



Monday, 2 November 2015

Senate Standing Committees on Economic - Personal choice and community impacts

Department of the Senate, PO Box 6100
Parliament House CANBERRA ACT 2600

RE: Questions on notice to Forensic Engineering Society

This document is in response to the questions below:

Proof Hansard- 11 September 2015, page 37:

CHAIR: I am familiar with their process of calculating risk for which there are actuarial tables, but how do engineers price risk—especially severe and rare risks—when there is no actuarial table around?

Mr Irwin: I cannot give you a clear answer to that. I think very often the data is based on estimates. It is rough and may be quite subjective. In cases where the risk assessment is very clearly one way or the other, that might not matter. You do not always need accurate data. I could take that question on notice and get you some better responses, if you wish.

CHAIR: I have some information that I want to ask you about in relation to the concept of ALARP—as low as reasonably practicable. Are you able to talk about that?

Mr Irwin: No. I have had a look, but I have not worked in that field. I can take it on notice.

CHAIR: Okay.

Preamble

In responding to the questions recognition has been given to the Terms of Reference of this Inquiry.

Further this document is primarily based on the 50 years of experience of one of our senior members in the area of road safety, 45 years of experience in the area of industrial safety, and 38 years of experience in the area of the agricultural safety. To this has been added the skills and experience of some other members.

It is probably true to say that the knowledge reflected here is at a higher level than the understanding of most engineers.

Note that one of the problems in this field is the well understood (by some) fact that in order for the human mind to manage all the potential information inputs from day to day, the subconscious mind processes that information initially and alerts the conscious mind to those things that are either a threat to the individual or are of interest to the individual. The end result of this process is that it is normal for human beings to have specific interests and for them to notice all those things supporting their interests to the exclusion of those matters which may not support those interests. As a result it is normal for humans to have biases in their worldview, and in their approach to particular tasks. If someone is of the view that the cost of road trauma to the Australian society is very high then they'll be inclined to find/develop information to support that view.



ALARP - as low as reasonably practicable

This has primarily been a workplace health and safety concept, though of course that does not exclude it from being used for guidance in any other safety related field.

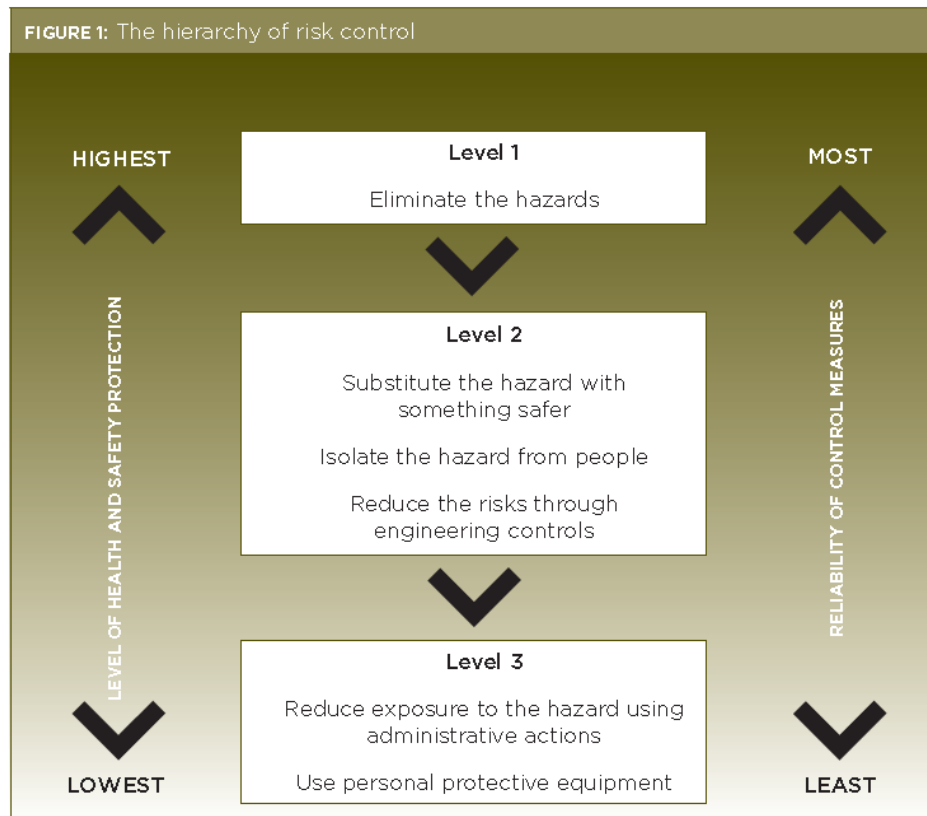
In Safe Work Australia's May 2013 Document: HOW TO DETERMINE WHAT IS REASONABLY PRACTICABLE TO MEET A HEALTH AND SAFETY DUTY, there is a definition of reasonably practicable:

'Reasonably practicable', in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done to ensure health and safety, taking into account and weighing up all relevant matters including:

- a. *the likelihood of the hazard or the risk concerned occurring; and*
- b. *the degree of harm that might result from the hazard or the risk; and*
- c. *what the person concerned knows, or ought reasonably to know, about the hazard or risk, and about the ways of eliminating or minimising the risk; and*
- d. *the availability and suitability of ways to eliminate or minimise the risk; and*
- e. *after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.*

Hierarchy of controls

And in eliminating or minimising risks there is a well recognised hierarchy of controls. These are shown in the same document in Figure 1 below.



Elimination refers to removing an activity altogether – for example if manual handling is used to move products from one process machine to another, and there is a rigid risk of manual handling injuries or they are our actual manual handling injuries, replacing that activity with mechanical handling devices like conveyor belts would eliminate the activity.

Substitution refers to substituting something in the process to eliminate the risk – as an example changing the reinforcing fibres used in cement sheeting from asbestos to cellulose fibres would eliminate the risk of asbestosis.

Isolating an activity relates in the broad scale to using guarding in all its forms.

Reducing the risk using engineering controls relates to redesigning the machinery to minimise or eliminate risk. For example having quad bikes/ATVs supplied to the market with crush protection devices designed into their structure would minimise the risks associated with rollover of those machines.

Administrative controls relate to procedures – for example a worksite might have a procedure that forklift drivers are required to wear their seat belts at all times. However in my observation except in a very small number of worksites this requirement has a very low compliance rate.

And finally personal protective equipment – gloves, high visibility vests, ear protection, safety boots – have a limited range of effectiveness against hazards in the workplace. This is related to the degree to which they are actually worn and the degree to which they are effective against hazards. For example boots provide protection against injury if a passenger car with tyres that normal pressure drives over the front of the boot. However if a forklift drives over the boot no protection will be provided – the foot will be crushed. Similarly high visibility vests make people more conspicuous but are of no assistance if the person is out of view – for example a forklift and pedestrian approaching the same blind corner from opposite directions.



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Cost is grossly disproportionate to the risk

This appears to be a simple concept – however how do you compare a cost (presumably measured in dollar terms based on determination of the net present value for example) with the risk?

And how is this done within for example the emotive view that every human life is priceless? The implication of this is that as long as a human life is saved any initiative is worthwhile.

The issues are discussed in the following section on pricing risk.

How do engineers price risk—especially severe and rare risks—when there is no actuarial table around?

It is assumed that the committee is interested in public risk or workplace safety risk rather than the risks associated with the design and operation of plant and machinery.

As an aside in respect of plant and machinery, engineers in their design work endeavour to guard workers from risk through a wide range of actions. They may include guarding to protect workers from entrapment or trauma, insulation or separation to protect workers from extremely cold products or extremely hot products or from high noise levels, incorporating isolation to protect workers from damaging vibration including whole body vibration; enclosing dangerous chemicals and fumes, providing a rollover protection on heavy mobile plant, et cetera. And in addition engineers will design plant and machinery to facilitate safe operation.



In respect of determining societal or workplace risk there are two primary aspects to this task:

1. firstly there is the determination of the risk profile – expected frequencies of fatalities, disabling injuries, other injuries requiring hospital treatment, and injuries requiring medical treatment/first-aid; and
2. the costs you put against those various levels of trauma.

Risk profiles

There are a wide range of sources of information available on risks associated with the workplace, with transport, and with some specialist activities.

For example Safe Work Australia provides information on workplace fatalities and on workplace serious injuries claims similar to that summarised at the end of this report. And they have available more detailed information where industries are separated into subcategories. The Safe Work Australia data is believed to be reliable because fatalities have to be reported, and serious injury claims are those occurrences where somebody is off work for more than a week at which point WorkCover will cover the costs associated with a claim.

However the workplace fatality rates and serious injury claim rates are low at around one per 40,000 employees per year and one per 100 employees per year. This compares to the fact that only 2% of Australian businesses have 20 to 199 employees, and only 1% have more than 200 employees. In addition around 61% of businesses have no employees from the point of view of the jurisdiction of WorkCover safety organisations. These are primarily sole proprietorships, partnerships and trusts. And in some sectors these types of businesses can dominate – for example there are a large proportion of partnerships in agriculture.

As a result, except in those industries with high rates of fatalities or serious claims, the safe work Australia data is limited in determining risk profiles.

At the lower levels of risk – lost time injuries (those cases where generally at least one shift of work is lost), and injuries requiring medical attention/first-aid, the available information is much more limited mostly because it is only companies with numbers of employees who collect and collate such data (and who are likely to have an OHS representative – management or worker).

There are sources of data which may assist. For example Workplace Western Australia compiles lost time injury information available at <https://www.commerce.wa.gov.au/publications/wa-key-osh-statistics> . The overall rate is around one per 25 employees per year, with some sub industries having rates as high as one in five or one in six employees per year. At the other end of the scale, those industries/professions which are primarily office-based have much lower rates of lost time injuries in the range of one in 50 employees to one in 200 employees per year.

Road trauma

Whether in the workplace or in society in general Road related fatality is and injuries feature to a high degree – vehicle related fatality is represent the most common traumatic deaths in the workplace.

There is a large amount of data available on road trauma from BITRE, state Road authorities, and insurers including state sanctioned third party injury insurers. And there are some specialist suppliers of information – for example national transport insurance which specialises in insurance for heavy vehicles and provides reports to the public.

However in spite of all this information, it has some serious limitations. The reporting of road related fatalities (note that generally these exclude fatalities related to vehicle use not on public highways, and where identifiable deaths that are suicides or deaths caused by medical conditions)



is comprehensive and available differentiated across age groups, gender, road user, speed zone, vehicle type et cetera.

At the next level – serious injuries (those injuries which result in people being admitted to hospital) the information is much less comprehensive and less reliable. One of the best sources of information that is publicly available can be obtained from Victoria’s transport accident commission by going to their website.

And at the next level – other injuries requiring medical attention – the information is relatively poor even though in most jurisdictions there is a requirement that such crashes be reported to police.

And at the property damage only level the publicly available information is poor, even though in some state jurisdictions these are required to be reported to police where the amount of damage exceeds a threshold. In addition some insurance companies require that a crash be reported to police before a claim is made (however as the police are acting on hearsay the reliability of the information on these claims is questionable). As a result when research is undertaken in relation to these crashes often data is obtained from insurance companies to get a better picture of these crashes.

To give some idea of the challenges in the Road trauma area the following comments are noted based on research to date:

- close to 100% of fatalities are reported and recorded;
- a high proportion of serious injury crashes are reported, though in some subgroups reporting rates may be much lower. For example it has been estimated that 55% of serious injuries resulting from motorcycle riding are not fully reported;
- in respect of injury crashes overall it is estimated that 25% to 30% are not reported to police, with many of these being at the lower injury level; and
- in respect of property damage only crashes, even in jurisdictions where they are required to be reported, it is estimated that 50% to 60% are not reported.

However there is a much greater problem with road safety related data.

I have been involved in road safety since 1965 and especially since 1986. I have reviewed a large number of road safety research reports and have used that information to develop a relative risk profile across four driver groups:

- very responsible drivers – the 30% of drivers with the lowest crash involvement;
- responsible drivers – the next 50% of drivers with low crash involvement;
- (these two groups may be combined to refer to the 80% of drivers who are responsible in their approach);
- irresponsible drivers – the next 12% of drivers with high crash involvement;
- very responsible drivers – the final 8% of drivers with very high crash involvement; and
- (these two groups may be combined to refer to the 20% of drivers who are irresponsible in their approach).

| | Best 30% | Next 30% | (Best 80%) | Next 12% | Worst 8% | (Worst 20%) |
|------------------------|----------|----------|------------|----------|----------|-------------|
| Fatal crashes | 0.10 | 0.34 | 0.25 | 1.33 | 8.00 | 4.00 |
| Serious injury crashes | 0.12 | 0.41 | 0.30 | 1.11 | 6.67 | 3.33 |
| Other injury crashes | 0.16 | 0.54 | 0.40 | 0.83 | 5.00 | 2.50 |
| Casualty crashes | 0.16 | 0.54 | 0.40 | 0.83 | 5.00 | 2.50 |
| All crashes | 0.16 | 0.54 | 0.40 | 0.83 | 5.00 | 2.50 |

As can be seen from the table there is a huge variation in crash involvement across the various groups. For fatal crashes the table above indicates and 80/20 rule applies – that is the 80% of responsible drivers are responsible for only 20% of fatal crashes.



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And as shown for the 80% of responsible drivers their injury crash rate, casualty crash rate, and all crash rate is 40% of the overall average.

In most workplaces, the majority of workers would fit in the responsible driver group and hence the publicly available fatality, serious injury, other injury, and property damage only crash rates have to be adjusted significantly to predict the sorts of rates that might be experienced by employees.

Finally, and unfortunately, since the early 1990s the information available in relation to Road trauma related risks has changed from being thoroughly researched and impartially reported, to being researched and reported to serve groupthink or specific agendas.

Most noticeably there is the research and information provided to the public in the area of speed, speed limits, speed limit enforcement, speed and crashes, and speed cameras. The public have been deliberately misled into believing that exceeding the speed limit is the biggest cause of fatalities across Australia. For example in Victoria there are two widely publicised statements –“the crash rate doubles for every 5 km/h above 60 km/h” and “speeding drivers are the biggest killers on Victorian roads that’s why you are photographed.” Both these statements are provably wrong! The biggest contributory factors to fatal crashes are distraction (probably a factor in around 65% of crashes), alcohol and/or drugs (and in most cases this is alcohol and drugs a factor in around 30% of fatal crashes), failure of vehicle occupants to wear seat belts or riders to wear helmets (around 20%), fatigued drivers (around 18%), drivers travelling below the speed limit but too fast for the conditions (around 17%), and then drivers exceeding the speed limit (around 13%).

Misinformation also applies to mobile phones – the best research available shows that talking on a mobile phone is not a risk factor any different to other activities associated with car travel – the high-risk component of mobile phone and smart phone use is those activities that take the drivers eyes off the Road – texting, reading emails, surfing the net et cetera.

And misinformation applies to fatigue – in general based on all the advertising and information provided to the public, the general belief is that fatigue is a major issue only in relation to long-distance travel. However in fact as Dallas Fell showed in her research in the early 1990s, the most common situations related to fatigue crashes were drivers setting out on trips when fatigued because of the need to get to work on time or two attend an appointment, and drivers setting out on trips when fatigued at the end of the working day. Both these have significant implications in the workplace.

Specialist activity data

In respect of particular risky activities, or in respect of particular workplace related diseases, there are organisations (government or otherwise) who collect statistics.

As an example the Australian Mesothelioma Registry, managed by the Cancer Institute of New South Wales, which reports in some detail on the incidence of mesothelioma.

And in respect of quad bikes/ATVs, a major safety issue in the agricultural industry, the United States Consumer Product Safety Commission has collated and reported data on deaths and injuries since the late 1980s, and related those to the number of ATVs being used across the USA. This allowed some predictions to be made in respect of likely rates in Australia. However subsequently it was realised that in the United States 75% of use of these vehicles was recreational whereas in Australia 80% of use was related to workplaces.

Research as a source of information

Otherwise it is possible to track down research in relation to a wide range of risks to society or the workplace, and with the application of critical review, to determine to a degree of accuracy the likely risks.



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However even here there are issues. For example the IARC in reviewing products and compounds in relation to their likelihood to cause cancer in humans, often bases their decisions on epidemiology studies which have an underlying problem in that they show correlations not causations. They have reviewed around 900 products and compounds to date and only found one to be non-carcinogenic. To give an example. The compounds in cigarette smoke are known to be carcinogenic, and contribute to a significant range of cancers. In epidemiology studies, if for example smokers tend to drink more alcohol than non-smokers, or if smokers tend to eat more red meat than non-smokers, that it is likely that alcohol or red meat will be identified as possibly carcinogenic or probably carcinogenic.

Workplace experience

Over time it is possible to develop measures of risk in operating workplaces. The accuracy of these risk measures depends on the number of employees working in a business, the number of years the business has been operating, and the frequency of trauma or disease (in respect of disease there is an additional problem being the time it takes for the disease develop – for example with asbestos-related diseases the time from exposure to diagnosis can vary from 15 to 60 years).

With very low frequency events – fatalities and serious claims - it is hard to determine the significance of a single occurrence. For example if the underlying rate is one event per million man hours, in the first million man hours through chance alone there is a 37% chance that there will be no events, and a 26% chance there will be two or more events. And in fact it would require 3 million to 4 million hours of activity before one could make a reasonably reliable assessment as to whether the underlying rate was one event per million man hours.

The cost of fatalities and injuries and diseases

Once a risk profile has been determined (with a variable degree of accuracy) the issue then is to place a cost against those negative outcomes.

The cost of a fatality/ human life

This is probably the most widely studied cost worldwide. And unfortunately the science (if any) has produced highly variable results. For example when I first began studying this field in 1987, I found costs based on economic analysis ranging from US\$20,000 in Portugal, to US\$800,000 in Australia, and to US\$3,000,000 in USA.

This more recently in 2011 in the USA, the EPA valued a human life at US\$9,100,000, the FDA valued a human life at US\$7,900,000, and the DOT valued a human life at US\$6,000,000.

And in 2008 in the USA the convention was to use US\$50,000 as the justifiable value for insurers to pay to extend a human life by one year. However Stanford economists undertook a research project in respect of kidney dialysis and determined a value of US\$129,000 per year.



The most comprehensive recent study in Australia is the BITRE report 118 Cost of Road Crashes in Australia 2006. It determines the following:

- the cost of a fatal crash \$2.67 million;
- the cost of a hospital injury crash \$266,000;
- the cost of another injury crash \$17,400;
- the cost of a property damage only crash \$9950;
- the human cost related to a fatality \$2.4 million;
- the human cost related to profound impairment \$3.82 million;
- the human cost related to severe impairment \$1.78 million
- the human cost related to moderate impairment \$542,000;
- the human costs related to mild impairment \$126,000;
- the human cost related to a hospitalised injury \$214,000;
- the human cost related to another injury \$2200;
- the total cost of crashes \$17.85 billion;
- the total cost of fatal crashes \$3.87 billion;
- the total cost of injury crashes \$9.61 billion; and
- the total cost of property damage only crashes \$4.36 billion.

Using various cost indices including the overall CPI, health related CPI, and automotive related CPI the above costs would be increased by around 20% in 2013.

However it can be argued that the above figures are significantly overestimated. This is because of two factors:

1. the estimates include calculations of the loss of productive output for people. For example if someone dies aged 24 in a Road crash, the value of their productive output for each year of the rest of their working life is determined and then discounted back to a present day value. And if someone is injured the value of their productive output lost for the period they cannot work is calculated. But what is totally ignored in relation to deaths is the fact that they also will not be consuming goods and services, a saving that should offset the cost of the loss of productive output; and
2. the estimates include calculations for pain and suffering based on the outcomes of litigation. However there is no discounting of those costs based on the fact that the vast majority of the crashes where someone is killed or injured do not result in litigation. By implication the majority of people do not see that litigation is worth pursuing.

Willingness to pay studies

An alternate approach to determine the value of a statistical life and/or the value of a statistical life year is to undertake studies determining the willingness of people to pay extra to reduce their risk of injury or death.

The latest study I am aware of is the Institute of transport and logistics study report *Estimating the willingness-to-pay and value of risk reduction for car occupants in the road environment* by David A Hensher, John M Rose, Juan de Dios Ortúzar and Luis I. Rizzi February 2009.

The methodology used was to present respondents with screens where they had a choice of two routes – a sample is shown below:



As shown, road types, speeds, number of speed cameras, travel costs, toll costs, levels of road trauma, and travel times vary between the routes.

Based on a large number of replications, they then calculated the following values on a willingness to pay to avoid basis. Note that the research was based on statistical analysis.

Practice Game

Assume that you had to drive somewhere and that you could take two different routes. Below are details of the two ways that you could drive. Please take a look at the characteristics of the routes and select the route that you would be more likely to choose.

| Route A | | Speed | Travel time | Route B | | Speed | Travel time |
|--------------------------------------------|------------|-------|-------------|--------------------------------------------|------------|-------|-------------|
| 1 lane each way | | 100 | 8 minutes | 1 lane each way | | 90 | 25 minutes |
| 2 lanes each way | | 80 | 8 minutes | 2 lanes each way | | 80 | 4 minutes |
| 3 lanes each way | | 110 | 24 minutes | 3 lanes each way | | 100 | 7 minutes |
| | | | 40 minutes | | | | 36 minutes |
| Time in free flow conditions | 30 minutes | | | Time in free flow conditions | 26 minutes | | |
| Time in slowed down conditions | 10 minutes | | | Time in slowed down conditions | 10 minutes | | |
| Running costs | \$4.22 | | | Running costs | \$3.28 | | |
| Toll costs | \$2.00 | | | Toll costs | \$2.00 | | |
| Deaths per year | 4 | | | Deaths per year | 0 | | |
| Severe, permanent injuries per year | 6 | | | Severe, permanent injuries per year | 4 | | |
| Injures requiring hospitalisation per year | 15 | | | Injures requiring hospitalisation per year | 10 | | |
| Minor injuries per year | 14 | | | Minor injuries per year | 12 | | |

Which route would you choose? Route A Route B

If you could also choose not to travel I would stick with the same route I would choose not to travel

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Figure 1: Example of a Final Stated Choice Screen

| | Fatality | Disabling injury | Hospital injury | Minor injury |
|------------------------------|-------------|------------------|-----------------|--------------|
| Car in urban environment | \$6,369,655 | \$310,292 | \$75,476 | \$16,552 |
| All injuries | | | \$44,783 | |
| Car in non-urban environment | \$6,298,082 | \$193,883 | \$56,937 | \$20,312 |
| All injuries | | | \$48,927 | |

Of course the table above raises questions as to why people would place different values on injuries in different environments.

These figures have been used to generate figures for the annual cost of road trauma in Australia of \$27 billion to \$35 billion.

In the Australian Safety and Compensation Council 2008 Report *The Health of Nations: The Value of a Statistical Life* the values determined for a statistical life was \$6 million (range \$3.7 million to \$8.1 million), and for a statistical life year was \$252,000 (a range of \$155,000-\$340,000).

However the trouble with these studies is that they are unbounded – that is there is no process whereby there is a check to see whether the person providing the responses has the ability to pay for any of the costs determined. For example to serve as a loan for \$6,369,655 at 4.6% over 40 years would require an annual repayment of around \$350,000. There would be hardly any families in Australia capable of paying that amount per year. High income households - the top 10% – on average have disposable incomes of only \$95,000 per annum



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Actual costs to businesses

The actual cost to businesses – that is the out-of-pocket expenses – are likely to be much lower than the figures above suggest.

For example I am aware of a case with an agricultural chemical company where the death of an employee resulted in two extended court cases, fines, compensation, costs of improving the plant to make it safer, and significant costs in time of the company's management. The all up cost was between \$1 million and \$2 million.

Separately I'm aware of a glass manufacturing company in a similar situation that pleaded guilty to the prosecutions, did not modify their plant, and made a low out of court settlement so that they're all up costs would have been of the order of 15% of the figure above.

Risk benefit analysis

As you would expect, based on all the above the actual calculation of risks and benefits associated with a business is highly complex and has a low level of precision.

As engineers all we can do is to determine the most likely risks scenario, including a high level estimate and a low-level estimate, as best we can determine the costs associated with those risks based on all the information available, and the easy part – determine the cost to ameliorate the risk (we can do this with much more precision than the rest of the task), and then determine the cost benefit ratio and undertake discussions in relation to reducing risk to ALARP.

Yours sincerely

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Terms of reference

The economic and social impact of legislation, policies or Commonwealth guidelines, with particular reference to:

- a. the sale and use of tobacco, tobacco products, nicotine products, and e-cigarettes, including any impact on the health, enjoyment and finances of users and non-users;
- b. the sale and service of alcohol, including any impact on crime and the health, enjoyment and finances of drinkers and non-drinkers;
- c. the sale and use of marijuana and associated products, including any impact on the health, enjoyment and finances of users and non-users;
- d. bicycle helmet laws, including any impact on the health, enjoyment and finances of cyclists and non-cyclists;
- e. the classification of publications, films and computer games; and
- f. any other measures introduced to restrict personal choice 'for the individual's own good'