Saving Lives, Saving Money

The costs and benefits of achieving safe roads

Dr Joanne Hill &
Caroline Starrs
April 2011

ROAD SAFETY FOUNDATION

RAC Foundation

The Road Safety Foundation is a UK charity advocating road casualty reduction through simultaneous action on all three components of the safe road system: roads, vehicles and behaviour. For the last decade, it has focused on leading the establishment of the European Road Assessment Programme (EuroRAP) in the UK and internationally, and is the UK member responsible for managing the programme in the UK and Ireland.

Road Safety Foundation is a UK registered charity (No. 295573).
Registered in England and Wales as a company limited by guarantee, No. 02069723.
Registered office: 60 Trafalgar Square, London, WC2N 5DS, UK.

Road Safety Foundation
Worting House
Basingstoke
Hampshire
RG23 8PX

Tel: 01256 345598
www.roadsafetyfoundation.org

The Royal Automobile Club Foundation for Motoring Limited is a charity which explores the economic, mobility, safety and environmental issues relating to roads and responsible road users. Independent and authoritative research, carried out for the public benefit, is central to the Foundation's activities.

Registered Charity No. 1002705

RAC Foundation
89-91 Pall Mall
London
SW1Y 5HS

Tel: 020 7747 3445
www.racfoundation.org

Saving Lives, Saving Money

The costs and benefits of achieving safe roads

Dr Joanne Hill &
Caroline Starrs
April 2011

Acknowledgments

The authors are grateful to the RAC Foundation and the Rees Jeffreys Road Fund for their financial contributions.

This report has been prepared by Dr Joanne Hill and Caroline Starrs (Road Safety Foundation). The report content is the view of the authors and does not necessarily represent the views of the RAC Foundation or the Rees Jeffreys Road Fund.

Analysis and validation was carried out by Dr Joanne Hill and Caroline Starrs (Road Safety Foundation). Cartography was carried out by Nick Moss (Road Safety Foundation) using Digital Map Data © Collins Bartholomew Ltd (2010). Photography by Dr Joanne Hill and TRL.

This project was supported by a Steering Panel comprising representatives of the Road Safety Foundation (John Dawson, Dr John Mumford, Dr Joanne Hill, and Caroline Starrs), the RAC Foundation (Professor Stephen Glaister and Elizabeth Box) and the Rees Jeffreys Road Fund (David Bayliss).

The authors are grateful to John Dawson and Dr John Mumford for their contributions to the report and Rob Salmon for managing the survey of local authorities and members of ADEPT (The Association of Directors of Environment, Economy, Planning and Transport) who provided information and allowed it to be used. The authors are also grateful to peer reviewers for their helpful comments during drafting.

Contents

List of Tables

List of Figures

List of Boxes

Forewords

**PROFESSOR STEPHEN GLAISTER, DIRECTOR
RAC FOUNDATION**

Road accidents have killed 30,000 people over the last decade and still kill six people a day. We understand road risks well enough to know how to reduce this toll of injury and death – yet we fail to implement cheap and effective measures to combat them. Would we tolerate this in any other area of public health?

It is now well accepted that a 'safe system approach' to road safety requires safe drivers, safe vehicles and safe roads. The road safety profession and motor manufacturers can reasonably claim to have had some success over recent decades. Higher standards of crash protection for car drivers and passengers mean that there are people now enjoying a healthy life who would otherwise have been maimed or killed. We must continue to make improvements in all three areas, but this report demonstrates that it is time to give more attention to the roads.

The report shows how it is now possible to assess the safety rating of a stretch of road from its physical characteristics and compare that rating against an expected standard. This is an important advance over the long-standing tradition of concentrating on accident 'black spots' where tragedies have already occurred.

It turns attention to the prevention of future tragedies by assessing a whole network and spotting those stretches which have a poor safety rating. We can estimate the cost of bringing a substandard stretch of road up to a minimum safety level, and estimate the expected benefits of doing so in terms of reducing the risk of death and injury.

Some will say that we have been focusing on road improvements for years and should now turn our attention to improving drivers' behaviour. This report does not argue against that course of action. But countries leading in road safety agree that roads should be designed to take account of the fact that all drivers make mistakes, and that the road environment should be made as 'forgiving' as possible.

We tolerate unsafe roads yet the cost of bringing the whole system up to minimum standards would be a manageable proportion of what we already spend on our roads; and this cost can be mitigated if we take the opportunities presented as we maintain and enhance the network. For instance, non-skid surfaces and crash barriers to protect against dangerously exposed trees can be installed during routine maintenance. The rates of return from redirecting resources to where they are most effective are so high that it beggars belief that we have not acted sooner.

The UK may once have been a world leader, but this report shows that we are in danger of falling behind far-sighted countries which have decided not to tolerate unsafe situations any longer. We are in danger of becoming complacent: our data are not always accurate; we have a poor understanding of who bears what costs of road accidents; local authorities are using different techniques to assess benefits and costs – there can be little reason to continue to use crude 'first year rates of return' when the use of more appropriate estimates of value for money requires just a little more effort.

As local authorities struggle with budget cuts, there is a concern that cash and professional expertise available for road safety will be reduced, rather than increased. The imperative is to use what we have more effectively, and this report offers guidance on how we can do that.

This report should make us angry and determined to act to see more lives saved – at little or no extra cost.

LORD DUBS OF BATTERSEA, CHAIRMAN ROAD SAFETY FOUNDATION

Saving Lives, Saving Money breaks important new ground.

It shows clearly that Britain loses 1.2%-2.3% of GDP annually in road crashes but, for the first time, maps the high concentration of crash costs on targetable A road and motorways.

Innovatively, the report proposes minimum Star Ratings for infrastructure safety using an internationally established system. This permits public, policy makers and engineers to get to grips with the levels of infrastructure safety we should normally expect for motorways and busy A roads while avoiding complex engineering nuances. It makes the benefits and costs of achieving safe roads transparent and a systematic approach possible.

Without a simple measurement of infrastructure safety, road engineers will remain tongue-tied in trying to explain what might be achieved through a programme of safety fencing, safe turning lanes or any of the other 70 proven safety engineering measures. Without normal methods of cost benefit analysis, safety programmes will continue – as this report has found – to be largely ignored in favour of programmes which are well evaluated.

This report was stimulated by OECD recommendations that countries should examine the institutional barriers that were preventing an economic focus on road crashes. It contains vital new evidence for senior policy makers in national and local government. Some of the highest returns from any public programme are available simply by generating and evaluating crash cost reduction programmes properly.

Safety engineering improvements are typically low cost and last decades. This report reveals that the average serious crash costs on a main road is more than £1m per kilometre in a decade.

Such a high concentration of crash cost explain why simple safety improvements can routinely pay back their costs within a year – and then go on saving lives and saving money on emergency services, hospitals and long term care.

The good news from the report is that we need mainly to introduce rational economics to help generate programmes and then evaluate them within existing budgets. The resulting programmes can be executed largely by upgrading missing safety features during routine maintenance over the next decade.

If this is done, we can save an extraordinary number of lives and serious injuries as well as billions in crash costs.

The findings of this report detailing the costs of crashes now need to be carried to the hundred or so authorities who are in a position to make roads safe. They need our support and encouragement to prevent not only unnecessary pain and suffering but the unnecessary billions ultimately borne by families and business.

Executive Summary

In the last decade, 30,000 people have been killed and a further 300,000 have been seriously injured in crashes on Britain's roads. Britons are four times more likely to die on the roads than in any other daily activity. Road crashes remain the leading cause of death amongst young adults. The contrast between the safety performance expected of road transport and the management of all other risks is stark, not least when compared with air, rail or marine safety.

The economic impact of road crashes is stubbornly constant. The rate of improvement achieved in recent decades in reducing the number of reported road deaths by 3% for example is too slow to make significant headway against the growing economic and societal cost of crashes involving bodily injury.

Road crashes that result in serious trauma are now largely preventable yet they consume, for example, around 75% of hospital capacity available for dealing with serious head injuries. Many nations are pursuing policies based on the actions that would be needed to eliminate road deaths, recognising the importance of a safe system approach where actions on roads, vehicles and behaviour are all considered. In 2008, the Organisation for Economic Co-operation and Development (OECD) reviewed the road safety policies of leading nations and called on members to implement the institutional management changes that were needed to focus on economic investment. In 2010, health bodies in the UK (the National Institute for Clinical Excellence, NICE) and internationally (the World Health Organisation, WHO) published material recognising safe road design – traditionally a preserve of road authorities – to be key in a total approach to the reduction of road injury. The recent reform of the Fire and Rescue Service, similarly, has put the management of high risks at its heart, and recognises formally that dealing with road crashes is one of its core activities.

The first section of *Saving Lives, Saving Money* examines, using published research, the costs of road crashes to the economy, and where those costs fall. It reviews the extent to which these costs – for – central and local government and public authorities such as the NHS and emergency services – are understood. It reviews the costs borne by households and industry, and examines insurance industry data.

The second section reviews how road and transport schemes are evaluated and the rates of return that are expected, and those actually achieved. It describes how the scale of ambition has changed in leading countries as the potential returns from adopting a systematic approach to casualty reduction are understood.

The third section maps the network of roads on which high crash costs are concentrated, and which could be efficiently targeted. It analyses and ranks the crash cost for each English region, Scotland and Wales, and tabulates the costs of crashes on main roads for which particular road authorities have a responsibility to provide visible 'crash cost centres'.

The fourth section proposes, for national discussion, economically rational levels of safety that could and should be achieved for Britain's main road network. These benchmark levels of safety balance the cost of carrying out effective programmes to improve the safety detailing of the infrastructure against the benefits from preventing death and injury. The result is an affordable, nationally significant, rational programme for the period 2011-2020 with value for money well in excess of most public programmes. The proposed programme would represent a significant contribution from the UK toward the UN Decade of Action for Road Safety, launched worldwide on 11 May 2011.

Prior to reaching a series of recommendations and conclusions, the fifth section of the report reviews a new survey of how authorities currently evaluate safety programmes. It proposes practical guidance on how crash cost reduction programmes can be generated and evaluated so that national agencies and decentralised authorities are able to make their own choices in a way that makes their performance transparent both to Parliament and local voters.

Section 1: The Cost of Road Crashes in Britain

The key findings of this section are that:

- Road crashes cost the British economy between £15 and £30 billion annually (1.2 – 2.3% GDP).

- The aggregate economic costs are well estimated by the Department for Transport (DfT) for general policy purposes and for evaluating the benefits of programmes to reduce casualties.

- The way that the cost of road crashes falls on individual services such as the NHS, the emergency services and, particularly, long-term care is inadequately understood and shared. The DfT considers the costs of care for up to 18 months while third-party court settlements value the costs for over half a century. The lack of transparency of the scale of the crash cost burden inhibits effective action.

- The direct financial costs paid in insurance premiums account for just under 1% of GDP annually (approximately £10 billion). An average comprehensive private insurance premium costs approximately £800. Insurance premiums however only reflect successful insured claims. Around 85% of individual insurance claims relate to property, but around half of claims by value are for bodily injury. While third-party claims for bodily injury can exceed £10 million, claims to the insured and a partner in a typical comprehensive policy are limited to around £10,000, with the remainder of the costs falling on the wider economy. The costs paid to the legal profession from motorists' premiums by insurers amount to £1 billion annually, excluding insurers in-house costs.

- The value of life and limb is closely linked to GDP per capita which typically rises at 25-30% per decade. The 3% average annual reduction in road deaths achieved in recent decades therefore barely makes headway in reducing the value of those that continue to occur.

- Further improvements in crash data recording and analysis are urgently needed so that consistent measurements of the protection standards of vehicles (NCAP rating) and infrastructure (RAP rating) are available for fatal and serious injury crash sites. This, and the linking of police crash records to hospital records, so that objective injury information is available, is vital to 21st century road and vehicle design.

Section 2: Economic Evaluation of Road and Transport Improvements

The Coalition Government is seeking nationally significant returns from capital investment and the business community is seeking initiatives to promote growth. Historically, the DfT has regarded programmes with a benefit-cost ratio (BCR) in excess of more than 2 as providing good value for money with a presumption of funding. With tightening finance, higher and quicker returns are needed to assist growth.

Recent research has revealed the scale of economic returns achievable by upgrading existing infrastructure and ensuring that simple safety features such as roadside barriers and safe junction layouts are implemented on busy roads. In Britain, BCRs equivalent to 5, 10 or even 20 are commonplace from such schemes. Large-scale systematic programmes on busy main roads in other countries such as Sweden, the Netherlands, Australia, and New Zealand are being rolled out to ensure safe roadsides, safe junctions, safe overtaking and safe villages.

In 2008, the OECD took stock of the major developments in international practice and published *Towards Zero: Ambitious Road Safety Targets and the Safe System Approach.* The report highlights the *"institutional management changes required in many countries to implement effective interventions through a strong focus on results to build the economic case for road safety investment".*

Three simple institutional problems have so far prevented British authorities from grasping the impact and importance of implementing large-scale systematic programmes:

- Safety engineering programmes have not been evaluated or assessed by authorities on the same basis as other major capital expenditure (i.e. in BCRs evaluated over the economic life of the investment), instead being judged on first year rates of return.

- Programmes have not been systematically generated using value engineering, where schemes offering efficient use of restricted resources and highest rates of investment returns over their economic life are prioritised.

- There is a lack of transparency and accountability when it comes to reducing the cost of road trauma, as the associated costs and impacts are spread across many groups including fire, police, ambulance, NHS, business and families.

Section 3: Identifying the Road Network Where Crash Costs Are Concentrated

For nearly a decade, Britain has been among path finding nations in seeking to systematically measure the risk posed to road users from road infrastructure. Practical support from Britain's leading authorities means that the measured risk of death and serious injury on Britain's motorways and main roads is now available across a 45,000km network. Results have been published annually since 2002 by the Road Safety Foundation, during which time improvements have been tracked, particularly progress in eliminating very high-risk sections of major routes.

This information has now been used for the first time as a key input in this report to map the distribution of serious crash cost across Britain. Defining 'crash cost centres' for individual authorities can make the scale of economic loss transparent to the public, and help trigger a proportionate response. In the decade 2011-2020, an average kilometre of this network can expect to see £1 million of loss in crashes involving death and serious injury alone. The inclusion of all injuries and damage broadly doubles this estimated cost. The following key findings relate to fatal and serious crashes on the motorway and A road network studied:

- Every year Britain suffers serious injury crash costs of £0.5 billion p.a. on motorways (excluding the substantial costs of traffic delays), £1 billion on national trunk roads, and £2.5 billion on local authority A roads – 40% therefore incurred by crashes on motorways and trunk roads. These costs are the equivalent of £10 per person on motorways, £20 on trunk roads and £50 per person on the local authority A roads.

- The average annual cost of death and serious injury per kilometre of motorway is £150,000. Britain's intensively used motorways have the highest concentration of serious crash cost of all the road types even though they are the least risky for individual road users.

- The average annual serious crash cost per kilometre on Britain's A roads is £82,000 – despite the fact that traffic flows on single carriageways are typically ten times lower than on motorways.

- Expressed as an average serious crash cost per kilometre travelled, the cost of road crashes on local authority A roads is 2.0-2.5 pence compared with 0.5 pence on motorways.

- Of the British nations and regions, South-East England loses the greatest GDP from serious injury crashes on main roads mainly because of its larger population.
- Scottish losses are 25% higher per capita than England.
- The Highways Agency network is Britain's single largest 'crash cost centre', with £1.2 billion of serious crash cost annually on its motorways and trunk roads (excluding substantial resulting traffic delay costs).
- Collectively, the largest block of serious crash cost is on local authority roads. English local authorities lose £2 billion annually on their A roads. A local authority outside metropolitan areas might typically be responsible for 300kms of A road with an annual serious injury crash cost in excess of £25 million.

Section 4: Establishing Minimum Rational Levels of Safety

Star Ratings are a high level measure of infrastructure safety obtained from inspecting and scoring the physical features of road design and layout known to have an impact on the likelihood of a crash and its severity. Following analysis and inspection of 7,500kms of British main roads, the following minimum benchmark levels of infrastructure safety are proposed for national discussion.

Table 1: Proposed minimum safety level by road type for motorways and A roads

Road type	Minimum Star Rating	Equivalent average risk rate (fatal & serious crashes per billion veh km)
Motorway	5-star	5 (Low risk)
Dual primary	High 4-star	10 (Low-medium risk)
Dual non-primary	Low 4-star	15 (Low-medium risk)
Single primary	High 3-star	30 (Low-medium risk)
Single non-primary	Low 3-star	35 (Low-medium risk)

Source: Authors own

Setting minimum benchmark safety levels in this way enables a new transparent and objective discussion to take place between engineers, public and elected members about what infrastructure safety standards should normally be expected without mandating improvement at any cost. For example, the New Zealand Transport Minister receives information on the Star Rating of the road involved within every fatality report. Ministers from countries as varied as the Netherlands and Malaysia have announced policy goals based on raising Star Ratings.

Setting minimum benchmark Star Ratings at this level implies that even by 2020 risks will be accepted on single carriageway routes that are six times higher than on motorways because investment is being targeted to reduce the greatest numbers of serious injuries given the funds available. Such an approach immediately demands an evaluation of the costs and benefits of a programme that might achieve the benchmarks.

Approximately half of the 2,000 sections of road examined in detail had a safety performance below the proposed benchmark level. The estimated present value of the benefits of raising the standard of these sections to the benchmark level is £34 billion (based on discounted figures over 20 years). Combined with maintaining the solid existing programme in urban cores and some treatment of very high-risk locations on minor local authority roads, this would offer a one-third saving of all British deaths from engineering measures alone – and a total crash cost saving worth around 0.5% of GDP. This would be further amplified if other education, enforcement and vehicle safety programmes were put in place.

The costs of implementing this programme over the period 2011-2020 was estimated with the assistance of local authorities in South-East England and after examining data provided by the Highways Agency on the costs of 70 standard safety interventions. For example, the average cost of upgrading sub-standard sections of motorway to the minimum 5-star level, where problems are largely of missing or inadequate side ‘run-off’ protection, was estimated at £0.5 million per kilometre.

The cost of the proposed programme across the network is £8 billion. At £800 million p.a. over the ten year programme this represents less than 10% of current annual spending on road maintenance.

The programme BCR would be 4 even if no cost was accommodated within existing essential routine maintenance over the decade and no further value engineering was completed. In practice, the programme BCR would rise substantially. Firstly, the most practical implementation is to upgrade safety during essential maintenance. Secondly, bulk procurement and consistent orders for safety equipment (e.g. installation of safety fencing) would allow British prices to fall to levels seen elsewhere in Europe.

Major projects which must be completed over many years before they achieve their benefits run significant risks of cost overrun in construction and poor performance when eventually open for service. In contrast, a major safety programme is highly modular with short lead times and quick, certain returns. Major safety programmes are front loaded for the highest returns with subsequent modules costed and value engineered based on the latest experience.

A major safety programme in Sweden has been phased so that 75% of network mileage is treated by 2020 and the remainder by 2025. If this strategy were pursued in Britain, the benefits of the proposed programme to 2020 would be £26 billion and the face costs £460 million annually with a BCR of 6. Target BCRs can be set higher to ensure procurement and value engineering efficiencies are achieved.

Section 5: Generating and Evaluating Road Safety Programmes

With the support of ADEPT (the Association of Directors of Environment, Economy, Planning and Transport), a sample of local authorities was surveyed to establish how they generated and evaluated schemes to improve infrastructure safety. The key findings of this survey were:

- The Police STATS19 form for recording crashes and DfT economic parameters were universally used.

- Nearly one-third of authorities use ‘black spot cluster analysis’, a technique introduced in the 1930s, rather than proactively eliminating known high risks along routes. Short period analysis, typically three years, was the norm but some authorities examined ten year crash histories.

- The returns from infrastructure investment were universally evaluated over the first year only and expressed as a ‘first year rate of return’. Whole life costs and benefits using BCRs were not typically used preventing comparisons with competing non-safety schemes.

- Where authorities set economic hurdle rates before a scheme would be funded, this was typically 100% rate of return (implying a BCR in the order of 10-15).

- A wide range of technical parameters and local weighting schemes were used.

- Evaluation of previously implemented schemes showed a typical intervention cost less than £100,000 to save a death or serious injury per year (i.e. less than £10,000 for each death or serious injury saved, for schemes with lifetimes of ten years or more).

- There was an appetite for improved guidance on generating and evaluating safety schemes.

While many of the variations in approach are fully compatible with empowering local choices there is a lack of good practice guidance for local authorities to refer to in this area. Without comparable measures, transparency and the transfer of best practice between authorities is hampered.

Sections 6 and 7: Summary of Key Findings, Recommendations and Conclusions

- A nationally significant high return programme to raise the safety of Britain's infrastructure is possible within current budgets in the period 2011-2020, particularly if implemented during the course of routine maintenance.

- Britain should define minimum benchmark levels for infrastructure safety which would be achievable on most main roads by authorities in the period 2011-2020, particularly during the course of routine maintenance.

- Transport ministers and local authority leaders should follow recent OECD recommendations and best international practice to set ambitious goals for the safety of the roads for which they are responsible, based on a properly evaluated economic case.

- Senior policymakers in each responsible road authority should call for the generation of a programme of crash cost reduction measures and evaluate these objectively and transparently alongside other priority programmes.

- The cost of road crashes on main roads should be published by the Road Safety Foundation annually for each authority, alongside its annual report tracking the risk of fatal and serious crashes on Britain's motorways and main roads.

- Elected local authority leaders should be provided with accessible published information, including independent critique, on the safety performance of the road infrastructure for which they are responsible.

- The Highways Agency, as Britain's single largest crash cost centre, should act as a model 'best practice' institution leading a vigorous crash cost reduction programme from which authorities throughout Britain can learn.

- The professional associations, the Road Safety Foundation, and the Highways Agency should develop professional guidance on the generation and evaluation of crash cost reduction programmes.

- Parliament and the Treasury should examine the value for money that can be provided by programmes to reduce death and injury, and investigate how institutional barriers to rational investment and priority setting can be overcome.

- Improvements in crash data recording and analysis are needed so that measurements of the protection standards of vehicles (NCAP rating) and infrastructure (RAP rating) are provided as standard. This, and the linking of police crash records to hospital records, is vital to 21st century road and vehicle design.

1. The Cost of Road Crashes in Britain

Road crashes impose a range of impacts on people and organisations not least the immeasurable pain, grief and suffering of family and loved ones. These include the obvious costs of fire, police, ambulance and medical services, and material damage to vehicles and property. Less obvious costs such as lost economic output, long-term care, insurance, administration, and legal and court costs are also incurred.

Britain's Coalition Government is seeking substantial efficiency improvements as it reduces public spending to tackle the budget deficit. With this crash cost valued at between 1.2–2.3% of GDP, a reduction in the number and cost of the most expensive injury crashes represents a significant efficiency improvement which would enhance the economy and reduce demand for a raft of public services.

This section examines the true cost of road crashes, reviewing the financial costs to the economy and how cost estimates are generated. The role of the insurance industry and the diverse crash cost centres, including emergency services and highway authorities, is addressed and recommendations for improvement are presented.

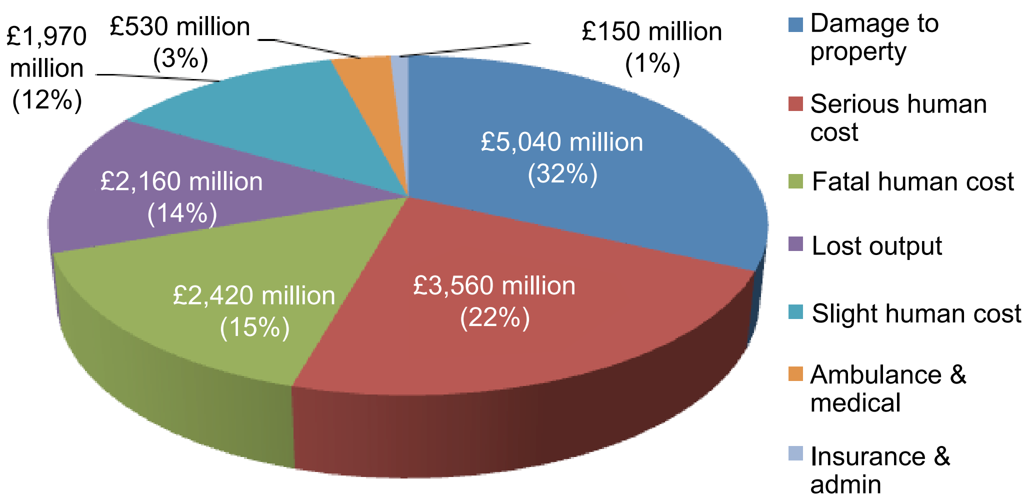
1.1 Government valuations of crash prevention

Well-designed interventions, such as the provision of safe roadsides or safe junctions along a route, have the potential to reduce the number of road crashes and their severity. Road safety schemes are assessed against affordability and economic effectiveness criteria to find those that represent a good investment return and a responsible use of public money.

In order to establish cost-efficient national, regional and local policies for casualty reduction and enable the economic evaluation of returns from practical programmes, crashes and casualties are assigned a cost, and form the key quantitative indicators for the appraisal of transport interventions. Combining these numbers with values for prevention yields a monetary estimate of the related costs and benefits of proposed improvement schemes. The economic return from an intervention is determined by how much greater the benefits are than the costs. Confidence in the costings is critical to ensure that they provide a robust and relevant basis for the prevention of road death, trauma and collisions.

The DfT estimates that in 2009 all road crashes cost the economy £15.8 billion (DfT, 2010a). This includes an estimate of the cost of damage-only crashes, but does not allow for unreported injury crashes – these could almost double the costs to £30 billion (3% of GDP). Figure 1 shows how this total crash cost is distributed.

Figure 1: Total value of crash prevention by cost component



Source: Using DfT (2010a: 39)

Since 1993, the DfT, with Treasury approval, has based the valuation of both fatal and non-fatal casualties on a consistent 'willingness-to-pay' methodology, encompassing both human and direct economic costs. Valuations include an amount to reflect pain, grief and suffering, as well as the lost output and medical costs associated with road crash injuries. The willingness-to-pay methodology assesses how much a sample of the population would be willing to pay for various improvements in safety. The mid-point of £1 million, of a range found to extend from £750,000 to £1.25 million in 1997, forms the basis for the DfT's value for the prevention of a death. A similar approach has been used to derive values for serious and slight casualties, each pegged to the fatality value. Annex 1 summarises the underpinning research.

The current values for prevention of casualties (at 2008 prices) by injury severity and class of road user are set out in the tables below (DfT, 2010b). These include various cost components:

- **Loss of output due to injury** is calculated as the present value of the expected loss of earnings plus any non-wage payments (national insurance contributions, and so on) paid by the employer. This includes the value of consumption of goods and services lost as a result of injury crashes.
- **Human costs** represent pain, grief and suffering to casualties, their relatives and friends. For fatal casualties the intrinsic loss of enjoyment of life, except consumption of goods and services, is included.
- **Ambulance costs and the costs of hospital treatment** covers the costs of attending the crash scene and subsequent treatment.

Injury crashes are classified according to the most severe casualty, but on average may involve more than one. For example, a crash involving one vehicle where one occupant sustains a slight injury and the second a serious injury would be classed as a serious crash. For this reason, the value of prevention for injury crashes is greater than that for the corresponding casualty.

Table 2 shows the total value of road crash prevention by severity and cost component. These represent minimum estimates, and do not take account of associated effects such as delays to other road users.

Table 2: Average value of road crash prevention by severity and cost component

				£ June 2008
Injury severity	**Lost output**	**Human costs**	**Ambulance & medical**	**TOTAL**
Fatal	578,840	1,103,980	990	1,683,810
Serious	22,300	153,400	13,510	189,200
Slight	2,360	11,230	1,000	14,590
Average, all casualties	10,940	39,270	2,410	52,620

Source: DfT (2010b: 3)

Elements of the value of prevention can be classified according to whether they relate specifically to casualties or to the crash as a whole. Casualty-related values include lost output, medical and ambulance costs, and human costs, since each individual casualty will incur costs in this area. Police, insurance and property damage relate to the crash. The total value of prevention is the aggregate of these (see Table 3).

Table 3: Average value of road crash prevention by severity of casualty/crash-related costs

	Cost component						£ June 2008
	Casualty-related costs			Crash-related costs			
Injury severity	Lost output	Human costs	Ambulance & medical	Police cost	Insurance & admin	Property damage	TOTAL
Fatal	635,746	1,250,867	5,833	1,963	309	11,436	1,906,154
Serious	25,281	172,027	15,155	259	192	5,199	218,114
Slight	3,131	14,897	1,327	60	117	3,102	22,633
All injury	14,814	53,155	3,263	113	130	3,500	74,974
Damage only	-	-	-	4	55	1,944	2,003

Source: DfT (2010b: 4)

The average number of casualties per crash and the cost of vehicle damage both vary by road category. For example, a serious collision on a non-built up road will on average involve 1.17 serious casualties, compared with 1.07 serious casualties on a built-up road, together with a greater amount of vehicle damage (DfT, 2010b).

Table 4 shows the variation in average values of prevention by road class and injury severity. The average value for a fatal crash is greater for motorways than for built-up and non-built up roads. This reflects the fact that a typical motorway crash will result in a higher fatality rate (which is attributable in part to the higher speeds permitted on this network).

Table 4: Average value of prevention by severity and class of road

	Road class[1]			£ June 2008
Injury severity	Built-up	Non built-up	Motorway	All
Fatal	1,806,191	1,973,602	2,064,494	1,906,154
Serious	209,844	234,473	243,542	218,114
Slight	21,465	25,188	29,928	22,633
All injury	59,718	121,041	89,080	74,974
Damage only	1,880	2,779	2,673	2,003

Source: DfT (2010b: 4)

1.2 Estimating crash numbers and implications of under-reporting

A major concern in valuations of crash prevention are not on how costs are compiled but on the weaknesses in how Britain defines and records crashes and injuries. The DfT has taken a number of significant steps to research and address these and to adjust costings appropriately, but concern about British figures continues to be publicly expressed by leading international researchers (e.g. Elvik, 2010).

[1] Built-up roads are those other than motorways with speed limits of 40pmh or less; non built-up roads are roads other than motorways with speed limits greater than 40mph

Box 1: British crash statistics and trends

Road crashes in England and Wales account for one in every 245 deaths (DfT, 2010a; ONS, 2010). In the last decade, 30,000 people have been killed and a further 300,000 seriously injured on Britain's roads. On average, 73 people are killed or seriously injured every day – a toll far greater than that seen in other forms of transport[2]. While the latest figures for the year 2009 show a steady decrease, reaching an all time low of 2,222 fatalities (57% lower than in 1990) and 24,690 serious injuries (down 59%)(DfT, 2010a; DfT, 2011), Britons are 4 times more likely to die on the roads than in any other daily activity (Allsop, personal communication 2011).

Road crashes are the leading cause of death in young adults and can readily require half a century of care, with significant reductions in quality of life. In 2009, 65 under-16's were killed and a further 18,307 injured on Britain's roads – 2,267 seriously (DfT, 2010a). Formal public health guidance is now in place focusing on road design and engineering safer routes (NICE, 2010).

Annual statistics reveal some important variations. For example, urban roads are more than twice as dangerous as rural roads per kilometre travelled and account for two-thirds of all road crashes. However, crashes on rural roads tend to be more serious, with 38% of road fatalities occurring on rural A roads and a further 21% on other rural roads. The vast majority of pedestrian injuries – 95% – occur on urban roads, with children being disproportionately at risk. Crashes on rural roads more often include car occupants.

Under-reporting and misclassification of injury severity is well recognised. Although the two are not equivalent measures, comparisons between police reports at the scene of a crash and hospital records of admissions and treatment show a substantial mismatch in terms of both absolute casualty numbers and recent trends over time.

Hospital Episode Statistics data, collated by the Department of Health, provide a means of monitoring the number of road traffic casualties admitted overnight to hospital, involvement by consultants, and hospital discharges for England. The external causes of injury for all admissions are recorded allowing road crash victims to be identified.

STATS19 data (generated by police STATS19 forms for recording crashes) provides information on personal injury road crashes occurring on Britain's public highways, and their consequent casualties. Data are collected by police forces and local authorities to an agreed national standard, and are collated and analysed by the DfT. STATS19 defines a serious injury as one requiring a person to be detained in hospital as an in-patient, or as one found on a broad list of injuries (ranging from life threatening to relatively minor) whether or not they are detained. The police are not necessarily informed that a casualty has been admitted to hospital following a crash, nor is there a duty on hospitals to reveal this information even if it is requested. It is generally accepted that whilst the STATS19 record is an underestimation of the true number of road crash casualties, it is nevertheless the most detailed, complete and reliable single source of information on the subject.

Comparison of hospital and police records shows that:

- an appreciable proportion of non-fatal crashes are not reported to the police (Ward *et al.*, 2006);
- the total number of annual road casualties in Britain, including those not reported to police, is currently estimated as 610,000-780,000, with a central estimate of 700,000 (Tranter, 2010). This is in comparison to the 215,000 currently officially reported (DfT, 2011);
- up to a-fifth of casualties reported to the police are not included in STATS19 data (see Ward *et al.*, 2006);

[2] A total of 9 people were injured in train crashes in 2009, and none killed. Only 1 person has been killed since 2005 (DfT, 2010a). In 2008, 395 deaths and serious injuries to plane passengers and crew were recorded (DfT, 2009a).

- there are three times as many casualties in road crashes as there are reported to, and by, the police (with under-reporting for cyclists and motorcyclists involved in single vehicle crashes much higher);
- to take account of misclassification and under-reporting/recording the number of serious casualties should be increased by a factor of 2.76 (Simpson, 1996).

The law requires crashes involving any personal injury to be reported to the police only if those involved have been unable to exchange personal and insurance information. However, the public can be unwilling to do so in an effort to protect premium-related no-claims discounts (Privilege Insurance, 2005). A survey of 2,000 respondents by Confused.com in 2009 found that 38% of motorists were so concerned about losing their no-claims bonus and incurring higher premiums that they avoided making car insurance claims altogether.

Studies also suggest that police underestimate injury severity more frequently than they overestimate, because of the inherent difficulties of assessing and classifying severity at the crash scene – this despite the definition of serious injury being ‘intentionally broad’ to allow a layman to determine severity quickly and easily.

Accepting these issues as part of the system means that the way in which casualty targets are monitored, and policy shaped is being undermined. This is particularly pertinent in the allocation of adequate funding to those central to preventing road crashes or stepping into the breach to save lives once a crash has occurred. A key step in determining whether all costs are being accounted for is to determine the major ‘crash cost centres’.

1.3 Road crashes – who pays?

In a serious road crash, victims may have to be cut out of the vehicle by the Fire and Rescue Service, attended by paramedics and other medical experts, and taken to hospital by the ambulance service. Police have wide-ranging and well-documented responsibilities as they move in to protect the scene, inform relatives and take witness statements. The costs of physical damage, from vehicle and property repairs to wreckage clearance, involve another chain of costs falling on highway authorities, insurance companies and private owners. With limited exceptions, the emergency and long-term medical care costs fall on the NHS (see section 1.5). The average length of a stay in hospital following a road crash is 3.9 days (DfT, 2010b). The cost of personal care tends to fall on family, freinds and local authorities.

Families pay direct costs through motor insurance premiums, and bear all the human costs of sudden violent death or injury which cannot be, or are not, reimbursed by third-party insurance pay-outs (see section 1.4). Much of the burden of long-term care inevitably falls on families, and this too can take these individuals out of the workforce. Where a breadwinner is unable to continue working and there is no third-party insurance payout, families can suffer a personally devastating loss of income.

Annually, families and business together pay the £407 million levy (Motor Insurers Bureau, 2010) made on all motor insurance policies to cover crash costs from uninsured drivers that cannot be recovered. Many smaller vehicle and property damage costs are not reimbursed through insurance as a result of policy excesses, unwillingness to lose a no-claims bonus or, in the case of larger businesses, self-insurance. Business bears some of the cost through insurance and lost production as employees (including family carers) become unavailable for work. The economy at large bears the balance, with taxpayers financing welfare bills that become payable when an individual is unable to work. The cost of lost tax revenues are made up by taxpayers.

1.4 The cost of road crashes and the insurance industry

Britain has had compulsory motor insurance since Herbert Morrison’s 1930 Road Traffic

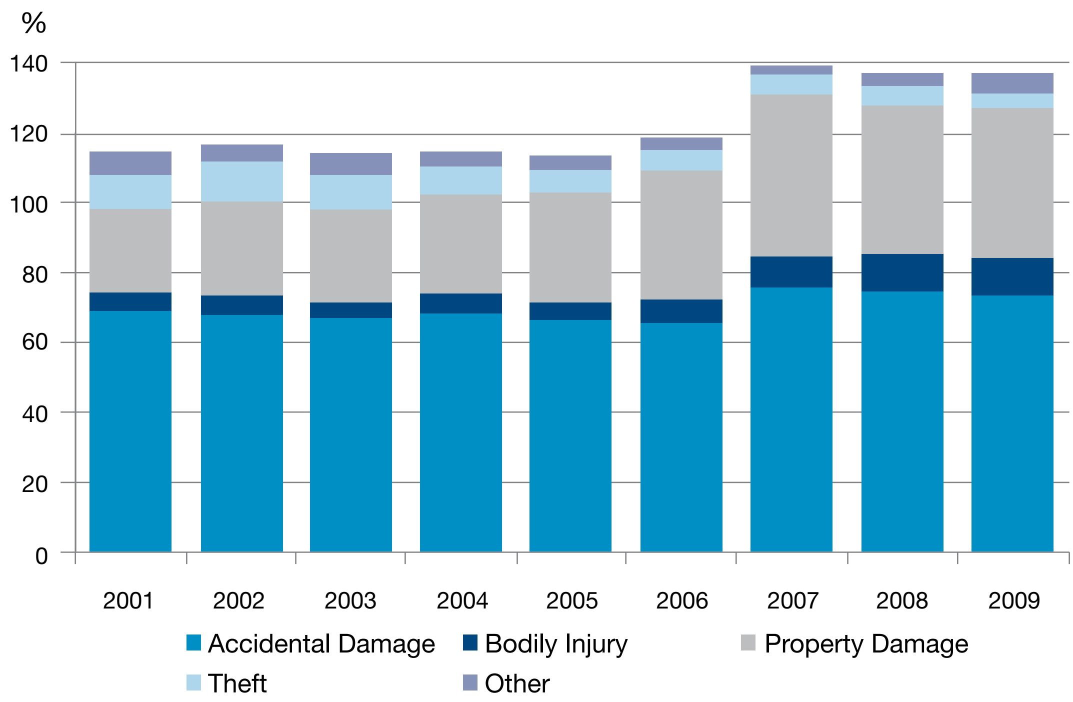
Act. Funding of the record £17.5 million court award cited in Box 2 will be settled through an insurance claim. The main types of risk covered by motor insurance policies include (1) damage to vehicles and property; (2) fire and theft; and (3) bodily injury. An individual claim can involve any or all of these.

Box 2: Record insurance court settlement

In October 2010, the English courts awarded a record £17.5 million compensation payout to a sixth-form student paralysed in a road crash. The young woman was 16 when, in November 2006, a lorry hit the car she was travelling in and left her with catastrophic brain injuries and confined to a wheelchair. Now twenty years old, she lives in a care home. The award means that she will receive a lump sum of £4 million, plus index-linked, tax free payments of £300,000 a year to cover care for the rest of her life.

Annually three-quarters of UK households purchase motor insurance. Each year around three million motor claims are made, with total net claim payouts in 2009 totaling £9.9 billion (ABI, 2010a), the majority involving minor damage such as bumps, dents and scrapes.

Figure 2: Breakdown of motor claim types in the private motor market



Source: ABI (2010a: 6)

Figure 2 shows the breakdown of various claim types in the private motor market (ABI, 2010b). A claim may have several elements including accidental damage, bodily injury, and property damage.

Of all private motor claims notified over the past nine years, 60-70% involved accidental damage. In 2009, just over 85% of motor claims related to property damage to property (including accidental vehicle damage, property damage, fire and theft), but claims for bodily injury now account for half of all payments. Bodily injury claims are accounting for an increasing proportion of total claims up from 4.7% in 2003 to 11% in 2009.

Higher claim costs for damage are associated with more serious crashes but the astonishing improvement in personal protection from crumple zones and airbags can mean significant repair costs in even low speed collisions. Higher claim costs for bodily injury are a reflection of a better survival rate afforded from safer vehicles.

The management information systems of the insurance industry provide rich insights into the cost of road crashes and changes over time, but the data do not cover all cost components in Britain. The total cost of road crashes to the British economy is substantially more than those settled through insurance claims, because so many of the individual elements fall outside of the insurance system, or are in a form where a cash transaction does not, or in practice cannot, result. The major omissions are those not made to keep an accident record clean or protect a no-claims bonus.

The Motor Insurers Bureau is a not-for-profit company run by members of the industry, supported by the Government, to reimburse those impacted by uninsured drivers. Annually, uninsured drivers injure over 20,000 and kill over 150 (Motor Insurers Bureau, 2010). The levy call to members in 2009 to meet claims was £407 million – a cost met by motorists buying cover. In recent years, with the DVLA and police, the Bureau has been a partner in the development of insurance databases that have proven successful in reducing the cost of uninsured drivers.

Many UK motorists may be surprised to find that they are not fully covered by comprehensive motor insurance. Compulsory motor insurance was introduced to protect the interests of third parties and as such a typical comprehensive policy, accounting for 90% of all those sold in the UK (ABI, 2010b) makes a significant differentiation between (i) injuries to third parties where cover is typically provided to a maximum £20 million, and (ii) injuries to the policyholder and their partner, where there may typically be a maximum of £5,000-£10,000 even in the event of death or brain injury. The distinction between self and third-party insurance is important to understand as just one of the major differences between the costs paid by the insurance system and the costs to the British economy at large. Unless there is an additional insurance in place, the driver of a vehicle deemed at fault in a crash (and their partner) may receive just £5,000 towards a lifetime of care. The remainder must be borne elsewhere.

Insurance for personal injury is managed differently in some other countries. Australia and New Zealand operate ‘no fault’ schemes so that the sums for which crash victims are insured does not depend on whether or not a court judges them to be at fault. There are disadvantages of this system, for example, it does not impose penalties on drivers with a poor safety record or permit a competitive market in personal injury insurance. However, a key advantage is the substantial saving in legal costs. The costs paid to the legal profession from motorists’ premiums by insurers amount to £1 billion annually, excluding insurers in-house costs.

Nations with the best road safety records now expect the severity of injuries to be mitigated by the quality of highway safety engineering. The New Zealand Transport Minister, for example, receives a monthly report of all fatal crashes, showing the Star Rating of both the road section and vehicles involved (personal communication, KiwiRAP 2010).

The issue of disparity between third-party and at-fault injury compensation has not surfaced as a concern in Britain in recent years, perhaps because the NHS is free at the point of need and mass motorisation took place after the welfare state was established. Care services support crash victims in the same way as they would anyone else in need. Some employees may also receive full or partial compensation for loss of income through company insurance schemes in the event that they are unable to work in the short (up to two years) or long-term.

Generally, a highway authority can only recover costs for damage to the road when it is not at fault itself and where it can also identify someone to claim from. For example, it is difficult to identify a driver colliding with a modern safety fence who will drive away unhurt. Although some powers and procedures exist, for the purposes of this report we have not been able to establish the extent to which the costs of NHS, highways authorities and other public bodies are reimbursed by insurance payments.

The headline concerns of the insurance industry are:

- the chronic and unusual lack of profitability in Britain;[3]
- rising bodily injury claims;
- fraudulent claims; and
- young drivers and motorcyclists, where the cost of bodily injury claims can be substantial and long-term.

The Motor Insurance Repair Research Centre at Thatcham represents a practical response to vehicle repair costs, conducting research and data to assist in the efficient, safe and cost effective repair of motor vehicles. They provide some 70% of the data that insurers use to define a cars' insurance grouping. Their work means that the insurance industry is helping to prevent the significant challenge of repair costs increasing exponentially. Advances in vehicle safety over the last ten years means that the NCAP safety performance of the typical new vehicle sold in Europe is now 4-star, with 5-star being achieved by some. This has made a major contribution to the reduction of road death and serious injury as new safer vehicles begin to replace older models. Thatcham is making a major contribution to keeping demands on repair costs within bounds as crumple zones, air bags, ABS, ESC and the increasing safety and comfort provided by electronic systems has been added as standard in modern vehicle design.

Headline consumer concerns about motor insurance focus mainly on price, and particularly on the cost to young men. The urgent inquiry by the Transport Select Committee on Motor Insurance announced in November 2010 was triggered by rapid rises in premiums during 2010, which reflected the industry's need to seek profitability. Lack of affordable insurance or innovation in targeted pay-as-you go products threatens to create an underclass of those who, feeling priced out of driving legally, drive without insurance.

Supported by strong global theoretical and empirical evidence (e.g. MacMahon & Dahdah, 2008), economists would expect all human costs from road crashes to rise in line with the growth in GDP or real incomes. As such, a typical British bodily injury claim might be expected to increase by 25-30% in real terms (i.e. over and above inflation) per decade. In addition, as the general longevity of the population increases, so too does the period over which care must be provided. The rising value in what we are willing and able to pay to prevent death and injury is a central strain on NHS funding but is little discussed when considering the overall financial benefits that accrue to the economy from road casualty prevention.

1.5 NHS cost recovery scheme

Since the 1930's, hospitals have been able to recover the costs of treating certain road traffic crash victims. On 5 April 1999 the Road Traffic (NHS Charges) Act came into force, providing a structured and centralised policy for the collection of NHS charges from insurance companies following specific road crashes.

On 29 January 2007, the scheme was replaced with the NHS Injury Costs Recovery scheme, expanding the circumstances under which the NHS can reclaim the cost of treating injured patients to all those involving personal injury compensation. Provision was also made for the recovery of ambulance costs, including the first journey to A&E and any subsequent transfers to other hospitals (Department of Health, 2007).

NHS charges are levied when a person is involved in a road crash and, as a result, receives examination or treatment at an NHS hospital, and subsequently claims and receives

---

[3] British insurers made an underwriting loss in 2009 of £1.6 billion – the 15th consecutive year of loss. Premium income decreased by 5 per cent and claims increased by 10 per cent (ABI, 2010b); AA British Insurance Industry Index, 2009, estimated that for every £100 spent on motor insurance premiums £105 is lost in claims.

compensation from the holder of a compulsory motor vehicle insurance policy. As a routine part of making a claim, a claimant is asked if they have received NHS hospital treatment and, if so, at which hospital. The insurer passes this information on to the Compensation Recovery Unit (CRU), part of the Department of Work and Pensions with links to all insurers. The CRU confirms with the hospital that treatment has been given, and established whether the person was treated as an inpatient or outpatient. Costs of treatment are calculated by the CRU using a simple tariff (as of April 2010):

- where the injured person is provided with NHS ambulance services: £177 for each occasion;
- flat rate for treatment without admission: £585;
- daily rate for treatment with admission: £719;
- a cap on charges in any one case of £42,999.

The insurer receives a time-limited certificate of NHS charges from the CRU which must be settled within 14 days of paying compensation to the crash victim. Once payment is made the money is transferred directly to the hospital and they are free to use the income for any purpose.

In the period 1 April 2009 to 31 March 2010, £182 million was paid to the NHS in cost recovery (note that this figure includes compensation for personal injuries and road crashes combined – both having been applicable since 2003). Payments to ambulance trusts totaled £6.5 million during the same period (Department of Health, 2010). Given the latest DfT cost allocation of £530 million for medical and ambulance services (shown in Figure 1), this suggests that the scheme may only be recovering around one-third of the total costs incurred.

1.6 Recommended improvements in valuations

For this report we examined a number of policy-sensitive issues – for example, we looked into whether the propensity for more serious injuries to car occupants on faster roads outside built-up areas was taken into account in the DfT's valuations and found that it was. We concluded that overall, the approach and underpinning research used by the DfT is of a high standard, and the costings are fit for purpose in their current role of providing a relevant basis for economic evaluation of practical programmes to prevent road death and injury. There is a need, however, to periodically update them, as the DfT is currently doing. The current valuations reinforce *economic* costs of road crashes in Britain as broadly equivalent to 1.2% of GDP, with *total* costs closer to 2.3%. While areas for improvement were found, none were deemed to have a material impact on overall economic evaluation of programmes.

While in aggregate the economic burden of crashes is well estimated, we found the costs to be unrealistic in a number of areas important to current policy formulation. This was primarily the case for those costs falling on public services. We note, for example, that when the Bain Report (Bain, 2002) examined the role and activities of the Fire and Rescue Service in 2002, it recognised dealing with road crashes as one of its core functions, leading to its formalisation inside a general strategy of risk prevention and duties. Likewise, The Home Office includes a measure of casualty reduction in its *Analysis of Policing and Community Safety Framework* (Home Office, 2010). In 1999 the Department of Heath set a target to reduce, by 2010, the death rate from accidents (including road crashes) by at least one-fifth and the rate of serious injury by at least one-tenth (Department of Health, 1999). The medical profession deal with the consequences of road crashes as part of the wider NHS covering ambulances, casualty wards, intensive care, convalescence and rehabillitation.

In the DfT estimates, we noticed the following weaknesses in particular:

- **Recording casualties using police officers at the crash scene does not correspond adequately with hospital records**. It's not practical that the Police, or indeed a doctor, should be asked at the point of a crash to reliably record whether the consequences are slight or serious. Injuries need to be understood in medical terms. Reporting can also vary over time, as different constabularies adjust explanations to guide officers who have to interpret ambiguous questions against what they can recall while, perhaps, dealing with multiple casualties in difficult circumstances.

- **There is no cost attributed to long-term care after 18 months,** yet courts are making multi-million pound awards for third-party compensation based on the decades of care that many victims will require.

- **The cost of £1,000 as an estimated average for police resources required to deal with a serious road crash is very low.** The figure appears to be based on a conservative estimate of the amount of officers' time involved, costed at the wage rate rather than basing it on the full cost associated with command and control, equipment and vehicles, allowing an allocation of normal overheads for recruitment, training, R&D, publications, consumables, and so on.

- Similarly, **the medical costs to the NHS of a single injury crash are estimated to be less than £1,000 even though road crashes are a known major source of demand**.

- International researchers have suggested that **long-term costs are underestimated** referring to evidence that shows a reduction in life expectancy amongst parents and partners who lose a family member in a road crash (Elvik, 2010).

The danger of failing to understand how each of the cost centres is affected leads to road crashes being seen as unavoidable, rather than a largely preventable cost. This is captured well in the OECD's *Towards Zero* report (OECD, 2008), which suggests that institutionalisation of road death and injury in the budgets of those dealing with the toll is part of the problem – in other words, everyone pays but no-one is responsible. Decentralisation policies can help to ensure that Britain spends less on coping with road crashes by making costs transparent and empowering authorities to act.

Budgets and procedures to compartmentalise road death and trauma have long been set – fire, police, ambulance, medical services, long-term care, compulsory insurance, and so on. While there is no direct financial incentive to invest to prevent road crashes, there is pressure on each organisation involved to minimise the associated financial costs. We recommend that each of the main cost centres be provided with a fully allocated cost of dealing with road crashes from a financial professional. This would form a solid starting point in establishing the true financial burden incurred, helping to define how to construct better systems to incentivise the management and control of the loss of up to 2.3% of Britain's economy.

Many local agencies engage in road safety work and they have more impact when their efforts are well co-ordinated. A new 'Total Place' initiative by the Treasury looking at how a 'whole area' approach to public services can lead to better services at less cost would work well in road safety. The methodology seeks to identify and avoid overlap and duplication between organisations – delivering a step change in both service improvement and efficiency at the local level, as well as across Whitehall (HM Treasury, 2010a).

The NICE formal public health guidance, focusing on the prevention of unintentional injuries among children below fifteen years of age through road design and engineering safer routes (NICE, 2010), advocates co-ordination between health professionals and local highway authorities to promote change. It recommends specifically that a senior health professional takes responsibility for the health sector's involvement in casualty reduction.

Highway engineers are responsible for providing a safe road network. In the last decade, ministers have tended to prioritise journey time reliability through reduced congestion rather than road safety. National and local highway engineers must address safety as a part of their responsibilities, with issues such as procurement, project management, incident clearance and construction standards being at least as pressing.

As public awareness of the need for safer roads increases, local communities are pressuring local authorities to address the design and layout of road infrastructure and to improve road condition. In a review of current road safety practice and funding, presented in detail in Section 5, we found that life-saving programmes are not being rationally generated or evaluated. Even where a local authority was found to be using economic appraisal, the cut-off rate implied no investment unless schemes delivered benefit-cost ratios (BCRs) of nearly 20 to 1 (some ten times greater than the estimated return achieved by the high speed rail programme).

The next section addresses the often poor political and professional understanding of the costs of road crashes, and the value that should be placed on prevention.

2. Economic Evaluation of Road and Transport Improvements

Cost-benefit analysis is used in the assessment of public projects generally and transport projects in particular. The DfT has used economic appraisal since the 1960s to evaluate the rates of return from transport investment. Valuations of the savings of a rail casualty implied by the decisions of ministers are typically at least ten times that of the published value of a road casualty (Eddington, 2006a; Dodgson, 2007). These valuations are based on actual rail investment expenditure, whereas it is difficult to find any investment decision for road casualty reduction based on the threshold as published. In practical terms, the legal framework for road and rail safety makes rail safety investment mandatory whereas the current general duty to maintain the safety of the highway places few specific obligations on road authorities to invest in safety measures (Elliot, 2009).

This section reviews the way in which transport programmes are evaluated, and presents evidence showing how road safety schemes offer competitive returns on investment.

2.1 Expected rates of return from transport and other public programmes

Infrastructure investment can benefit the nation for decades, if not centuries. Roman investment is still in operation and Victorian engineering still underpins much of Britain’s daily life. The motorway network, which

together with trunk roads provide the backbone of the nation's transport system, has recently reached a milestone, with early builds achieving half a century of service.

Good investment decisions are paramount to the nation's social and economic well-being. The Treasury is accountable to Parliament for how public money is spent, and a key underpinning principle applied to all expenditure is that it should provide value for money. Some fifty years ago, the DfT became the first Government Department to receive delegated approvals from the Treasury to sign off routine major projects, because of the objective processes that it had in place to assess the value for money derived from such schemes.

In Britain, Benefit Cost Ratio (BCR) is used to estimate economic returns from transport schemes. The Treasury's guidance emphasises that project appraisal must be carried out *"objectively and fairly, seeking good value for the public sector as a whole"* (HM Treasury, 2007). Transport spending by the DfT, for example, is required to consider the costs and benefits to the health service, emergency services, courts and local authorities, in addition to those incurred by immediate users such as rail passengers or motorists.

Cost-benefit analysis for roads has been the subject of much outside scrutiny. The Standing Advisory Committee on Trunk Road Assessment (SACTRA) was established in the 1970s to provide professional independent advice to ministers on the evaluation of major road schemes. Although its advocacy has on occasions been heavily debated, its work has been widely supported. SACTRA's most recent work reviews the relationship between transport and the general economy (SACTRA, 1999).

The vast majority of major road schemes derive their benefits from journey time savings. Discussions are ongoing as to whether journey times should equate to the level of benefit currently used. Environmental costs or benefits are assessed qualitatively alongside the economic benefits under the New Approach to Appraisal (NATA), the appraisal framework for transport projects and proposals in the UK. The economic costs include construction, maintenance, and scheme operation, while benefits are mainly in journey time savings, fuel savings (excluding taxation), and reductions in vehicle operating and crash costs. However, major road schemes continue to be targeted mainly at reducing traffic delays. Crash cost savings are generally incidental to the evaluation of major road schemes and account for only around 10-15% of the benefits. Some major junction improvements aim to reduce road crash costs, but they are promoted mainly as providing substantial delay reduction benefits at traffic bottlenecks.

Road projects seldom get credited with the social and environmental benefits that rail projects receive with the result that the disparity between the economic hurdle for road projects and that for projects in the rail and public transport sectors is stark. Yet the economic benefits from transport in a mature economy arise largely from reliability and predictability. If road investments are judged purely on journey cost saved, they will ignore this major benefit for projects typical of the current pool.

While there is a reasonable body of evidence available in Britain to demonstrate on value for money from casualty reduction schemes, this is based, almost exclusively, on the first year rate of return (FYRR) – that is the crash reduction benefits achieved within the first year after implementation of a scheme. The FYRR can be determined either by forecasting or monitoring the change in crash numbers. The available evidence is a result of both the widespread use of the FYRR methodology amongst road authorities and the requirement to collect data in these areas to populate the Best Value Performance Indicators (Audit Commission, 2010) and in the past, to report on progress in Local Transport Plans.

With a growing need to justify the use of resources, the development of an approach by which road authorities can assess the economic benefit of schemes efficiently is paramount. There are well-established methods and guidelines for determining value for money from larger road safety schemes (DfT, 2010b), typically those costing in excess of £5 million. Guidance on schemes less than £5 million is lacking. The DfT has historically published the guidance which it issues to officials on securing Value for Money when putting submissions to ministers (DfT, 2005) and the forecast BCRs achieved by projects are a key filter.

In the BCR method, benefits (based on crash reductions) are aggregated over the economic life of a project – normally 20-50 years. Benefits arriving in later years are valued less highly (‘discounted’). The costs (including construction, operating and maintenance) over the life of a scheme are similarly discounted and totalled. Road reconstruction projects, for example, might be evaluated over 20 years so that alternative construction methods can be compared on a ‘whole life cost’ basis. This allows comparison between an option with higher initial cost and infrequent maintenance and one with lower initial cost, more frequent maintenance and higher costs of traffic disruption. Discounting rules are 3.5% annual discount rate for the first 30 years and a schedule of declining discount rates thereafter (HM Treasury, 2003). Discounted benefits divided by discounted costs give the BCR. The advantage of this method is that it is easy to apply and gives reasonable transparency on net benefits.

A scheme for which the discounted present value of benefits is less than the discounted present value of costs has a BCR of less than 1, and is not considered to be economically viable. A good economic project is one which pays its costs back more than once in discounted present value terms. The DfT’s historic guidance has indicated that generally most, if not all, projects with a BCR exceeding 2 should be funded (DfT, 2005). The historic presumption is a scheme is:

- poor value for money if its BCR is less than 1, in which case it should not be funded;
- low value for money if its BCR is between 1 and 1.5 and very few such schemes should be funded;
- medium value for money if the BCR is between 1.5 and 2, and that some should be funded; and
- high value for money in excess of 2, with a presumption of funding.

Ideally transport authorities and agencies allocate funds to projects with the highest returns, and the Treasury ensures that funds flow to these public sector programmes. In reality, transport investment in Britain has for many decades been much lower than its European competitors (Liebling, 2010), despite significant rates of return. Scarce funding means that, in practice, high-return projects become crowded out by a day-to-day base load of ‘distress purchases’ where expenditure has to be made for pressing practical reasons (for example, prior political or contractual commitments, urgent unscheduled maintenance, court rulings and so on).

Britain also faces pressures on transport funding from prestige projects such as High Speed 2 (HS2), which are largely politically popular but where the rate of return is, at best, low or medium.

This will crowd out high-return schemes, which will lead to a backlog of projects, and may also lead to a reduction in capacity for searching out and generating the most competitive options.

The Coalition Government has recognised that capital spending, particularly in transport, is a priority and is searching for significant economic returns to the country. In his June 2010 statement the Chancellor told Parliament (HM Treasury, 2010c):

> "Well-judged capital spending by government can help provide the new infrastructure our economy needs to compete in the modern world. It supports the transport links we need to trade our goods, the equipment we need to defend our country, and the facilities we need to provide quality public services. I think an error was made in the early 1990s when the then Government cut capital spending too much – perhaps because it is easier to stop new things being built than to cut the budgets of existing programmes.
>
> We have faced many tough choices about the areas in which we should make additional savings, but I have decided that capital spending should not be one of them. There will be no further reductions in capital spending totals in this Budget. But we will still make careful choices about how that capital is spent. The absolute priority will be projects with a significant economic return to the country."

In the 2010 Spending Review the Government prioritised *"capital spending on transport projects which can offer high economic returns when compared to investment projects in other sectors. By focusing on projects that deliver greater benefits in return for their costs, the positive impact of capital spending on the wider economy can be maximised"*. The review also set out the protection of high-value transport maintenance and investment, including over £10 billion over the Spending Review period on new road, regional and local transport schemes with capital investment in transport in 2014-2015 being higher in real terms than 2005-2006 levels (HM Treasury, 2010b).

It is more difficult than might be expected to extract forecast BCRs of projects funded by the DfT and other national and local authorities on a comparable basis. The Eddington Report (Eddington, 2006a and b) and evidence submitted to the Transport Select Committee does however suggest that typical BCRs required historically for a public transport, light rail, or heavy rail project to receive approval range between 1.5 and 3 (de Rus and Nash, 2007). Road projects typically achieve BCRs of around 4.5-5. The proposed high speed rail link has a forecast BCR of around 2.4 (HS2 report, March 2010). Table 5 sets out a summary of BCRs from the Eddington Report by sector (from Dodgson, 2007).

Table 5: Average BCR results from transport schemes by sector

Sector	No. of projects	Average BCR
Highways Agency schemes	93	4.66
Local road schemes	48	4.23
Local public transport schemes	25	1.71
Rail schemes	11	2.83
Light rail schemes	5	2.14
Walking and cycling	2	13.55

Source: Dodgson (2007: 11)

With the exception of walking/cycling schemes, where only two such examples were included, average BCRs were highest for highway schemes, and lowest for local public transport schemes. If light rail schemes were included in the local public transport category the average BCR would increase from 1.71 to 1.78. In a review of BCR's in surface transport, Dodgson (2007) concluded that *"even after accounting for non-monetised environmental impacts, highway schemes often give better value for money than public transport, including rail, schemes".* This confirms the conclusion of an earlier paper by Affuso *et al.* (2003) that *"trunk road schemes might be expected to have better net returns than mainline railway schemes"*.

2.2 Rates of return achieved from road safety programmes

Major investment in the road network ended in practical terms by the end of the 1990s. One unintended consequence was that Britain's international position in safety engineering, once one of leadership, went into steep decline as the management structures and evidence-based research needed to support a road programme were brought to an end. Today road safety engineering is isolated within local road authorities following a shift in emphasis towards addressing human factors. Road safety engineering is also inadequately supported with the latest research and guidance, much of it now generated outside the UK. In evidence to the Transport Select Committee in 2008 the Director of the Dutch Road Safety Institute summed up the situation by commenting *"Until 2000 we were always looking to the United Kingdom when it came to road safety. You were the inventors of many good activities and policies. All of a sudden, somewhere in 2000, you stopped doing things and we continued with our efforts"* (Select Committee on Transport, 2008).

The national evidence base that safety engineering schemes deliver high economic returns is conclusive. The list below includes a snapshot:

- **Evans (2006)** identified local road authorities which held information on results of monitoring local road safety schemes, concluding that if the average life of schemes were ten years BCR would be ten times FYRR – (the BCRs being in the order of 2,000-3,000% – in other words, benefits were typically 20 to 30 times the cost). It might be expected that the BCRs for new safety projects would gradually fall over time because the best-value schemes were already implemented, but there was no evidence of this in the review. Evans concluded that *"the striking feature of local road safety projects is their very high cost effectiveness…compared with the returns from other uses of the resources."*

- **Atkins (2006)** reviewed all LTP1 Delivery Reports in order to identify examples of good practice (LTP1 was the DfT's five-year strategy for developing local integrated transport between 2001 and 2006). Of the £3.14 billion spent by local authorities on transport, 17% was for the delivery of road safety interventions. During the LTP1 period, this expenditure resulted in a 21% reduction in personal injury crashes. DfT internal research based on personal injury crashes during the LTP1 period showed that overall, road safety schemes offered high value for money, and calculated their benefit to be close to double their costs. Many schemes showed FYRRs in excess of 250%, representing high value for money if translated into BCRs.

- **Atkins (2009)** conducted one of the major reviews of the value for money of road safety investment at both national and local authority level. Data were collated for 408 schemes from 22 local authorities to calculate FYRRs. With greater than 99.9% confidence, the schemes at the treated locations reduced death and serious injuries at a rate greater than experienced nationally, although the researchers reported substantial difficulties in assembling comparable information. These schemes cost a total of £16.8 million with an assumed economic life of just 10 years, and an estimated BCR in excess of 13. Furthermore, FYRR for schemes on non-built-up roads was more than treble their total construction costs. For built-up roads FYRR exceeded construction costs. The report concluded that the highest returns relative to construction costs were obtained when mass action schemes were implemented, addressing all locations with similar crash problem over the whole area under consideration.

- **Road Safety Foundation:** Annually the Road Safety Foundation assesses and publishes the safety levels of Britain's main road network, revealing Britain's most improved roads and showing the investment made by the responsible authority to achieve reductions in death and serious injury. The most recent report, *Saving Lives for Less* (Hill, 2010a), found that the top ten most improved roads had cut fatal and serious collisions by 68% in just three years. Most of the authorities responsible were unable to identify the cost of the schemes that delivered these casualty savings but, on an assumed economic life of 20 years, the present value of benefits was estimated at £475 million.

- **Road Safety Foundation/RAC Foundation:** In a study carried out for this report (see Section 5) 18 local authorities responded to a questionnaire on scheme evaluation and a call to provide case studies showing evidence of high returns. Authorities collate data and undertake analysis on a local basis meaning that comparable information is often difficult to assemble. This underlines the value of the Road Safety Foundation's annual performance tracking across British authorities to standards which permit national and international benchmarking and assist transfer of best practice. The survey found that half of those who responded undertook cost-benefit analysis but exclusively using the FYRR method. A rationing cut-off of 100% was used by several authorities (implying a minimum required BCR of 10-20). Average annual expenditure on safety engineering in each authority was just £320,000, with a range of £0 to £725,000.

- **London:** Transport for London (TfL) invested a reported £200 million on road safety over a six year period and estimated that the programme delivered £3.5 billion of benefits in the same period. The expectation by TfL was that road safety engineering programmes deliver 100% annual returns (iRAP, 2008).

2.3 FYRR versus BCR

It is notable that the majority of published studies reviewing economic returns from safety engineering schemes use FYRR as the value-for-money measure. A key problem in using this for comparison is that different schemes have different useful asset lives and maintenance schedules. Since FYRR does not take this information into account, using it as the basis for assessment will tend to bias the promotion of schemes that generate a higher FYRR irrespective of the number of years over which the benefits could be achieved. For this reason a BCR that takes account of the useful life of a scheme, when comparing schemes with differing initial costs and life spans, is preffered.

The appraisal period is a critical element. DfT WebTAG (WEBsite for Transport Analysis Guidance) guidance (DfT, 2006) states that *"for some projects, the project life may be determined from the limited life of its component assets. In these cases, analysts should set out the evidence, and select an appropriate end year for the appraisal, subject to a maximum of 60 years"*. A key benefit of using a specific appraisal period is that it recognises that costs and benefits will extend beyond a scheme opening year, and that these are important in judging overall value for money.

In 2008, based on papers and contributions presented at the EuroRAP (European Road Assessment Programme) International Conference 2007, the Road Safety Foundation published *Getting Ahead: Returning Britain to European leadership in road casualty reduction* (Hill, 2008), showing that road authorities were not evaluating road casualty reduction schemes on a basis that allowed programme returns to be ranked and compared with other public and transport spending. Instead, as explained above, engineers were using a FYRR method which examined solely the benefits expected in year 1. Authorities said that, typically, for an expenditure of £100,000 they could expect to recoup the same amount at DfT valuations through savings in death and injury within the year. The economic significance of the fact that benefits were expected year after year as a result of improved junction layouts or safety fencing was not appreciated. Evaluated on a basis comparable with other transport schemes, investment in safety engineering may provide BCRs in excess of 5-10 even if average expenditure to save a death or serious injury each year were to rise from current low levels to £300,000.

The treatment of crash cluster sites exposes a second flaw in the way that schemes are evaluated. Authorities tend to use only the last three years of police reports to identify sites suitable for treatment. This can lead to investment in improvements at small cluster sites, and subsequent casualty reductions can be exaggerated by the well-known regression-to-mean effect[4]. The cluster approach also fails to focus investment proactively on removing known high risks from the network in cases where returns can extend beyond three years.

A third flaw in the way in which safety engineering schemes are commonly evaluated is that they can take no account of the traffic delays and widespread disruption that result from fatal and serious crashes. This is dependent on time of day and season, how busy the road in question is, and the availability and nature of alternative routes. Only the Highways Agency undertakes routine assessment of the costs of road crashes to other road users.

The DfT's April 2009 document *A Safer Way: Consultation on Making Britain's Roads the Safest in the World* (DfT, 2009b), summarises the situation well:

> "We are concerned that road safety engineering schemes are rarely appraised on the same basis as other transport schemes. They tend to be justified in terms of first year rates of return rather than whole-life benefit-cost ratios and to take little account of their wider impacts, for example on travel time, or of regression to the mean – whereby sites are chosen for engineering action on the basis of short-term increases in casualties that may be expected to reduce without intervention.
>
> Nevertheless, there is continuing evidence of the high value for money of such schemes. Evidence from stakeholders and from new research (Atkins, 2009) suggests that returns of more than 160 per cent in the first year are still commonplace. This is an exceptional return, even among high-value transport schemes. We also have evidence of the high returns still available from diverse engineering schemes such as side barriers and interventions to protect motorcyclists (Sexton & Johnson, 2009). Such economically beneficial schemes merit greater support than they are currently receiving".

It is recommended that this well-evidenced work should be referred to as the Government prepares their Strategic Framework for Road Safety.

2.4 Towards Zero Deaths and the Safe System Approach

The national evidence base conclusively finds that safety engineering schemes deliver high returns, and this reflects common international experience. The following examples are of larger-scale investments which have not been yet pursued in Britain, but which pave the way for a more strategic approach to road safety during the next decade.

2.4.1 Sweden and Vision Zero

In 1997, the Swedish Parliament, with all-party support, adopted its radical Vision Zero policy

4 In road safety, regression-to-mean is the explanation for the situation where a road has a high number of crashes in a particular period (in this case three years, a period not long enough for the figures to 'average out'), but because of the random factors involved in the causes of those crashes, it is more likely than not that there will be fewer at the same site in subsequent years, irrespective of whether there has been road safety treatment. Put simply, by deliberately choosing a site with an unusually high level of crashes in the first place, one is predisposing the results in subsequent years to drop in crashes at that site.

(see Tingvall, 2005). The policy introduced a future in which no-one is killed or suffers disabling injuries on the roads, and introduced gradual but radical change in how safety is approached and managed. Sweden has brought the annual number of deaths per million population below 30 (compared to 65 before the introduction of the new philosophy, and to 37 in Britain (DfT, 2010a)). The payback period of the measures it has already invested in to remove known risks is not necessarily immediate but will mature over the coming decade.

In the Vision Zero model, the safety of the road system becomes a shared responsibility between road designers, vehicle manufacturers and road users, governed by the following rules:

1. The designers of the system are always ultimately responsible for the design, operation and use of the road transport system, and are thereby responsible for the level of safety within the entire system;

2. Road users are responsible for following the rules for using the road transport system set by the system designers (e.g. wearing seat belts, being sober, obeying speed limits);

3. If road users fail to obey these rules owing to lack of knowledge, acceptance or ability, or if injuries occur, the system designers are required to take necessary further steps to counteract further deaths or serious injuries.

Vision Zero has had profound implications for road and vehicle design, not least in giving road designers more responsibility for the consequences of a crash and ensuring that routine and predictable events are engineered out. The most recent change in Sweden has been to reset speed limits based on these principles, alongside the introduction of a major systematic programme of improvement of road protection standards to eliminate known high risks.

Box 3: Ethical dimensions of 'Vision Zero'

Life and health can never be exchanged for other benefits within the society. Designers internationally (including in Britain) routinely trade off safety benefits against capacity benefits in road design, using economic appraisal. With public awareness, ministers can be pressed hard to show that safety is not being compromised (e.g. by using the hard shoulder as a peak-hour running lane on motorways). While absolutes are common in the European environmental legislation governing roads (for example, no encroachment is permitted regardless of circumstances on sites such as ancient woodland), safety absolutes are not common. This frequently leads designers to puzzle as to why wildlife, flora and fauna have become more precious than human life in the day-to-day processes they are required to follow. The Swedish approach places life and health on an equivalent footing to environmental absolutes.

Whenever someone is killed or seriously injured, necessary steps must be taken to avoid a similar event. Crucially, Vision Zero introduces a measure of biomechanical tolerance as a parameter of the safety of the system. Put simply, it states that the human body cannot survive an uncushioned impact of more than 25 mph. Therefore the system cannot be permitted to allow these forces since, as in rail and air safety, it is assumed that human beings will always make mistakes. The permitted speed of vehicles becomes specified by how well the vehicle and the road can reduce crash impact and injury severity.

The difficult campaign to make fundamental improvements to European standards of vehicle safety took place in the mid-1990s. The European New Car Assessment Programme (EuroNCAP), backed by motoring organisations and the British, Dutch and Swedish Governments, increased the typical crash performance of new vehicles for car occupants from 2 – to 4-star, and, in many cases now, 5-star. Results of independent crash tests were published and increasingly used by consumers when buying cars. Consumer pressure ensured a new market in safety. Progress on pedestrian safety has been slower, and the legislative route is now being used.

In 1999, European motoring organisations and the British, Swedish and Dutch Governments developed EuroRAP to tackle the problem of safe road design. Early work defining a Star Rating scale (the Road Protection Score) quickly confirmed that only motorways were built in a way that systematically sought to eliminate all forces that kill at the posted speed limit. However the paradox – that the fastest roads were the safest – was short-lived. The Swedish Government has used the principles behind RAP Star Rating to guide its review of speed limits. The new Swedish standard for single carriageways designed to 'Vision Zero' principles, already adopted by a number of other countries, quickly proved in service to be one of the safest. RAP road inspections across Europe confirmed that the roads on which most deaths take place have only 1 – or 2-stars. Recent work in several countries suggests, as a working rule of thumb, that the death and serious injury rate doubles with each loss of a star (AusRAP, 2008).

It is inevitable that road deaths will occur when existing roads are used at the current posted speed limit (let alone at speeds beyond the limit, or if people are not sober or fail to wear seat belts). As such, there remain only three ways forward to improve the protection standards of roads: institute and enforce lower speed limits, or raise protection standards, or accept a level of risk on roads much higher than that associated with any other daily activity (Allsop, 2008, personal communication). The economically efficient solution is that there should be investment in protection up to the point where it is more efficient to lower the speed limit. For example, in the urban core and residential areas, where there are both environmental and safety gains to be had, lower speed limits can become an acceptable and rational choice. In rural areas, longer journey times can destroy the viability of communities and long overdue investment in safety becomes paramount. Recent developments in Swedish policy are bringing closer the prospect that roads will be inspected for safety as robustly as planes, boats, rail and road vehicles.

2.4.2 Netherlands and Sustainable Safety

There are differences in emphasis between the Dutch 'sustainable safety' and the Swedish 'Vision Zero' approaches but it is the combination of Swedish and Dutch policies that gives us the modern safe road design goal of 'self-explaining and forgiving roads'. The document *Sustainable Safety: A new approach for road safety in the Netherlands* (van Vliet & Schemers, 2000) introduced principles of the new approach:

> " 'Sustainable Safety' recognises that 90 per cent of road accidents are attributable (to a greater or lesser extent) to human error. Consequently sustainable safety realises that the human is the weakest link in the traffic and transport chain. Furthermore, the human does not readily change or adapt and many attempts at influencing road user behaviour have failed or had merely short term effects. The limitations of the human remain evident. Motivation, attention, emotion, observation, prediction, knowledge and skills are all weaknesses that prevent the human from being the ideal traffic participant. All in all the human remains unpredictable and therefore is in itself not sustainable from a road safety perspective."

A goal of Dutch safe road design is to reduce the likelihood that fallible human beings will misread the road. A 'self-explaining road', on which the driver is encouraged to naturally adopt behaviour consistent with design and function, originated in the Netherlands. Self-explaining roads show road users with a clear road layout where they should be and what they should do to maintain safety. Different classes of roads should be distinctive, and within each class features such as width of carriageway, road markings, signing, and use of street lighting should be consistent throughout the route. The environment effectively provides a 'label' for the road type thereby lessening the need for separate traffic control devices such as additional traffic signs to regulate traffic behaviour. Only more recently did Dutch policy makers amend their principles to add the proposition that roads should also be 'forgiving', and be capable of protecting road users in the event of a crash.

The emphasis of Swedish and Dutch policies on safe road and vehicle design, and defining and enforcing evidence-based safe maximum speeds, is a logical consequence of the success in raising seat-belt wearing rates and making drink-driving socially unacceptable. Continuing education to sustain public understanding will be required, particularly as new generations come to drive. Focus on particular problem themes such as young males, motorcycling, distracted driving or driving while tired will be needed. However, achieving major further advances through education may also need the DfT and other stakeholders to seriously consider advances in vehicle design (for example, intelligent seat-belt reminders, alcolocks, speed alert systems, electronic stability control) and in safe road design. In 1997, the Australian road safety strategy identified that advances in safe road design were likely to deliver as much as behaviour and vehicle advances combined. In March 2008, the Dutch Government were the first to introduce an acceptable safety level for roads, announcing that all 2-star national roads, based on the EuroRAP Star Rating system, would be raised to 3-star or better.

2.4.3 OECD's Towards Zero

In 2008, the OECD took stock of the major developments in international practice, and reviewed the cost of road crashes and expenditures on road safety. The resulting report, *Towards Zero: Ambitious Road Safety Targets and the Safe System Approach,* captures the essence of advances in the leading countries, adjusting the language and approach from utopian to practical and economic. It explicitly supports the use of RAP protocols to assess high-risk sites offering the greatest economic returns and creates a platform which could be used to enable advances in major countries like Britain and the USA. Already half a dozen US states have declared themselves 'Towards Zero Deaths (TZD)' States. This report provides the economic framework for Britain to tackle the cost of road crashes in the way that the OECD recommends (see Sections 3 and 4).

In conclusion, crash cost reduction is not currently a major factor leading to the development of major road and transport schemes in Britain. However, the benefits from casualty reduction projects provide economic returns which are orders of magnitude greater than those of rail, public transport and many road projects. Efficient and effective delivery is all about setting clear goals, obtaining political support and putting in place financial resources and technical capability. The Dutch and Swedish policy approaches have resulted in substantial attention to safe road design on all parts of the network. The SUNflower comparative studies (Koornstra *et al.*, 2002; Lynam *et al.*, 2005) which include Sweden, the UK and Netherlands specifically, point to the opportunities to which Britain must pay attention on its rural road network.

3. Identifying the Road Network Where Crash Costs are Concentrated

Britain has not generated or evaluated systematic approaches to defining large-scale high-return programmes for casualty reduction in the same way as the Netherlands, Sweden and Australia have done, and as is now increasingly the case worldwide. The provision of crash cost mapping presented in this section provides a breakthrough aid for policymakers, enabling them to see road section by road section, how and where substantial social and economic loss is distributed across the British road network. It examines where the greatest savings could be made if the network were brought up to higher levels of safety. Annex 2 provides the detailed methodology used, with worked examples.

3.1 Estimating current levels of road safety

There are currently two main protocols in international use to measure the safety of roads consistently across borders (a process called safety rating) – *Risk Mapping* and *Star Rating*. Development of these methods was led by the Road Safety Foundation in 1999 supported by the British, Dutch, and Swedish Governments during the early establishment of EuroRAP. The creation of an international system to assess the safety of roads followed the success in raising car crash protection standards through EuroNCAP.

In recent years, the umbrella International Road Assessment Programme (iRAP) has enabled further support not only from national governments and non-governmental organisations, but also from international institutions

including the World Bank, the OECD, the European Commission, WHO and regional development banks. Stakeholders in some 60 countries now use one or both of the protocols. International comparisons of safety and investment programmes using these measures have been published. In 2010, a comparative performance of 15 European countries showed the safety performance being achieved on the legally designated Trans-European Road Network (Hill, 2010b).

3.1.1 Risk Mapping

Risk Mapping measures the rate of death and serious injury on a network where crash data are of sufficient quality to enable this. Since 2002 the Road Safety Foundation has published a risk map of Britain's motorway and A road network showing the number of fatal and serious crashes per billion vehicle km travelled – i.e. the average risk faced by an individual road user on a particular road section. The risk rating of individual sections is used to track performance, identifying whether crash numbers have increased, stayed the same or decreased over time. Results are extensively reported in the general media and professional press.

Risk is allocated into colour-coded bandings ranging from high-risk (black) to low-risk (green), allowing informed dialogue between the public, elected members, and professionals about the safety levels being achieved on main roads in national or local areas. Based on historic crash and traffic data, Risk Mapping is a measure of the 'outcome' on a particular section from the combination of road user behaviour, the safety of the vehicle and the road design and layout.

The results presented in this section build on the Road Safety Foundation's annual EuroRAP mapping and tracking. The methodology is further developed to show the distribution of crash costs on the British network and what this means for the major crash cost centres in the highest-risk areas.

3.1.2 Star Rating ('Road Protection Score')

Star Ratings are a high-level measure of infrastructure safety obtained from inspecting and scoring the physical features of road design and layout that are known to have an impact on the likelihood of a crash and its severity (such as lane and shoulder width, and the presence of safety barriers).

The Star Rating is derived from a Road Protection Score (RPS) – a numerical score which in turn is derived from a product of risk factors based on characteristics of the road which increase or decrease the likelihood of a crash and severe injury. An RPS is calculated for each 100 metre section of road, but the resulting Star Rating is typically averaged over a longer length as this is more appropriate to calculate and display route risks. Separate Star Ratings are derived for motor vehicle occupants, motorcyclists, cyclists and pedestrians. For the British EuroRAP network of rural roads outside built-up areas, this analysis only considers Star Ratings for motor vehicle occupants and motorcyclists, as other road user groups are not systematically involved in road crashes at these locations.

The Star Rating process is analogous to the scoring of crash test results for new cars. RPS scores are normalised into Star Rating bands using the same colour coding convention as that for Risk Mapping: a 5-star rating represents the safest road infrastructure design for the prevailing speed environment and a 1-star rating the poorest.

In contrast to Risk Mapping, Star Rating is a proactive measure of safety: it predicts where risk is highest based on the design and layout of the road infrastructure, using the relationship between speed and injury severity. The correlation between Risk Mapping and Star Rating is discussed in Section 4.

With the support of the Highways Agency, around 7,500kms of road has been inspected and coded in Britain to the 2007 protocol. The results of these inspections, however, only apply to the higher-quality national motorways and trunk roads operated by the Highways Agency in England. Results were published by the Road Safety Foundation in 2010 and showed that 50% of the motorway network achieved 4-stars; 78% of dual carriageways achieved 3-stars and 62% of trunk road single carriageways were rated 2-star. Some 35% of trunk road single carriageways were however, rated 3-star (Lawson, 2010)

The Star Rating protocol is used to estimate minimum infrastructure-based safety levels, and test the costs and benefits of programmes to raise the safety of the network.

3.2 Crash cost mapping methodology

In this section we present, for the first time, mapping showing the distribution of crash costs across Britain's motorways and A roads, using the DfT's values of crash prevention by injury severity and road type. To demonstrate the effect of traffic flow on crash cost distribution, two maps and associated results are presented:

1. Fatal and serious crash cost per km (i.e. crash density showing the risk to all road users); and

2. Fatal and serious crash cost per vehicle km travelled (i.e. a measure of risk by traffic flow showing the risk to individual road users).

The data were for Britain over the three year period 2006-2008. Collision data are from the STATS19 national road injury and accidents database provided by the DfT, and include all crashes involving a fatal or serious injury. Traffic flow data are from the DfT database which collates automatic and manual vehicle counts, the latter carried out at three-yearly intervals. Given the disproportionate numbers of deaths and serious injuries on rural as compared with urban routes, analysis was carried out for all British motorways and A roads outside of towns and cities. This 45,000 km (28,000 mile) network represents 10% of Britain's total paved road length, but over half of the road deaths.

Road sections of less than 5 km (about 3 miles) were excluded from analysis to eliminate those where there may be substantial fluctuations in crash numbers over time. Removing these sections resulted in a total network length of 42,261kms (26,260 miles) – 94% of the original total, 3,750 fatal crashes (95% of the original) and 21,272 crashes resulting in serious injury (93% of the original) for the three year data period 2006-2008.

For the purposes of this report, A roads have been sub-divided into the following categories based on jurisdiction and function:

- **Trunk A:** defined as major roads, usually connecting two or more cities, ports, airports, which form the recommended route for long-distance and freight traffic. Trunk roads are managed by national road authorities (Highways Agency, Transport Scotland and Transport Wales).

- **Primary A:** maintained by local councils, primary routes are identified by their direction signs, which feature white text on a green background with route numbers in yellow. They are shown in green on maps. The primary road network is fully connected, meaning that any part can be reached from another without leaving the network. Historically, these roads have been regarded as of more than local importance and their development has been grant-aided by central government.

- **Non-primary A:** maintained by local councils, non-primary A roads often exist where the route is important but there is a nearby primary route (either A road or motorway) which duplicates the road's function. They are shown as red on maps, and feature white signage with black lettering.

The level of protection against severe injury differs considerably by road type and function and this is reflected in the DfT's cost ratios for crash prevention (see Section 1). A typical motorway will have central barriers separating oncoming traffic flows, wide shoulders, roadside barriers protecting traffic from aggressive roadside objects, and grade-separated junctions minimising conflict. A typical rural single carriageway A road may have little or no median separation, exposed lighting columns, trees and signposts at the roadside and T – or cross junctions that can lead to brutal side impacts.

The Road Safety Foundation's EuroRAP data give separate numbers of fatal and serious crashes for individual road sections, and we were therefore able to take account of the weighting of observed crashes by road type and associated monetary values of crash prevention in the development of the crash cost mapping. Average values of prevention vary between built-up and non built-up roads and motorways, because the average number of casualties per crash differs between road categories. Furthermore, the costs of crashes tend be greater than the cost of individual casualties. For example, a fatal road crash in 2008 involved on average 1.08 fatalities, 0.32 serious casualties and 0.48 slight casualties (DfT, 2010a).

The values in Table 6, which are the latest DfT values (DfT, 2010b), were used to assign crash costs to individual road sections. These represent economic and societal costs, lost output, and medical and human costs but exclude costs relating to damage of vehicles, infrastructure or property. Figures for motorways are the average value of prevention per crash (in June 2008 prices). Figures used for A roads are the average value of prevention per crash for built-up and non built-up roads combined – because while the majority of routes included on the EuroRAP network were outside towns and cities, some built-up areas were included on routes where they passed through villages and small towns.

Table 6: Allocation of crash costs by injury severity and road type

Injury severity	Road type	Cost per crash
Fatal	Motorway	£2,064,494
Fatal	A road	£1,906,154
Serious	Motorway	£243,542
Serious	A road	£218,114

Source: Using DfT (2010b)

A motorway section with 10 fatal crashes and 5 serious injury crashes would therefore give rise to total crash costs of (10 x £2,064,494) + (5 x £243,542) totalling £21,862,650.

Total crash costs by road section have been calculated and allocated into five colour-coded ‘economic loss’ bandings from high to low, using the proportions shown in Table 7.

Table 7: Colour coded ‘cost’ bandings

High cost	Top 20% of road sections with the greatest economic losses
High-medium cost	Next 20% of road sections
Medium cost	Next 20% of road sections
Low-medium cost	Next 20% of road sections
Low cost	Lowest 20% of road sections

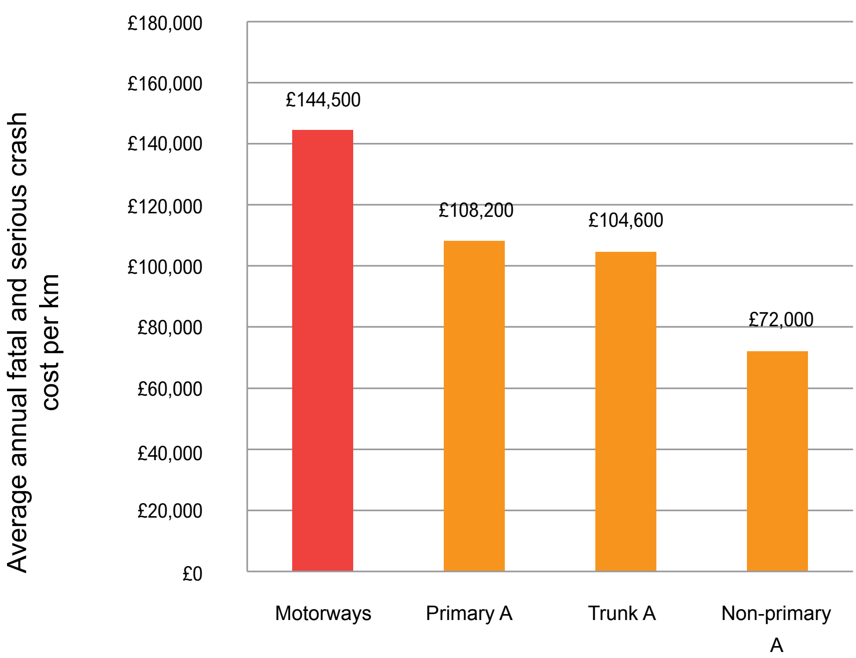
Source: Authors own

3.2.1 Fatal and serious crash cost per kilometre

Costs for individual road sections were based on numbers of fatal and serious crashes using the values in Table 6. Total crash costs on each section were divided by the section length to give crash cost per km. Figure 5 maps crash costs per km on Britain’s motorways and A roads.

Figure 3 shows the average annual crash cost per km for motorways, primary A roads, trunk A roads and non-primary A roads.

Figure 3: Average annual fatal & serious crash cost per kilometre across Britain



Source: Authors own

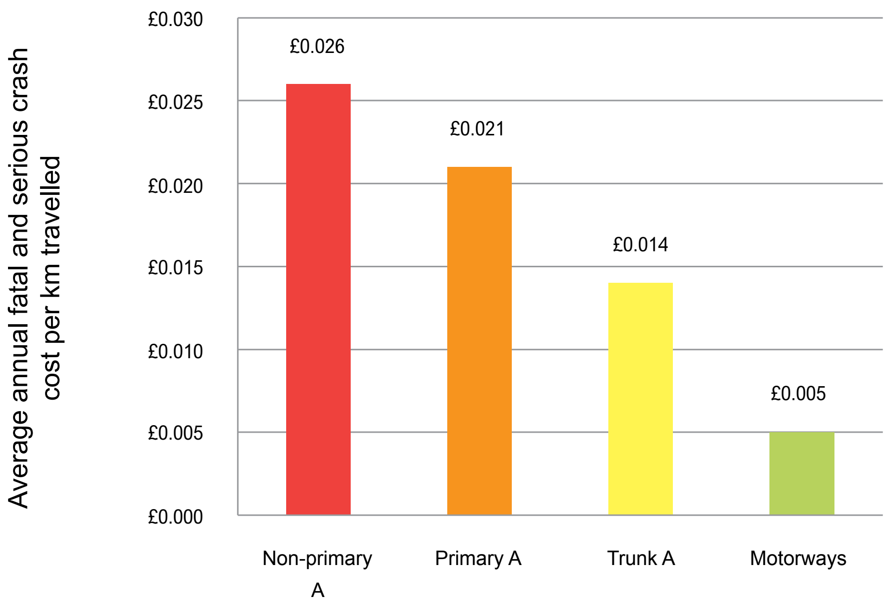
Motorways account for the highest crash costs, losing an average of £144,500 per km annually. This is significantly higher than the crash costs on all classes of A roads, all of which fall into the medium loss banding.

Motorway crash costs were double that of the non-primary A road network (£72,000 per km per year) – which is likely to be due to both the greater traffic volumes carried on motorways and the higher traffic speeds.

3.2.2 Fatal and serious crash cost per vehicle kilometre

As with costs per km, costs for individual road sections were based on the number of fatal and serious crashes using the values in Table 6. The total was then divided by the traffic volume carried (using annual average daily traffic, AADT). Figure 6 maps the average annual crash cost per vehicle km travelled for motorways, primary A roads, trunk A roads and non-primary A roads. Average values by road type are shown in Figure 4.

Figure 4: Average annual fatal & serious crash cost per vehicle kilometre across Britain



Source: Authors own

Falling into the medium-high loss banding, non-primary A roads account for the greatest loss at 2.6 pence per vehicle km per year. Loss on these roads is almost double that seen on trunk routes (falling into the low-medium banding with a cost per vehicle km of 1.4 pence per vehicle km) and over five times that of motorways.

The significantly higher traffic flows carried by motorways mean that loss on this network is the lowest of all road types, with economic loss falling in the lowest banding – at 0.5 pence lost per vehicle km travelled.

Scaled up to the total length of each road type across the network, this equates to an annual loss of £478.4 million on motorways, £864.3 million on primary A roads, £955 million on trunk A roads, and £1.4 billion on non-primary A roads. In total for all motorways and A roads outside towns and cities, Britain loses over £3.5 billion in crash costs annually.

Just under 40% of serious crash cost on main roads is concentrated on national motorways and trunk roads, mainly on the Highways Agency network. Local authorities made the case to the Road Safety Foundation in 2007 that they were facing major safety management problems on A roads off the primary route network and this led to the extension of the British EuroRAP network to non-primary A roads in the following year. The level of crash cost on non-primary A roads, which accounts for 37% of serious crash cost, reinforces the wisdom of examining this category of roads.

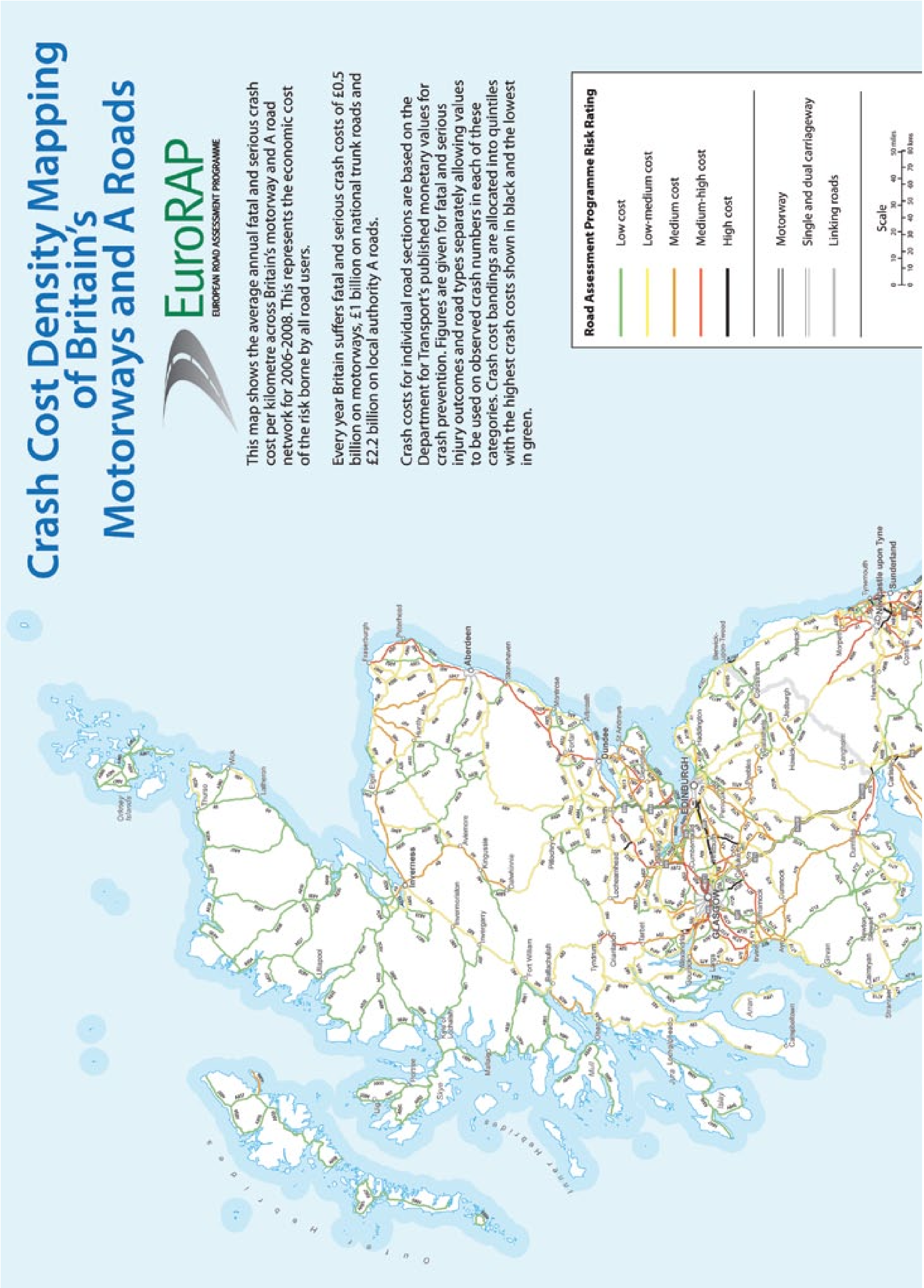
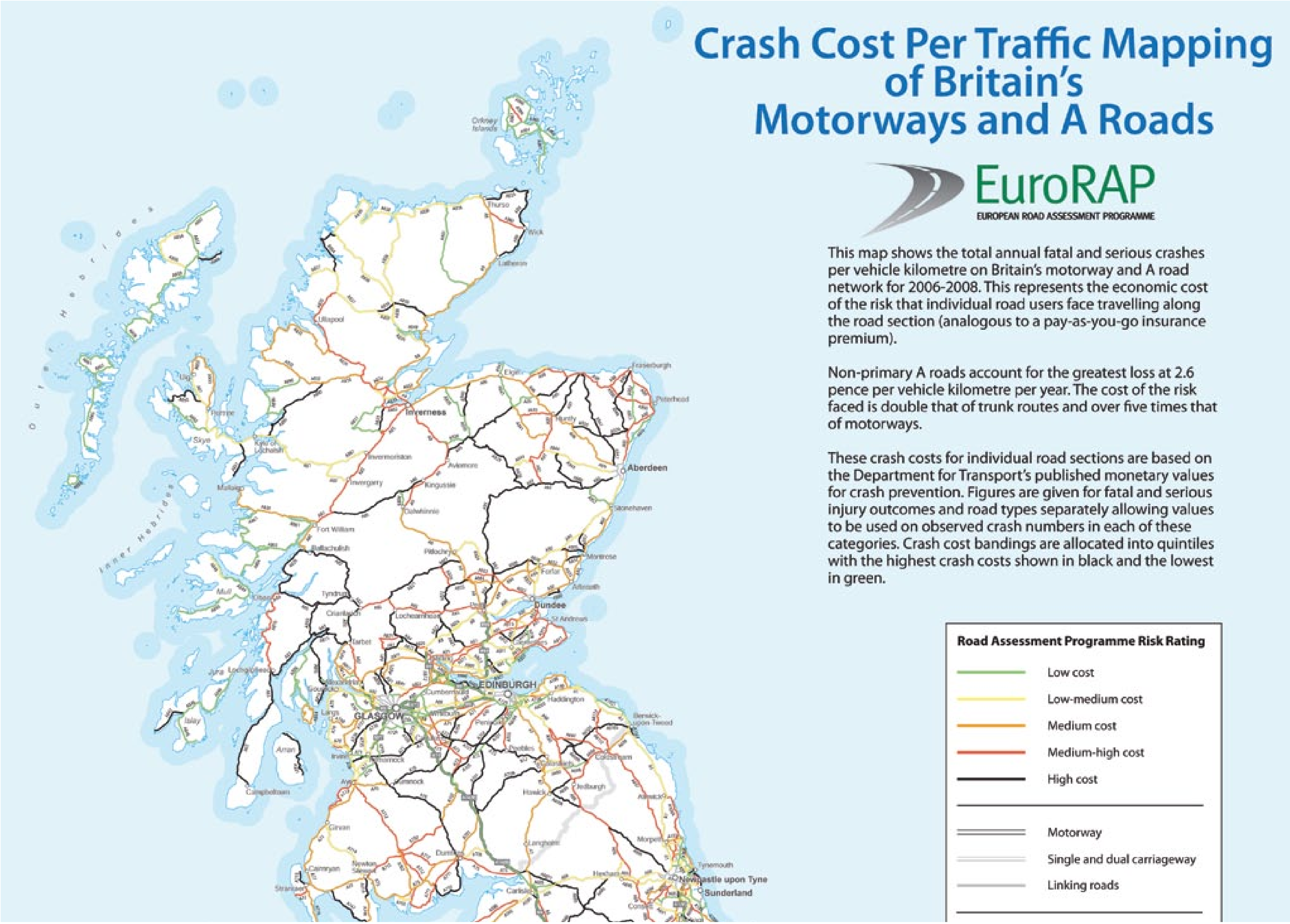


Figure 5: Fatal and serious crash cost per kilometre on Britain's motorways and A roads

Source: Road Safety Foundation (2011)

Figure 6: Fatal and serious crash cost per vehicle kilometre on Britain's motorways and A roads



Source: Road Safety Foundation (2011)

3.3 The differing crash costs across Britain

Comparative analysis shows differing crash costs by road type and geographical area revealing how authorities need to apply a variety of approaches and priorities. It also reveals where particular authorities need to work much harder than others.

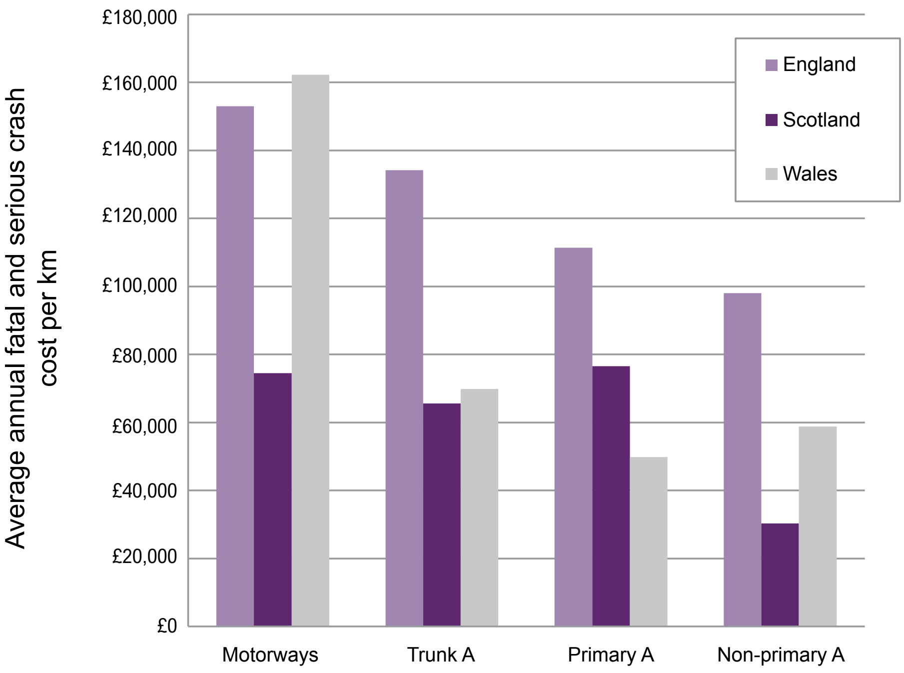
3.3.1 Crash cost density – fatal and serious crash cost per kilometre

Crash cost density mapping shows where high costs arise and helps to develop and understand the strategies needed to target the locations with the greatest losses. Serious crash cost can arise on all busy high speed main roads. This might also be the case when a road has untreated risks with modest traffic levels, or when seemingly safe roads with small deficits in protection standards are intensively used (e.g. flaws in run-off protection on motorways). Figures 7a-7c compare the annual serious crash cost density (fatal and serious crash cost per km) by road type across Britain.

Figure 7a shows the variation in serious crash cost density by road type for England, Scotland and Wales. Motorways and trunk A roads are maintained by national road authorities in each nation. Results are also shown for primary and non-primary A roads, maintained by local authorities.

Average cost is the sum of the crash cost for each region divided by the total length.

Figure 7a: Annual fatal and serious crash cost per kilometre on motorways and A roads for England, Scotland and Wales



	Motorways	Trunk A	Primary A	Non-primary A	Average cost
England	£153,042	£134,216	£111,362	£98,036	£114,972
Scotland	£74,480	£65,582	£76,588	£30,295	£45,084
Wales	£162,297	£69,892	£49,849	£58,824	£65,502

Source: Authors own

In detail the results show that motorways account for the greatest economic loss per km in England and Wales[5] – both of which fall into the medium-high loss banding. Scotland bucks this trend, with primary A roads accounting for the highest crash costs (£76,588 per km compared to £74,480 on motorways). Scotland's motorway network contains a significant proportion of recently built motorway, constructed to modern standards carrying lighter volumes of long haul traffic.

Of the three nations, losses per km across A road categories are highest in England, with all but the non-primary network rated in the medium-high loss banding. Serious crash costs on trunk A roads (£134,216) are double the rate seen in Wales or Scotland. On the primary A road network, England loses £111,362 per km annually, one and half times that in Scotland (£76,588) and over twice that of Wales (£49,849).

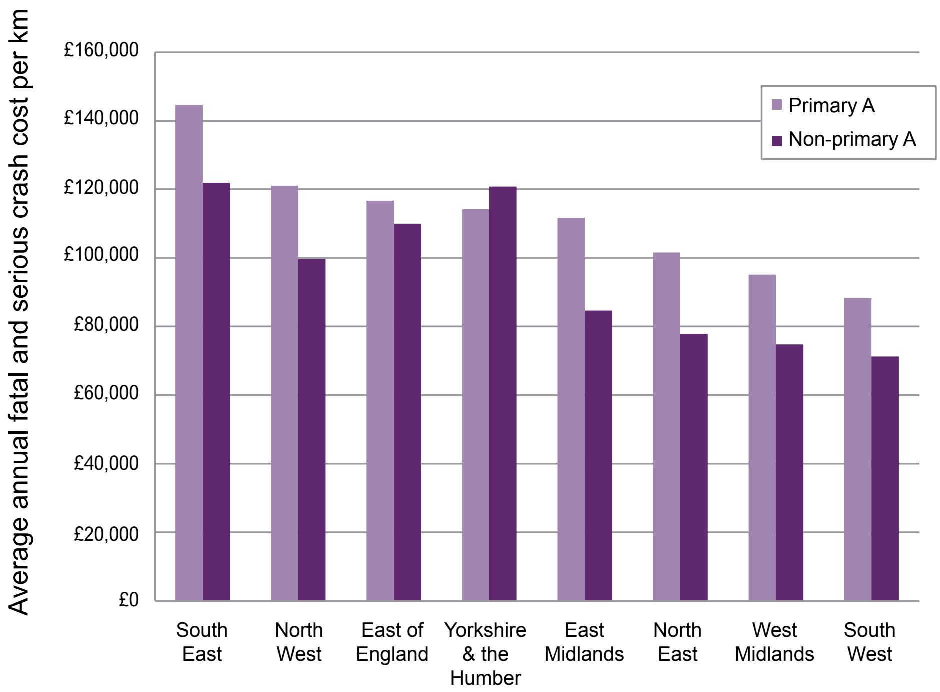
On non-primary A roads, Scotland incurs the lowest cost per km at just £30,295, half that seen in Wales and less than one-third the English equivalent. With just 3% of its total EuroRAP network comprising motorways, Scotland is heavily reliant on A roads for both long distance and commuter travel, with 62% of the EuroRAP network being non-primary A and 35% primary A. Scottish drivers have much greater exposure to single carriageway rural routes where the risk of a fatal or serious crash is typically higher.

Average cost per km across the motorway and A road network in each nation showed the greatest average losses in England (£114,972 per km annually), nearly three times that of Scotland (£45,084) and nearly double that in Wales (£65,502).

Figure 7b presents disaggregated values for non-national roads in English local authority regions (South-East, South-West, North-East, North-West, West Midlands, East Midlands, East of England, Yorkshire & the Humber)

[5] Note that Welsh motorways had a short overall length (104 km) over 2 individual road sections when compared with England (2,835 km over 120 road sections) or Scotland (373 km over 12 road sections).

Figure 7b: Annual fatal and serious crash cost per kilometre on primary and non-primary A roads, by English region



	Primary A	Non-primary A
South-East	£144,593	£121,957
North-West	£121,060	£99,679
East of England	£116,723	£109,982
Yorkshire & the Humber	£114,194	£120,767
East Midlands	£111,728	£84,695
North-East	£101,611	£77,908
West Midlands	£95,104	£74,779
South-West	£88,229	£71,259
Average cost	£111,362	£98,036

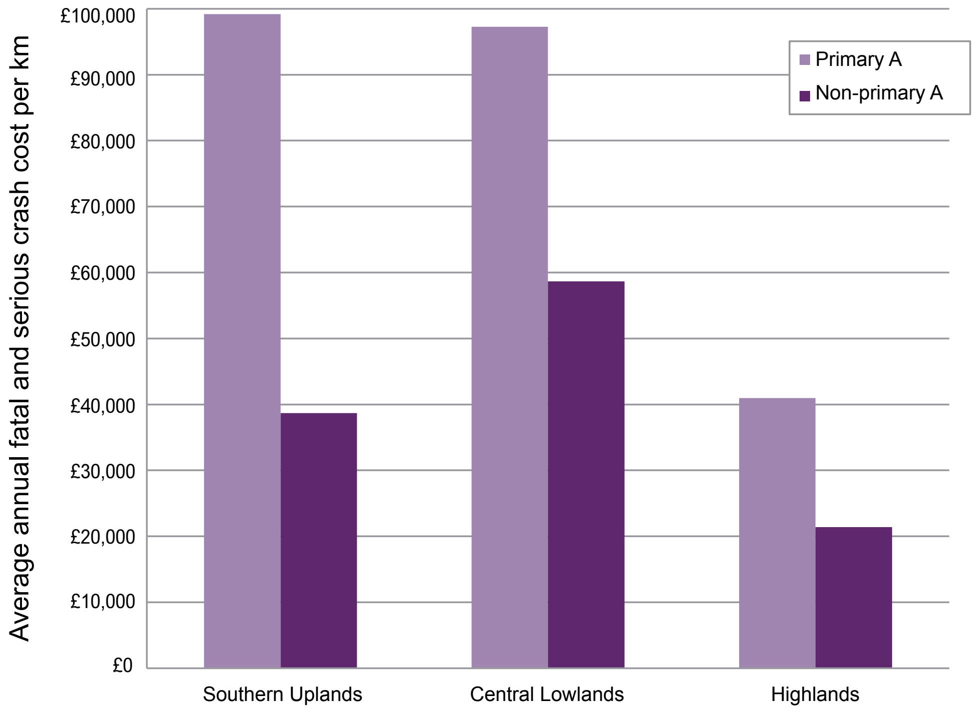
Source: Authors own

In the majority of English regions, primary A roads account for the highest annual crash cost per km, most falling in the medium-high loss banding.

On this measure the South-East has the highest crash cost of all British regions – £144,593 on its primary A road network and £121,957 on the non-primary routes. The A road network in this area of the country is comparatively busier than most, carrying 15% of Britain's single carriageway A road traffic.

Figure 7c shows fatal and serious crash cost per km on primary and non-primary A roads, by Scottish region (Southern Uplands, Central Lowlands and the Highlands). The primary A road network which is not trunk road is short and the traffic levels on non-primary roads outside the central belt are typically very low.

Figure 7c: Annual fatal and serious crash cost per kilometre on primary and non-primary A roads, by Scottish region



	Southern Uplands	Central Lowlands	Highlands	Average cost
Primary A	£99,181	£97,250	£40,950	£76,588
Non-primary A	£38,693	£58,667	£21,395	£30,295

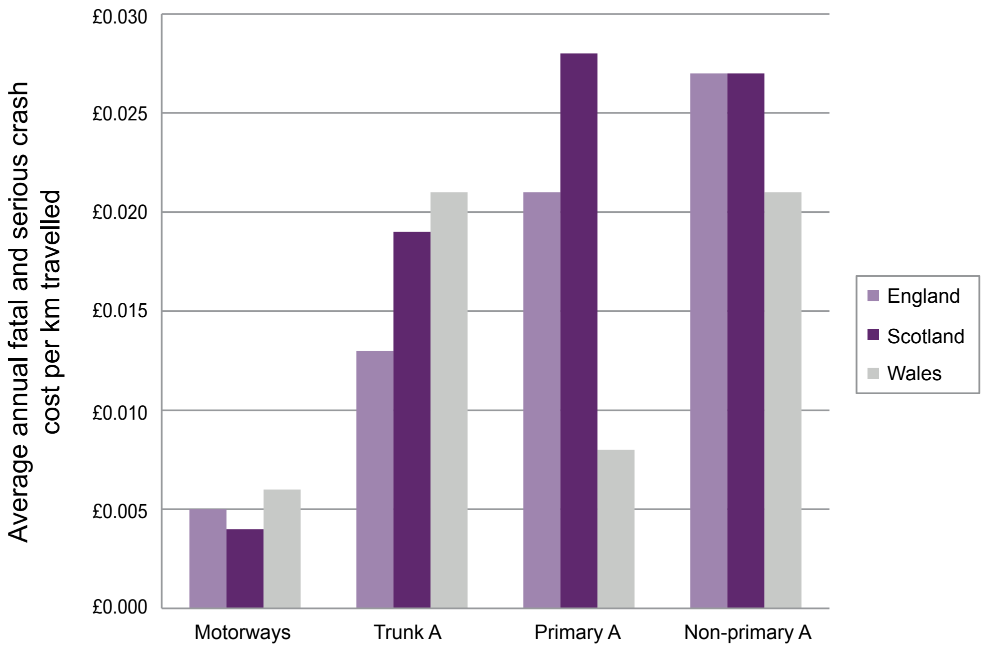
Source: Authors own

Amongst the Scottish regions, higher crash costs are incurred on primary A roads. In the Southern Uplands, primary A roads suffer over two and a half times the loss per km than non-primary routes (£99,181 compared to £38,693). In the Central Lowlands and the Highlands, crash costs per km on primary A roads are around double that of the non-primary A road network. Of all regions the Highlands suffers the lowest crash cost per km.

3.3.2 Crash cost per distance travelled – fatal and serious crash cost per vehicle kilometre

Mapping crash cost per vehicle travelled is not dissimilar in principle from revealing the insurance premium payable to travel a length of route. This measure shows the average risk an individual road user takes by travelling a route, with cost rising with increasing risk. Figures 8a-8c compare the fatal and serious crash cost per vehicle km by road type across Britain.

Figure 8a: Fatal and serious crash cost per vehicle kilometre on motorways and A roads for England, Scotland and Wales



	Motorways	Trunk A	Primary A	Non-primary A	Average cost
England	0.5p	1.3p	2.1p	2.7p	1.4p
Scotland	0.4p	1.9p	2.8p	2.7p	1.8p
Wales	0.6p	2.1p	0.8p	2.1p	1.7p

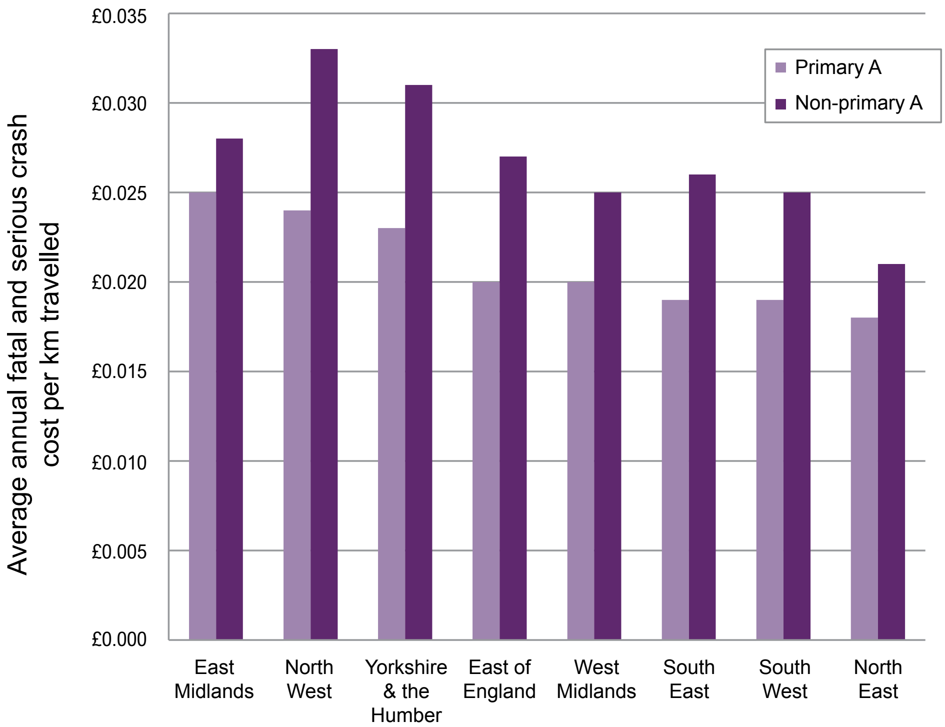
Source: Authors own

Figure 8a shows the variation across road types for England, Scotland and Wales. Crash costs per vehicle km are lowest on motorways in all nations – all of which fall into the lowest economic loss banding. The costs on motorways are around 0.5 pence while the costs are more than five times higher on non-primary routes in England and Scotland.

Amongst the road categories evaluated, Wales suffers the highest crash costs on motorways (0.6 pence per vehicle km annually) and trunk A roads (2.1 pence per vehicle km), but the lowest on non-primary A roads at 2.1 pence. Crash costs on Welsh primary A roads are significantly lower than those seen in England and Wales.

England has the lowest average cost per km travelled at 1.4 pence, and Scotland the highest at 1.8 pence.

Figure 8b: Fatal and serious crash cost per vehicle kilometre on primary and non-primary A roads by English region



	Primary A	Non-primary A
East Midlands	2.5p	2.8p
North-West	2.4p	3.3p
Yorkshire & the Humber	2.3p	3.1p
East of England	2.0p	2.7p
West Midlands	2.0p	2.5p
South-East	1.9p	2.6p
South-West	1.9p	2.5p
North-East	1.8p	2.1p
Average cost	2.1p	2.7p

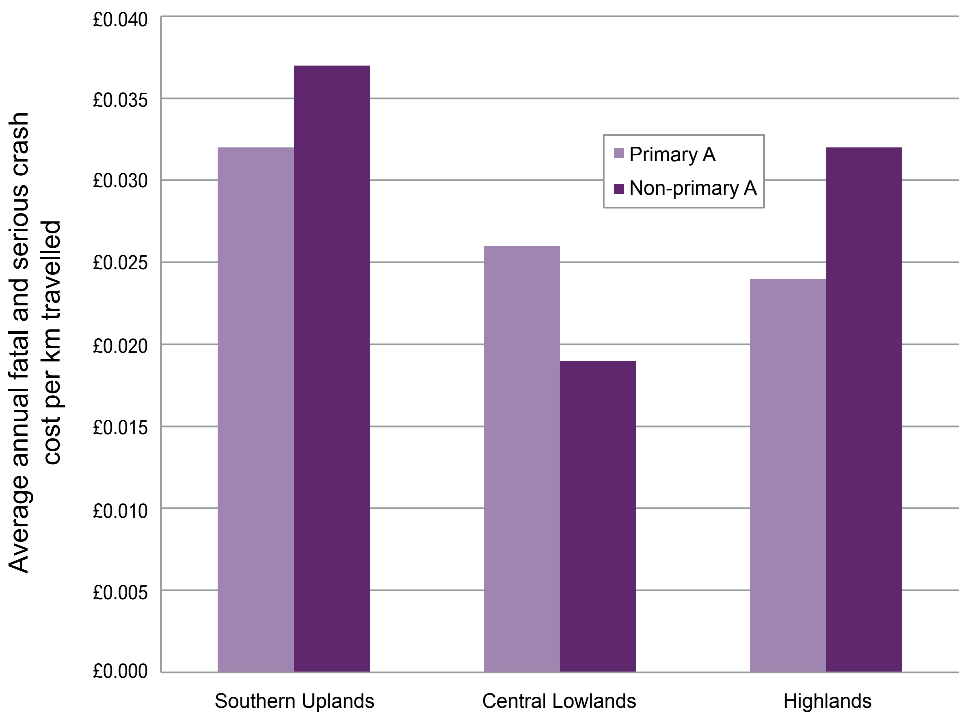
Source: Authors own

Figure 8b shows fatal and serious crash cost per vehicle km on primary and non-primary A roads, by English region.

In contrast to the trend seen in crash cost by density, on the measure of crash cost per vehicle km, in all eight English regions, non-primary A roads account for the highest annual loss, with an average cost of 2.7 pence. Overall, the greatest loss on non-primary A routes is seen in the North-West, where 3.3 pence per vehicle km is lost every year. Costs in the North-East are the lowest with just 2.1 pence lost per vehicle km annually – falling into the medium loss banding.

Figure 8c shows fatal and serious crash cost per vehicle km on primary and non-primary A roads, by Scottish region.

Figure 8c: Fatal and serious crash cost per vehicle kilometre on primary and non-primary A roads, by Scottish region



	Southern Uplands	Central Lowlands	Highlands	Average cost
Primary A	3.2p	2.6p	2.4p	2.8p
Non-primary A	3.7p	1.9p	3.2p	2.7p

Source: Authors own

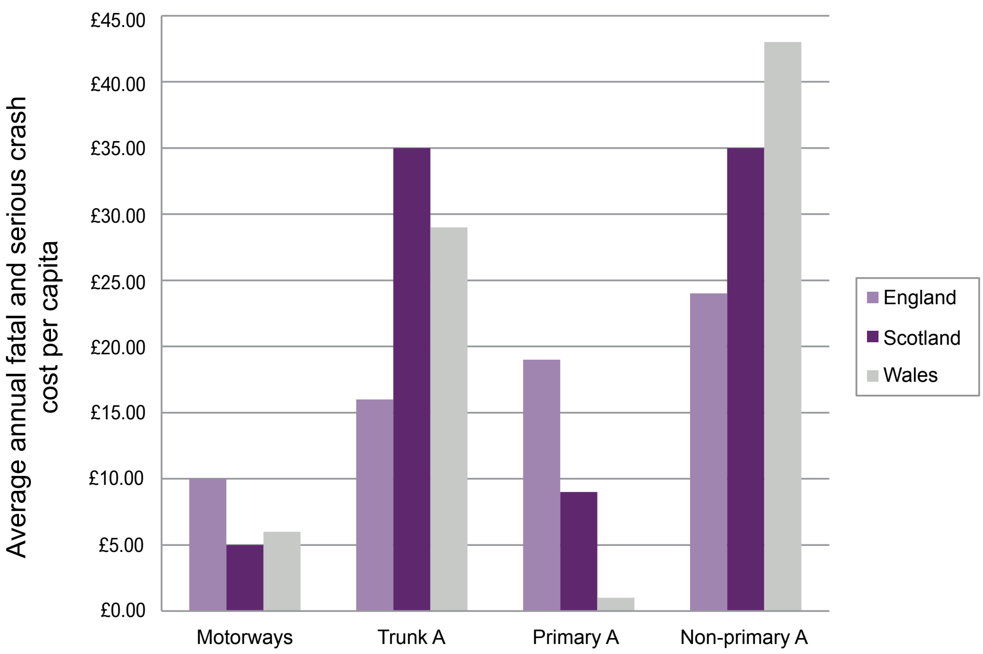
Average annual crash costs per vehicle km in Scotland are highest on primary A roads (2.8 pence), but are not significantly different to that seen on the non-primary A network (2.7 pence). Within the Scottish regions, the Scottish Uplands account for the greatest loss on both the primary A and non-primary A road network, at 3.2 pence and 3.7 pence per vehicle km respectively. The Central Lowlands region incurs significantly less on non-primary A roads than either the Southern Uplands or the Highlands. At 1.9 pence per vehicle km each year, this is almost half that seen elsewhere.

3.3.3 Crash cost per capita

In the previous section it is not clear whether England, Scotland or Wales suffers the greatest relative loss of GDP. Normalising these crash costs to loss of GDP per head of population helps to reveal whether the national loss is mainly a function of population or exposure to less safe roads.

Figure 9a shows the fatal and serious crash cost per capita on motorways and A roads for England, Scotland and Wales.

Figure 9a: Fatal and serious crash cost per capita on motorways and A roads, for England, Scotland and Wales



	Motorways	Trunk A	Primary A	Non-primary A	Average cost
England	£10	£16	£19	£24	£69
Scotland	£5	£35	£9	£35	£85
Wales	£6	£29	£1	£43	£78

Source: Authors own

Average GDP per capita lost is £69 in England and around 25% higher in Scotland at £85 with Wales mid-way between the two at £78.

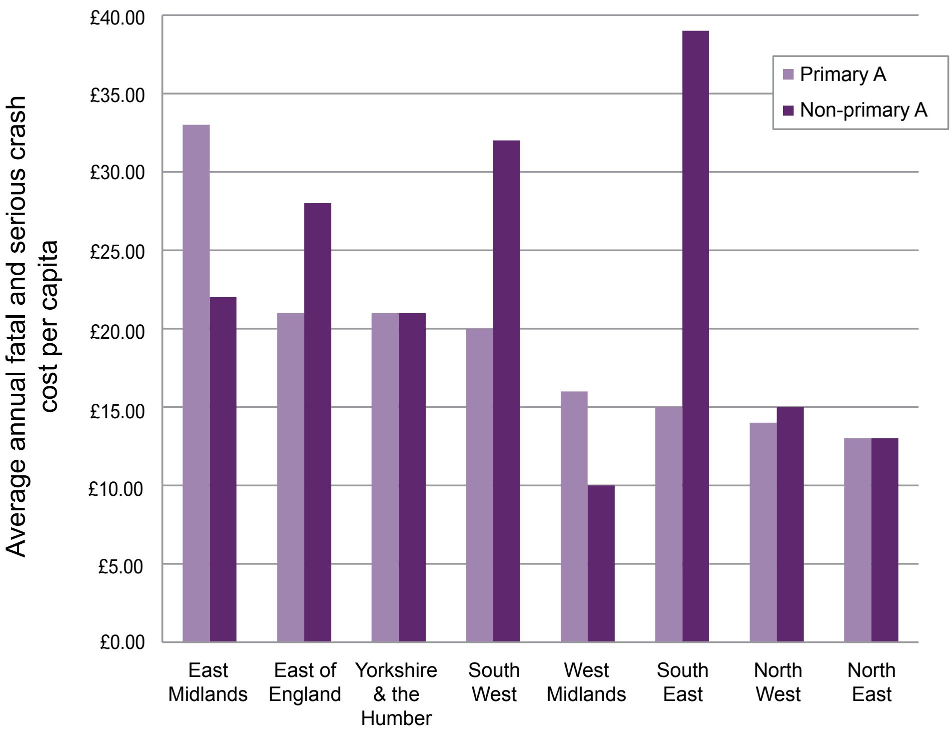
Per capita losses are high on non-primary A roads in all nations, with the greatest loss overall in Wales at £43 per person. The lowest economic losses are on the very short primary A road networks in Scotland and Wales.

With their major reliance and significantly high traffic volumes English motorways have the highest loss per person of £10 for the network.

Figure 9b shows fatal and serious crash cost per capita on primary and non-primary A roads, by English region.

Non-primary A roads on average account for a greater loss, at £24 per capita, compared to £19 for primary A roads. Of all English regions, the greatest losses on primary A roads fall in the East Midlands (£33 per capita). For non-primary A roads, losses are greatest in the South-East (at £39 per capita).

Figure 9b: Fatal and serious crash cost per capita on primary and non-primary A roads, by English region



	Primary A	Non-primary A	Average cost
East Midlands	£33	£22	£55
East of England	£21	£28	£49
Yorkshire & the Humber	£21	£21	£42
South-West	£20	£32	£51
West Midlands	£16	£10	£27
South-East	£15	£39	£54
North-West	£14	£15	£28
North-East	£13	£13	£27
Average cost	£19	£24	£43

Source: Authors own

3.3.4 Summary results: Scotland and Wales

Nowhere is the reliance on single carriageways greater than in Scotland and Wales. The quality of Scottish and Welsh road engineering is much admired, and the challenge of managing a long network over tougher terrains is formidable. Whatever the history and geography, the most recent British EuroRAP results (Hill, 2010a) finds the average risk rate (based on the number of fatal and serious crashes per billion vehicle km) for Scottish single carriageways to be the same as that for the whole of England. However, because Scottish road users have a much higher exposure to single carriageway than in other regions, Scottish trunk roads – and to a lesser extent those in Wales – need single carriageways to be above average in safety performance if the loss of GDP is to fall to the same level as England.

The Barnett formula, allocating block expenditure levels to Scotland and Wales at greater per capita levels than to England, was developed to take into account their greater road length as one of six key factors (Midwinter, 1999). Subsequently, it has been wholly for Scotland and Wales to decide on the expenditure levels they allocate to roads. This report makes it more transparent that there remains special safety issues in Scotland in particular, and that a national discussion about the investment levels and strategy for infrastructure safety is needed.

The economic investment strategy for Scotland and Wales will have a different shape from that for England, and be more focused on trunk roads (75% of all road deaths in Scotland are outside built-up areas). Discussion may benefit from examining the policies that other progressive less densely populated countries in northern Europe and Australia have been developing for their trunk roads.

3.3.5 Summary results: the Highways Agency network

A high proportion of total crash costs fall on the motorway and trunk road network operated by the Highways Agency. Of this, one-third is concentrated on motorways and two-thirds on the non-motorway network. Studies published in 2010 show the general deficiencies in the network: for example, in comparison with French auto-routes, British motorways have substantial deficits in run-off protection (Lawson, 2010). Junction and lay-by layouts on dual carriageways frequently fall below par. Single carriageways have substantial scope for safety improvement if approached with the determination currently being shown on Swedish national roads.

3.3.6 Summary results: Local Authority primary and non-primary A road networks

The single largest block of crash costs (61%) fall on the busy regional roads which are the responsibility of English local authorities. Of these, 60% fall on the non-primary network and the remaining 40% on the local authority primary route network, where there is likely to be a particularly strong case for higher levels of investment.

4. Establishing Minimum Rational Levels of Safety

Potential crash savings can be estimated on a route-by-route basis by setting benchmarks based on crash rates. However, setting benchmarks in this way fails to show whether action is needed in just one of the three areas of engineering, education, or enforcement, or in a combination of these. This section discusses the correlation between Risk Mapping and Star Rating and how the latter can be used to estimate crash risk based on engineering characteristics. The safety of Britain's motorway and A road network is assessed, and an affordable programme of improvement over the next decade presented, based on the setting of benchmark safety levels as is increasingly being adopted internationally. How such a programme would be rolled out, and the overall costs and benefits, is also presented. Detailed methodology is given in Annex 2.

4.1 Defining rational safety levels for Britain's roads

The majority of Britain's A roads carry substantial traffic flows, exposing significant numbers of road users to risk. Even an average daily flow of 3,500 vehicles implies more than 1 million movements per year, which is the threshold used in Sweden to trigger upgrading, including the provision of safety fence in the centre of single carriageways, and protected overtaking sections. Some British motorways expose more than 200,000 road users daily to risk, and we simply cannot afford them to lack basic safety features like roadside protection against aggressive objects such as trees and signing columns. In the next decade, at current risk rates, the M25 alone will see 1,000 killed or seriously injured.

Generally, as countries begin to manage safety to achieve measurable safety performance standards, the goal is to eliminate high-risk roads on the busiest part of the road network and move standards towards a minimum 3-star level. In 2008, the Dutch Transport Minister announced that the Netherlands would achieve a minimum RAP 3-star level on the national network by 2020. This announcement was made following an economic appraisal of the schemes required to do this, which confirmed that this operational target was in full harmony with the economic assessment. The Malaysian Government has made a similar announcement focusing on the 3-star level. Current international discussions for new road designs similarly are focusing on making explicit that new roads must achieve a 3-star safety standard for all road user groups. The Swedish Government has announced a programme that will see 75% of network mileage upgraded to the equivalent of a 3-star standard for roadside protection and overtaking protection by 2020. One hundred per cent coverage is programmed by 2025.

On the basis of the empirical evidence in Britain and the policy decisions being taken internationally, for this report we have tested the casualty savings and costs and benefits that would be realised if Britain were to benchmark a minimum 3-star standard for its motorways and A roads.

Table 8 sets out the benchmark Star Ratings by road type. Note that the safety level increases as roads become busier, such that Britain's intensively used motorways should achieve in future the highest 5-star level through consistency of safety detailing, particularly in respect of upgrading run-off protection. Single carriageway non-primary A roads are set at the low 3-star standard.

Table 8: Benchmark Star Ratings by road type

Road type	Benchmark Star Rating	Equivalent average risk rating (no. of fatal & serious crashes/ billion vehicle km)	Typical road features
Motorway	5-star	5	Infrequent grade-separated junctions; barriers protecting the roadside and along the median
Dual primary A	High 4-star	10	Grade-separated junctions; barriers protecting the roadside and along the median
Dual non-primary A	Low 4-star	15	Roundabouts or T-junctions with right turn lanes; barriers protecting the roadside and along the median
Single primary A	High 3-star	30	Roundabouts or T-junctions with right turn lanes; clear central hatching along the median and roadside hazards
Single non-primary A	Low 3-star	35	Roundabouts or T-junctions with right turn lanes; single white line only except at junctions and roadside hazards in most locations

Source: Authors own

Although systematic Star Rating inspections of the 45,000 km of Britain's A road network have not yet been carried out, it has been possible for the specific purposes of an aggregate economic evaluation to estimate the distribution of Star Ratings currently being achieved using road type, traffic flow and observed death and serious injury rates on approximately 2,000 road sections. The road types and risk combinations used are listed in Table 9, and the methodology applied is explained in Annex 2.

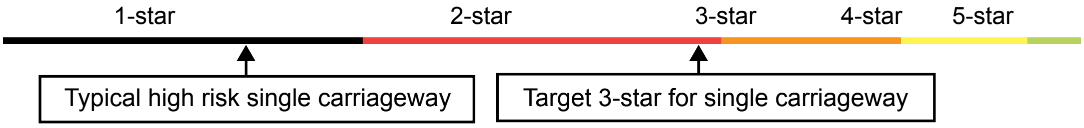
Table 9: Road types and risk categories used in estimation of Star Rating

Low	Low-medium	Medium	Medium-high	High
Single	Single	Single	Single	Single
Dual	Dual	Dual		
Motorway	Motorway			

Source: Authors own

A typical single carriageway rated high-risk on the EuroRAP Risk Map on this system would expect to score 1- or 2-star out of a possible 5-star. A 5-star road is one where the standards of protection for run-off, junctions, median and vulnerable users are fully safe for the speeds driven. Figure 10 illustrates what the methodology presented here seeks to achieve using an example of a high-risk (black) single carriageway by showing the extent of movement along the 5-star rating scale needed to achieve a benchmark safety standard.

Figure 10: Current and benchmark risk for a typical high risk single carriageway



Source: Authors own

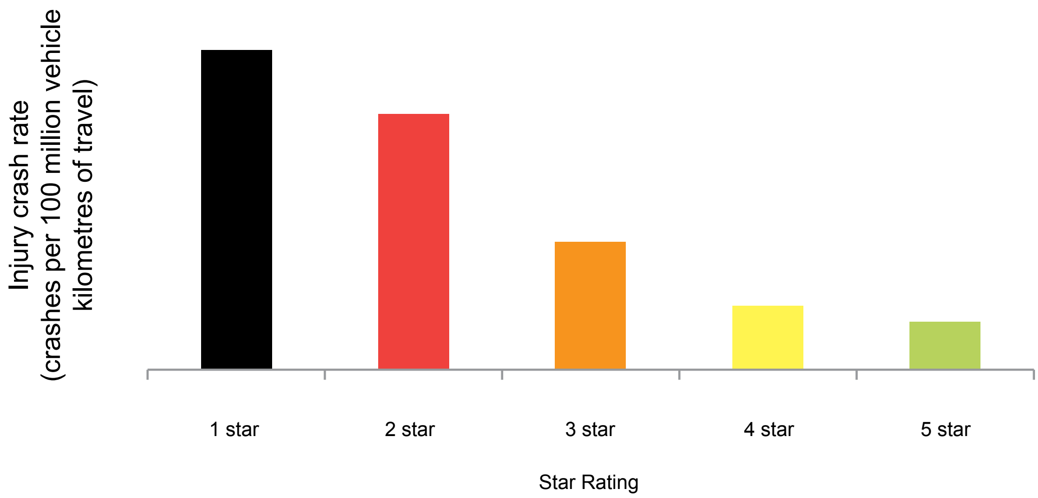
Where the estimated Star Rating of a route is lower than the benchmark level, potential crash savings and associated costs have been derived.

Studies (the majority unpublished) into the relationship between Star Rating and Risk Mapping have been carried out in Australia, Germany, Iceland, the Netherlands, New Zealand, Spain, Sweden (Stigson, 2009; Stigson *et al*., 2010), the UK and the USA (usRAP *et al*., 2009). A variety of different methodologies and approaches have been used and include (i) comparisons of Star Rating data with accelerometers in real world crashes; (ii) visual comparisons of crash rates and Star Rating maps; (iii) correlating average crash rates or crash costs with the Star Rating. These show a generally good correlation in aggregate between Star Rating and Risk Mapping, where decreasing average crash rates are associated with increasing Star Rating and vice versa. In other words, routes marked as high-risk on Risk Mapping are high-risk on Star Rating.

There have been particularly good matches between the Star Rating and average crash rates or costs where data sets are large and the routes being compared are relatively homogenous.

Figure 11 shows the crash rate per 100 million vehicle km travelled for each Star Rating on New Zealand roads (KiwiRAP, 2010) and clearly illustrates why national road safety policy focuses on upgrading 1– and 2-star roads to a 3-star standard.

Figure 11: Correlation between Risk Mapping and Star Rating



Source: KiwiRAP (2010: 9)

It is common in road assessment to know the total number of road deaths for a region, country or road but not the exact location of crashes along a route, or their distribution across a network. The RAP Star Rating protocol therefore incorporates a fatality estimation model used to allocate observed fatalities to individual road sections. Full details can be found in Annex 2.

4.2 Estimating the costs of the programme

Working with the Highways Agency and two local authorities, the historical costs of implementing 70 routine engineering countermeasures was surveyed from scheme records by the Road Safety Foundation in a separate, as yet unpublished, study. Results showed that the average cost per km of increasing the safety rating of a route by 1-star was:

- single carriageway: £200,000;
- dual carriageway: £350,000;
- mixed (single and dual) carriageway: £275,000;
- motorway: £500,000.

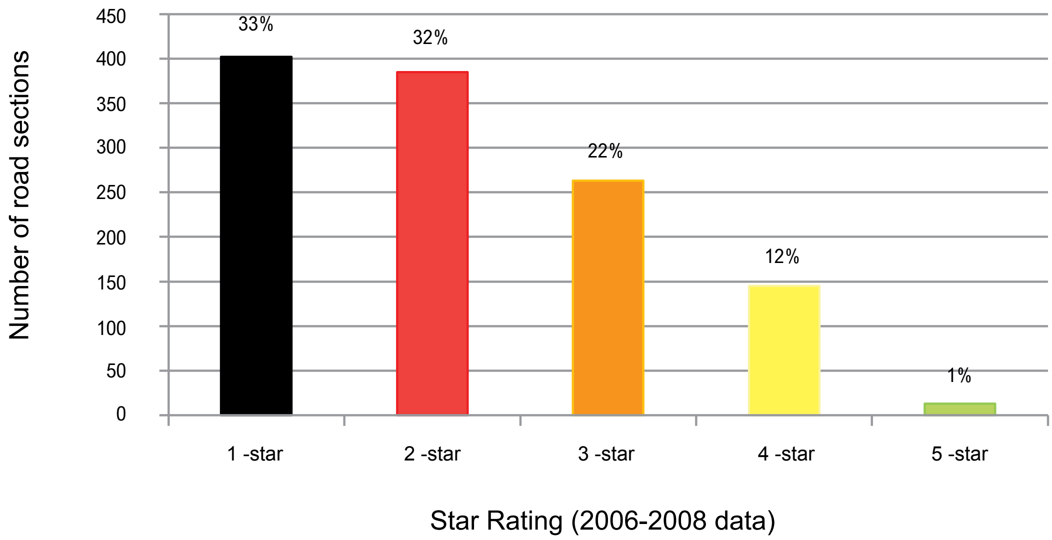
These cost estimates may be viewed as generally high for average figures. For example, raising the Star Rating of motorways and dual carriageways will usually require not a great deal more than the implementation of missing run-off protection. The budget provided above allows for more than the provision of safety fencing on both sides of the divided highway. However, it will often be found that safety fencing will be needed only to in-fill where it is missing; that only a small part of the motorway tree line, which has self seeded and encroached into the safety zone, will need removing; or that signs and poles can be replaced with collapsible ‘crash friendly’ design to modern standards.

Further, in implementing systematic longer-term programmes, authorities would find it easy to improve procurement practices. An earlier examination by the Road Safety Foundation found that the cost for implementing piecemeal sections of safety fence in Britain compared with large-scale programmes in Sweden led to British rates being some ten times higher. Bulk procurement alone will lead to significant cost savings.

4.3 Estimating the benefits and costs of achieving safe roads

Figure 12 shows the current estimated distribution of Star Ratings across Britain’s A road and motorway network, before investment to upgrade those road categories to benchmark levels (5-star for motorways, high 4-star for dual primary A, low 4-star for dual carriageway non-primary A roads and high 3-star for single carriageway primary A roads as shown in Table 8). The setting of minimum Star Ratings for safety performance would in practice mean implementing improvements on approximately 50% of motorway and A road network sections across Britain.

Figure 12: Estimated distribution of Star Ratings across Britain's A road and motorway network before investment



Source: Authors own

Implementing the new minimum safety standards would result in an estimated annual saving of nearly 600 lives a year in addition to significant savings in trauma and crash cost. Table 10 shows the estimated savings at a present value of £34 billion over a 20-year economic life (the parameters used in the evaluation are set out in Annex 2). This prize will require capital investment estimated at £8.2 billion over 20 years and yield a BCR of 4. Although the costs and benefits have been assumed to be incurred in year 1, the programme in practice would be best spread over the next decade at £820 million p.a. In light of current road funding, the average annual cost of the programme represents less than 10% current annual spending on road maintenance.

Costs per person for upgrade would be £110 in England, £341 in Scotland and £249 in Wales. Therefore over ten years if everyone spent £11 in England, £34 in Scotland and £25 in Wales anually there would be savings per person per year of £27 in England, £42 in Scotland and £39 in Wales for 20 years.

Overall, the programme would result in an estimated saving of 40% of fatalities and one-third of serious injuries on the total test network. If this programme were combined with maintaining the solid existing programme in urban cores and treatment of very high-risk locations on minor local authority roads, then a total saving of one-third of all deaths would be achievable from engineering measures alone representing around 0.5% of GDP. The savings would be further amplified if other education, enforcement and vehicle safety programmes were in place.

A programme such as the one examined here would be implemented over a decade. Discussions with local authority managers have revealed that much of the safety upgrading might be undertaken in parallel with routine maintenance. This means that the incremental costs might be much smaller where smart maintenance took place: old unsafe features would not be renewed but rather replaced by newer safer layouts. A significant long-term programme of safety upgrading would also challenge internal authority procurement systems that currently load smaller engineering schemes in a way that does not reflect true market cost.

4.3.1 Phasing

If the phasing approach adopted in Sweden, of 75% of all major roads upgraded to the equivalent of a 3-star standard for roadside protection and overtaking protection by 2020 were followed in Britain, then 75% of the total programme might be implemented in the initial decade. While savings are foregone, this approach provides more operational scope to ensure that all schemes programmed have the highest returns, increasing the programme BCR and lowering the initial cost. As shown in Table 10, the 75% programme has a present value of £26 billion and a cost of £4.6 billion. The BCR is 6 and the annual cost is £460 million.

Table 10: Benefits and costs for different programme sizes

Programme size	Benefits	Cost	BCR	Average cost p.a.
100%	£34 billion	£8.2 billion	4	£820 million
75%	£26 billion	£4.6 billion	6	£460 million
50%	£17 billion	£2.4 billion	7	£240 million
25%	£ 8 billion	£0.9 billion	9	£90 million

Source: Authors own

Table 10 also allows the incremental costs and benefits of alternative programmes to be revealed, and shows that all programmes maintain high returns. For example, the incremental cost of moving from the 50% programme to the 75% programme is £2.2 billion but the incremental benefits are over four times as high at £9 billion.

4.3.2 Distribution of costs and benefits

Analysis of costs and benefits based on the minimum safety levels reveals surprising consistency in the rates of return across the British nations and road types, as shown in Table 11. BCRs are based on the assumption that all routes that can be upgraded are subjected to safety improvements. Generally, rates of return are highest in England and higher in Wales than Scotland, but all road types and locations give attractive BCRs.

Table 11: Benefit-cost ratios by programme size, nation and road type

		BCR by programme size	
Road type	**Nation**	**100%**	**75%**
Motorway	England	6	7
	Scotland	4	7
	Wales	5	5
Dual trunk A	England	5	6
	Scotland	3	5
	Wales	3	4
Dual primary A	England	6	7
Dual non-primary A	England	5	9
	Wales	9	9
Mixed (single & dual) trunk A	England	4	5
	Scotland	2	4
	Wales	4	5
Mixed (single & dual) primary A	England	4	5
Mixed (single & dual) non-primary A	England	5	6
	Scotland	3	4
	Wales	5	6
Single trunk A	England	5	6
	Scotland	2	4
	Wales	2	4
Single primary A	England	5	5
	Scotland	3	4
	Wales	7	7
Single non-primary A	England	5	6
	Scotland	2	6
	Wales	3	6

Source: Authors own

The costs of upgrading the network to benchmark safety levels by road type are shown in Table 12.

Table 12: Cost by programme size, nation and road type

		Costs by programme size million (rounded to £0.1 million)	
Road type	**Nation**	**100%**	**75%**
Motorway	England	£585.4	£483.5
	Scotland	£57.8	£8.8
	Wales	£46.2	£46.2
Dual trunk A	England	£470.6	£347.0
	Scotland	£101.3	£10.0
	Wales	£13.8	£6.4
Dual primary A	England	£145.0	£112.2
Dual non-primary A	England	£65.3	£30.5
	Wales	£1.1	£1.1
Mixed (single & dual) trunk A	England	£476.2	£284.7
	Scotland	£167.2	£22.5
	Wales	£33.0	£23.0
Mixed (single & dual) primary A	England	£372.0	£278.5
Mixed (single & dual) non-primary A	England	£122.4	£100.0
	Scotland	£6.5	£1.9
	Wales	£43.8	£33.5
Single trunk A	England	£353.6	£273.6
	Scotland	£578.8	£79.0
	Wales	£343.0	£53.0
Single primary A	England	£1.616.4	£1.240.2
	Scotland	£184.2	£70.2
	Wales	£1.7	£1.7
Single non-primary A	England	£1.435.3	£931.3
	Scotland	£667.6	£104.9
	Wales	£262.0	£89.5

Source: Authors own

Figure 13 shows the costs of upgrading the network to benchmark safety levels on a per capita “postcode” basis In England based on a ten year period. Typical costs would equate to around

£7 per person per annum over the decade rising to £34 in Scotland. Of the English regions, costs would be highest in the South-West (£17 per person) and lowest in the North-East (£7 per person).

Figure 13. Costs of upgrading the network to minimum safety standards per capita across Britain

Source: Authors own

5. Generating and Evaluating Road Safety Programmes

Section 5 reports on a survey undertaken for this report on the current practices and methods used by local road authorities for the generation and evaluation of road safety schemes across Britain. Here we set out initial findings, conclusions and recommendations.

5.1 Current practice in road safety scheme evaluation

There is currently no standard or prescribed procedure for assessing the priority of road safety schemes at local authority level, whether funded from capital or revenue streams. Each authority will be influenced by a range of factors, including local policies and priorities, the results of crash data analysis, and the authority's own level of skill and capacity for innovation.

Many authorities have progressed from the crash investigation focus on cluster analysis and local remedial solutions which began in the 1930s. This approach served Britain well for half a century until major black spots were largely eliminated and the phenomenon of false clusters arising by chance became more common. Authorities today following best practice remain watchful of local clusters, but are beginning to focus on proactive assessments removing known high risks along routes.

The approaches of the individual authorities are, however, far from consistent, which makes it difficult to compare their performance in achieving safety improvements, or to provide convincing evidence about which methods of assessment will deliver the best results for their local communities. The DfTs Strategic Framework for Road Safety will steer the approach for the next decade and beyond and is scheduled for release in Spring 2011. It is therefore a key time to focus on how priorities are determined for future investment in safer road infrastructure, and on the knowledge base and guidance needed by authorities for its consistent implementation.

Initial contact was made with local authorities to test the support for a comparative survey of existing methods of setting priorities for schemes and to determine what data was likely to be available. The relevant senior officers of authorities outside conurbations were then contacted through the ADEPT Traffic and Safety Working Group at the end of July 2010, with follow-ups in September. Authorities were asked to respond to a questionnaire (see Annex 3) covering three main categories of information regarding their approach to investment in route safety improvements: (1) collision rates and severity weightings used; (2) collision data source and periods assessed; and (3) economic evaluation methods used.

Eighteen responses were gained from the resulting questionnaire. A summary of the responses is set out below. The responses showed a variety of approaches to assessments, and revealed that nearly one-third still use cluster site analysis alone and have not committed resources to assessing the safety of routes.

5.1.1 Crash rates used for route safety assessments

Some authorities used more than one collision rate for assessment, and in some cases undertook a staged approach with different rates for each stage. It was also noted that some authorities used collision rates for speed limit reviews on A and B roads, with or without assessments for route safety schemes.

Varying approaches were used to calculate collision rates and a variety of weightings were used to give more or less importance to death, serious injury and slight injury, and to vehicle occupants, motorcyclists, pedestrians, cyclists, and to children.

The measures used to assess crashes per km were distributed as follows:

- 5 authorities used a ‘crashes per km’ measure with varied weighting for death, serious or slight injury;
- 3 authorities used killed or seriously injured crashes per km;
- 1 authority used ‘casualties per km’ with a weighting of 3:2:1 for fatal, serious and slight injuries;
- 3 authorities used all crashes per billion vehicle km;
- 2 authorities used all casualties per billion vehicle km;
- 1 authority used killed and seriously injured per billion vehicle km for speed limit reviews on A and B roads.

Where weightings were used these varied widely. Examples of those given were:

- 2:2:1:2 for death, serious, slight and vulnerable user crashes respectively;
- 5:3:1:0 for death, serious, slight and damage-only respectively;
- 90:10:1:0 for death, serious, slight and damage-only crashes respectively.

Some authorities used more than one collision rate for assessment, and in some cases undertook a staged approach with different rates for each stage or purpose. Variations used included:

- all crashes per billion vehicle km;
- number of injury crashes;
- slight injury crashes per km.

Some authorities brought in additional measures at a second stage of prioritisation, after locations had already been identified for detailed examination using a simpler measure – for example, examining the percentage of deaths and serious injuries once a location had been identified with a high injury rate.

5.1.2 Crash data sets

The STATS19 data for recording crashes involving personal injury constitute the norm on which assessments are made. Records for damage-only crashes are generally not used, often being unavailable or incomplete. The 3-year defined period of the STATS19 data was used by the majority of respondents (11 authorities) for assessment but six authorities took account of five years, and three authorities took account of 10 years of historic data. Some authorities also made direct reference to the internationally standardised annual British EuroRAP data to provide an additional check on potential scheme priority assessment.

5.1.3 Economic evaluation

Over half of authorities calculated an expected FYRR to show the initial crash benefits of a scheme.

In evaluating schemes most of the responding authorities compared three years of crash data before and after scheme implementation, with one using assessment over five years. Only two authorities had assessed whole life costs against crash and/or casualty savings, and one was considering the use of net present value based whole life costing assessment.

A number of the respondents set minimum values for expected FYRR, with values ranging from 50% to 200% p.a. (i.e. the intervention would continue to save a further death or serious injury each subsequent year implying that costs per death and injury saved are less than £10,000 each depending on the discount rate and discount period used). Five authorities expressed a capability to assess actual cost per casualty saved, whilst four could assess the intervention cost per killed and seriously injured casualties saved.

Two authorities had undertaken evaluations of previous schemes which typically achieved an intervention cost of less than £100,000 per killed and seriously injured casualty saved (this compares with the current average cost to society of over £300,000).

The economic valuations used by authorities for the costs crashes were generally those provided by the DfT WebTAG.

In summary, the survey found local authorities practice in the assessment of projects to remove known high-risks from routes to be wide-ranging and varied. While the use of accident or casualty data based on police records of injury accidents is consistent, the degree and level of evaluation is variable both in terms of the amount of analysis undertaken and the methods used.

A significant minority of authorities have yet to view route assessment and the removal of known high-risks as a priority investment, because they are still engaged in local cluster site analysis and accident remedial schemes. There are a few authorities who have completed a review of all their main routes, and have implemented and evaluated route safety schemes during the past decade.

It is also clear from the local authorities' responses that there is a wide range of data used for assessing the justification, priority and performance of route safety schemes, and that no two authorities have exactly the same system of assessment. However, there is one common theme, in that the variations all use some form of accident or casualty data based on police records of injury accidents. Most use a rate per km, but in some cases the level of traffic flow is also taken into account.

Despite the variation in approach, many authorities warmly support the case for investment in route safety improvements, and there is both the expectation and evidence of the high levels of return that can be achieved. Figures reported by authorities suggest that most are still able to recommend schemes that deliver at least 100% FYRR, with some gaining returns in excess of 200%. These rates of return are regarded as unexceptional and are used as hurdle rates in some authorities.

The survey findings are clearly not at odds with the OECD view internationally that institutional management arrangements need attention if economic investment in crash cost reduction is to be brought forward in Britain.

5.2 Supporting standardisation with professional guidance

The survey revealed an appetite on the part of authorities for improved guidance on generating and evaluating safety schemes. While some of the local variations in approach are fully compatible with empowering local choices, many technical parameters used are pragmatically chosen for want of advice or standardised guidance. Guidance meeting authorities needs reduces training and development costs, draws on up-to-date research and knowledge, and provides more powerful tools. At worst, arbitrary differences between authorities act to obstruct transparency in authority performance and the transfer of best practice.

Guidance developed separately from this project by the Road Safety Foundation in consultation with national and local road authorities defines preferred data sets, and the recommended core process for identification and evaluation of priority route interventions. This process is based on the systems of crash risk mapping and road inspection methodologies which have been established in the UK during the last decade and used worldwide.

A national system of performance tracking should support implementation of guidance to enable comparison and sharing of good practice and results, and provide a broader evidence base for future investment in strategic and local route level priorities. For example, some local authorities have in the past used MOLASSES[6] and other data collation tools developed for national use and the collation of data, particularly for Local Transport Plans. Guidance on standard post-programme reviews ('before and after' studies) is essential for continuous improvement in value engineering of safety programmes.

[6] The Monitoring Of Local Authority Safety SchemES (MOLASSES) database was initiated by the Country Surveyors' Society's (CSS's) 'Accident Reduction Working Group' in1991, in an attempt to encourage more monitoring of safety engineering work undertaken by highway authorities. In 1993 TRL agreed to take it over and has been in charge of its operation since that time. The data in MOLASSES are supplied voluntarily by local authorities and to provide information on its effectiveness.

It is recommended that the Strategic Framework for Road Safety enable a consistent approach to assessment, prioritisation, and evaluation of route safety schemes, so that performance tracking can be achieved with outcomes being more directly comparable.

There are three main sets of data required for route safety assessment and priority setting:

- data on reported collisions/casualties;
- traffic flows (AADT); and
- description of existing route infrastructure (road type, layout, and safety related parameters).

These data sets need to be used in a systematic way to:

- understand the safety problems on routes and their component sub-sections;
- identify historic safety rates, and thereby rank the route sections in priority order for initial investigation;
- examine the options for introduction of safety improvement measures and assess their relative benefits and costs;
- refine the priority ranking, and assist the practitioner in making decisions on recommending schemes for priority implementation;
- provide a means of evaluation that supports both the decision to proceed with a scheme and to monitor its effectiveness over time; and
- enable comparison of results for performance tracking, both locally and nationally.

More specifically, consistency would be encouraged by the use of standard assessments of crash and casualty rates related to any proposed goals for casualty reduction and required for performance tracking reporting. For example, if the goals are expressed in killed and seriously injured casualties, the assessment collision rate used could be standardised to this measure either on a per km or per vehicle km basis. Alternatively, as most authorities tend to use crashes rather than casualties as their base data, it would be possible to standardise on fatal and serious crashes, but with recognition of the need to monitor the casualty/crash ratios for performance tracking purposes.

The Strategic Framework for Road Safety should also recommend – but not mandate – weightings for casualty severity and type. If the Framework helps to reform the institutional management of safety programmes so that funding is able to flow to the most economic programmes, then it is more likely that there will be wide acceptance that these weightings should be based on the DfT crash costs that are nearly universally used by authorities in their evaluation.

An understanding and incorporation of other relevant data, including the annual EuroRAP results for Great Britain showing high-risk roads and performance tracking of improvements, would assist local authorities in their road safety analysis and determination of priorities for route safety investment. Some authorities already use such data and have demonstrated progress in risk rate reduction.

Whilst the use of FYRR calculation is useful to highlight the immediate benefits of route safety improvements, these must be more fully assessed using a 20-year whole life cost-benefit analysis in order that casualty reduction programmes can be properly compared with other competing programmes.

5.3 The integration of maintenance and safety programmes

Using a whole life cost approach to plan, evaluate and prepare schemes also becomes essential if major programmes to reduce crash cost are to be properly generated. This is because the implementation of safety upgrading will achieve the highest returns over the decade 2011-2020 if rolled out with essential and preventative maintenance.

Highway maintenance is likely to remain relatively strong amongst local authorities, some of whom are still repairing the effects of severe weather over recent winters. Priority is therefore likely to be given to maintenance-related safety partly to limit liabilities for claims and partly to be responsive to complaints from the public about road condition. Whilst this may appear to have a negative effect on the funding available for road safety schemes, it presents a real opportunity to encourage better coordination of long-term programmes. The growth of asset management plans within local authorities provides a positive system for planning long-term co-ordinated investment in maintenance and safety programmes.

6. Summary of Key Findings and Recommendations

This report aims to assist government in the preparation and implementation of the Strategic Framework for Road Safety. Many of the key findings and recommendations have direct relevance to the Framework.

- In the decade 2011-2020, an average km of this network can expect to see £1 million of loss in crashes involving death and serious injury alone. The inclusion of all injuries and damage broadly doubles this estimated cost.
- Every year Britain suffers serious injury crash costs of £0.5 billion on motorways, £1 billion on national trunk roads, and £2.5 billion on local authority A roads – 40% therefore incurred by incidents on motorways and trunk roads.
- The Highways Agency network is Britain's single largest crash cost centre with £1.2 billion of serious crash cost annually on its motorways and trunk roads (excluding substantial resulting traffic delay costs).
- The largest block of serious crash cost is on local authority roads. English local authorities lose £2 billion annually on their A roads.
- Britain should set benchmarks for infrastructure safety that are achievable by authorities in the period 2011-2020, to be implemented particularly during the course of routine maintenance.
- Transport ministers and local authority leaders should follow recent OECD recommendations and best international practice to set ambitious goals for the safety of the roads for which they are responsible, based on the economic case for action.
- Senior policymakers in each responsible road authority should call for the generation and evaluation of a programme of crash cost reduction measures, and evaluate these programmes objectively and transparently alongside other priority programmes.

- The cost of road crashes on main roads should be published by the Road Safety Foundation annually for each authority, alongside its annual report tracking the risk of fatal and serious crashes on Britain's motorways and main roads.

- Elected Local Authority leaders, together with the public, should be provided with accessible published information, including annual independent critique, on the safety performance of the road infrastructure for which they are responsible.

- The Highways Agency, as Britain's single largest crash cost centre, should act as a model "best practice" institution, leading a stretching crash cost reduction programme from which authorities throughout Britain can learn.

- The Strategic Framework for Road Safety should support the professional associations, relevant expert charities and Highways Agency in developing professional guidance on the generation and evaluation of crash cost reduction programmes.

- Parliament and the Treasury should examine the value for money that can be provided by programmes to reduce death and injury and investigate how institutional barriers to rational investment and priority setting can be overcome.

- Technical improvements to the evaluation of crash cost and to the recording of serious crashes by police and hospitals should be made. In particular, more focus is needed in evaluating the cost of long-term care and the true financial costs of road crashes to healthcare and emergency services.

- The insurance industry should study carefully the initiatives in other countries in which the cost of damage and bodily injury claims have been driven down successfully through programmes to improve the safety of infrastructure.

- Scotland, and to a lesser extent Wales, should review what lessons could be drawn from the approach to infrastructure safety outside built-up areas in other progressive, but less densely populated countries, including Australia and northern Europe.

7. Conclusions

This report, using published research, new surveys and analysis, has shown that it is possible for Britain to pursue an affordable, high-return programme of national significance to reduce the cost of road crashes which currently amount to 1.2-2.3% of GDP annually.

To achieve this will require the government's Strategic Framework for Road Safety to address the institutional management issues raised by the OECD and focus on enabling economically rational high-return investment.

A crash cost reduction programme could be achieved in the period 2011-2020 through the key instrument of defining minimum levels of infrastructure safety and encouraging the upgrading of the 40% of motorways and A roads that currently fall below this level. Benchmarking just 4% of British roads in this way would bring benefits worth more than £30 billion over 20 years and save 6,000 lives over a decade whilst also preventing hundreds and thousands of injuries.

This programme is fully compatible with empowering local communities if accompanied by support for publication of independent and transparent information on safety levels that are being achieved, alongside the professional guidance on programme generation and evaluation which authorities seek.

The Highways Agency, for which the Secretary of State is responsible, has the single largest concentration of crash costs in Britain and the skills that can be used as a reference model for all authorities.

Unlike other major transport projects, this national initiative is modular and decentralised, and has benefits spread across every community. It has a very low risk of cost overruns or investment which fails to deliver promised benefits. Its rate of return is higher than most, if not all, competing programmes of national significance, and a target benefit-cost ratio can be set very comfortably at 5 or above.

Recent developments in asset management systems permit very high returns if safety upgrading is implemented as the norm during routine essential and preventative maintenance. Integrating maintenance and safety upgrading permits substantial economies with no more than reasonable skill in procurement, value engineering and evaluation.

The programme is affordable at less than 10% of existing spending on road maintenance by setting priorities based on the returns available.

The economic outcome of the programme would be a substantial reduction in costs to the health services, long-term care, emergency services, business and families. The social outcome would be a major reduction in the misery that sudden, violent death and crippling injury brings to families and society as a whole.

8 References

Affuso, L., Masson, J., & Newbery, D. (2003). *Comparing investment in new transport infrastructure: Roads versus railways?* Fiscal Studies. 24(3).

Allsop, R. (2008). Personal communication.

Allsop, R. (2011). Personal communication.

Association of British Insurers (2010a). *UK Insurance: Key Facts.* September 2010. Retrieved 9 March 2011 from www.abi.org.uk/Facts_and_Figures/53732.pdf

Association of British Insurers (2010b). *Analysis of the UK Motor Insurance Market 2009.* Data Bulletin. August 2010.

Atkins (2006). *Delivering Better Local Transport: Key Achievements and Good Practice form the First Round of Local Transport Plans*, London: Atkins.

Atkins (2009). *Contribution of Local Safety Schemes to Casualty Reduction.* Road Safety Research Report No. 108. London, DfT. Retrieved 9 March 2011 from www.dft.gov.uk/pgr/roadsafety/research/rsrr

Audit Commission (2010). *Best Value Performance Indicators.* Retrieved 9 March 2011 from www.audit-commission.gov.uk/localgov/audit/nis/pages/default.aspx.

AusRAP (2008). *Comparing Risk Maps and Star Ratings – AusRAP Technical Working Paper, April 2008*. Australian Automobile Association. Retrieved 9 March 2011 from www.aaa.asn.au/documents/reports/2008/Comparing_Risk_Maps_and_Star_Ratings_FINAL_(web).pdf.

Automobile Association (2009). *British Insurance Premium Index. First Quarter 2009.* Retrieved 9 March 2011 from www.theaa.com/motoring_advice/news/aa-british-insurance-premium-index-april09.pdf

Bain, G. (2002). *The Future of the Fire Service: Reducing Risk. Saving Lives – The Independent Review of the Fire Service.* London: Department for Communities and Local Government.

Chilton, S., Covey, J., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N. & Spencer, A. (1998), *New Research results on the valuation of preventing fatal road accident casualties. In Road Accidents Great Britain 1997. The Casualty Report*. London, Department of the Environment, Transport and the Regions.

COBA (2006). Table 13/1 *Components of accident aosts (2002 values and prices)*. In the COBA manual. Part Two. The Valuation of Costs and Benefits. DfT, May 2004. Retrieved 9 March 2011 from webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/economics/software/coba11usermanual/part2thevalofcostsandb3154.pdf.

Confused.com (2009). *Claims Gulf between Young and Old Calls for Motor Insurance Education*. Press release, 24 August. Retrieved 9 March 2011 from www.confused.com/corporate/press-room/general/claims-gulf-between-young-and-old-calls-for-motor-insurance-education-says-confused-com-737407271.

Department of Health (1999). *Saving Lives: Our Healthier Nation.* Retrieved 9 March 2011 from www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4049329.pdf.

Department of Health (2007). *Injury Costs Recovery Scheme*. Retrieved 9 March 2011 from www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_065276.pdf

Department of Health (2010). *The NHS Injury Costs Recovery (ICR). Scheme – Amounts Collected. Totals for England, Scotland and Wales – 1 April 2010 to 31 March 2011*. Retrieved 9 March 2011 from www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_124125.pdf

Department for Transport (2005). *Guidance on Value for Money: Explanatory Note.* Retrieved 9 March 2011 from www.dft.gov.uk/about/howthedftworks/vfm/guidanceonvalueformoneyexpla1006

Department for Transport (2006). *Cost Benefit Analysis.* TAG Unit 3.5.4. February 2006. http://www.dft.gov.uk/webtag/documents/expert/pdf/unit3.5.4.pdf.

Department for Transport (2009a). *Reported Road Casualties Great Britain: 2008 – Annual Repor*t. Retrieved 9 March 2011 from http://www.dft.gov.uk/pgr/statistics/datatablespublications/accidents/casualtiesgbar/rrcgb2008

Department for Transport (2009b). *A Safer Way: Consultation on Making Britain's Roads the Safest in the World.* London, DfT. Retrieved 9 March 2011 from www.dft.gov.uk/consultations/archive/2009/roadsafetyconsultation/roadsafetyconsultation.pdf.

Department for Transport (2010a). *Reported Road Casualties Great Britain: 2009*. London, DfT. Retrieved 9 March 2011 from. www.dft.gov.uk/adobepdf/162469/221412/221549/227755/rrcgb2009.pdf

Department for Transport (2010b). *The Accidents Sub-Objective. TAG Unit 3.4.1. Transport Analysis Guidance.* London, DfT. Retrieved 9 March 2011 from www.dft.gov.uk/webtag/documents/expert/pdf/unit3.4.1d.pdf

Department for Transport (2011). *Transport Statistics Bulletin. Reported Road Casualties in Great Britain. Quarterly Provisional Estimates Q3 2010*. DfT, February 2011. Retrieved 9 March 2011 from http://www.dft.gov.uk/pgr/statistics/datatablespublications/accidents/rrcgbq32010

de Rus, G. & Nash, C. A. (2007). *In what circumstances is investment in high speed rail worthwhile?* Working Paper 590. Leeds: Institute for Transport Studies, University of Leeds.

Dodgson, J. (2007). *Rates of Return on Public Spending on Transport.* London, RAC Foundation. Retrieved 9 March 2011 from http://www.ijonline.com/Downloads/Marketing/2db419d3-c592-44ef-bc8e-c1f0e2431a8c.pdf.

Eddington, Sir Rod. (2006a). *The Eddington Transport Study. Main Report: Transport's Role in Sustaining the UK's Productivity and Competitiveness*. London, HMSO.

Eddington, Sir Rod. (2006b). *The Eddington Transport Study. The Case for Action: Sir Rod Eddington's Advice to Government.* London, HMSO.

Elliot, C. (2009). *Transport Safety: Is The Law an Ass?* London, RAC Foundation. Retrieved 9 March 2011 from www.racfoundation.org/assets/rac_foundation/content/downloadables/transport%20safety%20-%20elliott%20-%20050509%20-%20report.pdf.

Elvik, R. (2010). *The Importance of Better Data on Traffic Injury – State of The Art.* Presentation given at European Road Safety Day. Brussels. 13 October.

Evans, A. W. (2006). *Economic Appraisal of Road Safety Measures in Great Britain*. Paper for 2nd International Symposium on Road Safety. Hong Kong. 5 August.

High Speed Rail Two (HS2) Limited (2010). *High Speed Rail – London to the West Midlands and Beyond*. A Report to Government by High Speed Two Limited, Part 9 of 11. London, HS2 Ltd. Retrieved 9 March 2011 from
www.dft.gov.uk/pgr/rail/pi/highspeedrail/hs2ltd/hs2report/pdf/chapter4.pdf

Hill, J. (2008). *Getting Ahead: Returning Britain to Leadership in Casualty Reduction.* RSF 02/08, Road Safety Foundation. Retrieved 9 March 2011 from
http://eurorap.org/library/pdfs/20100629-RSFreportweb_final.pdf.

Hill, J. (2010a). *Saving Lives for Less: Identifying the Network on which Britain's Road Deaths are Concentrated. EuroRAP 2010 Results.* RSF 2/10, Road Safety Foundation, July 2010. Retrieved 9 March 2011 from www.roadsafetyfoundation.com/dowloads/RSFreportweb.pdf.

Hill, J. (2010b). *How Safe Are You on Europe's Trade Routes? Measuring and Mapping the Safety of the TEN-T Road Network.* EuroRAP, 2010. Retrieved 9 March 2011 from http://ten-t.eurorap.org/.

Home Office (2010). *Guidance on Statutory Performance Indicators for Policing and Community Safety.* Part of the Policing Performance Technical Guidance. Performance Strategy Directorate. London, Home Office.

Hopkin, J.M. & Simpson, H.F (1995). *Valuation of Road Accidents*. TRL RR163, Crowthorne.

HM Treasury (2003). *The Green Book: Appraisal and Evaluation in Central Government Treasury Guidance.* London, TSO. Retrieved 9 March 2011 from
www.hm-treasury.gov.uk/d/green_book_complete.pdf.

HM Treasury (2007). *Managing Public Money*. London, TSO. Retrieved 9 March 2011 from www.hm-treasury.gov.uk/d/mpm_whole.pdf.

HM Treasury (2010a). T*otal Place: A Whole Area Approach to Public Services.* HM Treasury, March 2010. Retrieved 9 March 2011 from www.hm-treasury.gov.uk/d/total_place_report.pdf.

HM Treasury (2010b). Spending Review 2010. TSO, October 2010. Retrieved 9 March 2011 from http://cdn.hm-treasury.gov.uk/sr2010_completereport.pdf.

HM Treasury (2010c). *Budget Statement by the Chancellor of the Exchequer.* Retrieved 9 March 2011 from www.hm-treasury.gov.uk/junebudget_speech.htm.

International Road Assessment Programme (2008). *Safety First: How Road Authorities in London are Reversing the Trend*. Retrieved 9 March 2011 from http://www.irap.org/media/1488/Case_Study_London_TfL.pdf.

KiwiRAP (2010). *How Safe Are Our Roads? Star Rating New Zealand's State Highways*. New Zealand Road Assessment Programme. Retrieved 9 March 2011 from www.kiwirap.org.nz/pdf/KIWIRAP%202010%20book%20low%20res.pdf.

Koornstra, M., Lynam, D., Nilsson, G., Noordzij, P., Pettersson, H-E., Wegman, F. & Wouters, P. (2002). *SUNflower; A Comparative Study of the Development of Road Safety in Sweden, the United Kingdom, and the Netherlands*. SWOV, Leidschendam, the Netherlands. Crowthorne, TRL.

Lawson, S. (2010). *Protect and Survive: Star Rating England's Trunk Road Network for Safety.* January 2010. Road Safety Foundation, January 2010.

www.eurorap.org/library/pdfs/20100124_RPS_GB_Popular_Report.pdf.

Liebling, D. (2010). *International Modal Comparisons.* RAC Foundation Report Number 10/109b, August 2010. London, RAC Foundation.

Lynam, D., Nilsson, G., Morsink, P., Sexton, B., Twisk, D., Goldenbeld, C. & Wegman, F. (2005). *SUNflower+6 – An Extended Study of the Development of Road Safety in Sweden, the United Kingdom and the Netherlands.* Crowthorne, TRL.

MacMahon, K. & Dahdah, S. (2008). *The True Cost of Road Crashes: Valuing Life and the Cost of Serious Injury.* IRAP, 2008. Retrieved 9 March 2011 from www.irap.org/media/1511/iRAPValueoflifeseriousinjurypaper.pdf.

Midwinter, A. (1999). The *Barnett Formula and Public Spending in Scotland: Policy and Practice*. Scottish Affairs, 28.

Motor Insurers' Bureau (2010). *UK Drivers Have Some Front – 1 in 5 Young Drivers Admit to Fraud.* Press release, February 2010. Retrieved 9 March 2011 from www.mib.org.uk/NR/rdonlyres/6084928F-AD5D-463F-B178-D0DA346C1F4C/0/MIBAvivaFrontingreleaseFINAL.pdf.

National Institute for Clinical Excellence (NICE) (2010). *Preventing Unintentional Injuries Among Children and Young People Aged Under 15 – Road Design and Modification*. Public health guidance PH31, November 2010. Retrieved 9 March 2011 from www.nice.org.uk/nicemedia/live/13273/51626/51626.pdf.

Office for National Statistics (ONS) (2010). *Mortality Statistics: Deaths Registered in 2009.* Retrieved 9 March 2011 from www.statistics.gov.uk/downloads/theme_health/dr2009/dr-09.pdf.

Organisation for Economic Co-operation and Development (OECD) (2008). *Towards Zero: Ambitious Road Safety Targets and the Safe System Approach*. OECD Publishing.

Privilege Insurance (2005). *Accident Survey: 'Hidden' Road Accidents Hit New High.* Press release, April 2005. Retrieved 9 March 2011 from www.privilege.com/aboutus/accident_survey.htm.

Select Committee on Transport (2008). Progress towards the 2010 targets. In *Eleventh Report.* Retrieved 9 March 2011 from www.publications.parliament.uk/pa/cm200708/cmselect/cmtran/460/46004.htm.

Simpson H. F. (1996). *Comparison of Hospital and Police Casualty Data: A National Study.* TRL Report 173, Crowthorne.

Standing Advisory Committee on Trunk Road Appraisal (SACTRA) (1999). *Transport and the Economy.* TSO. London, August 1999. Retrieved 9 March 2011 from webarchive.nationalarchives.gov.uk/20050301192906/http:/dft.gov.uk/stellent/groups/dft_econappr/documents/pdf/dft_econappr_pdf_022512.pdf.

Stigson, H. (2009*). Evaluation of safety ratings of roads based on frontal crashes with known crash pulse and injury outcome.* Traffic Injury Prevention, 10(3): 273–278.

Stigson, H., Krafft, M. & Tingvall, C. (2010). *Use of fatal real-life crashes to analyze a safe road transport system model, including the road user, the vehicle, and the road*. Traffic Injury Prevention, 9(5): 463–471.

Tingvall, C. (2005). E*urope and its road safety vision – how far to zero?* The 7th European Transport Safety Lecture with comments by Allsop, R. and Machata K., June 2005.

Tranter, M. (2010). *Survey Data on Road Accidents.* Article in DfT (2010a) (q.v.).

usRAP, Midwest Research Institute, Iowa State University & AAA Foundation for Traffic Safety (2009). *Feasibility Assessment and Pilot Program*. Retrieved 9 March 2011 from www.aaafoundation.org/pdf/usRAP_report.pdf.

van Vliet, P. & Schemers, G. (2000). *Sustainable Safety.* Ministry of Transport, Public Works and Water Management. The Netherlands.

Ward. H., Lyons. R. & Thoreau. R. (2006). *Under-Reporting of Road Casualties. Phase 1*. Road Safety Research Report No. 69. London, DfT.

1

ANNEX 1: GOVERNMENT METHODOLOGY FOR VALUATION OF ROAD CRASHES

The following Annex sets out in summary the way that the research is used to build up estimates of the cost of road crashes in Great Britain. All but the human costs for a fatality component were derived from Hopkin & Simpson (1995) using June 1994 prices. Human costs were derived from Chilton *et al.* (1998).

A1.1. Lost output

Average earnings were estimated for 22 age and gender groups. It is assumed that as each group gets older they receive the average income for the age group they fall into. Assuming the income was worth more to the individual at present than in the future – future income was discounted at a rate of 6%. A 2% long-term growth rate was selected reflecting historical performance of the local economy.

Calculations were made in June 1994 prices and based on the number of fatalities in each age group. Data on earnings and consumption were in 1990 prices. Lost output for a fatality at June 1994 price was £272,690.

Serious casualties were categorised into three distinct groups. Three different costs were calculated and weighted to give a serious casualty loss of output value:

- **For those people who recover after one year:** the cost was calculated by combining average earnings with the average number of days off work in the first year, giving a lost output of £2,250 per casualty.

- **For those that recover within one to three years:** a cost was derived for an average recovery period of two years. Year one costs were derived and a growth rate of 2% applied to give a second year value. This gave a cost of £8,270 per casualty.

- **For those permanently and severely disabled and not expected return to work in their lifetime:** values were based on the distributions of accidents for three age groups: 0-15, 16-59 and over 60. Lost output value was £311,480 per casualty.

Weighting the three costs above based on hospital surveys, the lost output cost for a serious casualty was £11,500.

A1.2. Medical costs

Costs for a fatality were based on the use of the ambulance services, A&E and in-patient costs, blood transfusions and other overall administrative costs. The medical cost for a fatality was £510. For a serious casualty hospital treatment costs, district nurses, provision of medical appliances and social security benefits relating to the first 18 months of care were used. Costs associated with long-term disability such as those incurred by the local authority adapting homes, and costs to GPs were excluded since no information was available. The weighted medical cost for a serious casualty was £6,970.

A1.3. Human costs for a serious injury

Avoidance of non-fatal casualties was linked to the value of avoidance of a fatality, based on a national sample survey of willingness-to-pay to reduce the risk of injury. Indirect estimates of the value of serious injuries were derived relative to the value of a fatality. Respondents were presented with a range of probability of risks of failure and success and asked to specify the level of risk at which they would opt for treatment for the injury. Ratios for each injury state relative to those of a fatality were calculated from the results.

The human cost element of a non-fatal casualty was measured relative to the human costs and consumption component of a fatality. The ability to consume goods and services are part of the enjoyment of life and would therefore be taken into account by respondents in willingness-to-pay surveys. Value of consumption was estimated at £217,480. Adding this to the human cost figure of a fatality cost gave a value of £728,360. Combining the weighted values for each serious injury type gave a value of a serious injury as £70,910.

A1.4. Human costs for a fatality

Updated research, aimed at estimating a tariff of willingness-to-pay values of safety in a number of different contexts (including preventing road fatalities) was undertaken in 1995. A large proportion of respondents were found to be insensitive to the size of the risk reduction under consideration, with 40% having an equal willingness-to-pay for two different risk reductions. The approach was therefore refined into four stages:

- **Stage I:** questions were designed to test willingness-to-pay for the *'certainty'* of a quick and complete cure for non-fatal road injury of less severity and willingness-to-accept compensation for the *'certainty'* of sustaining the same injury;

- **Stage II:** willingness-to-pay and willingness-to-accept responses were used to calculate the rate of trade-off of wealth against risk of the non-fatal road injury;

- **Stage III:** willingness-to-pay and willingness-to-accept responses were used to calculate the rate of trade-off of risk of non-fatal road injury against the risk of death; and

- **Stage IV**: rates derived in stages II and III were combined to give the rate of trade-off of wealth against risk of death.

Prevention of a fatality was valued at between £500,000-£1,500,000 (including costs for loss of output and medical care), with the range reinforcing the widely spread distribution of responses. A refined range was set at £750,000 – £1,250,000. This was refined further to the mid-point of £1 million in the latest DfT WebTAG guidance (DfT, 2010b).

The individual costs above were combined with the weightings associated with average crash types to give the total costs of a fatal and a serious crash. For example, a fatal crash in 2008 on average resulted in 1.08 fatalities, 0.32 serious casualties and 0.48 slight casualties (DfT, 2010a). These values were multiplied by the associated costs of the casualties and combined with the overall cost components (police, insurance, damage to property) to give an overall figure.

A1.5. Damage to property

Damage to property costs were derived from a major insurance company and weighted according to the proportions of injury severity and road type. It is assumed that the costs were an over-estimate given the under-reporting of crashes and those not covered by insurance policies. A national questionnaire of 30,000 motorists was used to adjust the costs for this issue.

Vehicle damage costs were weighted by the average number of vehicles of different types involved and the severity level, derived from national statistics. In June 1994 prices, vehicle damage cost in the case of a fatal crash was £5,740. Serious crashes were valued at £2,600.

Payments made for damage to third-party property were identified from insurance claims and in June 2004 prices were £4 for a fatal, and £30 for a serious crash. Average cost of vehicle hire and payments made in view of loss of use by crash severity and location were estimated from the insurance company data – with a fatal crash valued at £130 and a serious crash at £80.

Combining these figures gave damage to property costs of £5,874 in a fatal, and £2,710 in a serious crash.

A1.6. Insurance administration

Insurance companies also incur administration costs associated with the handling of insurance claims. Costs in June 1994 prices were £160 for a fatal crash and £100 for a serious crash.

A1.7. Police costs

Estimates of police costs were separated into police officers' time and administrative staff time. Police time was estimated for six different categories of accident which included combinations of fatal and serious crashes on motorways, rural and urban roads. Accidents can range from one fatality in one vehicle to multiple vehicles and varying severities of casualties. The average length of time taken by police for each road type was weighted by the national distribution of crashes giving a value of £900 for a fatal crash and £120 for a serious. The time taken to complete the STATS19 form accident book and deal with enquiries gave an administration cost of £30 for a fatal crash and £20 for a serious. These costs combined gave police costs for a fatal crash of £1,020 and £140 for a serious crash.

2 ANNEX 2: TECHNICAL METHODOLOGY

A2.1. Introduction

A major aim of this report was to develop crash cost mapping demonstrating road section by road section where substantial GDP is being lost across the British road network, and to use this as the basis on which to propose minimum safety levels based on economic viability.

All data were for Great Britain over the three year period 2006-2008. Crash data were obtained from the STATS19 national road injury and accidents database provided by the DfT, and included all crashes involving a fatal or serious injury. Traffic flow data were obtained from the DfT database based on automatic and manual vehicle counts, the latter carried out at three-yearly intervals. Given the disproportionate numbers of deaths and serious injuries on rural versus urban routes, analysis was carried out for all British motorways and A roads outside of towns and cities.

Road sections of less than 5kms (about 3 miles) in length were excluded from analysis to eliminate those where there may be substantial fluctuations in crash numbers over time. Removing these sections resulted in a total network length of 42,261kms (26,260 miles) – 94% of the original total, on which there occurred, 3,750 fatal crashes (95% of the original value for the original network before removal of short road sections) and 21,272 crashes resulting in serious injury (93% of the original) for the three year data period 2006-2008.

To demonstrate how crash costs were derived for individual road sections the following Annex gives worked examples of each step, using 'Road A' with the following characteristics:

- 20 km;
- Single carriageway primary A road;
- 7,385 AADT (motorcycle AADT = 35);
- 3 fatal and 11 serious crashes between 2006 and 2008;
- fatalities: 2 involved vehicle occupants, 1 involved motorcyclists for head-on, junction and run-off crashes;
- serious injury casualties: 14 involved vehicle occupants and motorcyclists for the three main crash types;
- slight casualties: 94 involved vehicle occupants and motorcyclists for the three main crash types.

A2.2. Crash cost mapping

The values in section 3, Table 6, using the latest DfT values (DfT, 2010b), were used to assign crash costs to individual road sections. Figures for motorways are the average value of prevention per road crash (in June 2008 prices). Figures used for A roads are the average value of prevention per road crash for built-up and non built-up roads combined – because while the majority of routes included on the EuroRAP network were outside towns and cities, some built-up areas were included on routes where they passed through villages and small towns.

Total crash costs for individual road sections were calculated and the network assigned one of five colour-coded 'economic loss' bandings from high to low, using the proportions shown in section 3, Table 7. These proportions were used for both the crash cost per km and per km travelled maps and associated analysis.

The formulae below show how the crash cost per km and per vehicle km were calculated.

Crash cost per km p.a.: (F is the number of fatal crashes and SI is the number of serious injury crashes)

$$\frac{(F\ crashes\ [Average\ 2006-08]\ \times\ crash\ cost\ by\ road\ type) + (SI\ crashes\ [Average\ 2006-08]\ \times\ crash\ cost\ by\ road\ type)}{Length\ [km]}$$

$$= \frac{(1{,}906{,}154\ \times\ 3) + (218{,}114\ \times\ 11)/_3}{20km}$$

$$= an\ economic\ loss\ of\ £135{,}395\ per\ km$$

Crash cost per vehicle km:

$$\frac{Crash\ cost\ per\ km\ p.a.}{Annual\ traffic\ volume}$$

$$= \frac{£135{,}395}{7{,}385\ \times\ 365}$$

$$= an\ economic\ loss\ of\ £0.05\ per\ vehicle\ km\ per\ year$$

A2.3. Potential crash savings

This section describes the methodology used to calculate potential crash savings used as the basis for section 4 of the main report.

The current distribution of risk rates across the British motorway and A road network was established by examining flow and crash data across 2,000 sections of road more than 5 km long. Proposed minimum benchmark levels for safety were established with the highest safety benchmarks for the busiest roads (motorways) and the lowest for the least busy (non-primary A roads). The costs of achieving improved risk rates on the 1,000 sections falling below the proposed benchmarks was estimated together with the resulting crash cost saving to provide benefit cost ratios (BCRs).

The crash data has been manipulated in line with the Star Rating methodology, which scores the engineering standards present allowing an estimate of how much it would cost to improve high risk sections.

The Star Rating is derived from a Road Protection Score (RPS), a numerical score which is in turn derived from a product of risk factors, each produced for characteristics of the road which increase or decrease the likelihood of a crash and severe injury. An RPS is calculated for each 100 m section of a road, but the resulting Star Rating is typically averaged over a user-defined length to calculate route risks. The risk determined is associated with head-on, junction and run-off crashes only. Separate Star Ratings are derived for motor vehicle occupants, motorcyclists, cyclists and pedestrians. For the British EuroRAP network of rural roads outside of towns and cities, crashes involving cyclists and pedestrians were low. Therefore the analysis included here considers Star Ratings for motor vehicle occupants and motorcyclists only.

Road Protection Scores are normalised into Star Rating bands using the same colour-coding convention as that for Risk Mapping, depending on the level of safety which is ‘built-in’ to the road.

With the support of the Highways Agency, around 7,500 km of roads have been inspected and coded in Britain to the version of the protocol current in 2007. The results of these inspections however apply only to the higher-quality national motorways and trunk roads operated by the Highways Agency in England. Results were published by the Road Safety Foundation in 2010 and showed that 50% of the motorway network achieved 4-stars; 78% of dual carriageway achieved 3-stars and 62% of trunk road single carriageways were rated 2-star. Some 35% of trunk road single carriageways were however rated 3-star (Lawson, 2010).

The main objective of the methodology is to use the crash data to identify the level of risk for each road section, estimating where it sits on the scale from 1-star to 5-star, and to determine how many lives would be saved if the level of risk changed to a more acceptable level based on what can be achieved in the case of other roads carrying similar volumes of traffic.

Figure A2.1: Current and benchmark risk for a typical high risk single carriageway

Source: Authors own

A2.4. Fatality estimation from Star Rating results

There are many situations in road assessment where the total number of deaths may be known for a region, country or road but the exact locations may not. The RAP Star Rating protocol therefore incorporates a fatality estimation model to allocate observed fatalities to individual road sections.

The model determines the exposure to risk by road user type based on the user specific RPS. By combining the level of risk and vehicle km travelled, fatalities are allocated as follows:

$$\textit{fatalities on road section} = \textit{RPS} \times \textit{traffic}\ [\textit{vehicle km by road section}] \times \textit{calibration factor} \qquad (1)$$

The calibration factor ensures that the total estimated number of deaths on a network is equal to the observed number of deaths.

Since traffic is known on the network, as is the number of observed fatalities, the calibration factor gives a good estimate of the RPS for each road section.

A2.5. Adjusting the crash data

Because the available crash data are given in crash numbers rather than casualties, adjustment factors are needed for the number of observed motor vehicle occupant and motorcyclist fatalities. Data from the DfT's Road Crashes Great Britain (covering the data period 2006-2008) have been used to convert fatal crashes into fatalities using 1.12 casualties per crash for non built-up A roads and 1.16 for motorways.

Numbers of serious casualties have been derived by converting fatal and serious crashes into serious casualties assuming 1.05 serious casualties for every fatal and serious crash for both non built-up A roads and motorways.

For slight casualties the sum of fatal and serious casualties was multiplied by 5.19 for A roads and 9.9 for motorways. Converting the number of serious casualties back to fatal, serious and slight crashes means dividing the figure by 1.28.

A2.6. Calibrating the model

As discussed in section A2.4, by deriving the calibration factor for the network an estimation can be made for each road section's RPS, and subsequently an estimate of the number of potential lives that could be saved.

Within the Star Rating protocol, only one calibration factor is derived for the whole network. For this report a calibration factor has been calculated for a number of networks categorised by road type and EuroRAP risk rate banding as follows:

- single carriageway – low risk rate;
- single carriageway low-medium risk rate;
- single carriageway – medium risk rate;
- single carriageway – medium-high risk rate;
- single carriageway – high risk rate;
- dual carriageway – low risk rate;
- dual carriageway low-medium risk rate;
- dual carriageway – medium risk rate;
- motorway – low risk rate;
- motorway low-medium risk rate.

If the calibration factor for each of these networks does not differ significantly, then we can assume that the figure that would be true for the network would not differ significantly from the ultimate values for this methodology and a good assumption of the individual RPS for each road section can be derived.

The calibration factor for each of the networks given above are derived by adapting formula (1)

$$calibration\ factor\ for\ network = \frac{number\ of\ observed\ fatalities\ on\ network}{\sum_{i=1}^{n} RPS \times traffic_i} \quad (2)$$

$$i = road\ sections$$

To avoid two separate calculations but still ensure that both vehicle occupants and motorcycle fatalities are considered formula (2) is developed further using an assumption that motorcycle RPS is 1.5 times the vehicle occupants RPS (worked out through a separate exercise).

$$calibration\ factor\ for\ network = \frac{number\ of\ observed\ fatalities\ on\ network}{\sum_{i=1}^{n} RPS\ (motor\ vehicle\ traffic_i + 1.5 \times motorcycle\ traffic_i)} \quad (3)$$

$$i = road\ sections$$

Since the only unknown variable in formula (3) is the RPS, an initial assumption needs to be derived.

The assumption made is that there is a correlation between a high-risk rate and a low Star Rating, as found in other countries.

Using this assumption to derive the calibration factor and back tracking to form individual Star Ratings might be thought of as circular reasoning and ending up with results that match up with the initial assumption. This is not the case because the presence of serious crashes influences the risk rate in Risk Mapping. A high number of serious crashes compared with low traffic volume will give a high risk rate. Since there were no fatalities the characteristics of the road will certainly go some way to protect road users and therefore a higher Star Rating would be calculated.

The resulting calibration factors are summarised in Table A2.1.

Table A2.1: Summary of calibration factors across British EuroRAP network

Road type	Total observed fatalities	Calibration factor
Single high-risk	21	7.0
Single medium-high risk	151	5.0
Single medium risk	665	3.9
Single low-medium risk	1043	3.0
Single low risk	9	0.7
Dual medium risk	5	6.1
Dual low-medium risk	244	2.9
Dual low risk	77	2.3
Motorway low-medium risk	12	2.0
Motorway low risk	263	2.0
Mixed medium risk	49	3.7
Mixed low-medium risk	358	2.9
Mixed low risk	16	0.9

Source: Authors own

Calibration factors were found to be higher for high-risk roads and lower for lower risk roads. This may be expected because of the presence of other known factors influencing crashes. The calibration factor may be higher for a high-risk road because the Star Rating model assumes 5-star behaviour for these routes. It may not be the engineering features influencing the high number of fatalities but drivers driving at high speeds which no amount of good engineering can compensate for in the event of a crash.

Tables A2.2 to A2.4 give the typical banding features expected for roads by road type and EuroRAP risk rate map banding. The RPS that correlates with these engineering features is assigned to each subsequent road section for that road type and risk banding.

Table A2.2: Generic road layout for single carriageway by risk rate

Road attribute	High Risk	Medium Risk	Low Risk
Speed	90 km/h	90 km/h	90 km/h
Number of lanes per direction	One	One	One
Width of lanes	Medium	Wide	Wide
Distance to severe roadside objects	0-5 m	5-10 m	>10 m
Median type	Centre line only	Centre line only	Centre line only
Curvature	Sharp curve every 3 km	Moderate curve 1 every 3 km	Straight or gently curving
Junctions	Unsignalised 4-leg without right turn every 3 km	Unsignalised 3-leg with right turn every 3 km	Roundabout every 3 km
Paved shoulder	None	0-1 m	0-1 m

Source: Authors own

Table A2.3: Generic road layout for dual carriageway by risk rate

Road attribute	Medium Risk	Low Risk
Speed	110 km/h	110 km/h
Number of lanes per direction	Two	Two
Width of lanes	Wide	Wide
Distance to severe roadside objects	0-5 m left, barrier to right	Barrier to left and right
Median type	Barrier	Barrier
Curvature	Straight or gently curving	Straight or gently curving
Junctions	Unsignalised 3-leg with right turn every 3 km	Roundabout every 3 km
Paved shoulder	0-1 m	0-1m

Source: Authors own

Table A2.4: Generic road layout for motorway by risk rate

Road attribute	Low-medium Risk	Low Risk
Speed	110 km/h	110 km/h
Number of lanes per direction	Three	Three
Width of lanes	Wide	Wide
Distance to severe roadside objects	5-10 m left, barrier right	Barrier to left and right
Median type	Barrier	Barrier
Curvature	Straight or gently curving	Straight or gently curving
Junctions	Merge lane every 3 km	Merge lane every 3 km
Paved shoulder	0-1 m	>2.4 m

Source: Authors own

A2.7. Benchmark fatalities

Table A2.5 sets out the benchmark Star Ratings and associated RPS for motor vehicle occupants. These are based on historical data and what road types have achieved and what poorly performing roads should aim to achieve.

Table A2.5: Benchmark Star Rating and RPS by road type

Road type	Star Rating	RPS
Motorway	5-star	0.24
Dual primary	High 4-star	0.38
Dual non-primary	Low 4-star	0.66
Single primary	High 3-star	1
Single non-primary	Low 3-star	1.4

Source: Authors own

The benchmark number of fatalities for the network is derived by calculating how many fatalities would occur based on the calculated calibration factor for that road type combined with the benchmark RPS.

A2.9. Estimation of upgrade costs to achieve crash savings

For each route's estimated RPS, the Star Ratings are derived from the bandings specified in the EuroRAP methodology. Where estimated Star Ratings are lower than the benchmark Star Ratings the potential crash savings and associated costs are obtained by converting casualty figures back to crash figures.

The costs for upgrading roads to improve Star Ratings were sought from national and local road authorities and the following costs were assumed:

- £200,000 per km to increase a single carriageway's Star Rating by one star;
- £275,000 per km to increase a mixed carriageway's Star Rating by one star;
- £350,000 per km to increase a dual carriageway's Star Rating by one star;
- £500,000 per km to increase a motorway's Star Rating by one star.

For each route the difference between estimated and benchmark Star Ratings was calculated and then multiplied by the cost and length associated with the road type of the route. For Road A, the difference in Star Rating is from high 3-star (3.75) to 1-star (1), giving a difference of 2.75. The cost of upgrading is therefore,

$$cost\ of\ upgrade = 2.75 \times 20km \times 200{,}000$$
$$= £11\ million$$

The benefits of the scheme are a saving of 2 fatal crashes; 9 serious crashes; 44 slight crashes and 308 damage only crashes for a three-year period, giving 0.6 fatal crashes; 3 serious crashes; 15 slight crashes and 103 damage only crashes. The benefit in 2008 is shown:

$$= (0.6 \times £1{,}906{,}154) + (3 \times £218{,}114 + (15 \times £22{,}633) + (103 \times £2{,}003)$$
$$= £2{,}343{,}838$$

With this cost saving shown in June 2008 prices, we can assume that the 2010 price is an increase by 2% each year (from average increases in GDP) which gives a present value benefit in the first year of £2,438,529.

A life cost of 20 years is accepted by DfT economists for road maintenance schemes. The present value benefit for a life cost of 20 years is derived by the formula:

$$PVB\ (20\ years) = \sum_{i=0}^{20} \frac{Benefits}{(1+r)^i}\ where\ i = year\ and\ r\ is\ the\ discount\ rate$$

In Britain, we assume a discount rate of 3.5% as given in the HMT Green Book (HM Treasury, 2003).

The benefits at each year over the 20-year period are assumed to be 2% higher than the benefits for the year before. This gives a revised equation for the present value of benefits (PVB) for each route:

$$PVB\ (20\ years) = \sum_{i=0}^{20} \frac{1.02^i}{1.035^i}\ where\ i = year\ and\ B\ is\ the\ first\ year\ benefits$$

For the route shown above the PVB over the 20-year life is shown:

$$PVB\ (20\ years) = \sum_{i=0}^{20} \frac{1.02^i}{1.035^i}$$
$$= (£2{,}438{,}529 + \frac{1.02 \times £2{,}438{,}529}{1.035} + \frac{1.02^2 \times £2{,}438{,}529}{1.035^2} + \ldots + \frac{1.02^{20} \times £2{,}438{,}529}{1.035^{20}})$$
$$= £42{,}605{,}329$$

The calculation for the BCR of the route is shown:

$$BCR = \frac{PVB}{PVC}$$

$$= \frac{£42,605,329}{£11,000,000}$$

$$= 3.87$$

Therefore every £1 spent improving the road section will give a return of nearly four times initial cost.

A2.10 Validation of results

The two examples set out below show how the original assumption of a negative correlation between the Risk Rate and Star Rating does not necessarily translate through to the estimated Star Rating used for determining where improvement schemes should be targeted.

A680 (Rising Bridge – Whalley)

This route had 2 fatal crashes and 18 serious crashes in the 2006-2008 data period and was given a medium-high risk banding on the EuroRAP Risk Rate map. The initial assumption based on this risk banding was that this would score a 2-star in order to derive the calibration factor.

Since one of the fatal crashes involved a vulnerable road user, the number of fatalities involving vehicle occupants and motorcyclists was 1.12 (using adjustment factors from the crash information).Taking into account the calibration factor and traffic meant that the estimated Star Rating was 3-star.

A 3-star single carriageway means that for high speed sections there is generally good protection by way of barriers in most instances or straight sections which decrease the likelihood of a crash occurring. For low-speed sections where the likelihood of a fatality is low if people are sticking to the speed limits, the Star Rating for a vehicle occupant would be very high so for an average route Star Rating of 3-star where there are sections with a low speed limit, the high speed sections would typically be 1 or 2-star where the distance to roadside objects is short and there is no protection down the centre of the carriageway.

For the A680 section, the two images below relate to a typical 3-star route as there is a combination of low speed sections and the high speed sections are not well protected at the edge of the carriageway.

Figure A2.2: Village gateway

Figure A2.3: High-speed section with unprotected poles at the edge of the carriageway

A595 (Grizebeck – Workington)

Similarly roads with few crashes may have a low risk rating but the number of fatalities involved in the few crashes could be high, leading to a low Star Rating.

The A595 is a long route (77km) which had 37 fatal and serious crashes of which 7 were fatal. Combining the expected 7.84 fatalities on the route involving vehicle occupants and motorcyclists with a low traffic volume with AADT of 8,000 and the derived calibration factor we have a Star Rating of 2.25.

A typical 2-star single carriageway would have a high proportion of high-speed sections along the route with a single white line offering the only head-on protection and a lot of severe objects running close to the edge of the carriageway.

Looking at the characteristics of the route it is clear to see that the Star Rating was on the lower end of the scale with frequent bends and dangerous roadside objects close to the carriageway. The failure of the route to score a 1-star is due to a combination of its frequent passage through villages, low speed limits, and the presence of dual carriageway features to the north of the route.

Figure A2.4: Narrow lanes with white line down the centre of carriageway and a high number of trees close to the carriageway

Figure A2.5: Section of low-speed limit with central hatching

Figure A2.6: Dual carriageway with protection down the centre and side of the carriageway

3 ANNEX 3: SURVEY QUESTIONNAIRE

Route Safety Schemes Research 2010 – Priority Assessment and Valuation Methods.

NAME OF HIGHWAY AUTHORITY:	
CONTACT DETAILS (Name/Tel/Email):	

Please fill in any that apply to your authority's current methods and provide values used wwhere appropriate.

COLLISION RATES USED	Weighting fatal	Weighting serious	Weighting slight	Weighting VRU	Other / comments
All accidents/km					
All casualties/km					
KSI accidents/km					
KSI casualties/km					
All accidents/bvkm					
All casualties/bvkm					
KSI accidents/bvkm					
KSI casualties/bvkm					
Other rate used (please add comments)					
COLLISION DATA SETS	1 year before	3 years before	5 years before	Other period	Comments
STATS19 recorded data					
Damage only records					
Other data used (please add comments)					
ECONOMIC VALUATION METHODS USED *	FYRR (first year rate of return)	3 years before /after	5 years before /after	Whole life assessment (years)	Comments
Accident benefits					
Casualty benefits					
Intervention cost/ casualty saved					
Intervention cost/KSI saved					

* If you do not use a specific option but usually have sufficient data to enable this to be done in addition to your current approach. please insert * and add comment as appropriate

Note: VRU – vulnerable road user; KSI – killed or seriously injured; bvkm – billion vehicle km.

Saving Lives, Saving Money

The costs and benefits of achieving safe roads

Road crashes bring misery for tens of thousands of families each year when a loved one is involved in a serious road crash. But road crashes also cost money - up to £30bn annually or 2.3% of GDP. This report reviews the costs that fall on families, carers, NHS, emergency services and businesses.

This report shows that half of Britain's road deaths are concentrated on just 10% of our roads - the network of motorways and A roads outside urban areas. Every year Britain suffers serious injury crash costs alone of £0.5billion on motorways, £1 billion on national trunk roads and £2.5 billion on local authority A roads.

In the last decade, cars with 1-star and 2-star crash protection have been all but eliminated. Saving Lives, Saving Money breaks new ground by investigating the costs and benefits of eliminating 1-star and 2-star main roads in the coming decade. Over the next 10 years, road authorities can upgrade the safety features of their roads largely within existing budgets and during maintenance, reaping savings worth £25-£35 billion.

Road authority leaders will need to be systematic in generating and evaluating crash cost reduction measures, treating the highest risk roads to save lives and money.

The Road Safety Foundation and RAC Foundation support the Decade of Action for Road Safety 2011-2020

Road Safety Foundation, Worting House, Basingstoke, Hampshire, RG23 8PX.
T: 01256 345598. W: www.roadsafetyfoundation.org

Registered Charity No. 295573

RAC Foundation, 89-91 Pall Mall, London, SW1Y 5HS.
T: 020 7747 3445. W: www.racfoundation.org

Registered Charity No. 1002705

Designed and printed by The Javelin Partnership Limited
Tel: 0118 930 3123

Financially supported by:

ROAD SAFETY FOUNDATION

Rees Jeffreys Road Fund

RAC Foundation