Challenges of Sustainable Development: UMTP Risks to Ecosystem and Human Health

Paper presented at the Second OMEGA Workshop, and the Conference of the Association of European Schools of Planning, Napoli, July 2007

Nicholas Low

Draft: not for citation

Australasian Centre for Governance and Management of Urban Transport

Challenges of Sustainable Development: UMTP Risks to Ecosystem and Human Health

Abstract

If urban mega-transport projects (UMTPs) are to be given the imprimatur of 'sustainability', a wide range of issues relating to sustainability need to be recognized and discussed. One of them is the risk to ecosystem and human health posed by the construction and operation of UMTPs.

The paper opens with an account of 'sustainability'. This is intended to clarify the author's position regarding the logic of sustainability. This logic colours the discussion of what follows. The paper's main purpose is to explore what is involved in including ecosystem and human health risk assessment in the planning of projects. The paper then examines the risk management cycle, the context in which risk assessment occurs, and different kinds of uncertainty and risk. Then the paper goes on to identify more specifically the types of risk that may be incurred from the construction of UMTPs. Some techniques of identifying and measuring hazards in conditions of uncertainty are discussed. The paper indicates how such risk management may be included in the planning of UMTPs.

In conclusion, the paper tries to answer a question emerging from the discussion: given the difficulties, uncertainties and inevitable costs of useful risk assessment in this field, is it worth undertaking at all? Is it better to be blind and believe that one can see, or to be blind, and know that one is blind? What is at the heart of the rationality of risk and analysis, and how can this rationality be preserved in a context dominated by the play of power?

Acknowledgements

The author wishes to acknowledge the assistance of Professor Mark Burgman and the contribution of his excellent book: *Risks and Decisions for Conservation and Environmental Management*, (Cambridge University Press, 2005) which provided the perfect guide through the difficult terrain of environmental risk management. The author also drew material from an earlier paper and acknowledges the particular contribution of Dr Leigh Glover to the section in the present paper on diffuse risks of UMTPs ('The Future of Urban Transport: meeting the global challenges of the twenty first century' by N. Low, L. Glover and M. Imran, expected to be published in a forthcoming issue of *Environment and Planning B*).

Introduction

If urban mega-transport projects (UMTPs) are to be given the imprimatur of 'sustainability', a wide range of issues relating to sustainability need to be recognized and discussed. One of them is the risk to ecosystem and human health posed by the construction and operation of UMTPs.

It is widely recognized that UMTPs pose a risk not only to their proponents, investors and contractors (essentially financial risk) but also to the natural and human biological systems that receive them (natural risk). The risk may be small or large. Either way it may be worth taking because of the benefits the project incurs. We all take risks at every moment of our lives in order to obtain benefits, and it might even be said that a life without risks is not worth living. But if the risks are unknown it is not possible to tell whether they are worth taking. So well researched risk analysis appears to be a rational process to undertake.

The paper begins with an account of 'sustainability' that clarifies for the author the connection between human economy and natural ecology. The paper's main purpose is to explore what is involved in including ecosystem and human health risk assessment in the planning of projects. The core of the paper, then, examines the risk management cycle, the context in which risk assessment occurs, and different kinds of uncertainty and risk. Then we turn more specifically to the types of risk that may be incurred from the construction of UMTPs. Ways of identifying and measuring hazards are discussed. An example is provided of an UMTP in Melbourne, currently the subject of a process of risk assessment and decision. The paper concludes by focusing on the need to preserve the rationality of risk assessment in conditions dominated by the play of power.

The challenge of sustainable development

Urban mega transport projects are investments in *development* of transport systems in and between cities. The ultimate purpose of such developments is social welfare resulting from economic growth: the development of society and economy. The question is whether such investments in general or in particular cases are *sustainable*.

There is much debate about the meaning of the term 'sustainable' (see Dobson, 1998, Rogers et al. 2005). The concept of sustainability emerged from the scientific understanding that natural systems are neither costless to use, nor unlimited in extent, and that they are interwoven with each other in complex ways: 'the new science reveals a world both more complex and less tractable than the one our scientific-industrial society has traditionally assumed (Rees, 1999: 108). As Rees (1999; 102) observes, 'There is a growing consensus that the current economic development path [i.e. 'business as usual'] is itself inherently unsustainable'. Rees goes on to point out that the idea of an *environmental* crisis 'externalises the problem, effectively blaming it on defective ecosystems, which then need to be fixed or managed more effectively. This suggests a supply-side corrective approach which excludes any notion of constraining demand' (*ibid*:103). Whereas in reality the crisis is a human one.

This idea of sustainability came to inform the work of the World Commission on Environment and Development (Brundtland Commission) whose focus was reconciling environmental conservation with reduction of economic inequality amongst nations and the relief of poverty ('inequality is the planet's main environmental problem' WCED, 1987: 6). The Commission adopted an anthropocentric conception of sustainability: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Non-human entities and their rights were ignored.

Though 'development' suggests a broad concept embracing matters such as culture, good governance, social justice and human wellbeing, in practice the term has been widely interpreted simply as economic growth. Unsurprisingly the notion that economic growth can be reconciled with ecological conservation was quickly embraced by governments and businesses in the developed world and became an ideological mantra: the 'triple bottom line' (Elkington, 1998).

Though theoretically possible (see Jacobs, 1991), and in some particular cases implemented, relatively little action at the broader scale of governance has actually been taken to reconcile economic growth with ecological conservation in the key domains of industrial production, energy, transport and agriculture, or to monitor progress in these domains in order to check whether such reconciliation has actually occurred. A reasonable suspicion is that ‘sustainable’ has become the adjective of choice for any project an agent wishes to persuade stakeholders to accept.

The economist Herman Daly suggests a logical structure within which to situate a definition of the term ‘sustainable’ and this structure and definition will be the one adopted in this paper. Daly (1996) distinguishes between the economic concepts of ‘allocation’, ‘distribution’ and ‘scale’. *Efficient allocation* of resources (such as capital, labour and raw materials) means that just enough resources are being put into the global mix of productive activities to meet effective demand — that is, what consumers can pay for and according to how they allocate their subjective preferences for goods and services. A market system is, with good reason, believed to be the most efficient way of organising allocation. *Just distribution* refers to how wealth is shared amongst members of a population. If the distribution is severely skewed towards one section of the population, then the market will come to serve mainly that section. Democracy in some form tends to deliver a reasonably acceptable degree of social justice[1]. *Sustainable scale* is one in which the economy functions within its natural limits. Daly writes: ‘The term “scale” is shorthand for the physical scale or size of the human presence in the ecosystem, as measured by population times per capita resource use’ (Daly, 1996: 50).

Economic function	**Character of the optimal exchange**	**Social value achieved**
Allocation	Efficient	Prosperity
Distribution	Just	Fairness
Scale	Sustainable	Conservation of nature

Table 1 Economic functions, exchanges and values.

We arrive, then, at something like the conceptual matrix in Table 1. An optimal economic *allocation* is efficient. An optimal economic *distribution* is just. An optimal economic *scale* is sustainable. These words are important and meaningful. The social values to be achieved are prosperity, fairness and conservation of nature.

The last of these, ‘nature’, must be weighed separately and in its own right. An anthropocentric view of sustainability not only puts the welfare of humans above that of other species, but accords no moral standing to other species: other species are thus mere instruments of human welfare; they do not have ‘intrinsic value’. Philosophers have questioned whether that should be so (see Low and Gleeson 1998: 133-158, Plumwood, 2002). They have come up with a variety of different answers but they agree on one thing. There is no ethical justification for giving humans such total precedence, only human self-interest. So I have proposed that when it comes to planning UMTPs the following precept should be adopted: ‘What has to be planned is responsible use of the environment in a way that is socially just and can continue indefinitely without running down the environment’s capacity to provide inputs and absorb wastes, and without substantially reducing the complexity of life evolved over millions of years’ (Low, 2003: 17).

Of course there remain many imponderable questions with ever contested answers. What distribution of wealth will deliver fairness, and what mechanisms will deliver social justice? What

[1] For better or worse, China, a poor nation, now produces the luxury goods of the rich world and suffers the industrial consequences of pollution.

economic scale will ensure sustainability? Economic growth may be regarded as delivering social justice if it lifts the standard of living of the least wealthy (Rawls, 1971). This 'difference principle' in turn is based on the principle of large numbers: a small increment in wealth/income is valued by the poor more highly than a much larger increment is valued by the rich (Bernoulli, 1713 in Bernstein, 1996)[2]. More importantly, however, for the discussion to follow, when a UMTP is planned, how much and which elements of nature should be conserved? How much of human health should be put at risk for the sake of wealth?

The popularity of the idea of 'sustainability' or 'sustainable development' tempts policy makers to promulgate the belief that economic development in its present form can be unproblematically reconciled with fairness and conservation of nature if only we (governments, businesses, communities and individuals) just put our minds to the task. But this is not so, as Maurice Strong, the first executive director of the UN Environment Program, recognized when he said in 1992, 'Sustainable development involves a process of *deep and profound change* in the political, social, economic, and technological order, including redefinition of relations between developing and more developed countries' (Maurice Strong cited in Rogers et al. 2005: 43[3]). That profound change has not occurred. It is as well to keep the potential conflict between prosperity, fairness and ecological conservation in the front of our minds while working to reconcile them.

So how does Daly's structure help with the definition of 'sustainability'? Using a dictionary definition, 'sustainable' can mean any activity that can be expected to continue indefinitely into the future without substantial change. But that loses the essential meaning. For Daly, the term 'sustainable' meant an activity that can be continued indefinitely into the future *within the limits imposed by the natural environment*. Of course these limits are contestable. To use the term 'sustainable' without that key implication of *within the limits imposed by the natural environment* is not just slack usage, it is actively misleading. A sustainable economy is one that can be continued *within the limits*…. A sustainable society is one that can continue *within the limits*…. A sustainable business is one that can be carried on *within the limits*…. And so forth.

Unfortunately too often 'sustainable' is used in the simple sense of its dictionary definition: for instance a sustainable business or sustainable institution is one that can expect to carry on indefinitely into the future without substantial change. Or 'sustainable' is used to mean something else: 'social sustainability' for instance seems to have replaced the term social justice (Polese and Stren, 2000; Agyeman, Bullard and Evans, 2003). Why? Or 'sustainable' is used without any substantial meaning other than 'good': for instance a 'sustainable' motorway (Highways Agency, 2007). Using sustainability in the original sense of *within the natural limits* raises enough difficulties – some of which will be explored in this paper – without the additional confusion of its misuse and ideological use.

Unfortunately there is also a semantic issue with the word 'sustainable'. The word when properly used, proffers a claim that an activity *may* or *can* (is able to) take place within the natural limits. It is not a claim that the activity *is* taking place, or *has* taken place, within the natural limits. It seems there is an implicit lack of monitoring built into the construct because the word 'sustained', which would have to be used to denote a fact rather than a possibility, does not normally carry the environmental implications mentioned above. To inquire whether a mega-project is 'sustainable' is actually a linguistic malconstruction because the project has already taken place and therefore it should be possible to find out the facts. The implications of this malconstruction are unclear but could be significant. What is actually meant, however, is simple enough: to inquire whether the

[2] There are those who argue that beyond a certain level of wealth further increments may actually have a negative value (Layard, 2005; Hamilton and Denniss, 2005)

[3] Perhaps 'deep' and 'profound' mean the same thing, and are doubled up for emphasis. But perhaps 'deep' may be understood as extending from top to bottom of social structures, and 'profound' as meaning something like value change.

building of the mega-project has had a negative impact on the basic ecologies of the natural, including human, world.

So, to paraphrase the above discussion, in this paper the challenge of sustainability is to confront the difficulties of continuing to use the natural world for human purposes within the limits imposed by the necessity for that natural world and its basic ecologies, in which human and 'more than human' life is embedded, to continue essentially unchanged indefinitely into the future[4]. An urban transport mega-project is sustainable if does not contribute substantially to transforming the Earth's natural systems.

To state the matter thus is to emphasize starkly that 'sustainability' is not happening. Whatever the difficulties of deciding the finer questions mentioned above, the horrifying and crude 90% certainty of climate change is that the world's industrial economies are transforming the most central feature of all earthly ecologies, human and otherwise, the carbon cycle. The Earth is not being sustained, but rather by the end of this century will be irreversibly damaged (may indeed have already been irreversibly damaged) by human activity in such a way that many of the life forms we know today may become extinct. At this point it cannot be predicted with any certainty that human life will not be one of them.

Complexity, uncertainty and risk

The systems that UMTPs intervene in, and are embedded in, are *complex* and open ended. The human social systems that throw up mega-projects are also complex but they are not the subject of this paper. The concern here is rather with the ecosystems and species, including the human species, on which mega-projects impinge. Human health can of course be treated as a separate category with its own science, but in this paper human health will be treated as a subset of ecosystem health.

The impact of projects is *uncertain* because not enough is known either about how the ecosystems work or about the effect on them of extraneous events. Therefore it is necessary to address impact in the probabilistic terms of *risk* namely, 'the chance within a time frame, of an adverse event with specific consequences' (Burgman, 2005: 1). It is not an easy or straightforward matter to evaluate risk to ecosystem and human health. Most commonly, assessment of the risk entailed by a project is paid for by the project's proponents and conducted in an 'environmental impact assessment' after the project has been fully designed (an example is given below). The question behind such an assessment is: should the project be allowed to go ahead or not? However, by the time a project is fully designed, and political and public expectations have been raised, it is too late to pose the question and expect a realistic answer unshaped by the politics surrounding the decision, because the political costs of cancelling a project at a late stage are too great. If the answer is almost always to be 'go ahead', determined by political contingencies, it is not only a waste of time and money investigating the risk, it is also misleading and deceptive and gives the public a false sense of security in the project. So risk assessment must be embedded in a rational process of project planning – but, as we will see, only under certain conditions, otherwise risk assessment itself becomes misleading.

It is not necessary to have all the details of a UMTP worked out before the risk assessment process can start. For instance, if a tunnel, bridge, motorway or railway, or some combination of these, is to be constructed in a particular area, it is not necessary to wait until the design details are finalized to start assessing the risks involved to ecosystem and human health. Reasonable assumptions can be made about the location and nature of the project that can be corrected as the design proceeds. These assumptions can be entered into a risk analysis process.

[4] The term 'more than human' life is used by Val Plumwood (2002) in preference to 'non-human life' to remind us that homo sapiens is but one species of a vastly diverse planetary ecology that should not be reduced to a bare contrast with the human (human-non-human).

This process has been described in terms of a ‘risk management cycle’ (see Holling, 1978; Walters, 1986; Flyvbjerg et al, 2003; Burgman, 2005) summarized in Figure 1. To urban planners the cycle may recall analyses of the planning process that involve learning and iteration (Faludi, 1974). The onslaught of Marxist inspired criticism that followed publication of the learning models of planning is as relevant here as it was to urban planning. Basically the thrust of the critique was that urban planners are so embedded in a system of conflicting political interests that the only purpose served by the process models is as an ideological smokescreen covering decisions taken on the basis of structural economic and political power. Since this thesis is difficult, if not impossible, to refute, the debate was rather unproductive. The critics overlooked the possibility that the process or learning model of planning could function as a useful counterfactual: if there is to be better, less interest/power-determined planning, what would it be like? This question informs what follows, yet the first item in the risk management cycle is, nevertheless, ‘context’ which of course should include awareness of the deployment of power structuring the risk assessment.

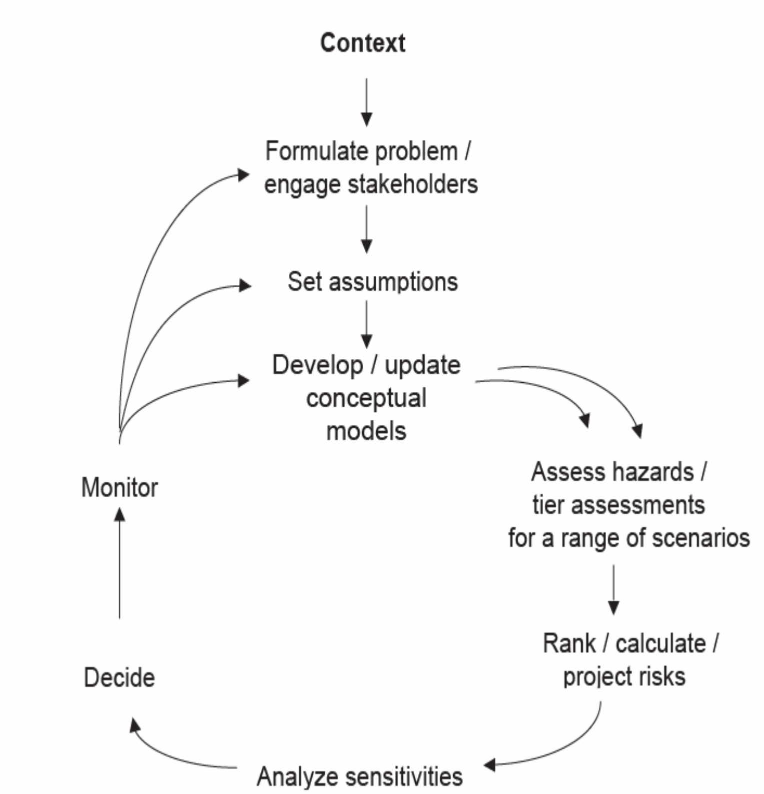

Figure 1. The Risk Management Cycle (Source: Burgman, 2005 Figure 3.3 p. 54)

<u>Context</u>

As Burgman (2005: 55) observes, ‘The people who control context can guide the outcomes of risk assessment’. Specifying and making clear to all participants the context of the risk analysis means identifying the management goals or ‘endpoints’ in meaningful terms, clarifying the trail of accountability – to whom the assessment is answerable, who pays for it, who conducts it, who participates, who determines whether the proposals and assumptions are acceptable – and setting out the budget and timelines for delivering results. The above conceptualisation of ‘sustainability’ implies that part of the context to be considered is the ecological context in which growth of the economy may be overtaxing the capacity of the planet to absorb impacts.

Suter (1993) defines ‘endpoints’ as expressions of the values to be protected such as clean water, protection of threatened species, public health. There are also ‘assessment endpoints’: how we know that the desired values are being achieved. For instance a healthy ecosystem may be one in which all ecological stages are represented, and populations of important plants and animals persist. Human health has been defined as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' and the ability to lead a 'socially and economically productive life' (WHO, 1946). But not all 'assessment end points' can be measured. There is no point in pretending to measure something that cannot realistically be measured such as a subjectively perceived aesthetic quality. There are also therefore 'measurement endpoints', items that can realistically be measured to indicate whether or not the desired values have been achieved. For instance, if 'sustainability' is a goal, assessing the life cycle carbon emissions resulting from a UMTP becomes critically important.

Stakeholders should be involved at this first stage. Unalterable conditions should be made clear so that stakeholders can decide whether they wish to participate under these conditions or not. Indicators are contestable and need to be discussed and agreed with stakeholders rather than just laid down by those conducting the assessment.

Problem formulation

All UMTPs are solutions to problems. Problems may include traffic congestion and bottlenecks, lack of access between where people live and where they work, slow speed of delivery of key freight tasks, lack of access to markets, even lack of employment opportunities. So what are the problems that a particular UMTP proposal solves? What is the range of hazards that a particular UMTP solution might generate? What might go wrong? What alternative solutions are to be considered? Burgman (ibid. p. 56) writes, 'Prior to specifying the details of conceptual models [of hazards and risks], the analyst and other participants should scope alternative management options, identifying as many as possible'. The identification of a hazard may steer the design team to seek an alternative solution to the problem. Participation of stakeholders is helpful in widening the range both of alternative solutions considered and potential hazards.

Conceptual modeling and hazard assessment

A conceptual model is a mental picture of all the components of a system affected by a UMTP: input and output, flows, cycles, system boundaries, and causal links among actions and events (Burgman, ibid. p. 56). If risk is to be assessed it is necessary to think out as precisely as possible the relationship between the UMTP and the impacted system. It will be necessary to build a conceptual model for environmental risk assessment of a UMTP. Stakeholders need to be included in the building of the conceptual model.

An example of conceptual modeling might relate to questions over the boundary of the system to be included when considering the impact of a motorway proposal. Is the boundary to embrace the whole urban transport system, or just the locality of the motorway? Is the system impacted to include the health of people across the city, or just along the motorway route? Is only the area of grassland habitat adjacent to the motorway to be included, or is the whole urban development the motorway serves to be included within the system – with possible hazards to more distant aquatic ecosystems from urban construction water runoff?

Hazards are negative things that might happen. There is at this stage no assessment of how likely they are to happen or how great the damage if they do. That is the task of risk analysis. No doubt UMTPs deliver benefits, but much less is known about the ecological and health hazards they generate. Some of these will be discussed in the next section. An important distinction that can be made is between locally focused hazards and diffuse hazards. As happened recently in the Northern suburbs of Melbourne, the threat from a motorway to remnant grassland containing the endangered species called the 'growling grass frog' is locally focused, whilst at the other end of the scale, the threat of the motorway to the atmosphere via increased greenhouse emissions is diffuse.

Risk analysis

Risk assessment involves a calculation of the probability of a hazard having an effect, and the probable severity of the results resulting from its occurrence. Analysis should also consider the acceptability of risk in different categories of activity. It seems that people are more likely to find risks acceptable if they are in control of the activity: for instance people will tolerate much higher risks while driving a car than they will when someone else is driving the vehicle such as in trains or aeroplanes. What is subjectively a 'tolerable' or 'reasonable' risk varies with the domain of activity and there seems to be no way that such subjectivities can be eliminated from risk analysis[5]. For this reason it is essential that stakeholders should be involved in the definition of acceptability of risks.

There are many methods of assessment of risks to ecosystem and human health. Burgman (2005) reviews a variety of methods in detail, some of which can be expressed in mathematical notation. Some of these methods are considered briefly below.

Sensitivity testing

Risk analysis requires a causal model, or models, to be built consisting of assumptions about what leads to what: strings and networks of causes and effects ending up in a prediction of outcomes, which in turn supports a decision to allow or reject a UMTP proposal. An essential element in risk analysis is testing whether significant changes in the assumptions in the model lead to substantial changes in the predicted outcome. This sensitivity testing tells us how robust the conceptual model is to the uncertainties, parameters and expert judgements contained in the model. If changed causal assumptions produce no great difference in outcome the model can be considered robust.

However if a model focuses on the central tendency of the system under analysis, and this tendency is confirmed, this still does not tell us much about what might still happen at the extremes or 'tails' of probable distributions.

Monitoring, updating and communicating

A model remains just a theoretical construct until it is tested in practice. A risk is a probability that a hazard might occur. Monitoring the actual effect of a UMTP on ecosystem and human health tells us what effects did occur. Moreover monitoring the effects of the process of UMTP construction can also suggest ways of reacting to the observed negative effects in order to reduce them. So monitoring of implementation is necessary for two reasons: both to learn about the reliability of risk assessment for UMTPs in a general sense and if necessary to adjust the conceptual models or even abandon them, and also to correct emerging negative effects resulting in a particular case. Needless to say, if stakeholders are to be involved in the process of risk assessment at earlier stages, clear communication to them of the results of monitoring is equally necessary.

Types of ecosystem and human health hazards associated with transport megaprojects

Hazards to ecosystem and human health from UMTPs fall into two categories: localized and diffuse, and of course the one merges into the other. A localized hazard can be part of a wider one. For instance if the location of a new railway track damages an area of vegetation that provides the habitat for an endangered species, that instance of damage has to be considered in the context of the wider availability of the type of habitat and the tendency for it to suffer damage by urban encroachment. The boundaries of the effects of traffic pollution on human health are

[5] There is nothing unusual about combining subjective evaluations with rational analysis. Economists call such subjective evaluations 'preferences'. The market balances preferences. Preferences for types of risk are no less rational than preferences for apples over oranges.

difficult to determine, and how far proximity to the source of the pollution is a factor in the incidence of disease is always open to question. Proximity may be used to establish a correlation between pollution and disease, but at a later stage the boundaries may be widened, as in the case of smoking and lung disease starting with correlation between smokers and disease to their own lungs, and later expanding to include cigarette smoke in the environment, or 'passive' smoking.

The localized-diffuse construct is a useful heuristic. Diffuse hazards are much less likely to be treated adequately in risk assessments of UMTPs, and their impact is less likely to be known and understood by the public, yet their impact may well be much greater than localized hazards that are typically entered for inclusion in environmental impact statements. There are reasons for this: it is very hard to delimit problems like global warming or road trauma (O'Brien, 2000). O'Brien notes that to exclude environmental problems that do not lend themselves to convenient packaging is arbitrary: 'How environmental problems are defined and grouped during comparative risk assessment exercises is a major determinant of how they are ranked. Thus ranking may be essentially an exercise in communal denial of fundamental environmental problems' (p. 117). The goal of sustainability, as defined above, demands that diffuse hazards must be included.

Diffuse hazards

Today the best known diffuse hazard arising from UMTPs is greenhouse pollution – the impact of urban transport on CO_2 and other greenhouse gases emitted by the power sources of vehicles (operational) and in the construction of transport infrastructure (embodied). Climate change is the greatest of all medium to long term hazards to both ecosystem and human health. The recent reports of the IPCC add both greater certainty to the link between human emissions and climate change, and greater urgency to perceptions of the problem (IPCC, 2007).

UN greenhouse gas inventory data show that developed nations (Annex 1 parties to the FCCC) increased their transport sector emissions by 20.7% between 1990 and 2003, an output that includes the former Soviet Union and Eastern block nations (UN, 2005: Figure II-18). Although many regard Europe as the leader in climate change policy, all member states' road transport emissions rose, collectively by 23% (EEA, 2004: 68). Although the USA is usually regarded as the black sheep of global climate change politics, its transport sector performed slightly better than Europe's: in the period 1990 to 2003 its transport emissions grew by 21% (UN, 2005: Table II-28). Of course, US transport energy consumption and greenhouse gas emissions are enormous (1811Tg CO_2e of greenhouse gas emissions in 2003). They were exceeded only by the emissions from Russia's and China's entire economies (UN, 2005: Table II-27).

Continuation of existing emission trends presents a dismal prospect for future emissions reduction. Several studies suggest that continuation of recent historic patterns will see total passenger travel increase, and increasing wealth fostering continued car ownership worldwide (Dargay and Gately, 1999; Schafer and Victor, 2000; WBCSD, 2004). China is now the world's third-largest oil consumer, the result of an annual increase in the rate of consumption of four per cent over the last 20 years (He et al, 2005). Chinese passenger transport has increased eight-fold, and freight transport 15-fold, over this period. Although private vehicle use is only a fraction of that of the OECD, vehicle sales are increasingly rapidly. Gallagher (2006) reports a 60% increase in 2003. Among the emerging economies, the EIA (2005) expects Asia to have the greatest growth in transport energy demand, particularly China, whose transport energy demand is forecast to grow at 6 per cent per annum and India, at 4.7 per cent, to 2025. Scenarios of future emissions vary considerably, with several high-profile institutions, such as the IEA, forecasting a continued increase in future greenhouse emissions, with transport being a major contributor.

Clearly the construction of UMTPs contribute to the growth of what Whitelegg (2003: 117) calls the 'distance intensive economy' – people travelling more and further in going about their day to day business. This is true insofar as UMTPs spread out over more space the location of journey origins and destinations. Under a business as usual scenario, distance intensity of economic activity leads to an increase in greenhouse emissions.

The issue of spreading is one of delimitation, obviously connected with global warming (O'Brien, 117). It is possible (if not probable) that UMTPs of a certain kind could serve distance intensity while reducing greenhouse emissions. It does not follow that a particular UMTP would contribute to an increase in emissions, at least in terms of operational emissions. That would depend on whether the UMTP in question assists a switch from a more greenhouse intensive mode to a less greenhouse intensive mode of travel. For example intercity train travel powered by electricity generated from a non-emitting energy source might substitute for air travel which is dependent on fossil fuel. However strategies to curb emissions to the degree necessary (70% on 1990) must include reduction in travel, so the hazard is real if a UMTP, either directly or indirectly, leads to an increase of travel.

Optimism about the greenhouse effects of sustaining travel demand on account of future developments in greenhouse efficiency of motors, alternative fuels, increased vehicle occupancy and so forth is almost certainly misplaced. The *International Energy Outlook 2005* (EIA 2005) expects alternative fuel use to remain modest in its forecasts to 2025. There are reasons to question the viability of reducing transport sector emissions based on fuel-switching strategies in the face of forecast growth in road travel. It is possible that only carbon-neutral vehicle technologies can offset such a growth trend in emissions, implying the significant penetration of fuel cell and hydrogen technologies that have yet to be proven viable on the mass scale required by the world's existing vehicle fleet (see, e.g. Service, 2004).

A second type of diffuse hazard resulting from UMTP construction comes from the loss of life, injury, and illness from road use. Globally, road traffic accidents claim a staggering 1.2 million lives annually (estimates range from 750,000—1.8m), with perhaps as many as 20—50 million injuries (WHO, 2004). This figure elevates transport mortality and morbidity to a major global health risk. Some researchers have characterized this condition as a 'pandemic' and a 'neglected epidemic' (Mohan, 2003; Nantulya and Reich, 2002). In fact it is the price of individual mobility, which some would argue is rather too high.

The WHO (2004: table 1.2) reports that road trauma in 1990 ranked ninth in the causes of global disease, and will rise to the third greatest cause in their forecast for 2020. Road deaths account for one quarter of the world's deaths from injury. As a cause of death, road traffic injuries are the second highest cause for those aged 5-14 and 15-29, and the third-highest for those aged 30-44 years, exceeded only by HIV/AIDS and TB (WHO, 2004: table 1.1). Even for children and infants (0-4 years), road traffic injuries rank 13th as a global cause of death (WHO, 2004). In low and middle income countries, road traffic injuries account for between 30 and 86 per cent of trauma admissions (WHO, 2004).

Socio-economic status is implicated in international and national accounts. Low and middle income countries account for 90 per cent of traffic injury-related deaths, occurring at the rate of 20.2 per 100,000 of population. Whereas in high income nations these deaths occurred at 12.6 per 100,000 of population (WHO, 2004: Table 2.1). If the West exports car industries and motorways to poor countries, it is also exporting road trauma. Distribution of trauma is highly skewed. For high-income nations, most deaths involve car occupants, but road crashes in poorer nations are more likely to involve the transport modes of the poor: crashes involving two wheeled vehicles, and vehicle-pedestrian crashes (WHO, 2004). Crashes produce greater impacts on the poor as they have fewer resources to deal with the consequences, such as access to emergency care and the permanent income losses from resulting from the death or injury of productive family members (Mohan, 2002).

While accident rates have fallen in the OECD, some predict that growing global wealth will increase road accidents. Kopits and Cropper (2003) demonstrate a historical link between rising income and road fatalities until a higher income is achieved (around US$8600 in 1985 value), when the association is reversed. Hence, rising world income leads to speculation that the global road death toll will increase by 66% between 2000 and 2020 (Kopits and Cropper, 2003). In Australia the car accounts for about 87% of passenger trips and about 89% of fatal transport injuries (including injuries from cars to cyclists and pedestrians). Public transport accounts for 13% of passenger trips and about 0.5% of fatal transport injuries. The remaining fatal injuries from transport are accounted for by water and air craft, trucks and vans. From this it can be seen that an increase in public transport use for travel would lead to a significant reduction in fatal injuries.

Individuals and communities subject to the influence of dangerous air emissions from transport sources suffer increased mortality and morbidity, a problem likely to increase with the trend of urbanization. For instance, Teufel et al (1999) concluded that in Germany cars were responsible for some 47,000 deaths annually, with many millions being affected adversely by major or minor illnesses resulting from inhaling particulates and gases.

Air pollution health effects have been subject to much research, and health impacts are typically in proportion to exposure levels, where thresholds for effects are absent or very low. Road traffic is, and is likely to remain, a major source of gaseous and suspended particulate urban pollutants, especially in lower income nations. For example, road transport is the major source of nitrous dioxide and benzene in urban areas and a significant source of fine and coarse particulate matter. Of particular concern are those traffic corridors where these pollutants become concentrated, remembering that outdoor air quality is a determinant of indoor urban air quality.

Localized hazards

While some hazards, such as climate change, are truly global in scope, most are localized. Infrastructure projects have particular local impacts on vulnerable terrestrial habitats, coastal ecosystems and human habitation. The boundaries of an affected area – and what counts as ‘affected’ – though, are mostly difficult to define. Let us consider some examples.

The effect of vehicle emissions on human health is, not surprisingly, known to be locally variable. Air pollution from airports has an effect on the surrounding population within the area most affected, defined by flight paths, runway orientation and prevailing wind direction (Whitelegg, 2003: 124-127). Studies of the links between lung cancer, leukemia, tumors of the central nervous system and malignant lymphomas in Sweden, Denmark, Los Angeles, Denver Colorado, and the Midlands in the UK looked for correlations between incidence of disease and residential proximity to the source of pollution. Not all the studies were conclusive, but, in several links were found between some cancers and pollution from diesel exhausts and, particularly the presence of benzene (Pearson, 2000; Nyberg et al. 2000; Nielsen et al. 1996, Harrison, et al.).

A large scale research study in California published in *The Lancet* in 2007 showed that otherwise healthy children – non-smokers and non-asthmatics – living within 550 yards of a motorway suffered significant loss of lung function between the ages of ten and eighteen (Sandstrom and Brunskreef, 2007). Lung function improved between 550 and 1650 yards from a motorway. Professor Stephen Holgate, professor of immuno-pharmacology at the University of Southampton said, ‘The implication of this study is that reduced lung function in childhood is a known risk factor for the development and worsening of asthma in children and the development of chronic obstructive pulmonary disease later in life’ (Fleming, 2007: 10).

A study by F and C Asset Management and Earthwatch Institute (F&C, 2004) found that loss of biodiversity and corresponding ‘revaluation’ of ecosystem services poses a significant risk to companies engaged in transport and in infrastructure construction. Risks included reduced access to land and markets, risk to reputation, security of supply, relations with regulators, and unforeseen liabilities. More examples of localized risks are mentioned below in the example of the Channel Deepening project in Port Phillip Bay.

Environmental risk assessment techniques

There are several assessment techniques commonly used to evaluate the risk to human health and the natural environment. Burgman (2005) discusses in depth the main conceptual methods: risk ranking, exposure assessment and logic trees, and two families of statistical techniques: interval arithmetic and Monte Carlo simulation. Different assessment methods emerge from different disciplines: for instance ecology, engineering, ecotoxicology, public health, and economics. These methods developed as ways of solving particular decision problems, and they are not all equally applicable to the environmental risks arising in the particular case of UMTPs. The question to be answered here is: what environmental risks will be incurred if a UMTP project goes ahead? A UMTP project is normally a large piece of engineering which, once built – or even once construction has started – leaves relatively little possibility of managing or reducing the risk[6]. In this it differs from the sort of ecological hazards arising from other forms of continuous industrial pollution where the output can be monitored and the process producing the pollution can be cleaned up if the hazard is serious enough[7]. Let us first consider the three conceptual methods, starting with risk ranking..

Risk ranking

Risk ranking, emerging from engineering, mining and other industrial settings is one of the most common forms of risk analysis and is widely used across the spectrum of decision-making. It depends on qualitative, usually subjective estimates of the likelihood of a hazard occurring, and the severity of the consequences if it does. Usually a matrix is created with likelihood on one axis and severity on the other. In a slightly different form, Burgman (2005: 159) gives the example of the Australian Paper company risk score calculator for occupational health and safety. This method involves the following steps (cited in Burgman, 2005 Figure 6.5):

1. Estimate the probability that a hazardous event will occur (on a scale between 'almost certain' and 'practically impossible').
2. Estimate exposure to the hazard (on a scale between 'very rare' and 'continuous').
3. Mark points on the 'Probability' and 'Exposure' lines on these scales and connect them with a straight line across the 'frequency tie line'.
4. Estimate the consequence of the hazard (on a scale between 'numerous fatalities' and 'first aid treatment'.
5. Draw a line from the intersection of the frequency line through the point on the consequence line, extending it to the 'risk rating' line (marked with four levels of risk).

Burgman points out that where ecosystems are too complex to model, this approach 'allows ecologists (and others) to integrate complex qualitative and quantitative information and generate assessments without extensive data and full understanding' (*ibid*. p. 165). Risk ranking has the advantage of operational simplicity and transparency, and it provides a wide range of professionals with a common language with which to talk about risk. However stakeholders should 'be involved in the process of building, testing, revising and interpreting risk assessments' (*ibid*) to arrive at agreed scales of likelihood and severity.

For UMTPs, effective risk ranking depends on prior research on the effects of the construction and operation of similar projects on similar environments, both related to human and ecosystem health in the locality, and on the wider and global environment. There is no reason why the

[6] Though risks arising from *use* of the infrastructure may be mitigated by reducing the amount of use, for instance road or rail traffic, but that would consume its benefits.

[7] This does not mean that monitoring should not occur. On the contrary, it should, but the results will be more useful to future UMTP evaluations than to the present one. The implication is that such research would need to be conducted by an impartial regulatory agency with oversight of UMTPs generally rather than by the owner-promoter of the particular project.

Australian Paper approach should not be used to include global risks from UMTPs such as climate change. In that case one would be looking at 'quite possible' on the likelihood scale, 'continuous' on the exposure scale and 'numerous fatalities' on the consequence scale giving a Level 1 (highest) risk rating.

Exposure assessment

The focus of exposure assessment, from the science of ecotoxicology, is the assessment, approval and auditing of pollutants and toxicants in a regulatory regime (Burgman, 2005: 169). This implies that this form of risk assessment is designed to monitor and regulate a flow of pollutants over time, including the flow through the environment and amongst species (the ecological meaning of 'transport'), and hazardous exposure to the pollutant. Ecotoxicologists measure dose-response relationships: how toxic the pollutant is and in what concentration. They try to assess safe levels of the pollutant, and the sensitivity of different species to it.

Exposure assessment is more relevant to continuous processes than to the construction of major infrastructure projects, though it could be used to monitor the local risk effects of pollutants from transport infrastructures after the event. For example, the risk of cancers from exposure to benzene, small particulates and other vehicle exhaust pollutants (see for example California EPA, 2007). Normally the cause of pollution is considered to be the vehicles that use transport infrastructure rather than the infrastructure itself but since the one cannot function without the other this assumption could be challenged: 'People who work in or live near freeways, refineries, chemical plants, loading and storage facilities or other places that handle crude oil and petroleum may be exposed to higher levels of fuel components than the general public, and face higher health risks' (*ibid*.)

Logic trees and decision trees

Logic trees are diagrams that link all the processes and events that could lead to or develop from a hazard. They are used to formalize conceptual models. Burgman considers them to derive from engineering, but of course they can also be found in philosophy with various notations and in various forms (e.g. argument mapping, cognitive mapping). They map what 'leads to' and what 'results from' a particular event or phenomenon. For UMTPs they can be useful in clarifying and opening up to public scrutiny the sets of assumptions that make up the conceptual models used in risk analysis.

Event trees link possible outcomes following an initiating event. Usually there is a bifurcation at each branch of the tree: yes or no, success or failure. Such an event would be the construction on a urban transport infrastructure project. Decision trees map potential decisions under different conditions. The alarming example given by Burgman (209-210) is of the person who wants to locate a gas valve in a dark room, having only a box of matches to provide light. The first bifurcation or 'decision node' is *strike the match – don't strike the match.* Each fork in the path then leads to another node: *gas is present – gas is not present* (presumably the explosive gas has no smell!) The final node is of course *explosion – no explosion*. The latter occurs in one out of the four possible branches.

Introducing a probabilistic character to the network, 'Bayesian' networks show similar consequential relationships among *uncertain* variables. They describe the probabilistic relationships among the elements of a logical system. They can then be combined with benefit-cost assessments of each event or act. 'Benefits and costs of each act may be specified quantitatively, together with the chance that the world is in each of the specified states' (*ibid*. p. 229). The risk of lighting the match can be weighed against the cost of crawling around in the dark to find the valve (some would call that tradeoff is a 'no-brainer'!).

Two difficulties with such mapping of causes and consequences are, first, that the total map for a large project can become extremely complex and unwieldy. Secondly, there is the possibility that different people will make different logic trees to represent the same problem. 'Clearly different ideas about the logical structure of a problem can contribute to substantial differences in risk estimates' (*ibid*. p. 240).

Logic trees may be subjected to sensitivity analysis – running a check on whether the outcome varies greatly with different logical assumptions. This is fertile territory for research into decision-making and public policy, revealing much about the belief systems of decision-makers. It also reveals the subjective basis of much supposedly technical analysis. But conflicting logic trees do not help make a decision. However, the way to reach a decision in such circumstances is to compare logic trees and for the actors to argue the points and seek consensus on a mutually agreed tree. The debate about the logic may in fact greatly improve the quality of the risk analysis.

Interval analysis and Monte Carlo simulation

The above techniques: risk ranking, exposure assessment and logic trees can be elaborated by statistical techniques. Interval analysis (Moore, 1979; Neumaier, 2001) reveals more of the inherent uncertainty in a judgement than a point estimate[8]. Citing Lobascio (in Ferson, Root and Kuhn, 1999) Burgman gives the example of a school located a certain distance from a source of groundwater contamination. A point estimate of the time taken for the contamination to travel through the ground to the school is, say, 500 years. So, if the life of the school is 100 years, it seems that the pupils are safe. However, interval analysis of uncertainty in each of seven parameters (distance to well, hydraulic gradient, hydraulic conductivity etc.) reveals that the time taken for the contamination to travel to the school could be anywhere between 32 and 234,000 years. This provides a more honest estimate of the risk to the school than the point estimate. The example can be generalized to any source of pollution from the construction and use of a UMTP.

Similarly where there is a range of expert opinion about risks from the construction of a UMTP, interval analysis can preserve the information contained in the variation of expert opinion rather than just reducing it to a point estimate. Burgman points out that, 'This wealth of information is lost from most risk ranking exercises. There is no reason to hide the uncertainties, unless it is to create an undeserved veil of certainty. Interval arithmetic provides a means for retaining them' (Burgman, 2005: 259). Interval arithmetic can be used in logic trees. Intervals can be defined for most logical operations, preserving the uncertainties in the logic tree (Neumaier, 1990).

Burgman states: ''The objective of interval analysis is to carry quantitative uncertainties through chains of calculations in a way that is guaranteed to enclose an estimate with at least the surety required.' (*ibid*. p. 254). Adapting Burgman's example for the UMTP case: an expert believes the probability that a new high speed railway line will destroy the habitat of an endangered species of frog is in the interval [0.6, 0.8]. The expert estimates that a proportion of the frog's habitat adjacent to the line in the interval [0.2, 0.7] will be destroyed. If we take the conceptual approach of risk ranking, the risk is the product of the likelihood and the consequence: [0.6, 0.8] x [0.2, 0.7] = [0.6 x 0.2, 0.8 x 0.7] = [0.12, 0.56]. (See Burgman, 2005: 254).

[8] 'Bounds' are 'statistical limits within which we are sure [to some extent] the truth lies. Upper and lower bounds are intended to provide an envelope that brackets the true value and the majority of possible outcomes' (Burgman, 2005: 426/7). Intervals divide up totals of observations or data sets. For instance the median divides an ordered set of data into two equal parts. A 'quantile' is a point in the ordered data set below which a specified percentage of the data lie. The first quartile is the point below which 25% of the data lie, the third quartile is the point below which 75% of the data lie. The interquartile range is the interval between the first and third quartile enclosing 50% of the data. Data sets can be divided in this way into any number of quantiles and intervals.

Interval arithmetic of course has its own limits. Information is lost about the central tendency, standard deviation, sample size, distribution shape and so on. The technique tends to compound uncertainty, and is only appropriate for numerical uncertainty, whereas uncertainty may also derive from imprecise or ambiguous language.

A simulation is an imitation of a real-life system, Monte Carlo simulation introduces random behaviour where the actual causal structure of the operation of a system is unknown or too complex to be modeled, and therefore such behaviour cannot be predicted deterministically. This applies when a person rolls dice. Even though we know the chance of a certain combination of numbers coming up we cannot predict the outcome of a particular roll. However for each uncertain variable the possible values can be defined within a certain distribution.

A variety of different distributions are used to represent the parameters of behaviour: for instance specifying the parameters of a 'uniform' distribution is equivalent to specifying an interval in interval arithmetic, a 'triangular' distribution represents a lower bound, an upper bound and a central tendency for a parameter and is sometimes used to represent expert judgement. The parameters that result from the *sum* of a large number of independent random processes tend to produce 'normal' distributions. Parameters resulting from the product of a large number of random processes produce 'lognormal' distributions. The choice of distribution is based on what we already know of the system from observations of behaviour. Of course this knowledge of the shape of distribution of occurrences of behaviour is usually itself uncertain.

Assuming there is a cumulative probability distribution for a variable, the question Monte Carlo asks is, 'What value of the variable will produce a risk less than or equal to the one specified?' (Burgman, 2005: 280). Monte Carlo simulation produces an answer by running repeated trials using random numbers.

An example of risk analysis from Melbourne: Port Phillip Bay Channel Deepening, an Urban Mega Transport Project with substantial environmental risk.

The Port of Melbourne Corporation, a state owned agency, proposes to dredge a deeper channel in Port Phillip Bay to allow larger cargo ships with deeper draught to enter the harbour[9]. The purpose is to maintain the international competitiveness of the port to 2035 (PMC, 2007a Executive Summary: ES3). If completed, the Channel Deepening project would qualify as an Urban Mega Transport Project within the terms of the OMEGA research. Its estimated cost is AU$763 million (currently around US$600 million) and its expected return is approximately AU$2 billion over thirty years. The Channel Deepening will have an impact not only on the Bay itself but on the urban residential environment around the shores, the commercial and recreational activities associated with the use of the Bay, and the transport system connected with the port. The Port Corporation requires multiple approvals under various Acts of Parliament (federal and state). The proponent must produce its own Environmental Effects Statement (EES) which is then subject to a public examination by an appointed expert panel. The EES produced in 2004 failed to satisfy the panel, and the Minister (State) sent the Port Corporation back to produce a supplementary EES with further scientific investigation. This Supplementary Environmental Effects Statement (SEES) was submitted and published in 2007.

[9] Port Phillip Bay 'is a complex system of interrelated and interdependent physical, chemical and biological processes. It is a large but shallow marine embayment, which has restricted water exchange with the open ocean. Its catchment includes metropolitan Melbourne and parts of the Mornington Peninsula, Werribee, Geelong and the Bellarine peninsula. The bay is a major asset to Victoria, and to Melbourne in particular, as a setting for urban development, shipping, industrial activities, natural resource economic uses, recreation and tourism' (PMC, 2007a: 8.4)

The SEES includes a comprehensive analysis of the risks to various locations and elements of the Bay and its ecosystems. These risks include increased turbidity in the waters and the risk of irreversible death of sea grass which is a key species in the ecosystem supporting fish populations and a colony of penguins. Damage will occur to the deep canyon at the entrance to the Bay through rock falling into it from the dredging operation. Most serious perhaps is the risk to ecosystem and human health from disturbance of severely contaminated sediment near the mouth of the Yarra River where it enters the Bay at the city end, which will have to be dredged and relocated.

The risk analysis within the SEES employs many of the techniques mentioned above. An iterative risk assessment process was used similar to the one shown in Figure 1 above:

- Communicate and consult – communicate and consult with stakeholders at each stage of the process.
- Establish the context – establish the context in which the analysis will take place, establish evaluation criteria, and define the structure of the risk analysis.
- Identify risks – identify when, where, why and how risk events could occur.
- Evaluate risks – compare estimated levels of risk with evaluation criteria, consider benefits versus adverse outcomes. (PMC, 2007b: 2.1)

A large amount of scientific research was carried out to establish reliable conceptual models of the Bay processes, including land form and seabed topography (bathymetry) hydrodynamic processes (the forces and flows of water), and the characteristics of the Bay's ecosystems. The 'risk quotient' of potential 'risk events' (hazards) was established by multiplying likelihood of occurrence by magnitude of consequences (risk ranking). Multiple event trees were constructed linking the dredging activities, initiating events productive of hazards, and subsequent chains of impacts and consequences. Then risk analysis was conducted for each event tree.

The logic of the process can hardly be faulted, nor can the thoroughness with which the risk assessment was conducted. Yet the entire process rests ultimately on expert experience and judgment. Adams (2007), in his paper for the January OMEGA conference points out that for the circle of 'risk perceived through science', 'However objective in appearance, assessments in this circle rest ultimately on subjective assumptions'. The SEES Risk Assessment states: 'The risk identification step is critical to the success of the risk assessment as the assessment is based on the risks identified and described by the team of specialists, and on the experience and judgment of its members' (PMC, 2007b: 5.1). Burgman (2005: 84-94) discusses in detail the problems of disagreement among experts, 'expert frailty' and how to use experts, even pointing out that in some circumstances expert judgment has been shown to be little more reliable than the judgment of lay persons. The judgment of risk to ecosystem and human health is really little more than an informed guess buried within a mountainous Environmental Effects report (15,000 pages long) on the science of the conceptual models and the process of analysis. The description of the risk analysis is contained in Technical Appendix 5 to the SEES.

If we consider just the problem of disposal of toxic mud, it is obvious that serious questions remain. 3.87 million cubic metres of toxic sediment (containing lead, arsenic and other heavy metals, and DDT residue) is to be pumped to ship from the seabed and deposited in the Bay in an extension to an existing underwater dump surrounded by supposedly impermeable underwater embankments or 'bunds', left to settle and then capped with half a metre of sand. The capacity of the dump to settle and contain the toxic sediments rests on the evaluation of previous experience. Exposure assessment and 'worst case' analysis commonly used in relation to land based toxic deposition was not used in connection with the underwater deposit, though obviously similar risks apply. The SEES admits that depositing the toxic sediment in land fill would be expensive and create risks of seepage. Why are standards relating to land-based deposits so much more stringent than sea-based deposits when the risks of failure would appear to be greater?

Inevitably, also, dredging will generate a toxic plume in the surrounding water. While this plume remains there is a risk that the toxic chemicals may enter the food chain of fish and other species, and eventually humans. Tests on three species of fish indicate that these species would be safe to eat. But shellfish and other species of fish were not tested. Even if it turns out that the three species selected for testing are representative, there remains the suspicion that other species may not be safe to eat. That suspicion alone will affect commercial and recreational fishing in the Bay. And what of the risk that is simply not assessed? Global warming is the elephant in the room. It is always a present risk where transport is concerned, but there is no discussion of whether deepening the channel will contribute to or mitigate global warming – though 'greenhouse' (sic) is listed as an asset (PMC, 2007b; para 5.2).

The specialist team ultimately responsible for assessing risks was selected by the project proponent. It consisted of dredging specialists, the authors of the SEES specialist studies, key personnel 'involved in the planning and development of the project', employed by the Port Corporation, and 'other key PoMC personnel'. The expert group seems heavily weighted in favour of proponents of the project. This, coupled with the fact that the whole SEES project costing $114 million is paid for by the proponents, raises the possibility of conscious or unconscious bias. Further, the discussion of 'context' is entirely technical, whereas Burgman points to the 'socially charged' context. There is no discussion of that aspect of context in the SEES. To know whether alternative voices were listened to, or whether real dialogue occurred during the consultative workshops would require much more detailed study of the process. One would need to know how disagreements on risks among experts were handled, whereas only the eventual resolution of disagreement is presented.

Finally, the Victorian Government has announced that the panel reviewing the SEES will include no members of the panel which rejected the first EES for the project despite the fact that the members are available. Moreover the Government has also announced that lawyers for the interests opposed to the channel deepening project will not be allowed to cross examine witnesses during the panel hearing of the SEES. This process of cross examination can reveal whether the risk analysis was properly conducted, whether alternative voices were heard and alternative assessments of risk addressed. Such probing is thus essential to the transparency of the process, and so serious is this ban on cross examination that Mr Chris Canovan, a leading planning lawyer engaged to represent the Port of Melbourne Corporation, is reported to have withdrawn his services (Millar, 2007). Only four weeks will be allowed for the process of examination of the 15,000 page SEES. These actions by the Government do not inspire confidence that the risk assessment process is fair and transparent and that real dialogue has occurred.

The risks of risk management

Adams (2007) warns that the professionalisation of risk analysis leads to over-concern about the negative aspect of risk, whereas taking risks can lead to positive outcomes. Burgman (2005) is ambivalent about the value of risk analysis for ecosystem and human health. On the one hand he warns that all risk analysis is socially conditioned, 'People stand to gain or lose substantially. Arguments are clouded by linguistic ambiguity, vagueness and underspecificity to which analysts themselves are susceptible. Prejudice gets in the way of constructive discussion' (p. 60). On the other hand he sees the proper application of the risk management cycle as a potentially transparent way of resolving disputes among stakeholders, getting people with different perspectives to see each other's points of view, and agree to compromise. Thus, 'risk assessment is just as important as a kind of social grease as it is an instrument of technical analysis…the process illuminates the thinking of people who advocate different solutions' (pp. 60, 61).

The ambiguity of language, the complexity of assessment, and the sheer volume of writing can be used to reassure and deceive. 'Science creates for itself a mantle of objective certainty. This impression often is unjustified or misleading'. (Burgman, 2005: 4). When Flyvbjerg, Bruzelius and

Rothengatter (2003) write ‘one approach to achieving effective elimination through risk spreading is to allocate project-specific risks to the public in general’ (83), Burgman would respond that the public in general needs to know not only what the likely risks are, but also how they are to be assessed and allocated. But the power of apparent scientific objectivity may deter even the stoutest objector from pursuing realistic concerns.

A strong subtext of Burgman’s book is that risk analysis is valuable only if it is part of a genuine deliberative process (see Torgerson, 1999; Smith, 2003 on deliberative democracy). Risk analysis can be deployed for strategic purposes to legitimate a decision already made. Unless genuine deliberative methods are employed it becomes just another weapon in the play of power rather than a rational process. For O’Brien (2000: 83-85) this theme is not the subtext but the main text. ‘Risk assessment raises questions about democratic values. The usual risk assessment process is inaccessible to lay people. It obscures and removes the right to say ‘no’ to unnecessary poisoning of one’s body and environment. Most risk assessments assume that potentially damaging behaviours are innocent until proven guilty. And many use public money to justify harm to the public’.

There appear, then, to be two contrary risks of risk analysis. The first is that of generating a fear of risk and thus inhibiting action of any sort. Adams refers to that danger. We become fearful and stuck, or over-managed. The second, referred to by O’Brien, is of being reassured and manipulated by risk analysis into a belief that all risks have been ‘managed’ or can be ignored.

Addressing both of these risks, O’Brien proposes that instead of risk analysis there should be a process of ‘alternatives assessment’. The key to this process is simply the enactment of rational choice: that at any point in a decision, alternative courses of action should be presented and evaluated. O’Brien points out that this process is already followed in a number of different settings in the United States (p. 147). The principles are set out in her chapter 13:

1. Presentation of a full range of options
2. Presentation of potential adverse effects of each option
3. Presentation of potential beneficial effects of each option
4. If the public might be affected, the assessment must be a public process
5. The assessment must be influenced by the public
6. Decision makers must be accountable to a public process of alternatives assessment.

There is not space here to elaborate on O’Brien’s principles. They are sometimes partially followed in Australian environmental assessments of UMTPs, but the most obvious lack in this respect is usually in the first and fifth principles: a full range of options is not generally considered. Real dialogue with the public and amongst experts does not occur in cases where the Government has already taken a position that the UMTP should go ahead. We may hypothetically divide UMTPs into three categories: those where the political structure is content to live with the deliberated outcome, those that the political structure has decided a positive outcome in advance and those that the political structure has decided on a negative outcome in advance. Only the first is truly rational. The other two can be manipulated via the context. For the other two the only purpose of risk analysis is legitimation.

Conclusion.

The risk management cycle identified here functions, like the process model of planning, as a normative counterfactual. It enables us to compare a particular case against a rational ideal. However, what exactly *is* the rational ideal? In essence it is the identification of alternative solutions, and the selection of a solution in conditions of un-coerced dialogue. It is *not* the diagram in Figure 1. It is the real process itself. On paper the process can be, and usually is, presented as identical to the ideal model in Figure 1. But the reality may be entirely different. That reality cannot be gauged by reading reports, or looking at diagrams in reports, but only by depth investigation of the process. The forensic examination in public of an environmental effects statement has a purpose identical to that of high quality academic research: to reveal the truth of what occurred in decision-making.

This paper first sought to clarify what is implicit in the word ‘sustainable’. What is called ‘the economy’ is really nothing more than the sum of human transactions with the natural environment. The economy is not separate from the natural environment. A *sustainable* economy is one that does not irreversibly deplete the natural environment of the planet on which humanity and all other species ultimately depend. Sustainability should, however, be conceptually differentiated from social or distributive justice, economic efficiency, and cultural integrity. Distinctive words should be used to refer to distinctive concepts.

The paper then went on to describe some of the mega-risks to environmental and human health from mega-transport projects. These have both diffuse (some global) and localised dimensions. If risk analysis is to be a useful process it cannot be focused solely on the local dimension, but must also address the diffuse and systemic risks. We know that the growth of mobility dependent on the burning of fossil fuel has resulted in greenhouse emissions that are simply out of control. UMTPs are the ‘keystone species’ of mobility growth. The capacity to decouple economic growth from mobility growth and emissions growth remains largely undiscovered. The systemic risks to human life and health from intense dependence on the private car are simply ignored, or traded off against the alleged benefits of mobility. The situation we live in is profoundly irrational and path dependent.

The next step in the paper was a discussion of the risk analysis techniques most used: the risk analysis process which presents as a model of rationality, risk ranking, exposure assessment, logic and decision trees, interval arithmetic and Monte Carlo simulation. These are all attempts to apply rational choice in conditions of uncertainty. They all depend in some way on the exercise of judgement.

The example of the Channel Deepening project in Port Phillip Bay demonstrated some of the simpler techniques in a live situation. The example also began to reveal some of the risks of risk assessment, how the process of rational choice can be subverted by political choice. Finally it was argued that the application of rational techniques of risk analysis is not sufficient to assure or even improve overall rationality. The key to rationality is the exposure of arguments and judgements to effective scrutiny; the real consideration of alternatives at every step; the involvement of the public and stakeholders at every step; the creation of situations throughout the process where the force of the better argument can win the day over the bets and guesses of politicians subject to the force of powerful vested interests.

References

Agyeman, J., Bullard, R.D. and Evans, B. eds (2003) *Just Sustainabilities, Development in an unequal world*, London: Earthscan.

Bernstein, P.L. (1996) *Against the Gods, The Remarkable Story of Risk*, New York: John Wiley

Burgman, M. (2005) *Risks and Decisions for Conservation and Environmental Management*, Cambridge, UK: Cambridge University Press.

California, EPA (2007) *Fuels and Your Health*, Fact Sheet, CalEPA, Office of Environmental Health Hazard Assessment and the American Lung Association of California. USA

Dargay J and Gately D, 1999, “Income’s effect on car and vehicle ownership: 1960 – 2015” *Transportation Research A*, **33** 101 – 138.

Dobson, A (1998) *Justice and the Environment, Conceptions of sustainability and dimensions of social justice*, Oxford, UK: Oxford University Press.

EEA (2004) *Analysis of Greenhouse Gas Emission Trends and Projections in Europe 2004* Copenhagen: European Environment Agency.

Elkington, J. (1998) *Cannibals with Forks, The Triple Bottom Line of 21st Century Business*, New Society Publications.

F & C (2004) 'Is Biodiversity a Material Risk for Companies? An assessment of the exposure of FTSE sectors to biodiversity risk' F & C (http://www.earthwatch.org/atf/cf/%7BBD9A05BF-0860-451E-AA86-7, accessed 24 March 2007)

Faludi, A. (1974) *Planning Theory*, Oxford: Pergamon Press.

Ferson, S., Root, W. and Kuhn, R. (1999) *RAMAS Risk Calc. Risk Assessment with Uncertain Numbers*, Setauket New York, USA: Applied Biomathematics.

Fleming, N. (2007) 'growing up near a major road "harms childrens' lungs"'. *The Daily Telegraph* UK Jan 26th 2007, p. 10

Flyvbjerg, B, Bruzelius N and Rothengatter, W (2003) *Megaprojects and Risk, An anatomy of ambition*, Cambridge: Cambridge University Press.

Gallagher K.S. (2006) 'Limits to leapfrogging in energy technologies: evidence from the Chinese automobile industry' *Energy Policy* 34 pp. 383 – 394.

Hamilton, C. and Denniss, R. (2005) *Affluenza, When too much is never enough*, Sydney: Allen an Unwin.

Harrison, R.M. et al. (2000) 'Analysis of incidence of childhood cancer in the West Midlands of the UK in relation to proximity to main roads and petrol stations', *Occupational and Environmental Medicine* 56 (11) pp. 774-780.

He K., Huo H., Zhang Q., He D., An F., Wang M, Walsh M. P. (2005) 'Oil consumption and CO_2 emissions in China's road transport: current status, future trends, and policy implications', *Energy Policy* 33 pp. 1499 - 1507

Highways Agency (2007) *Annual Report 1999-2000*
http://www.highways.gov.uk/aboutus/1426.aspx accessed Feb 6th 2007

Holling, C.S. (1978) *Adaptive Environmental Assessment and Management*, New York: John Wiley.

IPCC [Intergovernmental Panel on Climate Change] (2007)

Jacobs, M. (1991) *The Green Economy, Environment, sustainability and the politics of the future*, London: Pluto Press.

Kopits E. and Cropper M. (2003) 'Traffic fatalities and economic growth', *Policy Research Working Paper, No. 3035* Washington, DC: World Bank.

Low, N.P. (2003) 'Is urban transport sustainable' in N.P. Low and B.J. Gleeson eds *Making Urban Transport Sustainable*, Basingstoke, UK: Macmillan. pp.. 1-21

Low, N.P. and Gleeson, B.J. (1998) *Justice, Society and Nature, An exploration of political ecology*, London and New York: Routledge.

Layard, P.R.G. (2005) *Happiness: Lessons from a new science*, London: Allen Lane.

Mohan D. (2002) ‘Road safety in less-motorized environments: future concerns’ *International Journal of Epidemiology* 31 pp. 527 – 532

Millar, R. (2007) ‘Outrage at dredging probe ban’, *The Age*, Melbourne April 23rd p. 3.

Mohan D. (2003) ‘Road traffic injuries – a neglected pandemic’, *Bulletin of the World Health Organization* 81 pp. 684 – 685.

Moore, R.E. (1979) *Methods and Applications of Interval Analysis*, Philadelphia: Siam

Nantulya V. M. and Reich M. R. (2002) “The neglected epidemic: road traffic injuries in developing countries” *British Medical Journal,* 324 (7346) pp. 1139 – 1141.

Neumaier, A. (1990) *Interval Methods for Systems of Equations*, Cambridge UK: Cambridge University Press.

Neumaier, A. (2001) *Introduction to Numerical Analysis*, Cambridge, UK: Cambridge University Press.

Nielsen, T. et al. (1996) ‘City air pollution of polycyclic aromatic hydrocarbons and other mutagens: occurrence, sources and health effects’, *Science of the Total Environment*, 28,189-190 pp. 41-49

Nyberg, F. et al. (2000) *Epidemiology*, 11/5 pp 487-495.

O’Brien, M. (2000) *Making Better Environmental Decisions*, Cambridge Mass. USA: MIT Press.

PMC (Port of Melbourne Corporation) (2007a) *Port of Melbourne Corporation Channel Deepening Project, Supplementary Environmental Effects Statement*, Melbourne: Port of Melbourne Corporation.

PMC (Port of Melbourne Corporation) (2007b) *Port of Melbourne Corporation Channel Deepening Project, Supplementary Environmental Effects Statement*, *Technical Appendix 5, Channel Deepening Project Risk Assessment for SEES*, Melbourne: Port of Melbourne Corporation.

Pearson, R.L. (2000) ‘Distance-related traffic density in proximity to a home is a risk factor for leukemia and other childhood cancers’, *Journal of Air Waste Management*, 50/2 pp. 175-180

Plumwood, V. (2002) *Environmental Culture, The ecological crisis of reason*, London and New York: Routledge.

Polese, M. and Stren, R. eds. (2000) *The Social Sustainability of Cities, Diversity and the management of change*, Toronto and London, University of Toronto Press.

Rawls, J. (1971) *A Theory of Justice*, Cambridge, Mass. USA, Harvard University Press.

Rogers, P., Jalal, K.F. and Boyd, J.A. (2005) *An Introduction to Sustainable Development*, Cambridge Mass. USA, Harvard University Press.

Sandstrom, T. and Brunskreef, B. (2007) ‘Traffic-related pollution and lung development in children’, *Lancet* DOI 10.1016/50140-6736(07).

Service R. F. (2004) ‘The hydrogen backlash’, *Science,* 305 pp. 958 – 961.

Schafer A and Victor D G (2000) ‘The future mobility of the world population’ *Transportation Research A,* 34 pp. 171 – 205.

Smith, G. (2003). *Deliberative Democracy and the Green Political Theory*. London: Routledge Taylor and Francis Group.

Suter, G.W. (1993) *Ecological Risk Assessment*, Boca Raton, Florida: Lewis.

Teufel, D. et al. (1999) *Oeko-Bilanzen von Fahrzeugen*, UPI Bericht 25, 6, Auflage, Umwelt und Prognose Institut: Heidelberg, Germany.

Torgerson, D. (1999). *The Promise of Green Politics: Environmentalism and the Public Sphere*. Durham: Duke University Press.

UN [UNFCCC] (2005), Key GHG Data: Greenhouse Gas (GHG) Emissions Data for 1990—2003”, Submitted to the UNFCCC (United Nations Framework Convention on Climate Change Secretariat).

Walters, C.J. (1986) Adaptive Management of Renewable Resources, New York: Macmillan.

WBCSD (2004) *Mobility 2030: Meeting the Challenges to Sustainability*, Geneva: World Business Council for Sustainable Development.

World Commission on Environment and Development (1987) *Our Common Future* [The Brundtland Report] Oxford: Oxford University Press.

WHO [World Health Organisation] (1946) *Constitution of the World Health Organization*, Geneva.

WHO [World Health Organisation] (2004) *World Report on Road Traffic Injury Prevention* Peden M, Scurfield R, Sleet D, Mohan, D, Hyder A A, Jarawan E, Mathers C (Eds) Geneva: World Health Organization.

Whitelegg, J. (2003) ‘Transport in the European Union: Time to Decide’ in N. Low and B. Gleeson, eds. *Making Urban Transport Sustainable*, Basingstoke, UK: Palgrave-Macmillan pp. 115-131.