Risk tolerability and rail safety regulation

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1 Introduction

Current rail safety practices are heavily influenced by traditional engineering fail-safe and occupational health and safety approaches, with expenditure decisions guided by the principle that actions should be implemented unless their cost is grossly disproportionate to the benefit they deliver. This is a higher standard than used in the road transport sector, where government spending is generally guided by a need for benefits to equal or exceed cost, and a general position that the benefits of regulation should equal to exceed its cost.

This paper addresses these approaches, and suggests that the effective difference between the decision criteria of gross disproportionality and benefit-cost ratio of one or more is not as severe as might be immediately apparent. However, the expenditure criterion of benefit-cost ratio of one or more is preferred because of imprecision in the definition of gross disproportionality.

The paper also notes that some literature on transport safety argues that higher levels of expenditure on rail safety might be warranted by specific characteristics of railways. Empirical studies have found little evidence to support the higher unit valuation of improved safety outcomes for railways compared with road transport.

Finally, the paper discusses three implications of excessively high rail safety standards. Firstly, funding constraints mean the standards are likely to be unachievable, and regulators must either compromise standards or close services. Secondly, excessively high standards impede the commercial performance of rail, against a general government and community desire for rail to play a larger role in the transport sector. Finally, excessively high rail safety standards compared with road transport leads to a misallocation of resources that may result in more death and injury in the transport sector than need be the case.

2 Current practices in setting safety standards

2.1 Rail industry

Regulation of safety in the rail industry is currently undertaken through two channels:

- occupational health and safety (OHS) legislation, which covers those who work for the business (which includes the likes of contractors as well as employees) – and also extends to passenger and public safety; and

- rail safety laws that require track managers and rail service operators to be accredited with State/Territory regulators. Accreditation requires the presence of safety systems, as described in Table 1. These systems are intended to protect all who may be affected by railways, including workers, passengers and others in the community.

[1] The author gratefully acknowledges discussions and comments from Barry Moore, Director Policy at the National Transport Commission. The views in the paper are, nevertheless, those of the author, and do not necessarily reflect the views of the National Transport Commission, for which the work was undertaken. A detailed report of the work on which this paper is based can be found at http://www.ntc.gov.au/DocView.aspx?page=A0231040340092002O.

Table 1 Safety requirements of accreditation applications by track managers and railway service operators

‘	Legislation	Require-ment	Features of safety system or criteria for assessing the system
New South Wales	Rail Safety Act 2000 (NSW)	Safety Manage-ment System (SMS)	The SMS should: • identify and analyse risk • design and implement controls to manage risks • monitor the controls • upgrade system in response to monitoring
Victoria	Transport Act 1983 (Vic)	SMS	Assessment of SMS to consider at least: • proposed actions • appropriateness of the SMS • safety levels achievable at a reasonable cost • need for efficient and competitive rail transport services • consistency with generally accepted risk management principles • level of safety relative to that for competing transport modes
Queensland	Transport Infrastruct-ure Act 1994 (Qld)	SMS	• As for Victoria
South Australia	Rail Safety Act 1996 (SA)	Safety Standards and an SMP	Application should describe: • safety standards relevant to safe construction, maintenance & operation of infrastructure and services SMP should: • identify risks • specify systems, audits, expertise and resources to address risks • specify who is responsible for implementation and management of the SMP
Western Australia	Rail Safety Act 1998 (WA)	Safety Standards and SMP	• As for South Australia

Source: Derived from Coors Chambers Westgarth (2004)

This arrangement results in overlap between general OHS legislation and specific legislation dealing with railway safety, involvement of an additional set of state-based regulators in the industry, potential for conflict between the standard of safety required to meet OHS and rail sector obligations, and scope for rail regulators in each State/Territory to draw differing conclusions about appropriate safety standards. These outcomes are detrimental to an efficient national railway system.

As indicated in Table 1, guidance on criteria to be taken into account when setting safety standards is provided in only two States (Victoria and Queensland). Regulators in the other States shown must determine appropriate standards without legislative guidance on priorities. There is no readily available literature that summarises how the rail regulators have applied the laws with respect to safety, in particular the safety standards that they have assessed to be consistent with available guidelines (in Victoria and Queensland) or have judged to be appropriate in the other States. In the case of NSW, though, the Independent Transport Safety and Reliability Regulator explicitly notes that it “does not consider its role is to achieve ‘safety at any cost’ but it would be disappointed [to see] a substitute analysis of whether a counter-measure is warranted with some subjective test of whether a counter-measure is commercially affordable” (ITSRR 2004:22).

Rail safety legislation in most States makes reference to Australian Standards on Railway Safety Management, the Rail Code (AS4292), which in turn refers to the principle of reducing

risks 'as low as reasonably practicable' (ALARP) – this principle, which is widely articulated as a benchmark criterion by rail safety agencies (eg DOI Vic 2004, ITSRR NSW 2004 and HSE 2001) is discussed in more detail later in this paper. Recently released draft guidelines from the Department of Infrastructure, Energy and Resources of Tasmania (DIER Tas 2004) are also based on this principle. The draft guidelines note that cost benefit analysis may sometimes be necessary though, as in the United Kingdom from where the principle originates, the benefit-cost ratio at which expenditure is warranted is not indicated.

The Australian Rail Safety Regulators Panel (2004) noted that "In determining risk treatments and applying the ALARP test, the elimination of risk must be given due consideration, and where elimination is not reasonably practicable, the Hierarchy of Control must be applied." With regard to the latter, the report notes that "In controlling the risk, one or more of the following measures should be taken (in the order specified) to minimise the risk to the lowest level reasonably practicable: 1. Substituting the hazard giving rise to the risk with a hazard that gives rise to a lesser risk. 2. Isolating the hazard from the person put at risk. 3. Minimising the risk by engineering means. 4. Minimising the risk by administrative means (for example, by adopting safe working practices or providing appropriate training, instruction or information). 5. Using personal protective equipment." No clearer guidance is provided on the ALARP test, with the indication that "only if it can be shown that there is gross disproportion between the cost, time and trouble required to eliminate or control the risk, and the likelihood and potential harm of the risk in question, should cost considerations prevail."

Increased emphasis is being given by governments in Australia, at both State and Commonwealth levels, to the costs and benefits of government regulation. New regulatory initiatives are usually subject to review and documentation in the form of regulatory impact statements. Guidelines for preparing regulatory impact statements (eg COAG 2004) encourage quantification of costs and benefits, though do not establish decision criteria such as a benefit-cost ratio of one or more. Nevertheless, the general principle is established that "the aim of any national standard setting process should be to achieve minimum necessary standards, taking into account economic, environmental, health and safety concerns" (COAG 2004:1). The practice of the National Transport Commission (NTC) is to use a benefit-cost ratio of one or more as the economic criterion for regulatory change.

Having established an appropriate regulatory standard in Australia (which could be either a prescriptive or performance-based standard), the NTC expects regulated parties to comply with the standard. Unless there are grounds for exemption, commercial viability and other factors cannot be used as reasons for failure to meet the standards. This practice is generally common to regulated industries.

2.2 Road transport

Regulation of vehicle safety in the road transport sector is implemented through Australian Design Rules (ADRs), safety requirements of infrastructure are guided by road engineering standards, and transport operations are conducted through legislation and supporting regulations. ADRs establish vehicle standards and are largely directed to ensuring a minimum standard of safety. Development of these Rules is managed by the Department of Transport and Regional Services (DOTARS) using a consultative process in which the NTC and Federal and State/Territory Governments are engaged.

There is no explicit guidance on the setting of standards for ADRs. However, the willingness of people to pay for safety measures built into vehicles suggests that the benefits are judged to be at least equal to the cost of the measures.

A benefit-cost ratio of one is also the general criterion for decision making on road expenditure (eg Austroads 2004:31), though funding constraints mean that implemented projects often have higher rates of return.

Road design is heavily influenced by formal standards that set minimum characteristics for factors that affect safety, eg road width, curvature, design speed and sight distance. Implementation of proposed projects that meet these minimum standards is generally also subject to the criterion of benefit-cost ratio at least one. Subject to optimal road design (ie avoiding under or over-design), the criterion of a benefit-cost ratio of one or more effectively constrains the level of safety to an economically viable level.

Road transport regulation generally defines specific responsibilities and offences for breaches of these requirements. Road transport regulation is usually based on prescriptive requirements governing vehicles and road use (eg vehicle dimensions and speed limits), although some vehicle requirements are more performance based (eg stopping distance). The NRTC is currently leading a national investigation of the application of performance-based standards for road transport regulation.

2.3 Occupational health and safety

OHS laws demand a generally high standard of safety. As an example, the Occupational Health and Safety Act 1985 (Vic) seeks to eliminate risks to health, safety and welfare of people at work as far as is practicable, where practicable means having regard to the severity of the hazard or risk in question, the state of knowledge about the hazard or risk, and ways of removing or mitigating it, the availability and suitability of ways to remove or mitigate the hazard or risk and the cost of removing or mitigating the hazard or risk.

This is a qualified version of practicability (if practicable is taken to be an action that is humanly possible), and thus can be more precisely defined as “reasonably practicable”, which is the terminology generally used in OHS literature.

With regard to the influence of cost, an extensive history of OHS case law indicates that expenditure should be made to mitigate risk up to the point where the cost would become grossly disproportionate to the risk involved. However, while grossly disproportionate clearly means that an action should be taken even if the cost is greater than the benefit gained, the extent of the imbalance between cost and benefit is neither defined nor even intimated in readily available literature, and is subject to court interpretation from time to time.

3 Analysing risk tolerability in railways

3.1 Approaches to standard setting

A general framework for treating workplace risks is provided in by the Health and Safety Executive, which is responsible for establishing safety standards in the UK (HSE 2001). The framework identifies three categories of risk: (a) risks that are sufficiently rare, unforeseeable or minor in their consequences that they require no action; (b) risks that have a high probability of occurrence or a potentially severe impact as to be unacceptable and hence need the risks to either be removed irrespective of their cost or banned; and (c) remaining risks that can be tolerated if sufficient expenditure is made to reduce them to as low a level as is reasonably practicable (ALARP).

The criterion used in judging the adequacy of the expenditure-benefit trade-off in the last of these cases, which is the focus of this paper, is gross disproportionality. This requires rail safety regulators to assess costs and benefit of proposals to determine if they are ALARP compliant. However, the lack of an unequivocal definition of the ratio of costs and benefits that represents gross disproportionality reduces the usefulness of the criterion.

This approach can be contrasted with two other potential frameworks. In the first, all risks could be reduced to the extent practicable. This is a stringent framework because it means anything that can be done should be done, ie limited only by technology and human capacity. No analysis of costs or benefits is required in this approach because they do not

affect the level of intervention. In practice, this approach leads to impractical consequences and is not used (see Maxwell 2004, Chapter 10 with regard to OHS legislation).

A less strict benchmark is to set safety standards at a level that ensures that the benefits of regulation are equal to or greater than the cost of implementing the measures (including the cost of the regulatory process), ie the benefit-cost ratio should be equal to or greater than one. This net social benefit approach ensures that no more is spent on rail safety than the benefits that accrue to the community, and releases funds for other purposes.

The essential difference between the frameworks is the extent to which cost is taken to be a consideration in decision-making. Both the gross disproportionality and net social benefit criteria require analysis of the costs and benefits of proposed measures.

Gross disproportionality is the criterion generally adopted by railway systems in Australian and the UK, whereas net social benefit is usually used for railways in the USA and road expenditure in Australia (and elsewhere). In practice, these standards may not be met. Funding constraints may result in potential road projects having benefit-cost ratios of more than one not being implemented, and are likely to also result in some ALARP-compliant railway projects not being implemented – though may possibly still result in implementation of rail safety projects with benefit-cost ratios of less than one.

3.2 Factors affecting rail safety regulation

A number of overarching issues influence the scope of a safety regulatory system and the context in which risk tolerability, and the safety regimes that follow, should be addressed. They include:

Ethical issues: Four issues are pertinent: ethical behaviour by the rail industry (ie do they have sound, consistent and open systems for addressing safety); the ethics of economic evaluation of safety proposals and the associated placing of a monetary value on human life (which is generally accepted as being reasonable); ethics related to equity in the use of limited resources (ie using funds in a way that favours some people over others); and ethics related to equity between those who seek and those who pay for higher levels of safety (ie that people do not seek an excessively high standard because they expect others to pay the cost). The last three of these issues require that financial constraint be recognised, and account be taken of the level and incidence of costs and benefits, and the opportunity cost of expenditure on rail safety.

Practicality: A regulatory system must also be practical. Hence, it is a reasonable desire that there should be no deaths or injuries from rail activities. However, to use this as the criterion against which rail regulators set standards to be met by track managers and train service operators would, given current knowledge and resources, result in regulators either failing to meet their charter or closing railways because of the industry's inability to meet the standard. That is, unreasonably high safety standard requires regulators to either impose conditions on track managers and train service operators that could force them into bankruptcy, or require infrastructure and services not meeting the standard to be closed.

Common law: Railway organisations may also have their actions judged against benchmarks established through case law. However, a feature of case law is that it evolves on the basis of new evidence. This opens the way for the railway industry to investigate and develop sound bases for safety standards, and to justify these standards in court actions rather than simply deferring to current standards.

Market failure: The general basis for safety (and other) regulation by government is to redress market failure. This is generally taken to be instances where any of the key ingredients for market efficiency (eg a competitive environment, perfect knowledge, and absence of externalities) are missing and hence the market will not deliver an optimal

outcome. Identifying the market failure to which regulation is directed is a necessary step in identifying sound regulatory schemes (eg ORR 1998: Section B1). It is even more explicitly considered in preparation of regulatory impact statements in the USA, and is reported as a statement on the need for the proposed action. This step ensures that proposed regulatory actions are focussed on the essential need for intervention.

It may be interpreted that there is also a view that regulation is warranted if the level of safety determined by a perfectly efficient market is considered inadequate. This is difficult to establish objectively, and hence needs to be used with care. It is, essentially, a political judgement that needs to be supported with information if the decision is to be informed.

Leaving aside OHS regulation, which is largely beyond the influence of the rail industry in Australia, market failures that may warrant rail regulation include: (a) inadequate information for users on risk due to poor communications and technical complexity; (b) the externality of societal concern that goes beyond the effects on rail users and suppliers; (c) under-compensation of those affected by safety failures; and (d) industry structure wherein government ownership of track managers and train service operators may distort investment (with possible effects ranging from under-investment in safety on the presumption that shareholding governments will bear losses in the case of accidents, to excessive safety expenditure as a contingency against political risk).

The first of these (ie the market failure of consumers being unable to make fully informed decisions) is best redressed by better provision of information. To the extent that societal concern can be minimised through sound railway management, there is less cause for regulation with regard to the second market failure. The nature and cause of any under-compensation of costs from incidents needs to be determined to establish if regulation can redress the situation. Finally, transparent accounting and consistent and unambiguous safety criteria and enforcement could be used to address the last of the failures. It is necessary in all cases to establish that the expected benefits outweigh the cost of regulation and take account of the potential for regulatory failure.

As discussed in the next section, some of the costs and consequences of rail incidents will be internal to the railway industry, which should reduce the need for regulation. The use of higher safety standards than customers are willing to pay for through tariffs does not provide a general case for government subsidy, though would do so if the higher standards were mandated by government against market judgements. Subsidy might also be justified for higher passenger safety standards where these become an externality to freight services. Subject to sound management by the rail industry to minimise societal concern, any remaining societal concern is an externality to the industry. Section 3.5 considers the evidence for the placing a monetary value on societal concern.

Fit-for-purpose standards: There is considerable variety in railways and the risks associated with them. Safety standards in mineral railways, which are an integral part of a production process, are likely to be driven by financial concerns because of incidents can have considerable flow-on effects. Lower standards may be acceptable for railways in sparsely populated areas that carry seasonal, relatively low volume, price sensitive freight such as grain. Suburban railways, especially those carrying both freight and passenger traffic, can place many people at risk, and therefore need higher safety standards. Safety regulation can respond to such differing circumstances of railways by using fit-for-purpose performance standards that are developed within a framework of consistent principles regarding risk tolerability, risk management and justification of expenditure on safety improvements.

Rail viability: Setting an excessively high safety standard for railways adds to railway costs and reduces the economic viability of the mode. Victoria and Queensland currently indicate that safety regulation should recognise the need for competitive rail services (see Table 1).

In addition, excessive rail standards may result in higher social costs if the resultant elevated rail costs divert freight and passengers to road transport.

3.3 Consequences of incidents

Railway risks that are realised as incidents have three categories of consequences:

- personal loss, ie the effect on people directly affected by the incident, including workers, passengers, freight and the public at large;
- reputation loss for railways, which may be reflected in loss of traffic and revenue (commercial revenue and, potentially, diminished public backing for subsidies); and
- societal concern, which HSE (2001) identifies as being linked to risks that can lead to catastrophic failure and where consequences may be irreversible, have inequitable impacts on the community, and pose a threat to future generations. Environment-related risks are an example of societal concern, though major railway crashes that involve multiple failures are catastrophic failures that commonly receive much attention. A general interpretation is that societal concern relating to rail incidents is the distress that goes beyond the personal and reputation loss of the incidents, including that felt by people not directly affected. A consequence of this concern is pressure on governments to improve safety.

Given proper compensation by railways to those affected by incidents, the first two of these consequences are manifested as a financial impact on railway organisations. Unless other market failure is present, there should be little need for safety regulation in respect of them because railways can establish safety standards knowing that they bear the consequences of standards that are either too high or too low. In practice, compensation of those affected by incidents may not be equal to the full societal cost of the impact, in which case the costs of an incident are not internalised to the railway industry.

3.4 Risk tolerability

Factors that affect people's perception, and hence tolerability, of risk are described slightly differently in the literature. For example, Wolff (2002:14, drawing on Slovic et al 2000) indicates factors such as: familiarity (a new risk may be treated with greater caution than an old one); voluntariness (people are more tolerant of risks where they can control their exposure to hazard); degree of control (tolerance of risk is higher if the probability of risk can be influenced); potential for catastrophe (there is a lower tolerance for risks that could result in a catastrophe); dread (some risks induce more fear than others); and how well known the risk is to science.

Sandman (1987) uses the term "outrage" factors to describe the issues that affect perceptions of risk, and notes that the literature identifies some twenty such factors, including: process (the extent to which the agency is open with the community); voluntariness (voluntary risk is more acceptable than coerced risk); morality (some risks are considered to be unacceptable, by some people at least); dread (the consequences of some risks are considered to be more horrible than others); and concentration (a single accident that kills a large number of people may arouse more concern than the same number killed in individual accidents).

"Social amplification" of risk contributes to the considerable concern for railway safety in the UK, where "intense media scrutiny and reporting will make issues especially vivid to people, and this can lead to an intensifying of attitude" (Wolff 2002:17, referencing Kasperson 2002). Wolff notes that this can lead to individuals over-estimating the risk when making travel decisions, and can also exacerbate societal concern.

Societal concern, exacerbated by outrage, influences the community's perception of the tolerability of risk. To the extent that the concern is biased by misperception and amplified by the publicity that inevitably follows railway incidents, the tolerability of risk is further reduced, and yet higher safety standards are sought. Overselling the standard of rail safety similarly raises expectations and hence the negative reaction to incidents that occur.

Two other factors are important in considering concern about risk. Firstly, there is considerable diversity between people in their attitude to risk. Thus, setting a standard that addresses the average level of concern will result in risk-averse people still feeling that the standard is too low. Setting a standard to satisfy the most risk-averse person requires a system that is exceptionally, and possibly impractically, safe.

The second issue is that rail users may be considered to not have control over factors that affect the safety of their trip, and hence may seek greater assurance about the level of safety. By making a decision to travel by rail, users implicitly accept the loss of control. They may, however, feel outrage if they consider themselves to have been deceived about the consequences of surrendering control. (This issue of loss of control does not solely apply to rail transport. While drivers of road vehicles have control over their vehicle, they have no control over the behaviour of other motorists. Moreover, the quality of vehicle design and maintenance, and road and signage condition, is the responsibility of others. Vehicle passengers have less control over their safety than drivers.)

3.5 Managing societal concern and risk tolerability

Press coverage and political reaction to rail crashes provides some evidence for general community concern. The key factors that appear to influence the concern are a denting of trust in publicly controlled institutions, the horror of multiple deaths and injury, and perhaps the shock of failure in a transport mode believed to be safe. Social amplification may exacerbate the effect. An issue is the extent to which these are simply short term reactions, and the economic cost that should be ascribed to societal concern.

It is commonly claimed that people appear to be more concerned about the occurrence of a multiple fatality accident than the same number of people dying in a number of accidents (eg RSSB 2003:10 and RSSB 2002:14). Jones-Lee and Loomes (1995) conclude that there is no satisfactory moral or ethical reason for such concern given that the same loss of human life occurs. They suggest that a sounder argument is for a premium related to the imprecision with which large scale accidents can be predicted (because they occur rarely, and generally involve some unique combination of human and system failure) and the uncertainty of the consequences of them. However, there was no evidence in their empirical research of a significant scale issue. The research also indicated a view "that money spent on reducing single-fatality accidents would yield a tangible return in the form of a measurable reduction in the frequency of such accidents". This effect seemed to have offset the imprecision and uncertainty effects that favoured a premium for multiple fatality accidents.

Sandman (1987) suggests that "Since the public responds more to outrage than hazard, risk managers must work to make serious hazards more outrageous and modest risks less outrageous", using examples of campaigns against drunk driving and smoking as examples of the former. In the case of railway safety, where the safety record is high – and relatively better than for road transport – it is likely that the second matter is more relevant.

Risk tolerability by train users and societal concern is influenced by public confidence in the rail industry. Poor communications and practices by the industry that reduce risk tolerability and increase societal concern may be interpreted as requiring the industry to implement a higher standard of safety with higher levels of expenditure. However, it is generally acknowledged that the better approach to reducing societal concern and improving risk tolerability is to improve practices in the rail sector (eg Wolff 2002, and Elliot and Taig 2003).

Measures such as transparent and sound safety management systems, good public awareness and communications, and fairness are likely to reassure the community and reduce their inclination to misjudge risks associated with rail transport. These need to be supported by clear specification of safety standards and consistent enforcement of the standards.

It is concluded that societal concern can be exaggerated, and risk tolerability reduced unnecessarily. Their potential cost can be minimised through good management practices. Insofar as societal concern needs to be considered in appraisal, it should be addressed in terms of its specific components (eg lack of control, multiple fatalities, regulatory trust, etc) rather than bundled into a general catch-all concept.

3.6 Interpreting ALARP

ALARP (as low as reasonably practicable) provides a risk management framework for identification of risks and remedial measures, and guidance on safety expenditure decisions. The extent and manner of evaluation of expenditure proposals appears to vary. The guidelines provided by the Health and Safety Executive and Rail Safety and Standards Board in the UK indicate that this should be done in the general form of a benefit-cost analysis albeit with the benchmark criterion being gross disproportionality of costs relative to benefits rather than a benefit-cost ratio of one as required for the net social benefit approach.

The origins of the gross disproportionality criterion appears to be a judgement in the British Appeal Court in 1949 in the case of Edwards v National Coal Board, which related to compensation to the widow of a miner accidentally killed in a coal mine. The compensation in that case was £984 (equal to about £22,000, or A$55,000, in 2002 prices – derived from Evans 2005a). It may therefore be inferred that safety measures should be implemented unless their cost is disproportionate to this compensation amount. This inference leads to the conclusion that the gross disproportionality criterion, and hence ALARP, are to be guided by financial analysis, which is informed by the market price benchmark of court awards.

In contrast, the net social benefit approach follows the technique of social benefit-cost analysis, which is based on resource values (ie the underlying value of costs and benefits) rather than their financial price as indicated in the market. In addition, not all costs and benefits have market prices (eg environmental impacts). The results of economic and financial evaluations of the same project can therefore differ, sometimes substantially.

For example, to foreshadow a more detailed discussion in the next section of this paper, the current resource value of an avoided death in the UK of £1.25 million is 57 times the compensation paid in the case of Edwards v National Coal Board (all values expressed in 2002 prices). The real value of court awards for premature death has risen since that time: drawing on Evans (2005a), it averaged £157,000 in 2002 prices between 1952 and 2000, and appears to have still been less than £0.2 million through the 1990s. Accordingly, it is possible for a net social benefit approach with a benefit-cost ratio of one to not necessarily be inconsistent with the gross disproportionality criterion inherent to ALARP. This matter is discussed further in the next section.

ALARP is a helpful framework for identifying and managing safety interventions. However, the imprecision of “reasonably practicable” and “grossly disproportionate” compared with a benefit-cost ratio of one or more constrains its usefulness. This could be redressed by replacing the gross disproportionality decision criterion with the net social benefit criterion.

3.7 Valuing safety improvements and implications

Evaluation of safety expenditure requires the value of benefits to be established. Of particular importance is the value of an avoided fatality (generally described as the value of a statistical life – VOSL) and of avoided injuries, which are used to establish the benefits

expected to result from a safety improvement. For practical reasons, this paper considers only VOSL in detail, though principles can logically be extended to injuries.

Two methods are generally used to estimate VOSL: the value of lost human capital, which is an ex-post valuation of the net loss of economic and social potential that results from premature death; and willingness-to-pay to reduce risks as revealed by peoples' decisions to take preventive or trade-off actions, which is sometimes called the value of preventing a fatality (VPF). VPF has the merit of being an ex ante value, ie its role is to assist in determining actions that are worth taking to prevent a failure that would result in loss of life. The VPF is generally higher than the VOSL based on the lost human capital approach. While there are technical limitations with both approaches, VPF is the more commonly used valuation approach in studies reported in the literature. Some estimates of VOSL are:

- Abelson (2003) summarises the results of a number of studies, and reports a general use VPF of US$6.1 million (in 1999 prices) in the USA, C$4.3 million (in 1999 prices) in Canada, and about US$1.5 million in Europe. He reports the values to generally be in the range of $3.3 million to $6.6 million (Australian dollars unless otherwise indicated).

- The Federal Railroad Administration in the USA currently uses a VPF of US$3.0 million ($4.2 million). This value, which was set by the US Department of Transportation in 2002 (US DOT 2002), is used for all transport modes (ie road, rail, water and aviation) and for all who might be affected by transport incidents (ie workers, passengers and the public at large).

- In the UK, the current VPF for fatalities in road crashes is £1.25 million in 2002 prices (DFT 2002:8) – equal to $3.2 million (also in 2002 prices). Evans (2005b) describes that the rail industry has used a value of about £3.5 million, following the British Rail practice of including a premium to allow for factors such as the lack of control that passengers have over risks associated with rail travel and societal concern.

- There is no general purpose VOSL in Australia. Austroads (2003:6) reports the cost of a road fatality at $1.31 million in 2002 prices, while the Bureau of Transport and Regional Economics estimated the cost at $1.5 million in 1996 prices (BTE 2000). Both of these values are based on the lost human capital approach.

Hiselius (2003) reviews the literature on differences in VPF for road and rail, taking account of factors such as dread and knowledge, controllability of risk, moral indignation, equity, accident scale, and socio-economic variables. The paper concludes that there is "no clear-cut evidence of whether risk reductions in the railway area are preferred to reductions in the road traffic area", but goes on to say that "there seems to be more indications suggesting that the value of safety is higher for railway traffic than for road traffic" (Hiselius 2003:28). The apparent contradiction between these statements may reflect statistical variability and limitations in available data.

In the UK, two empirical studies to determine the VPF for rail have been undertaken in recent years (in 1998 and 2000 – see HSE 2000a&b, and Chilton et al 2002) – the survey methodologies considered the value of railway fatalities (and also deaths due to fires) relative to the VPF for fatalities in road crashes. The two surveys estimated the VPF for rail to be 83 percent and 100 percent respectively of that for road. As the second survey occurred shortly after a major train crash, it is possible that the value was influenced by a heightened concern for rail safety, which more properly is a reflection of societal concern than the direct value of loss of life.

It is expected that the empirical work undertaken in the UK should have registered any premium that rail passengers might attribute to factors such as the lesser degree of control they have over their travel than car drivers and dread at the type of death or injury that they

might incur in a rail accident compared with a road crash. The absence of a premium for the VPF in rail compared with road suggests that such factors are not present, or are countered by some other factors that have the reverse effect.

The results of these surveys therefore suggest there is no generally accepted basis for valuing the loss of life differently for rail and road. Evans (2005b) provides further discussion on this subject, and reports that the UK Government's formal position is that the VPF should be the same for rail and road accidents. Hiselius (2003:11) notes that Sweden, Norway and the USA also use the same values for road and rail transport. This conclusion, and the general agreement in the literature that the VPF is the more appropriate value to use in economic evaluation of safety improvements, suggests a need for Australian transport authorities to re-address the issue, and to establish an appropriate single value for use in the assessment of transport projects in Australia.

Abelson (2003) suggests that an appropriate VPF for general public policy purposes in Australia, in 2002 prices, should be $2.5 million for avoiding an immediate death of a healthy person in middle age (about 40), adjusted by $108,000 per year (discounted at 3 percent) for persons of different ages.

Given the historic legal basis for ALARP, the value of life used in an ALARP evaluation is likely to be similar to the compensation that would be awarded by the courts if the proposed measure was not implemented. Lost earning forms the major part of such awards, in which case compensation would be less than the VOSL based on the human capital approach and much less than VPF. Indicatively, lost earnings accounts for about one-third of VOSL based on the human capital approach, which suggests lost earnings equal to an average of $0.43 million based on the Austroads estimate of VOSL.

With a VPF of $2.5 million (as per Abelson 2003), an ALARP evaluation for a project that would save one life and which has a benefit-cost ratio of one based on VPF (which implies justification for expenditure of $2.5 million) would indicate costs almost six times the anticipated ALARP benefit (ie avoided compensation of $0.43 million), all other things being equal. Thus, a project that has a benefit-cost ratio of one based on VPF meets the disproportionality criterion inherent to ALARP. Whether a gross disproportion criterion is achieved remains a matter for judgement.

It is evident that the two approaches do not simply involve different presentations of a given set of costs and benefits, but rather reflect a different accounting of costs and benefits – with the ALARP analysis being in the form of a financial analysis in contrast to the social benefit cost approach in which VOSL is used.

3.8 Intra and inter-sectoral implications

The cost of railway crashes will generally be highest for those involving passengers because of the value of lost lives and injuries. This warrants higher safety standards for passenger services and rail lines carrying these services. The latter raises the cost of providing freight services where present on the same lines, and hence reduces the commercial viability of freight services and risks loss of freight traffic. Possible responses to ensure rail freight transport is not disadvantaged are to require passenger services to bear the entire incremental cost of the higher standards and/or to lower safety standards for passenger services from the current criterion of gross disproportionality. Using a net social benefit criterion for rail expenditure would reduce expenditure needs and ensure horizontal equity with the road transport sector, while still ensuring that safety is properly taken into account.

With regard to the comparison of road and rail transport, Evans (2005b) notes that the cost of preventing a fatality in road transport with well designed local road safety schemes is about £0.1 million. By comparison, the average cost of the Train Protection and Warning System recently implemented in the UK was £11 million (though the average for the first 90

percent of reduced fatalities was a less extreme £4 million per avoided fatality). He concludes that "it is clear … society could prevent more fatalities at the same time by devoting relatively more resources to road safety and less to rail safety."

This incongruity would be less severe if the value of saving lives in rail transport was markedly more than for road transport. However, as indicated previously, there is little evidence to justify a higher valuation. Similarly, there is no clear case for a significant economic value to be ascribed to societal concern about rail crashes, especially relative to road accidents (noting that there is also public concern with major bus crashes).

A study of 185 proposed or implemented risk interventions across a range of sectors in the USA claimed that the estimated cost of interventions ranged from some thousands of dollars to several billion dollars per year of life saved. Reallocating funds to more cost effective interventions could have more than doubled the lives saved (with an additional saving of 60,000 lives per year), or the same life saving could have been achieved with a cost of intervention of about US$31 billion less (Tengs and Graham 1996).

It is concluded that: use of rail safety standards that are higher than for road transport does not appear to be supported by empirical studies of the value of safety benefits; legislating or regulating higher safety standards for rail than road raises the cost of rail services, with detrimental traffic, commercial and community impacts; and additional lives could be saved by more closely aligning rail and road safety standards, with relatively more spent on lower cost road measures and less on costly rail measures.

4 Implementing more efficient and effective safety standards

The discussion of previous sections points to some key issues that are needed for efficient and effective rail safety standards to meet the community's tolerance for risk and best use of resources given competing demands and concerns.

- **Securing public trust**. Securing public trust is an essential part of any business that relates to the public, as occurs with railways. It is also a means for avoiding risk premiums due to excessively high expectations and uncertainty that would otherwise require higher safety standards and expenditure. Securing public trust requires sound, transparent and consistent systems that provide the community with a realistic understanding of the risks associated with rail transport and confidence in the presence of procedures to manage the risks.

- **Integrating organisation, investment and working methods**. Quality infrastructure plays an important role in ensuring safety systems. However, human error plays a role in most incidents, with improvements in organisational arrangements and working methods therefore able to reduce risks. Cost effective safety systems need to involve all of these components. These systems are also vital to communicating with the public to gain their trust with respect to rail safety.

- **Establishing practical safety standards**. An objective for rail safety such as "a safe rail system" provides insufficient guidance to rail regulators and industry on appropriate standards. Historic practices appear to result in a bias to high standards. Excessively high standards will be unachievable, unsustainable, or will result in misallocation of resources that increases the cost of transport and may result in more people being killed and injured in the transport sector than need be the case.

  At a minimum, there is a need to articulate standards that are defensible, practical and enforceable. Ideally, consistent road and rail standards are needed to ensure inter-modal equity and to maximise safety benefits in the transport sector as a whole. As Australian rail systems carry a variety of traffic in a range of circumstances, a "one-

size-fits-all" safety standard is unlikely to be appropriate. Safety standards therefore need to be expressed in a way that is underpinned by uniform principles that allows safety measures to be fit-for-purpose.

Finally, the arrangement in the USA whereby the Federal Railroad Administration, as the industry regulator, assumes responsibility for OHS as well as other aspects of railway safety offers a simpler means for achieving internal consistency and efficiency in rail safety management than is possible in Australia with its multiple jurisdictions, sectors and standards.

- **Developing evaluation frameworks and capacity**. While economic evaluation is not a perfect tool, it remains the soundest means for comparing costs and benefits of proposals. Improvements such as the introduction of risk analysis into economic evaluation (using probability based data rather than simple average values) and a better understanding of the value that the community places on safety enhances its ability to reasonably compare the costs and benefits of actions. Further consideration needs to be given to the VPF that should be used for road and rail evaluations in Australia, acknowledging the conclusion that the same value should be used for both modes.

  The net social benefit criterion (ie a benefit-cost ratio of at least one) is preferred to gross disproportionality because of the imprecision of the latter, the general use of economic evaluation to support consistent decision making regarding public expenditure, and to optimise societal outcomes from transport activities.

  Economic evaluation does not directly indicate the distribution of costs and benefits between people in the community. The lack of such understanding might explain why some proposals that have benefits which exceed costs may still face critical review by some in the community. Disaggregation of costs and benefits by their incidence can provide an understanding of distributional consequences of proposals and thus enable decision-makers to be better informed about the implications of proposals. Risk analysis will enhance this understanding.

- **A national approach**. Regulatory regimes that vary between jurisdictions impose an additional burden on train service operators who have cross-border activities. Developments such as the report of the Rail Safety Regulators Panel (2004) facilitate national consensus on risk tolerability and safety standards that can reduce regulatory costs for industry and facilitate system inter-operability.

5 Conclusion

There is little evidence to support the higher unit valuation of improved safety outcomes in rail compared with road, with the reasons for a higher valuation being less strong than imagined or have off-setting effects To a large extent, improved rail management can reduce the need for higher expenditure. Governments in the USA and United Kingdom, amongst others, currently use a common value for the loss of life from incidents in road and rail incidents. A similar approach also seems appropriate for Australia, using soundly derived values for avoided fatalities and injuries.

The ALARP framework provides a widely accepted and practical guide for rail safety management. However, its expenditure criterion of gross disproportionality is imprecise, provides limited practical guidance, and is likely to lead to excessive expenditure on rail safety. Conventional benefit-cost analysis, well applied and with a net social benefit criterion, provides a more consistent and sounder framework, and will support an allocation of resources in the transport sector that will maximise community benefits. The ALARP

framework would be enhanced if it was to use the net social benefit criterion in the place of gross disproportionality.

More generally, rail safety will be enhanced by implementing safety practices that secure public trust and hence avoid risk premiums due to excessively high community expectations and uncertainty; making effective use of working methods, training and organisational arrangements to improve rail safety; establishing rail safety standards that are defensible, practicable and enforceable, that are fit-for-purpose recognising the variety of traffic using Australian rail systems, and that ensure inter-modal equity; developing evaluation frameworks and capacity to support objective decision making on rail (and road) safety standards and expenditure; and recognising the need for States and Territories to regulate track managers and train service operators within a consistent national approach to minimise regulatory costs for industry and ensure system inter-operability.

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