Managing transport risks: what works?

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Abstract

What does a transport safety regulator have in common with a shaman conducting a rain dance? They both have an inflated opinion of the effectiveness of their interventions in the functioning of the complex interactive systems they purport to influence or control. There is however a significant difference. The clouds are indifferent to the antics of the shaman and his followers. But people react to the edicts of a regulator and frequently not in the way the regulator intends. There are two different kinds of manager involved in the management of transport risks: there are the “official”, institutional, risk managers who strive incessantly to make the systems for which they are responsible safer, and there are the billions of individual fallible human users of the systems, each balancing the rewards of risk against the potential accident risks associated with their behaviour. Conventional road safety measures rest on a model of human behavior that assumes that road users are stupid, obedient automatons who are unresponsive to perceived changes in risk and who need protecting, by law, from their own and others stupidity. The idea of risk compensation underpins an alternative model of human behavior: that road users are intelligent, vigilant, responsive to evidence of safety and danger and, given the right signals and incentives, considerate.

1. Introduction: “We know what works”

In March 2010 The United Nations proclaimed 2011-2020 the Decade of Action for Road Safety (UN announcement 2010). It aspired to promote road safety everywhere, but especially in countries in the early stages of motorization with the highest accident rates. Credit for this proclamation has been claimed by the Make Roads Safe campaign of the FIA Foundation (Make Roads Safe 2010). On the campaign’s website a “TAKE ACTION” tab offers a selection of Make-Roads-Safe T-shirts, banners, publications and wristbands, but no suggestions for what might actually be done to make roads safer. Former UK defence secretary Lord Robertson, who is chairman of the campaign, is a bit more specific. He claims “We know what works: making vehicles safer and designing roads to be safe for all road users; tackling inappropriate speed and drink driving; promoting seat belt use and helmet wearing; improving driver training and police enforcement.”

The spearheading of the campaign by the FIA (Federation Internationale de l'Automobile), the organization that glamorizes "inappropriate speed" through its promotion of Formula 1 racing, is an incongruity that seems thus far to have escaped comment elsewhere. At the time of writing (November 2010) the Make Roads Safe campaign is the most prominent feature on the FIA home page (**www.fia.com**) - competing for attention with pictures of racing cars doing exciting things at inappropriate speeds.

At the launch ceremony for the campaign John Sammis, representing the United States, drew attention to the "6,000 of his fellow citizens killed and the more than half a million injured in 2009 due to distracted driving, particularly text messaging" (UN announcement 2010). This contribution highlights a significant problem for those who claim to know what works.

In the United States laws banning text messaging while driving are a matter of state jurisdiction; some states have passed laws others have not. This has created a natural experiment in which the accident experience of states with laws can be compared with the experience of those that haven't. In 2010 the Highway Loss Data Institute published a report on the effect of the laws. It concluded:

> *The results of this study seem clear. In none of the four states where texting bans could be studied was there a reduction in crashes. It's important to remember that the public safety issue in distracted driving is the crashes resulting from cell-phone conversations and texting, not the use of these devices*, per se*. If the goal of texting and cellphone bans is the reduction of crash risk, then the bans have so far been ineffective. Bans on handheld cell-phone use by drivers have had no effect on crashes (HLDI, 2009), as measured by collision claim frequencies, and texting bans may actually have increased crashes.* (HLDI 2010)

The texting study concludes with a plausible speculation to explain the increase in crashes in *states that passed laws banning texting while driving:*

> *This unexpected consequence of banning texting suggests that texting drivers have responded to the law, perhaps by attempting to avoid fines by hiding their phones from view. If this causes them to take their eyes off the road more than before the ban, then the bans may make texting more dangerous rather than eliminating it.*

The perverse effect of texting bans created a difficulty for US Department of Transportation Secretary Ray LaHood, a strong advocate of texting bans. He dealt with the difficulty by simply denouncing the study as "ridiculous" (www.textkills.com/?p=1418) and by issuing an angry, hand-waving dismissal of the method of assessment used by the HLDI, stating that the same method would have cast doubt on the efficacy of seatbelt and drink-drive legislation (USDoT 2010). As we shall see below this is a less than convincing argument. Like Lord Robertson, and numerous other road safety campaigners, LaHood knows what works and is exasperated by evidence that contradicts this "knowledge".

The American experience with texting bans is but the most recent installment of a long-running saga. In 1985 the late Frank Haight, the long-term editor of *Accident Analysis and Prevention,* one of the most highly regarded scientific journals in the field, observed:

> *One sees time and again large sums of money spent [on road safety] in industrialized countries, the effect of which is so difficult to detect that further sums must be spent in highly sophisticated evaluation techniques if one is to obtain even a clue as to the effectiveness of the intervention.* (Haight 1985)

2. History: what works?

Since the earliest days of mechanized transport there have been efforts to manage the risks that accompany it. In Britain the famous Red Flag Act (the Locomotive Act of 1865) required traction engines to be preceded by a man walking 60 yards ahead, at no more than 4 mph, carrying a red flag. This requirement was not repealed until 1896 – coincidentally the same year in which the first pedestrian was killed by a car in Britain.

Since then countless road safety measures have been implemented, in many jurisdictions: speed limits, accident black spot treatments, vehicle construction regulations, drink drive laws, road signage, traffic lights, seatbelt laws … to name but a few.

Concerns about the risks attached to transport have deep roots. The *Dublin Police Act* of 1842 created the offence of “driving furiously” – the same style of driving attributed to Jehu in the Old Testament (2 Kings, 20). As recently as November 2008 the Irish Law Commission (Law Commission 2008) was consulting on whether this offence should be abolished. Whether it has now been abolished I am afraid that, at the time of writing, Google does not relate.

Intriguingly, despite decades if not millennia of interest in the problem of managing transport safety, there is remarkably little agreement about what works. Consider Figure 1. Since 1950 road accident fatalities per kilometer travelled in Britain have dropped dramatically.

Figure 1 about here
Deaths per billion vehicle kilometers - GB

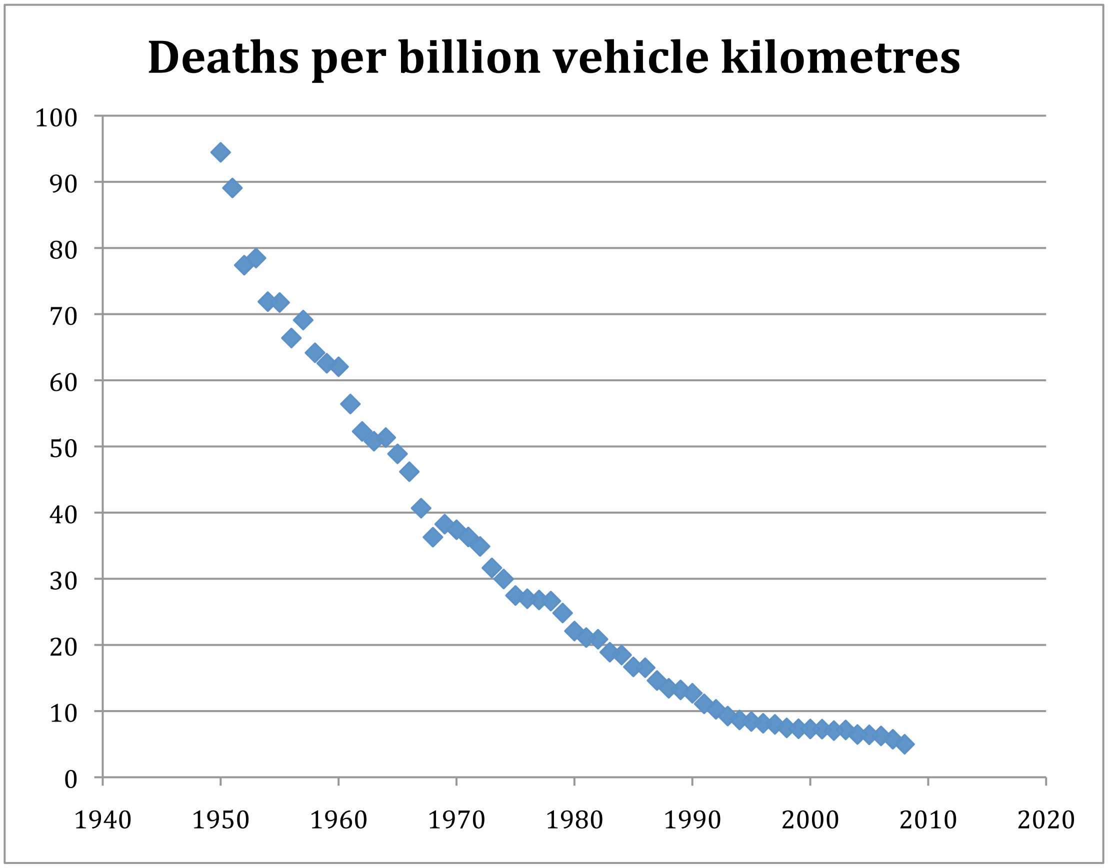
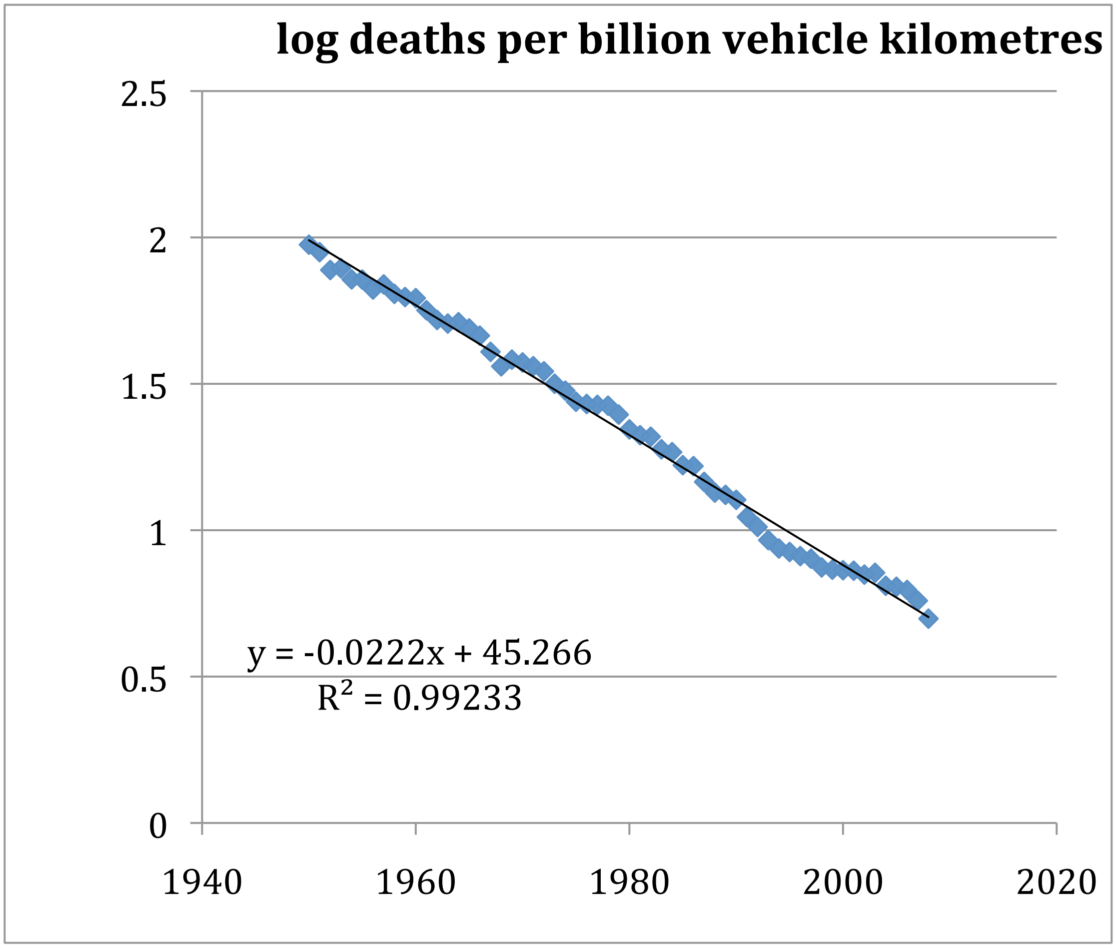


Figure 2, with the vertical axis transformed into logarithms, shows that the trend between 1950 and 2008 can be approximated by a straight line whose slope reveals that over this period deaths *per vehicle kilometer* decreased at a rate of 5.2% per year. The risk of death per kilometer travelled at the end of the period was one twentieth of the risk at the start of the period. Clearly something was working to make travel safer. But what?

Figure 2 about here
Log deaths per billion vehicle kilometers - GB



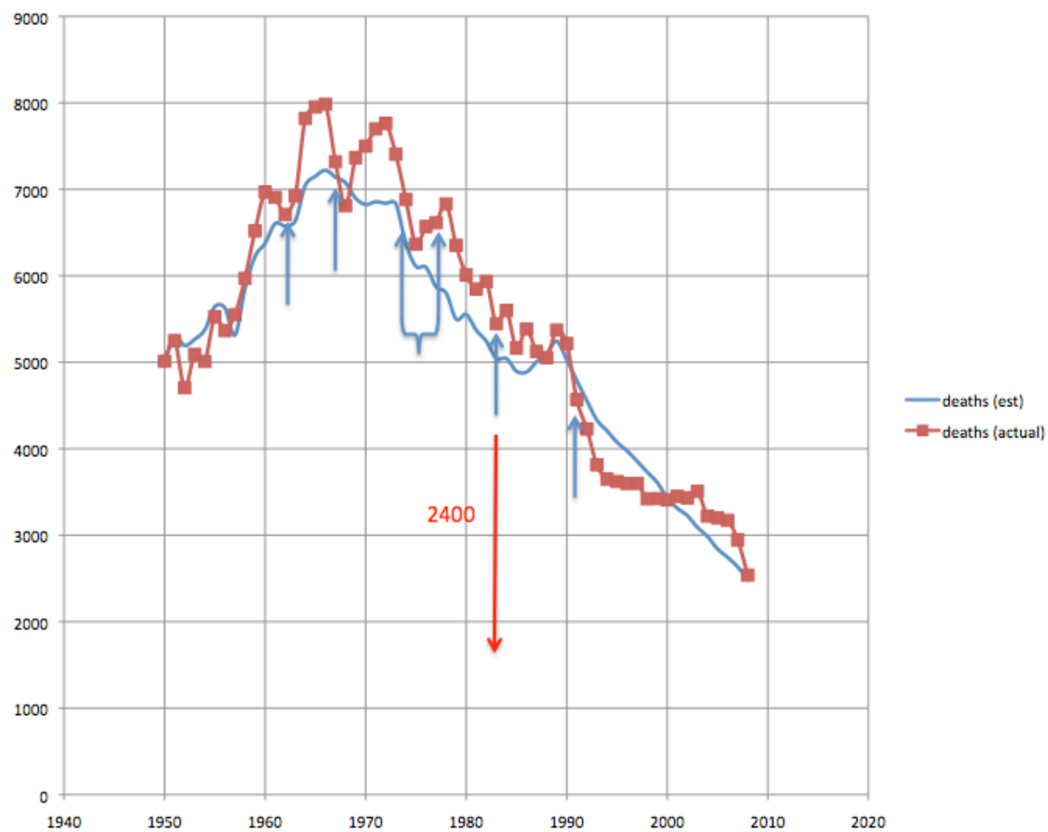
The downward trend illustrated by Figure 2 does not mean that the number of road accident fatalities decreased every year. Figure 3 shows that in years when traffic grew a rate higher than 5.2% the number of fatalities tended to increase, and when it grew more slowly they tended to decrease.

Figure 3 about here
Road accident deaths Great Britain: 1950-2008

The arrows on Figure 3 indicate (with the exception of the 1991 arrow) the introduction of significant road safety measures – government interventions intended to make the roads safer. Each should have produced, according to the prior claims of their promoters, a sharp downward step in the graph displayed in Figure 2. But the steps are not there.

The first, **the 1962 Traffic Act**, imposed new speed limits, increased the maximum fines for speeding and careless driving by *150* per cent, and introduced the "totting-up" procedure whereby drivers could be disqualified for three offences. The second, **the Road Safety Act of 1967** made it an offence to drive with over 80 mg. of alcohol per *100* ml. of blood. The third pair of arrows

Figure 3 Road accident deaths Great Britain: 1950-2008



brackets **the "energy crisis" speed limits**. Between December 1973 and April 1977 various speed limits were imposed in response to the energy crisis and then repealed; they were introduced as a fuel conservation measure, but were warmly welcomed by safety experts as a safety measure. The fourth, the seat belt law, took effect in January 1983; it made the wearing of seatbelts in the front seats of cars and vans obligatory and was introduced with the claim that it would save 1000 lives a year. The fifth arrow we shall come to shortly.

The **1962 Traffic Act**. The penalties provided by law for motoring offences are intended to act as incentives to safer driving - disincentives to law-breaking being equated with disincentives to unsafe behavior. The objective of the new speed limits, larger maximum fines, and the totting-up procedure (whereby 12 penalty points led to disqualification) was to increase the severity of the punishment for the most persistent offenders. However, changing the law did not necessarily lead to a change in practice; although the maximum permitted fines for speeding and careless driving had been increased by 150 per cent, the average fine handed out by the courts did not increase at all (Plowden 1971). Following the implementation of the measures contained in the 1962 Traffic Act the number of road accident deaths, which had fallen over the previous two years, climbed more steeply than the trend identified in Figure 3 until reaching a post-war peak in 1966. Perhaps the increase would have been even greater without the 1962 Act. Perhaps not.

1967: **the breathalyzer.** The introduction of blood alcohol limits in October 1967 and a new method of testing coincided with a sharp drop in road accident fatalities. It appears likely that the new limits and the breathalyser deserve credit for a substantial part of this decrease. The number of over-the-limit dead drivers dropped from 25 per cent to 15 per cent. The number of deaths between 2200 and 0400 hours (the period in which most drink-drive offences are committed) dropped by 31 per cent. However the effect was temporary. By 1969 the percentage of drivers killed in accidents while over the legal limit was back above its pre-law level. It is difficult to see a clear correlation between drinking and driving and total road accident deaths. By 1983 the number of over-the-limit dead drivers had risen to 31% while total road accident fatalities had dropped from 6810 in 1968 to 5445.

In 1983 *Accident Analysis and Prevention* devoted an entire issue to the problem of impaired driving. The guest editor summarized his long experience of drunken driving countermeasures in a despairing introduction:

> *Once again, drinking and driving has come to the fore as a public concern. The beginning of every decade over the past 30 years has seen a surge of interest in, and concern over, drinking a driving. This concern has led to millions being spent throughout the world on countermeasures, with little measureable success in reducing the problem. (*Vinglis 1983)

It is frequently argued that the temporary success achieved by some drink-drive “blitzes” proves that the problem could be solved by some combination of more draconian penalties and more vigorous enforcement. Scandinavia, with its low permitted alcohol levels, rigorous enforcement and draconian penalties for over-the-limit driving is frequently held up to the rest of the world as an exemplar. But Ross in a 1976 article entitled “The Scandinavian Myth” (Ross 1976) cast doubt on this hypothesis. His interrupted time-series analyses revealed no effect of the Scandinavian drink-drive laws on the relevant accident statistics.

His analysis suggested that tough drink-drive legislation is only like to work where it accords with prevailing public opinion. He noted the existence of a politically powerful temperance tradition in Scandinavia. Many people considered drinking and driving a serious offence (if not a sin) before it was officially designated as such by legislators. The absence of a detectable effect of Scandinavian drink-drive laws on accident statistics at the time the laws came into effect suggested, according to Ross, that the laws were symptomatic of a widespread concern about the problem, and that most people likely to obey such laws were already obeying them before they were passed. The laws, in effect, simply ratified established public opinion.

Where laws are passed that run ahead of public opinion there appears to be a conspiracy involving motorists, the police, judges and juries to settled for a level of compliance and enforcement that accords with public opinion. In Britain after 1983 there was an impressive decrease in the number of dead drivers over the legal limit. The cause appears not to have been any specific intervention by the government, but a change in social attitudes.

1973-1977: the energy crisis speed limits. In December 1973, a blanket speed limit of 50mph was applied to all roads in Britain not already subject to a lower limit. At the same time petrol prices were increased by 20 per cent, followed by another increase of 20 per cent in February 1974, and a further increase in April; between December 1973 and April 1974 petrol prices increased by about 57 per cent. The motorway speed limit was restored to 70mph at the end of March, and in May the 70mph limit was restored to other all-purpose roads previously subject to that limit. In November 1974 the limit on some all-purpose roads was reduced to 50mph and on others to 60mph. Finally, in April 1977 Parliament agreed that the 50 and 60mph limits on all-purpose roads should be raised again to 60 and 70mph - in the face of protest and dire predictions by safety experts.

In 1974 and 1975 the total number of road deaths decreased. In 1976, 1977 and 1978 they increased. However the contribution of the different modes of travel to the changes in the total numbers of deaths in these years varied considerably. One response to the large increase in the price of petrol that accompanied the energy crisis was a large increase in the use of more energy efficient, but also more dangerous, motorcycles. Between 1975 and 1978 there was an increase of 465 in the total number of road deaths per year, but most of this increase (325) was accounted for by motorcyclists. In 1977, after the last of the energy crisis speed limits was repealed, the total number killed – excluding motorcyclists decreased. After 1978 deaths for all modes, despite the dire predictions of road safety campaigners advocating lower speed limits, decreased markedly.

1983: the seatbelt law. The effect of the 1983 seatbelt law remains the subject of extraordinary myth making. On the 31st of January 2008 Britain's Department of Transport celebrated the 25th anniversary of the laws coming into effect with a press release in the name of the Road Safety Minister claiming:

> "Twenty five years of seatbelt wearing laws have helped save 60,000 lives." (DfT 2008)

Others were quick to claim a share of the credit. The website of the Royal Society for the Prevention of Accidents claims:

> "**1982** – RoSPA's president, Lord Nugent, secured **compulsory wearing of seatbelts** with a late amendment to a Transport Bill. The law is estimated to have saved 60,000 lives to date." (RoSPA 2010)

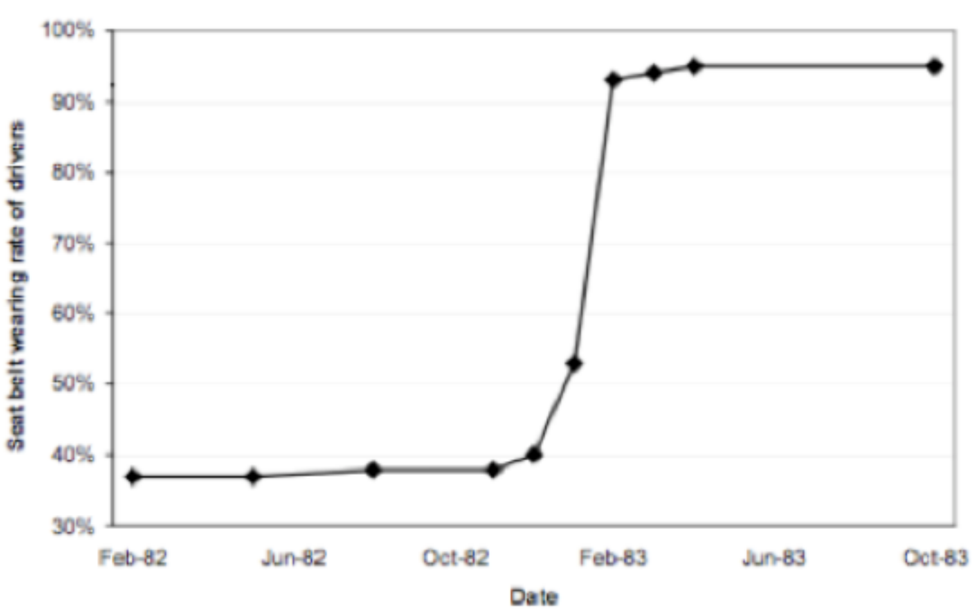
While the Parliamentary advisory Council on Transport Safety explained their role as follows:

> "On the 31st January 2008, the 25th anniversary of the law change which made front seatbelt wearing compulsory was celebrated. PACTS itself was set up by Barry Sheerman MP as part of the fight to get mandatory seatbelt wearing turned into legislation. Eight years later it became compulsory for all backseat passengers to use seatbelts and it is estimated that since the introduction of the first law change in 1983, *seatbelts have prevented 60,000 deaths* and over 670,000 serious injuries**."**(PACTS 2010)

The 60,000 claim has been endlessly recycled in the national and local press, radio and television, by the police and on websites including those of the National Health Service, insurance companies, law firms and numerous others rather marginally connected to road safety concerns such as the Yorkshire Dales National Park. Such is the mesmerizing power of large numbers that the claim even escaped the usually sharp editorial eyes of a large team of highly experienced transport researchers who maintained in a report for the Department for Transport that "Over the past 25 years the compulsory wearing of seat-belts has been estimated to have saved at least 60,000 lives." (Erel Avineri et al. 2009)

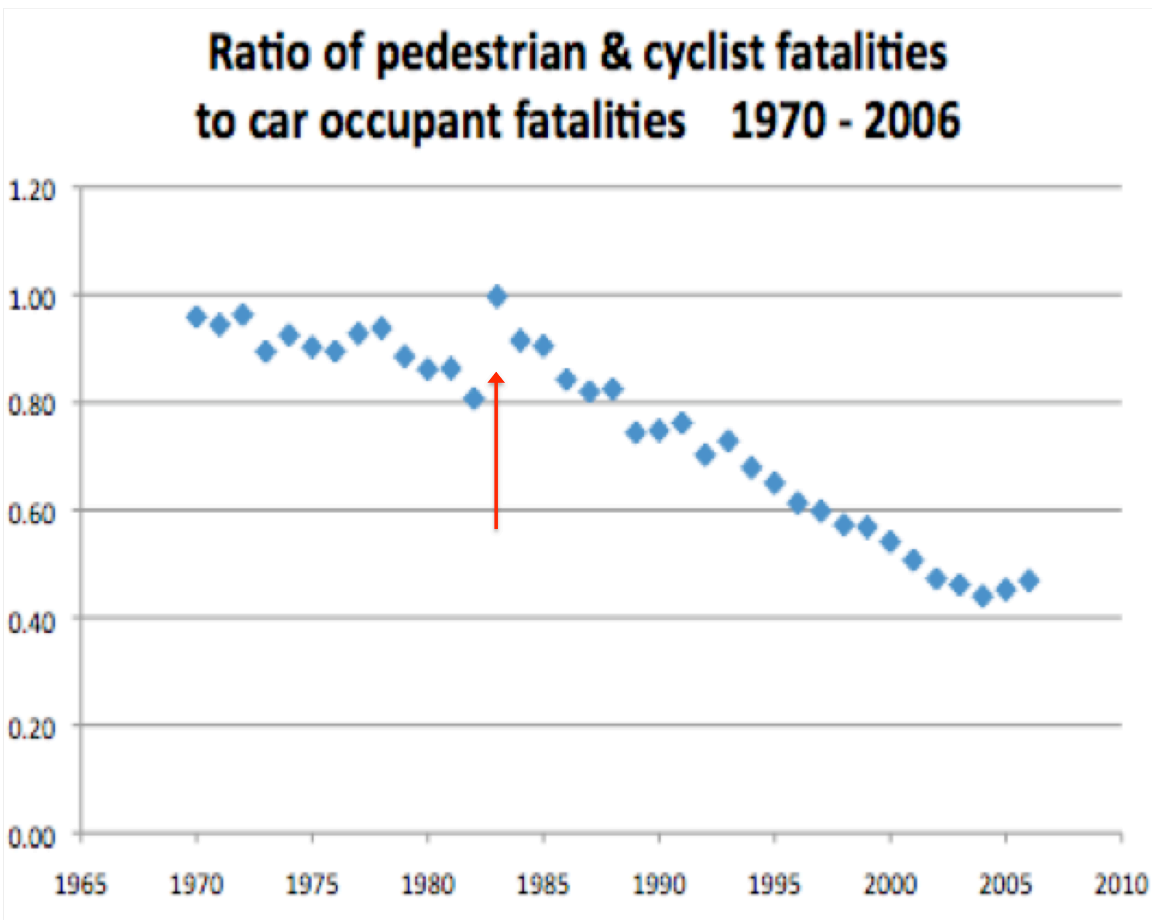
60,000 lives saved over a 25-year period averages 2,400 per year (shown on Figure 3). The increase in wearing rates at the time the law came into effect was large and abrupt (see Figure 4). The claimed effect of the law should have been evident in Figure 3 as a sharp downward step in the established downward trend. Instead the trend leveled off, not resuming until after 1990.

Figure 4. Seatbelt wearing rate of drivers



There is however a sharp step effect to be seen in the road accident data. The ratio of pedestrian and cyclist fatalities to car occupant fatalities had been declining for many decades as the numbers travelling in cars increased and the amount of walking and cycling decreased. In 1935 the ratio was 6 to 1; by 1982 it was down to 0.8 to 1. In 1983 it jumped 25% to 1.0 and it was another 7 years before it fell below 0.8. Consistent with the result in other jurisdictions with seat belt laws there was a shift in the burden of risk from those best protected in cars to more vulnerable road users on foot or bicycle. (Adams J 1995 ch 7 & Adams J 2010)

Figure 5 about here



In **1991** total road accident fatalities decreased by 12.5 per cent. This was the largest annual decrease since the war years when fuel shortages removed large numbers of vehicles from the roads. Frustratingly for road safety campaigners, it is not possible to attribute the decrease in 1991 to any of the safety measures introduced in that year. Indeed, 1991 was a quiet year on the road safety front in terms of the implementation of new safety measures. Table 1 presents the most significant new safety interventions in 1991 listed in *Road Accidents Great Britain 1991*, and the associated casualty effects, where available, from published sources.

Table 1 Road safety measures implemented in 1991

* twelve 20mph zones introduced -- *the decrease in casualties in built-up areas was less than the overall decrease*,

* £31 million allocated for local safety schemes -- *a sum equal to the value of 41 fatal accidents in a DoT cost-benefit analysis*,

* chevron markings tried out on the M1,

* trials of nearside pedestrian signal at junctions,

* launch of 'The Older Road User' campaign -- *the decrease in casualties for those over age 65 was less than the overall decrease*,

* campaign to encourage wearing of cycle helmets by children – *decrease in cycling casualties to ages 0-15 less than overall decrease*,

* change in law requiring adults in rear seats to wear belts in cars where belts are fitted and available -- *comparable statistics not available, but decrease in total rear seat casualties less than overall decrease*,

* campaign to encourage drivers to slow down in areas where children are likely to be about -- *decrease in casualties suffered by pedestrians and cyclists age 0-15 less than overall decrease*.

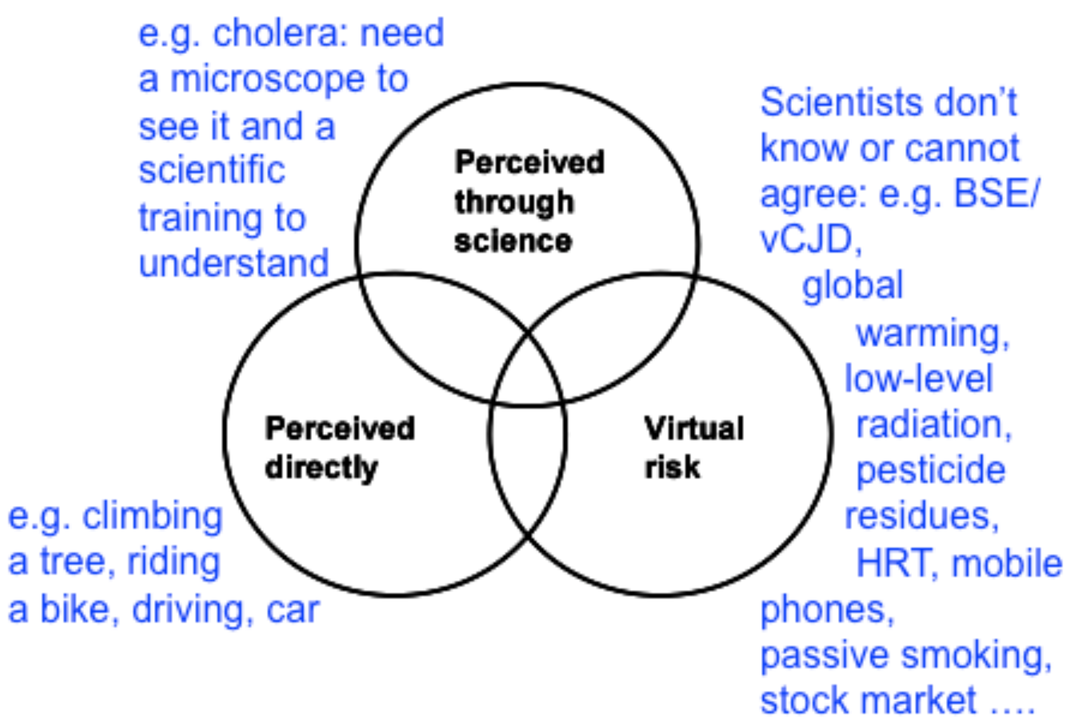
A more plausible explanation for the record decrease in road deaths in 1991 than any actions on the part of the Department of Transport or other safety organizations, is that the decrease coincided with the most severe recession since the war. There is clear evidence that road accident casualties go up and down with the economy. (Adams 1985, ch 7)

3. Further Research – explaining the paradox

Figures 1 to 3 represent what for most transport risk managers is a paradox. They display an enormous decrease in the death rate per volume of traffic with no significant connection to road safety measures introduced by legislators or regulators. None of the measures in Lord Roberts list of "we know what works" have been proven to work (Adams 1985 & 1995).

In seeking an explanation for this paradox it will be helpful to place it in a wider risk-management context. Figure 5 presents a risk typology that is germane to most discussions of a wide variety of risks and their management. Presented as a Venn diagram it suggests that it can be useful to distinguish three different, but not mutually exclusive, types of risk. Typing the single word 'risk' into Google produces hundreds of millions of hits. One need sample only a small fraction in order to discover unnecessary and often acrimonious arguments caused by people using the same word to refer to different things and shouting past each other. The typology offered in Figure 5 can help to dispose of some unnecessary arguments and civilize others.

Figure 5. Different kinds of risk.



Risks in the *perceived directly* circle are managed using judgment. We do not undertake a formal, probabilistic risk assessment before crossing the road; some combination of instinct, intuition and experience usually sees us safely to the other side.

The second, *risk-perceived-through-science*, circle dominates the risk management literature. In this circle we find books, reports and articles with verifiable numbers, cause-and-effect reasoning, probability and inference. This is the domain of, amongst others, biologists with microscopes searching for microbial pathogens and astronomers with telescopes plotting the courses of incoming asteroids. This circle contains contributions from the whole range of science, technology and the social sciences – from physics and chemistry to epidemiology and criminology. But the central science is statistics – the discipline that has probability at its core. This is the circle in which most of the published work on road safety can be found.

The circle labeled *virtual risk* contains contested hypotheses, ignorance, uncertainty and unknown unknowns. If an issue cannot be settled by science and numbers we rely, as with directly perceptible risks, on *judgment*. Some find this enormously liberating; all interested parties feel free to argue from their beliefs, prejudices or superstitions. It is in this circle that we find the longest-running and most acrimonious arguments. Virtual risks may or may not be real, but beliefs about them have real consequences.

Road safety is an intensively studied subject. It is awash with numbers, numbers adduced in support of the efficacy of existing road safety measures or in support of new ones proposed. And yet, despite all these numbers, we have the paradox described above. This suggests that most of the debate about road safety should be consigned to the third circle – virtual risk. After decades of road-safety interventions we still appear to be unclear about what works.

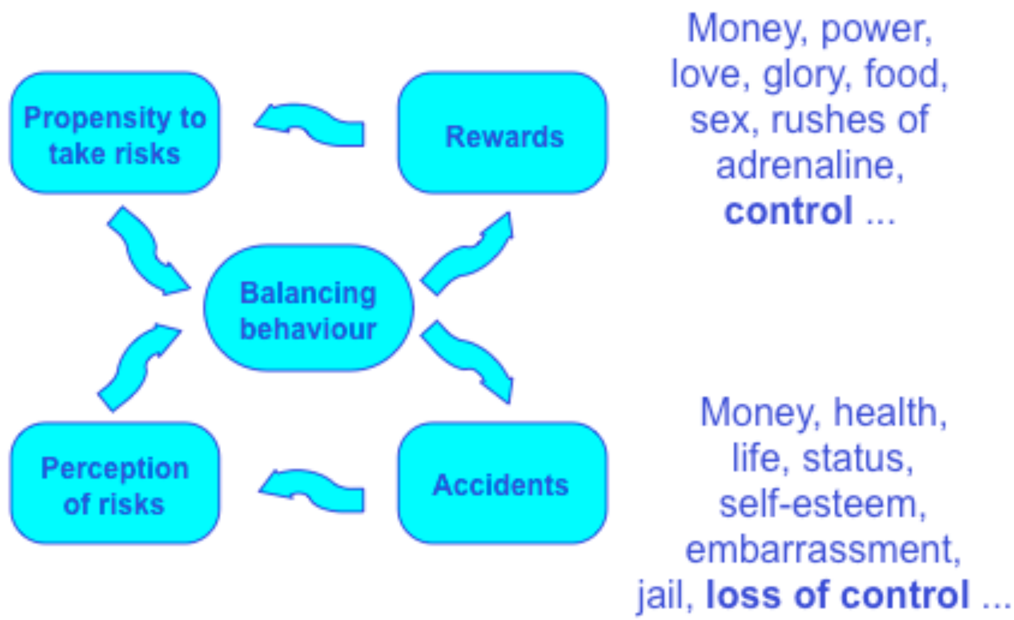
Why should there remain any uncertainty about "what works"? Surely we know about the crash-protection benefits of seatbelts, air bags and crumple zones. So why should the contribution of such benefits be so difficult to find in the aggregate statistical outcome?

Different risk managers

A major part of the explanation lies in the fact that there are two very different sets of risk managers at work and their work tends to be found in different circles of Figure 5. One set might be called "institutional risk managers". These are the legislators and regulators who make and enforce the rules governing transport safety, and the highway and vehicle engineers concerned with making roads and vehicles safer. Their quantitatively embellished work can be found mostly in the *perceived through science* circle. Their endeavors are routinely frustrated by the behavior of a second much larger set of risk managers consisting, world-wide, of billions of road users managing directly perceived risks guided by individual judgment.

Figure 6, the "risk thermostat", presents a model of the risk management process that can help to demystify the paradox described above.

Figure 6. The risk thermostat



The model postulates that

- everyone has a propensity to take risks – the setting of the thermostat;
- this propensity varies from one individual to another;
- this propensity is influenced by the potential rewards of risk taking;
- perceptions of risk are influenced by experience of accident losses – one's own and others';
- individual risk-taking decisions represent a balancing act in which perceptions of risk are weighed against propensity to take risks; and
- accident losses are, *by definition*, a consequence of taking risks (to take a risk is to do something that carries with it a probability of an adverse outcome); the more risks an individual takes, the greater, on average, will be both the rewards and the losses he or she incurs.

Credit for discovering this phenomenon is shared between a University of Chicago economist, Sam Peltzman (1975) after whom it is labeled by economists as the "Peltzman effect", and a Canadian psychologist Gerald Wilde who dubbed it "risk compensation" and later "risk homeostasis". Wilde's most recent elaboration of the effect can be found in *Target Risk* (Wilde 1994 & 2001)

The risk compensation model might also be called cost-benefit analysis without the £ or $ signs. It describes a phenomenon know to the insurance industry as "moral hazard" - they have discovered that their customers are less careful about locking up if they have contents insurance. It is a conceptual model, not one into which you can plug numbers and from which you can extract decisions; the Rewards and Accidents boxes contain too many incommensurable variables; our reasons for taking risks are many and diverse, and vary from culture to culture and person to person.

Most institutional risk managers work with a different model. “Reducing Risks, Protecting People” is the mantra of Britain’s Health and Safety Executive, the country’s foremost risk manager. It is also the title of the publication in which it explains its decision making process (HSE 2001). In terms of Figure 6 this process is confined to the bottom loop. It exemplifies the thought processes of most institutional risk managers, including those working on the management of transport risks. Outside the offices of investment banks and hedge funds most institutional risk managers have only a bottom loop. Often their job specification precludes contemplation of the rewards of risk taking. Their job is to prevent accidents. The rewards loop is someone else’s business – perhaps the marketing department.

But road users, whether pedestrians, cyclists or motorists have top loops. While trying to avoid accidents they are also in pursuit of the rewards of risk. These can range from getting from A to B on time, to the adrenaline rush of the boy racer or making contact with the person calling or texting one’s mobile phone.

The model proposes that safety interventions that do not reduce the setting of the thermostat (propensity to take risks) will be offset by behavior that seeks to restore the balance of risk.

Antilock braking systems provide a good example. When introduced, their superiority persuaded many insurance companies to offer discounts for cars with antilock brakes. Most of these discounts have now been withdrawn. The ABS cars were not having fewer accidents, they were having different accidents. Or perhaps they were having fewer accidents, but no fewer fatal accidents; the evidence from various studies is less than conclusive – leaving antilock brakes still in the disputed *virtual risk* category of Figure 5.

The opening sentences of the Executive Summary of a recent US Department of Transport study on the long-term effect of ABS in passenger cars and LTVs states:

> *Antilock brake systems (ABS) have close to a zero net effect on fatal crash involvements. Runoff- road crashes significantly increase, offset by significant reductions in collisions with pedestrians and collisions with other vehicles on wet roads. But ABS is quite effective in nonfatal crashes, reducing the overall crash-involvement rate by 6 percent in passenger cars and by 8 percent in LTVs (light trucks – including pickup trucks and SUVs – and vans) (NHTSA 2009)*

The report notes that early studies of the initial effectiveness of ABS produced results that were “counterintuitive”:

> "The overall effect of ABS on fatal crash involvements was close to zero.
> Vehicles with four-wheel ABS had significantly higher rates of fatal run-off-road crashes than vehicles without ABS. In fact, the overall effect netted out to zero only because this increase was offset by a reduction in collisions with other vehicles on wet roads. These fairly strong statistical results did not square with intuition. The behavior of ABS on the test track did not provide any obvious reason that run-off-road crashes should increase; if anything, they suggested there ought to be a benefit."

In listing hypotheses to explain these perverse findings it is clear that the NHTSA's intuition was not informed by the risk compensation hypothesis. Still puzzled by their statistical findings, and seeking reassurance that antilock brakes are an effective safety measure, the report announces a 2008-2012 evaluation plan (Allen et al 2008) that will seek to answer the following questions:

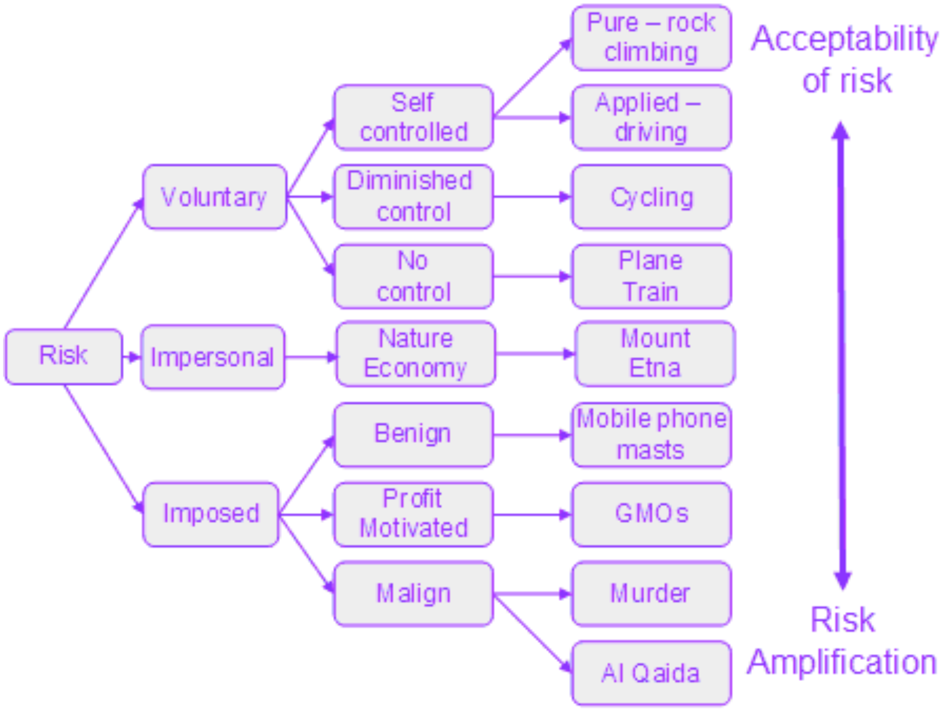
- What is the overall effect of ABS on nonfatal crashes?
- Even if the net effect of ABS on fatal crashes is close to zero, does ABS prevent enough nonfatal injuries and property damage to endorse ABS technology for its safety benefits? (p 16)

It is sometimes argued that a risk compensation effect should only be found in cases where there is a clearly perceptible change in a vehicle's performance. It might help, it is accepted by some, to explain the statistical outcome associated with antilock brakes, but not with seatbelts; i.e. its effect should be confined to risks falling in the *directly perceptible* circle of the Venn diagram in Figure 5. But most people will admit to feeling safer when belted or, if habitual wearers of seatbelts, to feeling exposed and vulnerable without it. This feeling is surely amplified by highly publicized (and grossly exaggerated) claims for their effectiveness.

What kills you matters
In listing some of the contents of the *Rewards* and *Accidents* boxes in Figure 6 *control* and *loss of control* were highlighted. Figure 7 sets out the significance of this factor.

Acceptance of a given actuarial level of risk varies widely with the perceived level of control an individual can exercise over it and, in the case of imposed risks, with the perceived motives of the imposer.

Figure 7. What kills you matters



With 'pure' voluntary risks, the risk itself, with its associated challenge and rush of adrenaline, is the reward. Most climbers on Mount Everest and K2 know that it is dangerous and willingly take the risk. Similarly thrill-seeking young men driving recklessly are aware that what they are doing is dangerous; that is the point.

With a voluntary, self-controlled, applied risk, such as driving, the reward is getting expeditiously from A to B. But the sense of control that drivers have over their fates appears to encourage a high level of tolerance of the risks involved.

Cycling from A to B (I write as a London cyclist) is done with a diminished sense of control over one's fate. This sense is supported by statistics that show that per kilometer travelled a cyclist is much more likely to die than someone in a car. This is a good example of the importance of distinguishing between relative and absolute risk. Although much greater, the absolute risk of cycling is still small – 1 fatality in 25 million kilometers cycled; not even Lance Armstrong can begin to cover that distance in a lifetime of cycling. And numerous studies have demonstrated that the extra relative risk is more than offset by the health benefits of regular cycling; regular cyclists live longer.

While people may voluntarily board planes, buses and trains, the popular reaction to crashes in which passengers are passive victims, suggests that the public demand a higher standard of safety in circumstances in which people voluntarily hand over control of their safety to pilots, or bus or train drivers.

Risks imposed by nature – such as those endured by people living on the San Andreas Fault or the slopes of Mount Etna – or by impersonal economic forces – such as the vicissitudes of the global economy – are placed in the middle of the scale. Reactions vary widely. Such risks are usually seen as motiveless and are responded to fatalistically – unless or until the risk can be connected to base human motives. The damage caused by Hurricane Katrina to New Orleans is now attributed more to willful bureaucratic neglect than to nature. And the search for the causes of the economic devastation attributed to the 'credit crunch' is now focusing on the enormous bonuses paid to the bankers who profited from the subprime debacle.

Risks imposed by one's fellow humans are less tolerated. Consider mobile phones. The risk associated with the handsets is either non-existent or very small. The risk associated with the base stations, measured by radiation dose, unless one is up the mast with an ear to the transmitter, is orders of magnitude less. Yet all around the world billions of people are queuing up to take the voluntary risk, and almost all the opposition is focused on the base stations, which are seen by objectors as impositions. Because the radiation dose received from the handset increases with distance from the base station, to the extent that campaigns against the base stations are successful, they will increase the distance from the base station to the average handset, and thus the radiation dose. The base station risk, if it exists, might be labeled a benignly imposed risk; no one supposes that the phone company wishes to murder all those in the neighborhood. The extent to which traffic is seen as an imposed risk varies widely. Parents of young children and cyclists are much more likely to feel it as an imposition than drivers of SUVs and big cars.

Even less tolerated are risks whose imposers are perceived to be motivated by profit or greed. In Europe, big biotech companies such as Monsanto are routinely denounced by environmentalist opponents for being more concerned with profit than the welfare of the environment or the consumers of its products. Manufacturers of high-performance cars are assigned by some campaigners to the same category, their arguments sometimes adding damage to the environment to the danger posed to vulnerable road users.

Less tolerated still are malignly imposed risks – crimes ranging from mugging to rape and murder. In most countries the number of deaths on the road far exceeds the numbers of murders, but far more people are sent to jail for murder than for causing death by dangerous driving. In the United States in 2002 16,000 people were murdered – a statistic that evoked far more popular concern than the 42,000 killed on the road – but far less concern than that inspired by the zero killed by terrorists.

Which brings us to Al Qaida and its associates. How do we account for the massive scale, world-wide, of the outpourings of grief and anger attaching to its victims, whose numbers are dwarfed by victims of other causes of violent death?

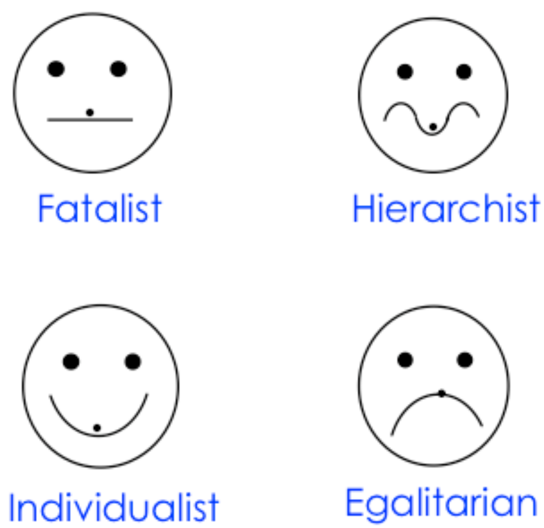
In London 52 people were killed by terrorist bombs on 7 July 2005, about six days worth of death on the road. But thousands of people do not gather in Trafalgar Square every Sunday to mark, with a three minute silence, their grief for the previous week's road accident victims.

The dangers that can be tracked to the malign intent of terrorists are amplified by governments who see it as a threat to their ability to govern – to their ability to control events. To justify forms of surveillance and restrictions on liberty previously associated with tyrannies, 'democratic' governments now characterize any risk to life posed by terrorists as a threat to *Our Way of Life*.

Our way of life

How 'we' manage risk to safeguard our way of life depends on who 'we' are. Figure 8 presents in cartoon form a typology of cultural biases commonly met in debates about risk (for the pre-cartoon version see Adams 1995).

Fig. 8. A typology of cultural biases



These are cartoon caricatures, but nevertheless recognizable types that one encounters in debates about threats to safety and the environment. With a little imagination you can begin to see them as proponents and defenders of different ways of life. In a report for Britain's Health and Safety Executive (Adams and Thompson 2002) they are described as follows:

• *Individualists* are enterprising 'self-made' people, relatively free from control by others, and who strive to exert control over their environment and the people in it. Their success is often measured by their wealth and the number of followers they command. They are enthusiasts for equality of opportunity and, should they feel the need for moral justification of their activities, they appeal to Adam Smith's Invisible Hand that ensures that selfish behaviour in a free market operates to the benefit of all. The self-made Victorian mill owner or present-day venture capitalist would make good representatives of this category. They oppose regulation and favor free markets. Nature, according to this perspective, is to be *commanded* for human benefit.

• *Egalitarians* have strong group loyalties but little respect for externally imposed rules, other than those imposed by nature. Human nature is – or should be – cooperative, caring and sharing. Trust and fairness are guiding precepts and equality of outcome is an important objective. Group decisions are arrived at by direct participation of all members, and leaders rule by the force of their arguments. The solution to the world's environmental problems is to be found in voluntary simplicity. Members of religious sects, communards, and environmental pressure groups all belong to this category. Nature is to be *respected and obeyed*.

• *Hierarchists* inhabit a world with strong group boundaries and binding prescriptions. Social relationships in this world are hierarchical with everyone knowing his or her place. Members of caste-bound Hindu society, soldiers of all ranks and civil servants are exemplars of this category. The hierarchy certifies and employs the scientists whose intellectual authority is used to justify its actions. Nature is to be *managed*.

• *Fatalists* have minimal control over their own lives. They belong to no groups responsible for the decisions that rule their lives. They are non-unionised employees, outcasts, refugees, untouchables. They are resigned to their fate and see no point in attempting to change it. Nature is to be *endured* and, when it's your lucky day, *enjoyed.* Their risk management strategy is to buy lottery tickets and duck if they see something about to hit them.

Transport risk managers, in the terms of this typology are statuary Hierarchists who make the rules and enforce the rules. For the foreseeable future they can expect to be attacked from the Egalitarian quadrant for not doing enough to protect us, and from the Individualist quadrant for over regulating and suffocating freedom and enterprise.

During the public debate that preceded the passage of Britain's seatbelt law the principal participants could be readily assigned to quadrants of this typology. The proponents of the law were Hierarchists, otherwise labeled "the Nanny State" by Individualists in the lower left-hand quadrant who were, in turn, labeled "loony Libertarians" by the law's supporters. The Egalitarian quadrant was divided. It contained traditional safety campaigners such as the Royal Society for the Prevention of Accidents and the Parliamentary Advisory Council on Transport Safety who supported the law. But it also contained campaigners for pedestrian and cycling safety who had bought into what was then the radical new idea of risk compensation and saw the seatbelt law as a threat to their constituents.

What sort of risk?

Figure 9 below, borrowed (and amended) from the risk management manual of a major airline, presents yet another way of looking at the different types of risk set out in Figure 5.

On the steep part of the curve risks, whether up Mount Everest or down a Victorian (or Chinese) coal mine, are usually obvious (directly perceptible), but the responses are diverse and often contentious. Certainly traditional Everest mountaineers are resentful of bureaucratic interference in their risk taking. But their traditions are being compromised by commercial tour companies who, at great expense, offer to guide people to the top and back *safely*. A fatality in 1999 led to a claim of negligence and an out-of-court settlement for £70,000. (Mountain clients 2007) Britain's oxymoronic Adventure Activities Licensing Authority, instituted to ensure safe adventure, is also seen, by Individualists, as a threat to traditional risk-taking freedoms.

Large risks associated with employment are commonly viewed as imposed risks, imposed by economic necessity especially when the employees are poor (as in the case of Victorian, or Chinese, coal miners). Here interventions in the form of regulation and inspection are more readily accepted - but not always with the expected result. The Davy Lamp, which most histories of science and safety credit with saving thousands of lives, is usually described as one of the most significant safety improvements in the history of mining. But it appears to have been a classic example of a potential safety benefit consumed as a performance benefit. Because the lamp operated at a temperature below the ignition point of methane, it permitted the extension of mining into methane-rich atmospheres; the introduction of the "safety lamp" was followed by an increase in explosions and fatalities. (Aldbury D & Schartz J 1982)

But when all the obvious measures are in place accidents will still, occasionally, happen. 100% safety is a utopian goal. Indeed it is possible to have too many safety measures. So long as there is a residual dependence on the vigilance of fallible humans, their level of vigilance will depend on the strength of their belief that something can go wrong. The impressive safety record of civil aviation, and all the safety redundancy built into modern aircraft and their operating systems have created a problem of keeping pilots awake on long flights across time zones. Why should they stay alert for the whole of their working lives in anticipation of something they believe will never happen? When you are on the flat part of the curve you do not have a clue whether further safety precautions will have any beneficial effect. The area above the flat part of the *human reliability curve* might be thought of as a zone of *virtual risk. T*here are circumstances within this zone where further safety measures can have a perverse effect – where the belief in such measures can induce complacency – the *Titanic Effect.*

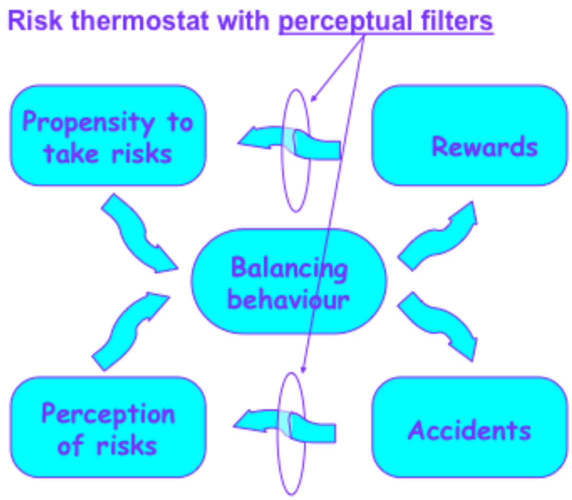
Figure 9. The human reliability curve

Filters

The variety to be found in the risks and rewards boxes of the *risk thermostat* and the variable responses to them illustrated in Figure 7 (What kills you matters) by the different actors presented in Figure 8 suggest that the r*isk thermostat* should be fitted with perceptual filters. The same objective facts can have an enormously varied influence on risk taking behavior.

Figure 10 can serve as a description of the behavior of the driver of a single car going around a bend in the road. His speed will be influenced by his perception of the rewards of risk; these might range from getting to the church on time to impressing his friends with his skill or courage. His speed will also be influenced by his perception of the danger; his fears might range from death, through the cost of repairs and loss of his license, to mere embarrassment. His speed will also depend on his judgment about the road conditions – is there ice or oil on the road? How sharp is the bend and how high the camber? – and the capability of his car – how good are the brakes, suspension, steering, and tires?

Figure 10. Perceptual Filters

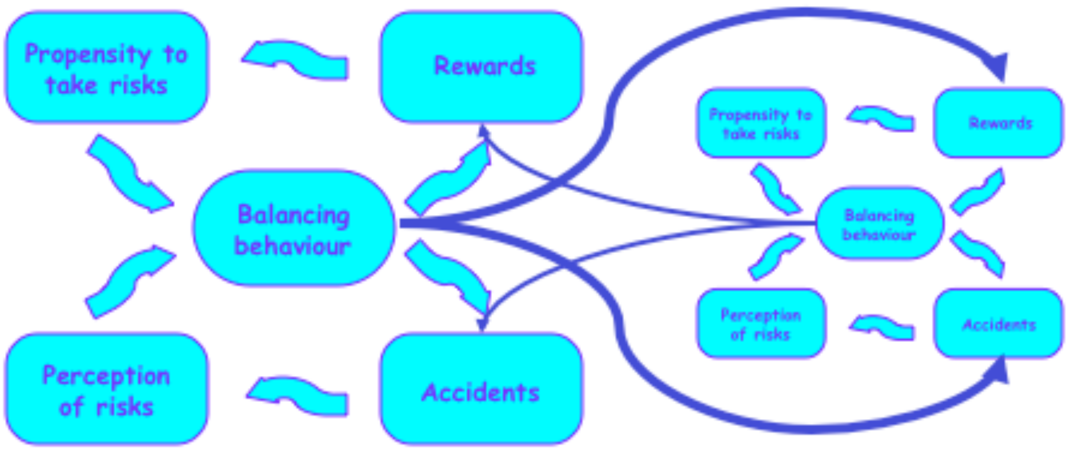


Overestimating the capability of the car or the speed at which the bend can be safely negotiated can lead to an accident. Underestimating those things will reduce the rewards gained. The consequences, in either direction, can range from the trivial to the catastrophic. The balancing act described by this illustration is analogous to the behavior of a thermostatically controlled system. The setting of the thermostat varies from one individual to another, from one group to another, from one culture to another, and for all of these, over time. Some like it hot – a Hell's Angel or a Grand Prix racing driver, for example – others like it cool – a Caspar Milquetoast or a little old lady named Prudence. But no one wants absolute zero.

Risk: An Interactive Phenomenon

Figure 11 introduces a second road user to make the point that risk is usually an interactive phenomenon. One person's balancing behavior has consequences for others. On the road one motorist can impinge on another's "rewards" by getting in their way and slowing them down, or help thrm by giving way. One is also concerned to avoid hitting other motorists or being hit by them. Driving in traffic involves monitoring the behavior of other motorists, speculating about their intentions, and estimating the consequences of a misjudgment. Drivers who see a car approaching at high speed and wandering from one side of the road to the other are likely to take evasive action, unless perhaps they place a very high value on their dignity and rights as a road user and fear a loss of esteem if they are seen giving way. During this interaction enormous amounts of information are processed. Moment by moment each motorist acts upon information received, thereby creating a new situation to which the other responds.

Figure 11. The truck driver and the cyclist



On the road and in life generally, risky interaction frequently takes place on terms of gross inequality. The damage that a heavy truck can inflict on a cyclist or pedestrian is great; the physical damage that a cyclist or pedestrian might inflict on the truck is small. The truck driver in this illustration can represent the controllers of large risks of all sorts. Those who make the decisions that determine the safety of consumer goods, working conditions, or large construction projects are, like the truck driver, usually personally well insulated from the consequences of their decisions. The consumers, workers, or users of their constructions, like the cyclist, are in a position to suffer great harm, but not inflict it.

The world, at the time of writing, contains about 6.5 billion risk thermostats, and they interact. Figure 12, the *Dance of the Risk Thermostats*, provides a tiny window on a few of these interactions. Some of the thermostats are large – presidents with fingers on buttons – most are tiny – shepherds in Afghanistan or children chasing balls across streets. In a rapidly globalizing world the lines of interaction are growing longer and more numerous.

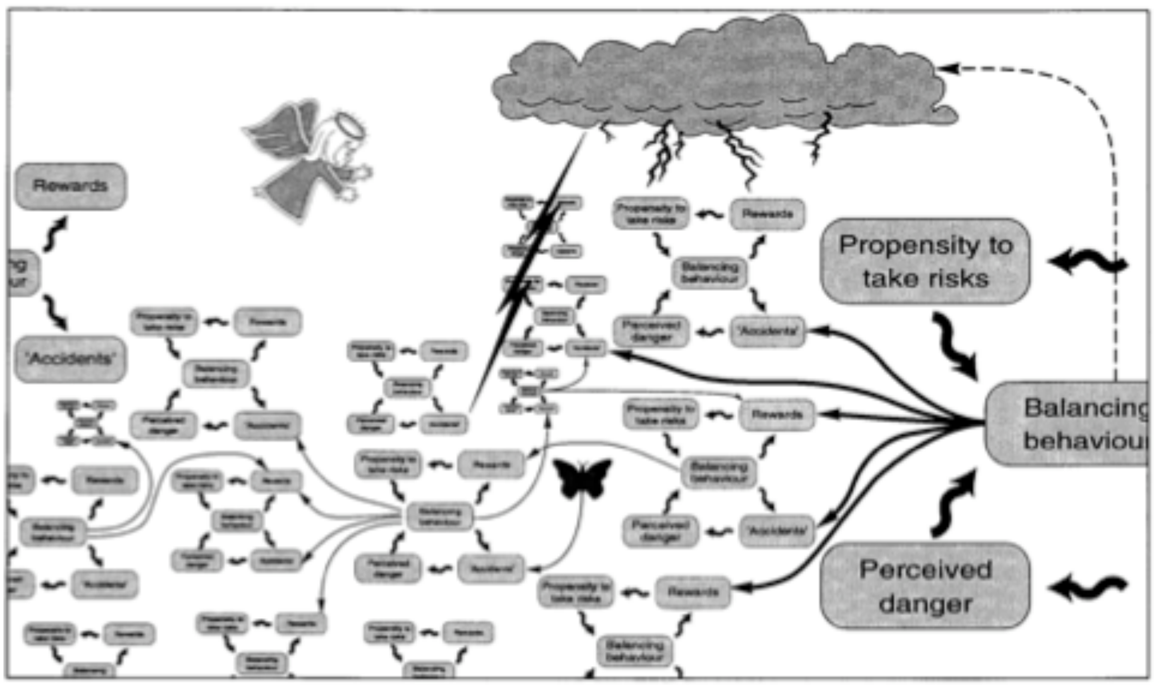
Overhanging everything are the sometimes destructive forces of nature – droughts, floods, earthquakes, hurricanes, plagues. The broken line symbolizes the uncertain impact of human behavior on nature. And lurking below are those seeking to control or influence them, from would-be climate engineers to shamans conducting rain dances. And fluttering about the dance floor are the Beijing butterflies beloved of chaos theorists: they ensure that the best laid plans of mice and men "gang aft agley."

The winged creature at the top left was added in response to survey that revealed that 69 percent of Americans believe in angels and 46 percent believe they have their own guardian angel. The "angel factor" must influence many risk-taking decisions – from those of suicide bombers to those of risk taking motorists; Deus é Brasileiro (God is Brazilian) is an expression invoked by Brazilian motorists who have terrified me. (Adams 2009, preface)

Figure 12 shows but an infinitesimal fraction of the possible interactions between all the world's risk thermostats; there is not the remotest possibility of ever devising a model or building a computer that could predict accurately all the consequences of intervention in this system.

In the mix are jihadists and CIA operatives, financial regulators and sub-prime mortgage brokers, occupational health and safety regulators, employers and employees, doctors, no-win-no-fee lawyers, police judges and juries. And in the realm of transport risks one finds engineers, regulators and the regulated.

Figure 12. Dance of the risk thermostats



4. Conclusion

Most transport risks are likely to remain in the contested *virtual risk* circle of Figure 5. Many will doubtless continue to insist that they know what works. However the United Nations Decade of Action for Road Safety and the Make Roads Safe campaign referred to at the beginning of this essay would appear doomed to disappointment in the developing countries on which their efforts are focused. Wherever one looks one finds the tendency illustrated by Figures 1, 2 and 3 repeated. As the number of cars in a country increases the death rate per car decreases. In countries in the early stages of motorization each vehicle is incredibly lethal. Poor countries with a small number of modern cars, with a hundred years of safety technology built into them, are achieving kill-rates per vehicle as high or higher than those at the time of Model-Ts. This phenomenon has become known as Smeed's Law, after Reuben Smeed who established the relationship over 50 years ago (Adams 1985, 1987).

The confidence of some institutional transport safety managers that they "know what works" is undermined all round the world by the behavior of billions of individual risk managers who *react* to the impositions of the official risk managers, but also to the behavior of everyone else on the road. It is known that seatbelts provide significant protection in crashes, that helmets reduce injury caused by a knock on the head, that antilock brakes are superior brakes, that alcohol increases the likelihood of accidents, and speed their severity. But whenever safety measures attempting to put this knowledge to effective use are imposed from on high by institutional risk managers the result is at best disappointing.

So what did cause the declining death rates described by the Smeed Law? Here we must speculate; the myriad interactions involved in the dance of the risk thermostats defy capture by any known computer. If one accepts Figure 6 as a plausible description of the process of risk management, one looks to changes in the setting of the thermostat for an explanation. As we get richer we become more risk averse.

Car ownership correlates strongly and positively with income. As nations become richer they can afford, *and demand*, higher levels of safety and security. The setting of the collective thermostat is turned down. Reference was made above to the risks experienced in Victorian (or Chinese) coalmines. In poor countries life is cheaper and safety standards of all sorts are lower; life expectancy at birth is much lower and road accident rates much higher.

In the most affluent countries of the world there is a trend toward increasing institutional risk aversion and growth in the numbers of institutional risk managers. Their job is to reduce accidents, and then get them lower still. For them, one accident is one too many. As noted above their risk thermostats have no top loop. But despite the increase in the activity of institutional risk managers it is often difficult to discern the effect of their work. As in the case of "The Scandinavian Myth" discussed above their growing activity appears to be symptomatic of increasing societal risk aversion rather than the cause of a decrease in accidents.

Growing concern for the safety of children on the road might serve as another indicator of an increase in societal risk aversion in affluent countries, and an explanation for a significant part of the plummeting death rate illustrated by Figures 1 and 2. Today in Britain, per 100,000 children, the road accident death rate is less than a quarter of what it was in 1922 when there was hardly any motorized traffic and the country had a nation-wide 20 mph speed limit. This is not because the streets have become safer for children to play in; there is now much more metal in motion. It is because few children are allowed out on their own anymore. In 1971 80% of seven and eight year old children got to school unaccompanied by an adult. By 1990 this had dropped to 9% (Hillman et al 1990), and by 2010 it had become a child protection issue.[1] The decrease in child road accidents appears to be overwhelmingly attributable to a decrease in exposure, and the decrease in exposure attributable not to institutional edict but to a growing fear on the part of parents of the threat posed to their children by traffic.

At present the two countries with the best road safety records in the world are pursuing diametrically opposed philosophies of road safety. The Swedish “Vision Zero” policy assigns ultimate responsibility for road safety to the institutional risk manager in the form of the state. The responsibility of users of the system is to obey the rules. It asserts that the rules for the system are that:

> *1. the designers of the system are always ultimately responsible for the design, operation and use of the road transport system and 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; obeying speed limits)*
> *3. if road users fail to obey these rules due to lack of knowledge, acceptance or ability, or if injuries occur, the system designers are required to take necessary further steps to counteract people being killed or seriously injured.* (Hill J 2008)

In the Netherlands, a country with an even (slightly) better road safety record, there is a growing enthusiasm for “shared space”. This is an intriguing idea pioneered by the late Hans Monderman, a highway engineer in Friesland. He removed almost all the traffic lights, pedestrian barriers, stop signs and other road markings that had been assumed to be essential for the safe movement of traffic.

For traditional highway engineers his idea was anathema. Since the advent of the car they have planned on the assumption that car drivers are selfish, stupid, but obedient automatons who had to be protected from their own stupidity, and that pedestrians and cyclists were vulnerable, stupid, obedient automatons who

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[1] In England in 2010 two controversies appeared in the press in which parents were threatened with child protection orders for allowing their children what used to be the widely accepted freedom to get to school unaccompanied: http://www.telegraph.co.uk/family/7872970/Should-the-Schonrock-children-be-allowed-to-cycle-to-school-alone.html and http://www.bbc.co.uk/news/uk-england-lincolnshire-11288967

had to be protected from cars – and their own stupidity. Hence the ideal street was one in which the selfish-stupid were completely segregated from the vulnerable-stupid, as on the American freeway or European motorway where pedestrians and cyclists and pedestrians are forbidden. Where segregation was not possible, in residential suburbs and older urban areas, their compromise solution was the ugly jumble of electronic signals, stop signs, barriers and road markings that now characterize most urban environments.

Monderman observed those using the streets for which he was responsible and concluded that they were not stupid, but nor did they obey all the rules and barriers that assumed that they were, and nor, on the whole, did they behave selfishly. Pedestrians, he noticed, were nature's Pythagoreans – always preferring the hypotenuse to the other two sides of the triangle. Given half a chance they did not march to the designated crossing point and cross at right angles to the traffic; if they spotted a gap in the traffic they opted for the diagonal route of least effort.

And motorists did not selfishly insist on their right of way at the cost of mowing down lots of pedestrians. Monderman decided that those for whom he was planning were vigilant, responsive and responsible. He deliberately injected uncertainty into the street environment about who had the right of way. The results were transformative. Traditional highway engineers have never been concerned with aesthetics. Their job was to move traffic safely and efficiently. They dealt not with people but PCUs (passenger car units). The removal of the signals, signs and barriers that were the tools of their trade not only greatly improved the appearance of the streetscape but, by elevating the status of the pedestrian and cyclist relative to that of the motorist, made them more convivial as well.

Claes Tingvall, who is credited with being the architect of Sweden's Vision Zero, said in an interview "Vision Zero … is a shift in philosophy. Normal traffic policy is a balancing act between mobility benefits and safety problems. The Vision Zero policy refuses to use human life and health as part of that balancing act; they are non negotiable. … Part of the Vision Zero strategy is to improve the demand for safety." (Tingvall undated)

A concluding speculation.

Tingvall's characterization of "normal traffic policy" as "a balancing act between benefits and safety" is a fair approximation of the risk management behavior described by the risk thermostat in Figure 6. But who decides that the thermostat should be set to zero? If it were truly set to zero for all road users no one would move.

In both Sweden and the Netherlands, one senses a high and still growing demand for safety. This is perhaps the ultimate explanation of the good accident records of both. This increasing demand might be characterized as a progressive reduction of the setting of both the Dutch and the Swedish societal risk thermostats.

Every pedestrian, cyclist and motorist is also a risk manager, performing "a balancing act between benefits and safety". Anyone with direct experience of how this act is performed in countries at the early stages of motorization (as well as those studying their accident statistics) will know that the performance in such countries is very different from that in highly motorized countries.

The UN's Decade of Action for Road Safety seeks to promote road safety everywhere but is focused primarily on the least motorized countries with the highest accident rates. The claim quoted at the beginning of this essay that "we know what works", in the light of the evidence reviewed here, appears hubristic. Unless and until ways are devised to lower the settings of the collective risk thermostats of these countries, the slaughter on their roads looks destined to increase in the early rapid-growth stage of their motorization. The policy maker's choice of setting of the thermostat is of marginal relevance; it is the average setting of the thermostats of *all* the participants in complex interactive systems that determines the accident outcomes.

The challenge for those trying to make roads safer is to change attitudes - to promote greater risk aversion on the road. There are encouraging precedents. The stigmatizing of smoking and drunken driving has greatly reduced the practice of both; but the change took many years. Perhaps the wide-spread distribution of Make-Roads-Safe T-shirts, banners, publications and wristbands by the Make-Roads-Safe campaign is not a bad way to start. But recruiting the endorsement of the campaign by superstars of motor-racing, the most spectacular possible exemplars of high-risk driving, is a less obvious method of promoting risk aversion on the road

References

Adams J (1985) *Risk and Freedom: the record of road safety regulation,* Transport Publishing Projects. Available free online at http://john-adams.co.uk/wp-content/uploads/2007/10/risk%20and%20freedom.pdf

Adams J 1987 Smeed's Law: some further thoughts, *Traffic Engineering and Control* **28** (2): 70-73

Adams J (1995) *Risk*, UCL Press, London.

Adams j (2009) *Risco*, Editora Senac, São Paulo. The preface, Deus é Brasileiro, is available in English at http://john-adams.co.uk/wp-content/uploads/2008/12/deus-e-brasileiro1.pdf

Adams J (2010) Seatbelts - http://john-adams.co.uk/category/seat-belts/

Albury D & j Schwarz (1982) *Partial Progress.* London: Pluto Press.

Allen, K., Dang, J. N., Doyle, C. T., Kahane, C. J., Roth, J. R., & Walz, M. C. (2008). *Evaluation Program Plan, 2008-2012* pp. i and 9. NHTSA Technical Report. DOT HS 810 983. Washington, DC: National Highway Traffic Safety Administration.

Department for Transport press release (31 January 2008) *25th anniversary of seatbelts - 60,000 lives saved* - http://www.direct.gov.uk/en/Nl1/Newsroom/DG_072333

Erel Avineri et al. (2009) Individual Behaviour Change: Evidence in transport and public health, Department for Transport Contract PPRO 04/06/33, Project team: Erel Avineri, Kiron Chatterjee, Andrew Darnton, Phil Goodwin, Glenn Lyons, Charles Musselwhite, Paul Pilkington, Geof Rayner, Alan Tapp, E. Owen D. Waygood, and Peter Wiltshire.

Haight FA (1985) *The Developmental Stages of Motorization: Implications for Safety*, Pennsylvania Transportation Institute, Penn. State University.

Health and Safety Executive (2001) *Reducing risks, protecting people: HSE's decision-making process,* Crown copyright 2001 - http://www.hse.gov.uk/risk/theory/r2p2.pdf

Hill J (2008). "Getting Ahead: Returning Britain to European leadership in road casualty reduction" (PDF). Road Safety Foundation. http://www.saferoaddesign.com/media/1752/bookletweb.pdf.

Hillman H et al (1990) *One False Move … : a study of children's independent mobility*, Policy Studies Institute, London.

HLDI (2010) *Texting Laws and Collision Claim Frequencies*, Vol. 27, No. 11 September 2010 Highway Loss Data Institute Bulletin (http://www.iihs.org/research/topics/pdf/HLDI_Bulletin_27_11.pdf)

Law Commission (Ireland) (2008) Statute Law Repeals: Consultation Paper City of Dublin Repeal Proposals - http://www.lawcom.gov.uk/docs/dublin.pdf

Mountain Clients (2007) Family Launches Lawsuit Over Everest Death - http://www.mountain-clients.org.uk/2008/06/family-launches-lawsuit-over-everest-death-23-jan-2007/

NHTSA (2009) *The Long-Term Effect of ABS in passenger cars and LTVs,* DOT HS 811 182 August 2009, *www-nrd.nhtsa.dot.gov/Pubs/811182.pdf*

Parliamentary Advisory Council for Transport Safety (2010) PACTS Newsletter:

DfT Celebrates 25th Anniversary of the introduction of seatbelts - http://www.pacts.org.uk/newsletters.php?id=2

Peltzman S (1975) The effect of automobile safety regulation. *Juornal of Political Economy vol 83, no 4, 677-725.*

Plowden W (1971)*The motor car and politics 1896-1970,* Bodley Head, London, p. 455.

Ross HL (1976) The Scandinavian myth: the effectiveness of drinking and driving legislation in Sweden and Norway. *Evaluation Studies – Review Annual* vol.1, Sage.

Royal Society for the Prevention of Accidents (2010) *Our success stories* - http://www.rospa.com/about/successstories/

Tingvall C (2009) Road Safety Interview: Sweden's Vision Zero, Allianz, http://knowledge.allianz.com/en/globalissues/safety_health/road_safety/road_safety_vision_zero.html

UN Department of Public Information (2010) "General Assembly Adopts Text Proclaiming Decade of Action for Road Safety (2011-2020), Aimed at Reducing Traffic-Related Deaths, Injuries", http://www.un.org/News/Press/docs/2010/ga10920.doc.htm

Vinglis ER (1983) Guest Editor's Introduction, Accident Analysis and Prevention, 15, 405-406.

Make Roads Safe (2010) "Make Roads Safe is the Campaign for Global Road Safety", http://www.makeroadssafe.org/about/Pages/homepage.aspx

USDoT (2010) "Make no mistake; DOT and its safety partners will continue fighting against distracted driving": http://fastlane.dot.gov/2010/09/make-no-mistake-dot-and-its-safety-partners-will-continue-fighting-against-distracted-driving.html

Wilde GS (1994) *Target Risk* PDE Publications, Toronto. Online at http://psyc.queensu.ca/target/#contents . Second edition, not online, 2001.