended only to indicate the relative investment that might be worthwhile. Nevertheless, there appears to be much scope to consider further the potential for cost-effective investment, particularly providing high-quality merge junctions on dual carriageways and median treatment and junction improvements on single carriageways.

Final decisions on measures to adopt will take into account which changes are likely to be most cost effective to invest in. For this it is necessary to add the cost of the design changes into the equation. Costs vary across Europe but it is clear that in large-scale upgrading programmes there will be economies of scale. EuroRAP does not consider the priority of investment at individual sites, but seeks justification for substantial programmes across the whole network. Such programmes would be developed as mass action programmes, benefiting from cost rates associated with such large-scale programmes. Its philosophy is also that road engineers should not be constrained to traditional measures but should seek more cost-effective solutions.
tions to reducing the risks identified.

A complementary means to achieve these risk reductions is to reduce traffic speeds on these roads. An appropriate speed should balance safety and mobility costs, taking account of the well-established link between speed and collision risk. But clearly for strategic roads, the primary aim should be to make the road sufficiently safe to carry traffic at high speeds.

CONCLUSIONS

On British inter-urban major roads most risk is associated with a small number of collision types, which in turn are associated with specific road design. By looking at the way in which risks are distributed on different roads, it is possible to estimate the potential benefits from design improvements and identify the measures likely to justify investment.

(i) Disaggregating the overall risk for severe collisions shows that the largest contribution to risk on the non-motorway roads comes from collisions at junctions.
(ii) At these junctions there is less than half the level of risk associated with grade-separated junctions compared with at-grade junctions.
(iii) Adding a median to divide low-flow single carriageway roads heads the list of ways to reduce risk to individual motorists, but substantial reductions in risk can also be obtained from junction improvements on both single and dual carriageway roads.
(iv) The biggest change in collision numbers per kilometre can be obtained by improving a poor-quality dual carriageway with many accesses at-grade to a grade-separated design.
(v) A reduction of almost half this in the number of collisions per kilometre could be obtained by halving the junction risk on single carriageway roads.
(vi) Adding a median divide to single carriageway roads yields similar potential reduction in collision numbers on both low-flow and high-flow roads.
(vii) Analysis of Net Present Value shows that there appears to be much potential for cost effective investment, particularly by providing high-quality merge junctions on dual carriageways and junction improvements and medians on single carriageways.

ACKNOWLEDGEMENTS

The work described in this report was carried out in the Safety Group of TRL Limited, at the AA Motoring Trust and at EuroRAP AISBL. The authors are grateful to Dr Jeremy Broughton for his quality review and to Tom Sutch who managed the British data.

The authors acknowledge the guidance or technical contributions of John Dawson (EuroRAP AISBL) and Dr Joanne Hill (EuroRAP AISBL/AA Motoring Trust), Professor Rod Kimber (TRL) and all members of the EuroRAP Technical Committee, comprising representatives of motoring clubs, road administrations and other bodies from more than 20 European countries. In Britain the AA Motoring Trust and EuroRAP AISBL work in consultation with the County Surveyors’ Society (CSS) working group chaired by Brian Goodwin, local highway authorities, with the Highways Agency (represented by Peter Whitfield), the Department for Transport (Mark Magee), the Scottish Executive (Hugh McCafferty) and the National Assembly for Wales (Richard Morgan).

In 2004-05 EuroRAP has been supported by the European Commission, the FIA Foundation for the Automobile and Society, Toyota Motor Europe, the AA Motoring Trust and ACEA, the European car manufacturers’ association.

REFERENCES


![Figure 6: Potential change in risk if opposing traffic streams on a single carriageway road with a relatively high AADT are separated by a median](image1)

![Figure 7: Percentage of junction collisions by junction type for each road type](image2)

Table 4: Investment justified in measures focusing on different aspects of road design

<table>
<thead>
<tr>
<th>Measure</th>
<th>Annual Benefit £k per km</th>
<th>Assumed Life-Years</th>
<th>Net Present Value £k per km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convert grade-separated dual carriageway (DC) to motorway</td>
<td>21</td>
<td>20</td>
<td>316</td>
</tr>
<tr>
<td>Halve risk from run-off on motorway</td>
<td>14</td>
<td>10</td>
<td>121</td>
</tr>
<tr>
<td>High quality merge junctions on DC</td>
<td>44</td>
<td>20</td>
<td>651</td>
</tr>
<tr>
<td>Halve junction risk on DC</td>
<td>30</td>
<td>10</td>
<td>256</td>
</tr>
<tr>
<td>Halve risk from run-off on DC</td>
<td>14</td>
<td>10</td>
<td>121</td>
</tr>
<tr>
<td>Halve junction risk on single carriageway (SC)</td>
<td>20</td>
<td>10</td>
<td>168</td>
</tr>
<tr>
<td>Median in low-flow SC</td>
<td>17</td>
<td>10</td>
<td>145</td>
</tr>
<tr>
<td>Median in high-flow SC</td>
<td>17</td>
<td>10</td>
<td>144</td>
</tr>
<tr>
<td>Halve risk from run-off on SC</td>
<td>7</td>
<td>10</td>
<td>62</td>
</tr>
</tbody>
</table>
Just four types of collision account for about 80 per cent of fatal crashes on inter-urban roads across Europe. The design and standard of these roads determines the extent to which the collisions occur and severity of resultant injuries.

Mass action programmes provide the opportunity for systematic large-scale upgrading of sections of the road network with the widespread application of measures known to reduce injury. Investment priorities can be determined by analysing how the four collision types contribute to risk of severe injury on road sections of different types, and by assessing the number of severe collisions that could be reduced and thus the investment justified in upgrading.

The biggest reductions in risk on British non-motorway inter-urban major roads will come from reducing collisions at junctions; risk can also be greatly reduced on some roads by using a median to divide single carriageway roads. The biggest changes in severe injury collision numbers can be obtained from improving those poor-quality dual carriageways that have many at-grade accesses to a grade-separated or improved merge design. There are likely to be particularly good investment returns in providing high-quality merge junctions on dual carriageways and junction improvements and median treatment on single carriageways.