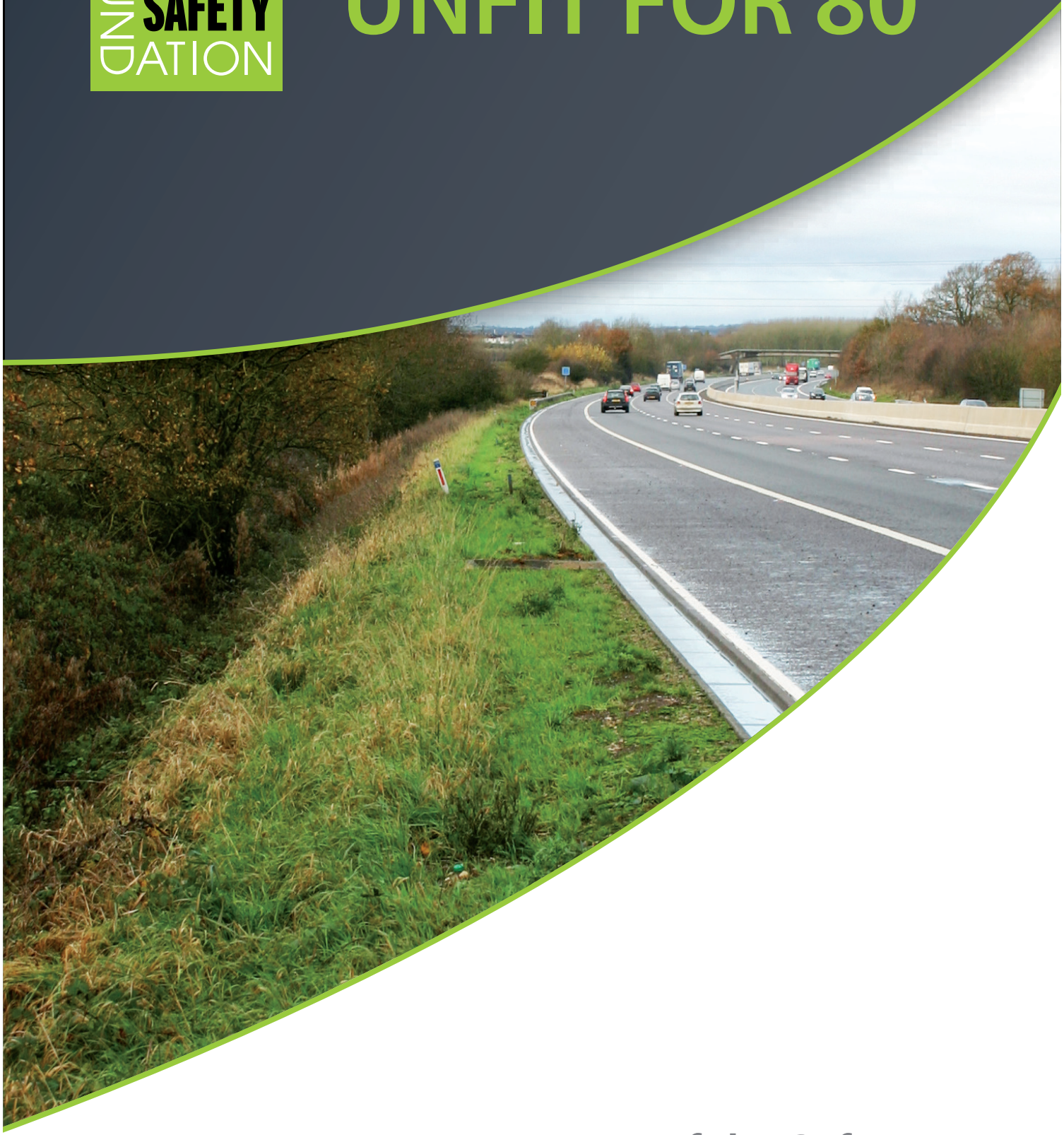
ROAD SAFETY FOUNDATION

# UNFIT FOR 80



## An Assessment of the Safety of England's Motorways

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.

The Road Safety Foundation is the member responsible for managing the EuroRAP programme in the UK and Ireland.

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## An Assessment of the Safety of England's Motorways

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Sole responsibility for this report lies with the Foundation and the opinions expressed do not necessarily reflect the views of contributors or financial supporters.

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# 1. INTRODUCTION

In October 2011, the Department for Transport (DfT) announced that it would consult on raising the motorway speed limit to 80 mph for light vehicles on suitably engineered motorways. The headline arguments advanced by DfT for change were that:

- half of motorists already exceeded the 70 mph limit and the moral legitimacy of the system would be restored;
- vehicles had become safer;
- there would be resulting economic benefits;
- other EU countries had higher limits.

The then Secretary of State commented that otherwise law abiding citizens had lost respect for the current 70 mph limit and that cars were now significantly safer than in the past. He pointed to the higher speeds permitted in major economic competitors such as France and Germany and said that many hundred million pounds in economic benefits could flow from raising the limit. He recognised that there could be slightly increased risks and said these would not have a significant impact on safety.

This paper assesses the past and current safety of England's motorways. Central to this assessment is the Foundation's own unique data sets. The Road Safety Foundation has tracked the rate of death and serious injury, section by section, on British motorways for the last decade. It has also physically inspected the entire English motorway system recording key safety engineering features, such as crash protection, at 100 metre intervals.

In addition, because the data for England has been collected and analysed to European Road Assessment Programme (EuroRAP) protocols, the Foundation can compare British results with other countries such as France and Germany.

This paper also examines what speeds we drive at on English motorways and the crash protection standards of both roads and vehicles on motorways today. It looks at our attitudes to the speed limit and assesses the risks and rewards from raising the limit to 80 mph.

The paper concludes with what can and should be done to increase motorway safety and deliver increased economic benefits.

# 2. HOW FAST DO WE DRIVE ON MOTORWAYS NOW?

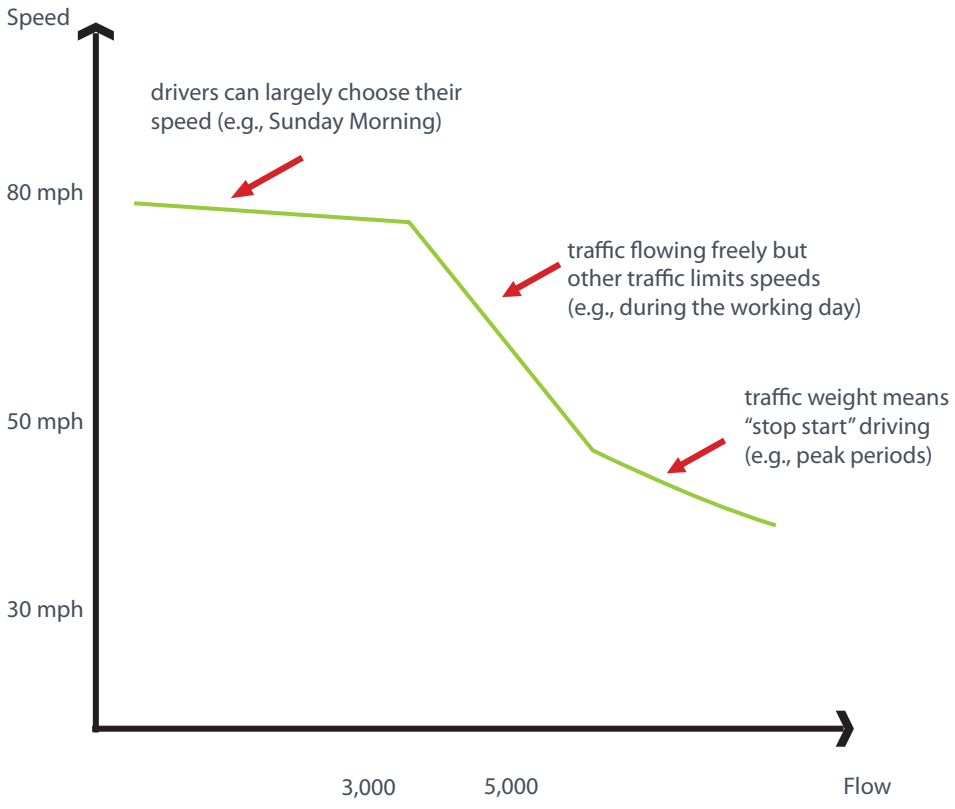
The DfT collects high quality data on the speed of motorway traffic and provides an accurate estimate of the speeds drivers achieve.[2] However, the normal statistical reports reflect the dense traffic conditions on motorways rather than the speeds drivers would like to drive. The DfT statistics average three very different driving conditions:

- free flowing traffic where people can choose their speed at will (e.g., Sunday morning);
- speeds in busy traffic where the motorway is flowing freely but drivers can in practice drive no faster than the general traffic flow (e.g., motorways during the working day);
- stop-start driving excluding speeds below 25 mph (e.g., peak periods).

For example, the data shows that 32% of all drivers travel at less than 64 mph which largely reflects busy traffic conditions. The data also shows that 30% of drivers travel at 75 mph or above which is only feasible outside busy periods on many stretches of motorway.

The general form of the standard motorway speed-flow curve used by the DfT in their economic appraisals is illustrated in Figure 1 below.

**Figure 1. Standard motorway speed-flow curve**




Flows illustrated are vehicles per hour in one direction for a dual 3-lane motorway

# 3. HOW SAFE ARE ENGLISH MOTORWAYS? THE CRASH STATISTICS

The Foundation's database shows that the average risk for an individual driver of death or serious injury on an 'A' road is five times higher than on motorways.[3]

However, when a serious crash does take place on a motorway it is more likely to be fatal, to involve more people and to result in more serious injuries. Such crashes, because they are rare and newsworthy, also tend to be reported in national news. The 'routine' death of 4 young people in a car on an 'A' road commands local newspaper headlines but when numbers rise above this level central government and national newsdesks typically react.

The 1,870 miles of motorway account for 8.5% of all major roads in England (1% of all roads). This small mileage of is intensely used - half of English motorways carry more than 30 million vehicles per year.

Motorways account for 6% of all English road deaths. **There are approximately 800 serious crashes on English motorways annually.** Around 100 people die and a further 800 are seriously injured.

**A 10 mile stretch of motorway has 4 fatal or serious injury crashes every year on average.**

In the most recent 3-year period analysed by the Foundation (2007-2009), there were 9 fatal and serious injury crashes for every 1,000 million kilometres driven on English motorways.

In the 2001-2010 period, motorway deaths fell by 42%. However, deaths on British roads generally fell by more (47%).

The rate of risk varies between motorways. Table 1 shows the 5 sections of motorway which were the most risky to travel on in the period 2007-2009. Table 2 shows the safest.

**Table 1: England's highest risk motorways**

| Motorway | Section | Region | Length (km) | Fatal and Serious Crashes | Risk Rate (Fatal and serious crashes per 1,000 million vehicle km) |
|---|---|---|---|---|---|
| M621 | J2 to J2A | Yorkshire & Humber | 7.5 | 10 | 28.2 |
| M1 | J6 to J8 | East of England | 6.9 | 20 | 22.8 |
| M6 | J33 to J34 | North West | 10.9 | 14 | 21.2 |
| M1 | J9 to J10 | East of England | 5.3 | 13 | 20.1 |
| M1 | J26 to J28 | East Midlands | 14.8 | 33 | 18.1 |

**Table 2: England's lowest risk motorways**

| Motorway | Section | Region | Length (km) | Fatal and Serious Crashes | Risk Rate (Fatal and serious crashes per 1,000 million vehicle km) |
|---|---|---|---|---|---|
| M49 | M49 | South West | 9.0 | 0 | 0.0 |
| M62 | J20 to J22 | North West | 10.7 | 2 | 1.8 |
| M54 | J0 to J7 | West Midlands | 34.7 | 5 | 3.2 |
| M42 | J3A TO J7 | West Midlands | 17.4 | 8 | 3.4 |
| M4 | J8/9 TO J12 | South East | 28.6 | 15 | 3.8 |

## 4. ARE CARS BECOMING SAFER?

In the last 3 years, international institutions have overwhelmingly recommended adopting a so-called *Safe System* approach to reducing serious road crashes. This approach requires that drivers, vehicles manufacturers and road authorities all accept and fulfil their responsibilities for making road travel safe – safe driving in safe vehicles on safe roads.

The motor industry and leading road authorities in other countries are systematically designing their education, enforcement, and road infrastructure to be *Safe System* compliant. Sweden, for example, is taking a series of actions to achieve 75% of road travel by 2020 as *Safe System* compliant - up from around 25% in the previous decade.

In *Safe System* design drivers have the responsibility to wear belts, be sober, and obey traffic laws including the speed limit. In the same way that aircraft and rail systems support professional pilots and railway drivers, the systems provided by vehicle manufacturers and road authorities should "nudge" drivers back into normal driving when they drift. Enforcement should punish those who wilfully break laws. When things go badly wrong, emergency systems like airbags and crash barriers should prevent death and serious injury.

Speed is fundamental to the design of a *Safe System*. As speeds rise, injuries will increase unless adequate protection is in place or increased to match. The human body inside a modern car can be protected from death and serious injury in frontal impacts up to 40 mph, through in-vehicle protection systems such as crumple zones, airbags, and seat belt pre-tensioners. Protection against brutal side impacts can be achieved up to 30 mph.

Above these speeds, crash energies must be absorbed by both road and vehicle acting together. The vehicle alone cannot protect the body in a high speed motorway impact. It is possible, for example, to walk away badly shaken, possibly with cuts and bruises, from a crash beginning at 80 mph if a belted driver runs-off into a well maintained pre-tensioned safety fence.

Consumers have been informed since 1997 about the safety performance of vehicles through the independent New Car Assessment Programme (EuroNCAP in Europe). This programme crash tests new cars and star rates them for the protection they provide. Since the introduction of EuroNCAP testing, car safety performance has risen by around 2-stars from a typical 2-3 stars to 4-5 stars.

Each EuroNCAP star translates approximately into a 15% reduction in death and serious injury.

Cars are typically scrapped after 14 years. New cars also do a higher mileage than old. This means that the vast majority of travel on English motorways today is undertaken by cars which have been designed and independently tested to achieve crash protection standards significantly higher than 20 years ago. Recent research, including British research from TRL[4] cited by the government in its recent road safety strategy document,[5] concludes that improved vehicle safety accounts for more than half the reduction in road deaths in the last decade: the benefits across Europe are already estimated to exceed 50,000 deaths.

The vehicle fleet has largely become safer in the last decade through better crash protection. The greatest potential for reducing deaths in the next decade is on higher speed roads outside built-up areas. This will be delivered through crash avoidance technology and road engineering catching up to complement improved vehicle crash protection.

# 5. HOW ARE PEOPLE KILLED AND SERIOUSLY INJURED ON ENGLISH MOTORWAYS?

Most crashes on roads of all types are routine and predictable. Millions of road deaths worldwide have provided statisticians with insights into the rates of death and serious injury to be expected without even examining the crash statistics on a stretch of road.

The majority of serious crashes in developed countries take place at sites of known high risk where people have not died before. Recommended practice by British professional bodies is that authorities should "proactively" search out the high risks which are known to kill and maim and eliminate them before someone is killed. More than 10 million Britons have been killed or seriously injured since motorisation and these crashes have provided sad and ample evidence of where interventions should be targeted. The *Safe System* approach means systematically ensuring safety features have reached the quality necessary to protect.

People die on roads in 4 main broadly equal ways:

- head-on crashes;
- brutal side impacts at junctions;
- running off the road and colliding with aggressive objects; and
- being hit as pedestrians or cyclists by vehicles.

The *Safe System* approach means road operators are responsible for ensuring routine and predictable driving errors do not lead to death or serious injury. The rate of death and serious injury depends on features such as:

- the protection between traffic in opposing directions (e.g., single or dual carriageway; central reserve safety fencing);
- the junction layout (e.g. split level junctions; roundabouts; signals; priority junctions with or without safe turning bays);
- the quality of roadside protection (e.g., presence of poles, trees or steep embankments too close to the roadside);
- whether there is any paved shoulder outside a running lane that can be used to recover in an emergency;
- bends and sight lines;
- the quality of signing and marking;
- the skid resistance of the road;
- level of traffic flow and presence of pedestrians, cyclists, motorcycles and commercial vehicles;
- actual traffic speeds and the speed limit.

Motorways are designed to protect against all the main crash types. Pedestrians are prohibited. There is safety fencing in the central reserve. Junctions are split level. All rigid obstacles and embankments should be more than 10 metres from the carriageway and if not there should be safety fence protection.

With advancing knowledge, the proportion of fatal motorway crashes that are difficult to foresee or eliminate has risen. For example, rumble strips alongside the hard shoulder have been introduced and proved effective in reducing the number of vehicles drifting off the carriageway and striking people or vehicles on the hard shoulder.

Modern motorways should have the following safety features:

- generous lane widths and a hard shoulder providing ample recovery space;
- generous sight lines;
- large signs that can be read at high speed which allow drivers ample time to absorb the information and make decisions such as when to exit and change lanes;
- gently changing curvature (only the earliest British motorways were designed to be straight);
- safety fencing dividing the carriageways (introduced as standard in the 1970s after public disquiet with cross-over crashes but still not universally installed on dual carriageways);
- safety fencing or generous safety zones at the roadside with all aggressive objects shielded;
- split level junctions with generous acceleration lengths and visibility for merges and adequate deceleration lengths.

England's most heavily trafficked motorways can carry a million vehicles within a week. A one in ten million combination of circumstances can arise every 3 months. Even though they may seem minor, the rate of exposure to any risk is so intense that even minor flaws in motorway layout or safety provision are likely to have serious consequences sooner rather than later.

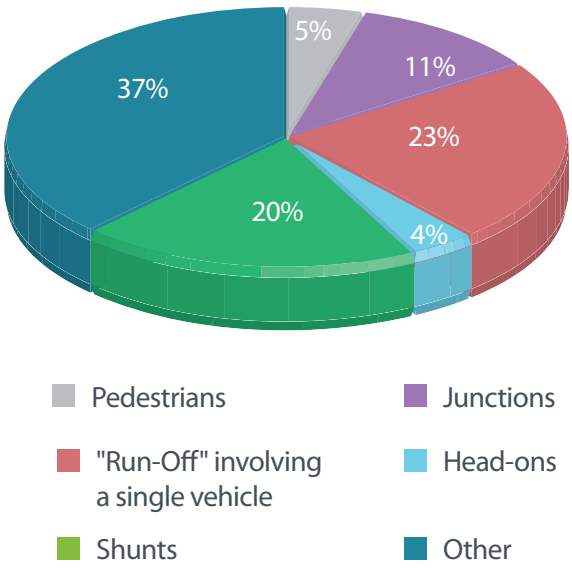
In practice, many serious crashes on motorways arise from circumstances which should be expected but are not "normal", including:

- "pedestrians" on the hard shoulder;
- roadworks;
- extreme weather;
- spilt loads;
- rear-end shunts when free flowing traffic breaks down.

The importance of electronic control and information systems increases as motorways become busier. Information systems warn of hazards (congestion, fog, spills, weather, etc.) and lane closures ahead and manage expectations of journey speeds. Control systems can vary lane use and vary and enforce speed limits.

Figure 2 below gives a breakdown of English motorway crashes from the Foundation's database involving death or serious injury to car occupants in the three years 2007-2009.

**Figure 2. Type and Percentage of Serious Crashes on English Motorways Car Occupants (2007-2009)**




The Foundation's database focuses on "single vehicle run-off" crashes. This establishes the minimum number of serious crashes involving a vehicle running off the road and enables the rate of failure in roadside protection to be established unambiguously. In practice, there are many more crashes involving multiple vehicles where weak run-off protection fails to help prevent death or serious injury.

Figure 2 identifies the two types of crash (after those in the 'other' category) that account for the majority of serious motorway crashes:

- run-off crashes;
- shunt crashes.

# 6. THE SAFETY RATING OF ENGLISH MOTORWAYS: OVERALL RESULTS

The Road Safety Foundation, with support from the Highways Agency, has inspected the entire English motorway network and examined the safety detailing every 100 metres to protocols established internationally by the European Road Assessment Programme (EuroRAP). These results were reported in 2010.[6]

The overall Star Rating is shown in Figure 3. The key result is that half the motorway network achieved the maximum 4-star rating and half 3-stars.

Overall, no general problems were found with central reserve fencing or junctions. However, significant problems were found with "run-off" protection.

**Figure 3. Star Ratings on English motorways**

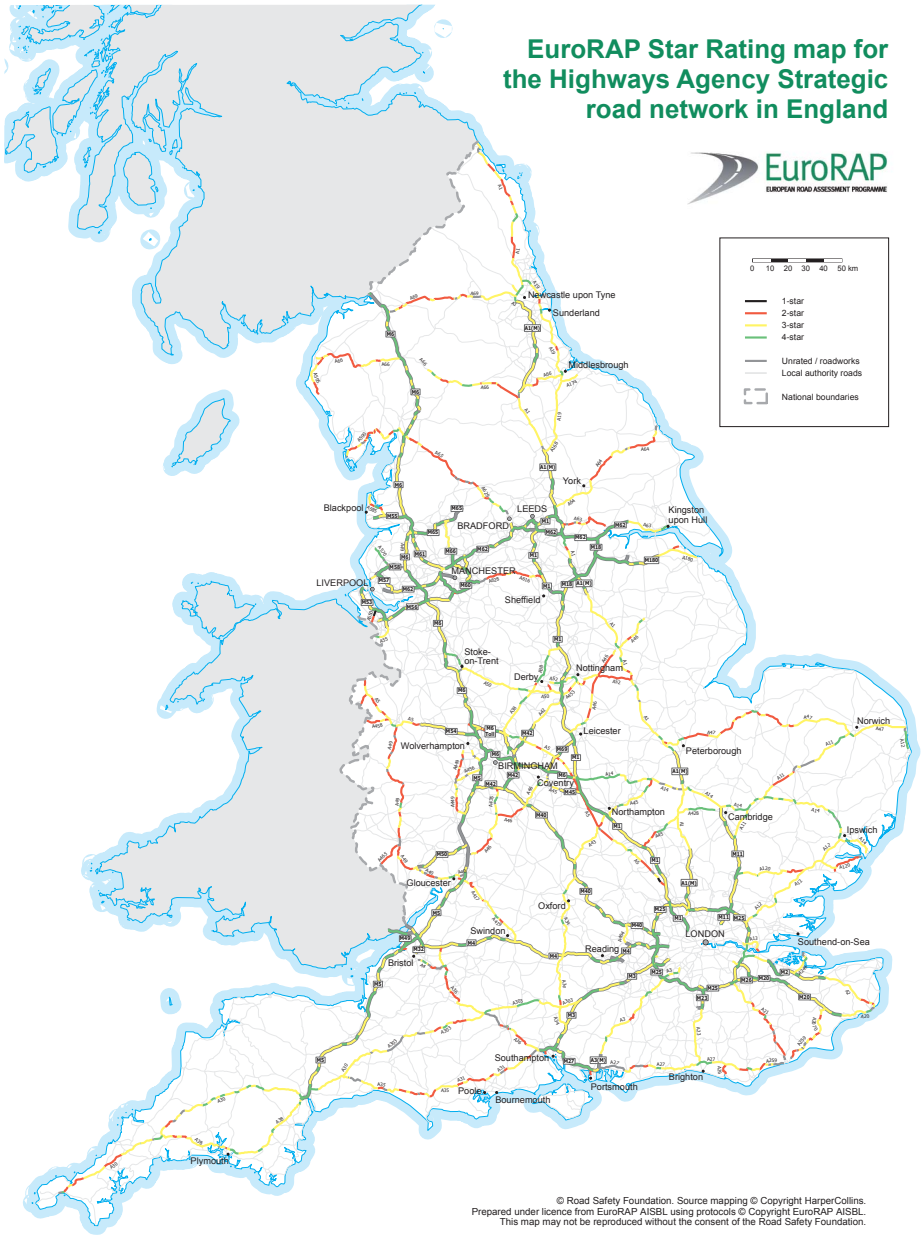
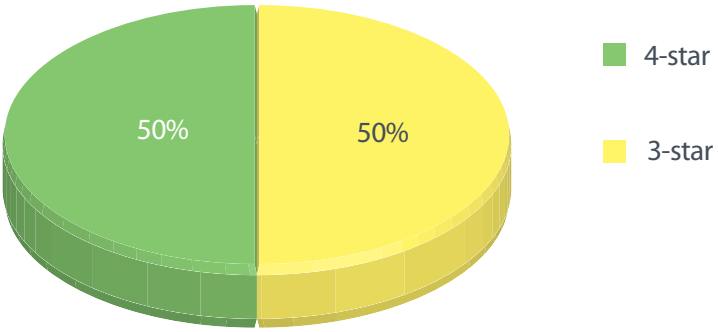


**Figure 4. Star Ratings on English motorways***

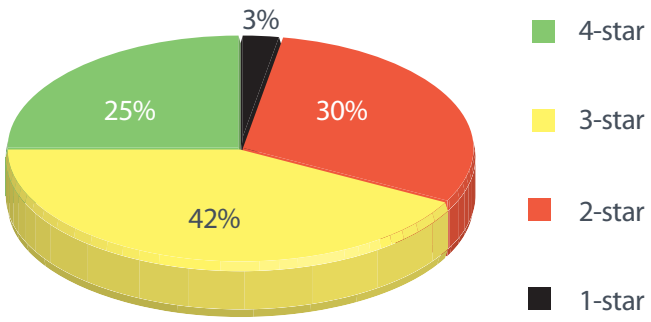



## 7. FLAWS IN RUN-OFF PROTECTION

Nearly half the motorway length failed to achieve 4-stars because its "run-off" protection was too weak in too many locations along its length. A further quarter of the motorway length could be further improved to be fully *Safe System* compliant. French and German motorways also have flaws in "run-off" protection but inspection surveys show they are more consistent than English motorways.

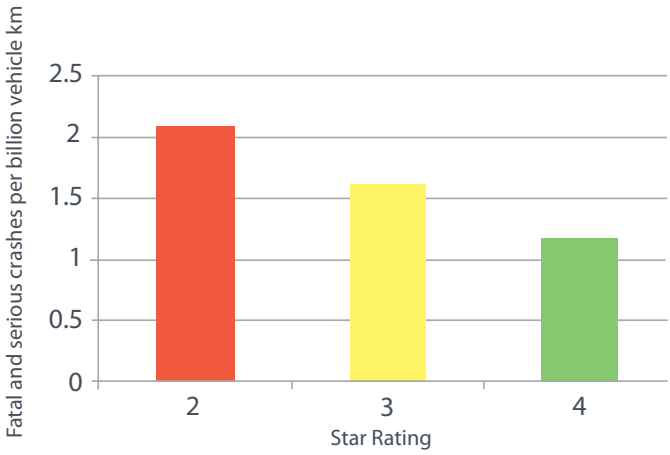
This analysis has been undertaken across 100 metre sections of motorway. Figure 6 shows an analysis of how the rate of death and serious injury from "single vehicle run-off" crashes broadly doubles on English motorways on average between the sections with good "run-off" protection (4-star) and those with significant flaws (2-star).

**Figure 5. Run-off Star Ratings on English motorways***




*Distribution of total Star Ratings (smoothed to 3km, RPS1.0 Calculator)

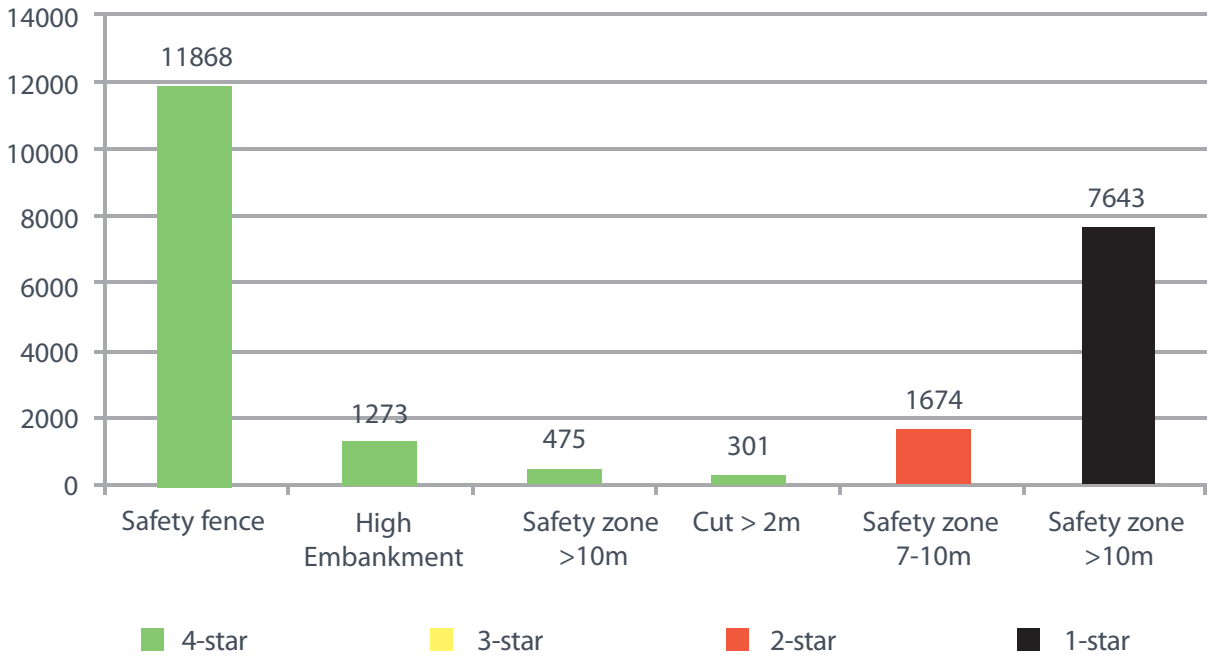
**Figure 6. Risk of fatal and serious single vehicle nearside run-off crashes vs nearside run-off Star Rating**



Although very few motorway sections are *Safe System* compliant along their whole length, a more detailed analysis examining 23,000 sections in 100 metre lengths shows only a third of the network actually needs treatment to achieve compliance.

The Foundation's inspections assume that where safety fence is installed it is well maintained and installed to the Highways Agency's requirements. The Foundation notes with concern the claims by those in the supplier industry that severely deteriorated safety fence is widespread across the Highways Agency's network.

**Figure 7. Distribution of "run-off" hazard and protection elements by 100 metre length**



# 8. SHUNT CRASHES

Figure 8 shows an analysis from the Foundation's database of how busy England's motorways are. Broadly, half the network length carries more than 85,000 vehicles per day.

The new analysis in Figure 9 shows how the rate of fatal and serious shunt crashes on English motorways rise as traffic increases. The number of crashes rise exponentially.

**Figure 8. Variation of traffic flows (AADT) on England's Motorways**

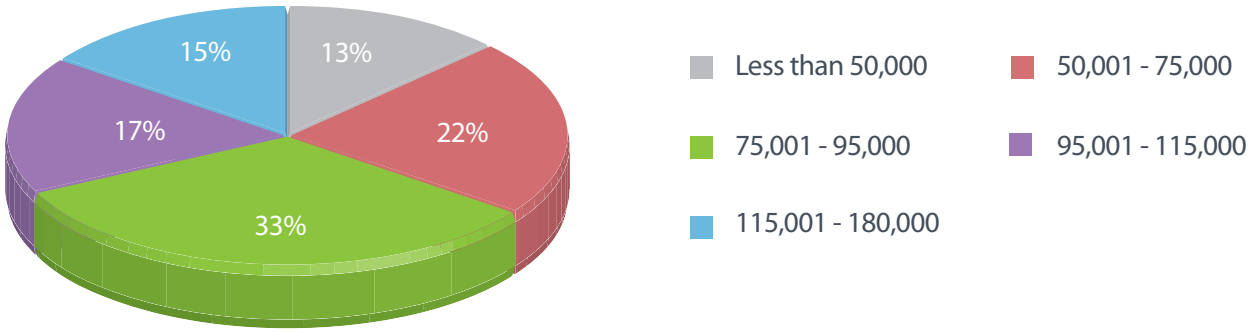
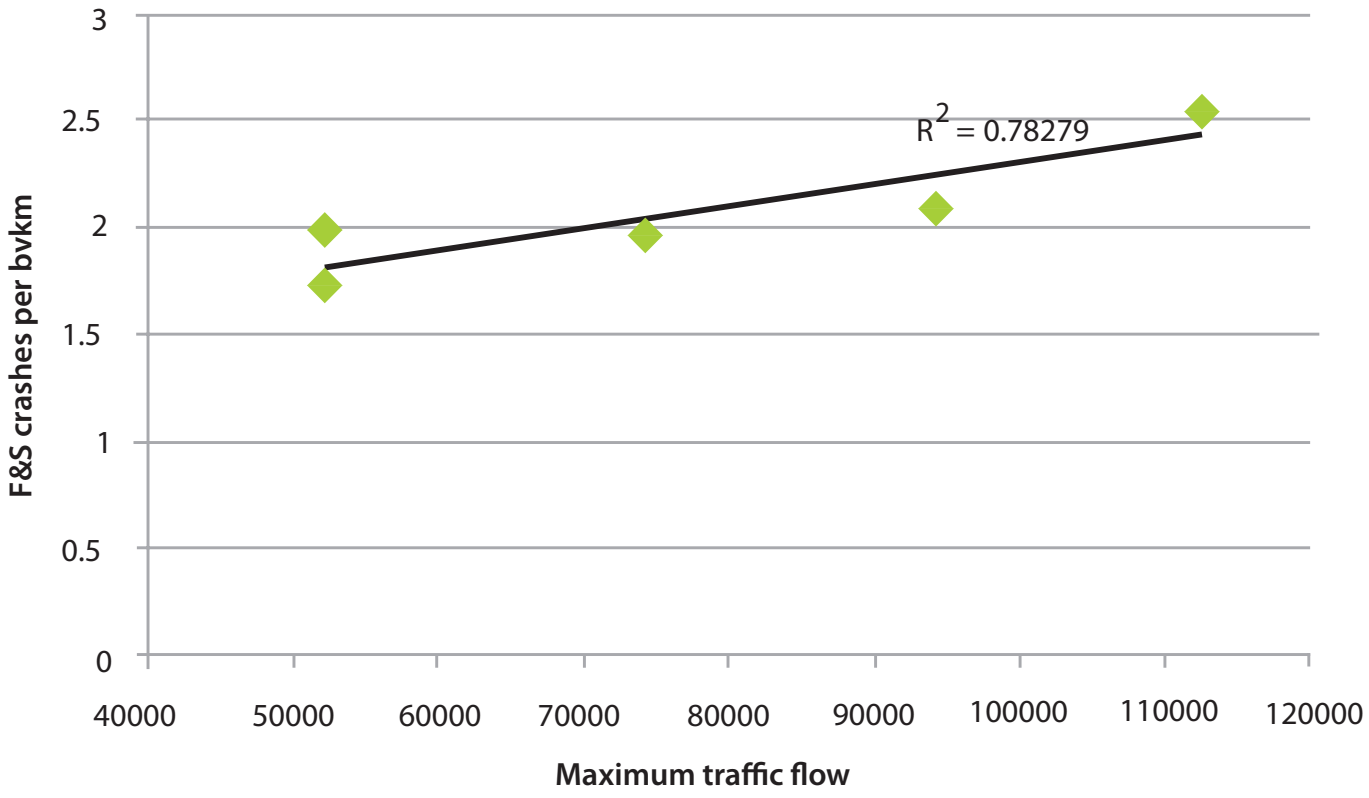



**Figure 9. Risk of shunt crashes vs motorway traffic volume**



Today, upmarket vehicles are equipped with long range radar providing forward alert warnings of slow traffic ahead and adaptive cruise control which can automatically adjust speed and headway without driver intervention. The vast majority of vehicles do not have these features and they will not be the norm across the vehicle fleet for at least a decade.

On motorways, unexpected standing or slow moving traffic can be lethal. Drivers joining motorway traffic queues commonly feel vulnerable and switch on hazard lights to warn following traffic not to run into them. Despite the very high flows, very little of the English network has more than basic motorway information systems. Full "controlled" motorway systems, where variable message signing warns of queues ahead and adjusts speed limits, are restricted to extreme hotspots like the western M25 near Heathrow or M42 near Birmingham Airport.

**Figure 10. M42 controlled motorway**


**Figure 11. Systems on a controlled motorway**

# 9. OUR ATTITUDES TO MOTORWAY SPEED LIMITS

A recent opinion survey found that only 30% of Britons regard exceeding the speed limit as wrong[7]. Specific surveys into the motorway speed limit find that drivers believe that over 90% of motorists generally exceed the 70 mph limit in free flowing conditions[8].

Discussion on raising the motorway speed limit to 80 mph has taken place on a number of occasions and public attitudes appear to have been consistent for the last decade. The recent Populus survey for the AA carried out in March 2011[8] allowed drivers to vary their response to a question on the 80 mph limit and varying enforcement regimes.

The survey suggests that the so-called "enforced 80" regime is the only one around which majority public support could be built for an increased limit.

Such a limited tolerance regime is feasible. Meaningful speed enforcement on motorways was introduced with variable speed limits on controlled motorways in the mid-1990s and, more recently, with average speed cameras at motorway roadworks. France has also recently introduced robust speed camera enforcement on autoroutes.

**Table 3. Opinion survey results**

| Do you think the motorway speed limit should be increased to 80 mph? | |
|---|---|
| Yes, but enforced strictly | 24% |
| Yes, and enforced as the 70 mph limit is now | 40% |
| No, it should stay at 70 mph | 32% |
| No, it should be reduced | 3% |
| Don't know | 1% |

*Source: Populus, March 2011; 12,869 respondents*

# 10. WHAT ARE THE ECONOMICS OF INCREASING THE SPEED LIMIT?

If driven speeds on motorways were to rise yet further from today's levels then:

- vehicle operating costs would increase, particularly fuel consumption;
- crashes and crash severities would rise increasing crash costs;
- delay costs during crashes would rise;
- there would be costs associated with implementing the change;
- journey times would decrease bringing cost reductions from reduced travel times.

The DfT has standard valuations for all the above factors which are broadly supported by professional economists. For example, travel during working time is evaluated at the wage rate plus overheads. Personal time is valued at 25% of the wage rate.

The Foundation has reviewed the DfT estimates of crash costs and, in aggregate, finds them acceptable. From these valuations, it is estimated that £0.4 billion per annum is currently lost in serious crashes on English motorways alone excluding substantial travel delay costs. These are typically as much again as the crash costs on motorways.

If driven speeds are already at 80 mph in free flowing traffic for all drivers who wish to travel at this speed when they are able to do so (see section 2), there is little scope for economic benefits from increased speeds.

There is however scope for economic benefit in increasing crash protection standards from investing in improved "run-off" protection and control systems. The costs involve removing trees that have been permitted to grow too close to the motorway edge, provision of safety fencing on unprotected embankments (cf. Selby rail crash) and investment in controlled motorways on the higher risk sections (e.g., see Table 1 and Figure 9).

The Foundation estimates a benefit-cost ratio exceeding 7 from an investment programme of approximately £50 million per year in the period to 2020. The benefits would be substantially greater if the programme were executed during scheduled maintenance as would be expected. The benefits would be higher still when the costs of traffic delays during serious crashes are taken into account.

# 11. CONCLUSIONS

Some 800 serious crashes occur annually on English motorways, resulting in 115 deaths. The cost of serious motorway crashes is £0.4 billion annually excluding traffic delays.

England's motorways are intensely used. Over half of England's motorways carry more than 85,000 vehicles per day. Drivers are not free to choose their driving speed because of the presence of other traffic for much or most motorway driving.

An examination of DfT's extensive database of driven speeds suggests drivers who wish to may already be driving at or close to 80 mph when unaffected by the presence of other traffic. English roads generally have become safer over the last decade with a 47% drop in the number of deaths, but motorways have not done as well with only a 42% drop.

The major cause for the reduction in all serious road casualties in the last decade is improved vehicle safety. Today's vehicle fleet can however still only protect up to an impact speed of 40 mph. Vehicle crash protection systems must work in conjunction with motorway protection systems such as pre-tensioned safety fences in order to provide protection at motorway speeds.

Independent safety rating of England's motorways finds that only 50% have the maximum 4-star rating. Half the remaining network has significant flaws in "run-off" protection and there is room for improvement on a further 25%.

The analysis shows "run-off" crashes account for at least a quarter of all serious motorway crashes. The serious "run-off" crash rate doubles on English motorway sections with low protection.

"Shunt crashes" account for a further 20% of motorway crashes. The analysis shows clearly that shunt crashes on English motorways increase steadily with traffic flow.

An "enforced 80 mph" strategy is feasible with technology as demonstrated on the M42 and M25 "controlled motorways" and with average speed cameras at motorway road works.

Opinion surveys reveal no evidence of broad public support for increasing the speed limit to 80 mph unless there is an "enforced 80 mph" strategy so that driven speeds stay broadly as they are today. Given this is the only plausible strategy, no material economic benefits arise from increasing the speed limit.

Surveys suggest only 30% of the public believe exceeding the speed limit is wrong. It is not desirable that there are some speed limits which are meant and some which are not. The principle argument to change the approach to the motorway speed limit is to increase respect for all speed limits.

Only a handful of motorway sections are lightly trafficked enough with adequate "run-off" protection to entertain 80 mph as a legal default speed. An 80 mph limit in England can only plausibly be introduced within a system of variable speed limits.

The Highways Agency was permitted to pilot peak period hard shoulder running only with great caution and did so successfully. It would be possible to pilot legal sanction of 80 mph when all the engineering and weather conditions allow at quiet times on sections of existing "controlled motorways".

Piloting of the 80 mph limit must be accompanied by measurement of speeds both on the "controlled" motorway and on adjacent sections of the network in case higher speeds are induced.

The government is seeking economic benefits. The benefit-cost ratio from improving motorway safety exceeds 7 even if improvements were not carried out during scheduled maintenance and traffic delay costs are excluded. The social and economic case for investment is extraordinarily high, perhaps exceeding 15-20.

The Foundation's data identifies where the highest risk motorway sections are together with the infrastructure weaknesses. These can help the Highways Agency or its successors in its programming of the highest return priorities for investment. The Foundation will continue to track independently whether the improvement in safety performance is adequate.

The Foundation recommends the key measures to deliver economic benefits and improve the safety of motorways should be to:

- bring motorways up to a minimum 4-star standard by 2020;
- install full motorway control systems across the network where flows exceed 85,000 vehicles per day by 2020 and improve the value engineering of these systems;
- install general information and warning systems across the remainder of the network by 2020;
- ensure signing and marking regimes follow best international practice so that they can be read by the vehicle systems which are being introduced in the period 2012-2015 (see *Roads that Cars can Read*). [9]

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# UNFIT FOR 80

## An Assessment of t
## of England's Mo

The government has propo tted speed - with speed limit to 80 mph. affic flow, have become safer and that law abi for the 70 m would r high es would motorwa

This report looks ish analysis of the Found good engineering data. mph

The findings show at least half o 800 serious motorway crashes on motorways result from e 0.4 bn – double that if running off the road or from shunts. Wi ites are counted. High return, faults in roadside engineering double the ri ents to safety engineering are serious run-off crashes. The number of shunt c ain ways to boost GDP - the best buys rise exponentially with traffic flow. Half of English r" protection (such as installing missing motorways carry more than 85,000 vehicles daily. ences) and electronic controls on busy motorways.

Busy motorways need electronic control to help avoid shunts and pile-ups. The M42 and M25 are rare exceptions which have investment in electronic

England's motorways may be intensely used but can become more reliable and a world class *safe system*.

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