



The Royal Academy
of Engineering

Report and proceedings of a seminar on:

The Economics and Morality of Safety

Thursday, 16 February 2006





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Chairman: Mr John Turnbull FREng

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ISBN 1-903496-26-8

April 2006

Published by

The Royal Academy of Engineering

29 Great Peter Street, London, SW1P 3LW

Tel: 020 7227 0500 Fax: 020 7233 0054

www.raeng.org.uk

Registered Charity Number: 293074

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Introduction

This seminar was one of a series organised by The Royal Academy of Engineering Risk Project. The objective was to explore two weighty topics; the Economics and Morality of Safety. They are of course related. One overarching question is the extent to which there is a conflict between financial and moral goals.

As the transcript of the seminar makes clear the key issues and concerns were laid out very succinctly in seven excellent presentations. These raised a lot of points and questions from participants. But the time allotted did not allow as much discussion as was wished. Many issues were unresolved and it is clear that more time would have been welcomed.

The Background

The issues of financial viability and societal acceptance were at the heart of this latest seminar. Product and process safety is crucial to gain public approval. The media immediately pounces, in moral terms, on any suggestion that safety has been compromised on the grounds of cost. And public disapproval is vociferous and uncompromising. Although the trend of rail safety improvement in the UK continued, and arguably improved, post privatisation, Railtrack found itself continually on the defensive after any accident. The media pressed the argument that safety was being given lower priority than shareholder dividends. And ultimately this contributed significantly to the company's demise. It was felt that safety and the public interest were better served by a not-for-profit organisation.

And yet we all know that there is no such thing as absolute safety. There would still be risk even if we applied all our resources to safety. The only risk free world is a dead world. So the line has to be drawn somewhere. But what decides where we draw the line? And who decides this? Is it simply a matter of balancing potential harm against potential benefits? Can this be done in pure monetary terms? Or are there moral and emotional drivers that come into play and have a major influence on how lawmakers, regulators, companies, public bodies and the community judge whether a given level of safety protection is adequate?

The seminar looked at these issues in broad terms. A crucial question was whether it is appropriate and acceptable for different methodologies and criteria to be used in different industries and public service sectors. If it is not, how do we achieve consistency? If differences are inevitable how can we justify this?

Summary

The presentations and discussions can be summarised under a number of headings.

The Moral Framework:

Because safety failures inflict harm on people and their property there is a strong moral dimension to the debate. It was argued that in everyday life it is accepted that a small degree of risk can be imposed on others provided that it is generally accepted to be small in relation to the benefits. For example it is OK to drive a motor car even though a driver runs risk of, say, a stroke and causing a

fatal accident. But more generally it is not morally acceptable for individuals and companies to cause harm to others for the sake of profit. This applies even if the enterprise is agreed to bring significant benefits to the community at large. The position is different for democratically elected governments. The political process empowers them to act for the common good. Thus, it is acceptable for soldiers to be sent to war by a government in defence of the community.

Qualitative versus Quantitative

ALARP (As low as reasonably practicable) lies at the heart of UK safety thinking. But how is this to be interpreted? A strong case was made in the seminar for a quantitative, economic approach even to the potential for fatalities. This was said to be endorsed by the Treasury and employed in practice by the UK Railway Industry and the Highways Agency. It was made clear that the methodology was a matter of statistical modelling and was not to be interpreted in any sense as putting a monetary value on a human life. While accepting the power of Cost Benefit Analysis the problem of making reliable estimates of the likelihood of accidents and their consequences meant that it had limited value. This applied especially to the sort of very low frequency, high impact events that are involved in the nuclear, civil aviation or oil industries. The Nuclear Power industry presentation illustrated very well how both qualitative and quantitative approaches could inform judgement and decision taking.

Qualitative assessments can be very powerful and are widely employed. Concern was expressed that techniques such as HAZOP, which combine quantitative and qualitative methodologies were not more widely used.

The Role of the Regulator

The role of the HSE has changed dramatically over the years. It has had to become much more sophisticated in its approach as the role has moved from health and safety in the workplace to a much wider remit concerned with public safety. Technology developments, increasing public expectations, political and media pressure all mean a much more demanding environment. In summary this means that the HSE is no longer a simple advocate of more safety and adherence to regulations, but has to be able to take into account the often conflicting pressures in today's world and balance these carefully in its deliberations. The same themes were apparent in a presentation on the CAA. The CAA is an industry-funded regulator. This is a loud and clear signal that the civil aviation industry sees its safety performance as key to business success. The safety record of the industry is remarkable and the transparent sharing approach to accident investigations, incident reports and recommendations all play crucial roles.

HSE emphasised that despite its changing role, there is still a lot of improvement to go for in the traditional areas of work place safety by instilling traditional lessons and good practice.

Zero Tolerance and Safety Culture

It was clear from the presentations by the Nuclear Industry, Civil Aviation and especially the Oil Industry that the management goal was "no accidents". The potential for serious harm is recognised and every effort has to be made to eliminate the possibility. Presentations made clear that this was not primarily a matter of adding safety protection devices and technology onto plant. Best

available technology was part of the thinking but the key message was that safety thinking has to permeate the whole organisation and that all of the stakeholders have to recognise that good safety is good business. Of course there is a philosophical issue to be addressed. 100% safety and zero risk would shut down the business. So where does the line get drawn? There was not time in the seminar to really explore this dilemma in depth. The implicit conclusion was that the benefits that the organisation's operations provided outweighed any perceived risks. This argued for staying in business. So the business' viability would not be sacrificed on the altar of zero risk. But a successful organisation should be available to afford all that it takes to provide safe operations if the management skills and culture are right. This seems to be an area worthy of more exploration especially in comparison with areas like road transport and healthcare where it seems to be accepted that ongoing accidents and consequent fatalities are accepted.

Societal Acceptance

Many present at the seminar were concerned at our low level of understanding of what drives the perceptions and attitudes of the community at large. Two themes emerged. One was the role played by the media and the other was the need for better communication skills on the part of technical experts. But it was recognised that public opinion was a powerful force and played a crucial role in events like the Brent Spar story, and GM crops, and would influence future energy strategy. HSE acknowledged its importance and also the need for more exploration of the topic. Societal acceptance could well be a crucial factor leading to the inconsistencies and paradoxes noted below.

Inconsistencies

Various inconsistencies were identified in the seminar.

The apparent difference between a zero tolerance approach and an acceptance of accidents as routine has already been noted.

Within the transport sector there seemed to be glaring differences. Civil Aviation sets a very high standard of safety performance and seems to be in the zero tolerance camp. Road transport seems to be at the other extreme. It seemed that the 3000+ fatalities a year on UK roads were more or less accepted as inevitable by the community. Certainly the amount of resource and resolve which is put into preventing them is tiny compared to that in the railway industry. Clearly the attitudes of society at large and the cultural trappings of motor cars and driving play a big part. It was pointed out that a fundamentally different approach is taken in healthcare. The government sets a budget and the NHS seeks to prioritise cases within that financial constraint on their relative, rather than absolute merits. The approach to accidents and fatalities caused within the health sector is conditioned by this culture.

Conclusion

The seminar was well attended and feedback from participants has shown a high level of interest in the topics covered. But there were complaints that there was not enough time to address the very ambitious agenda. Some of the key points raised are summarised in the Appendix following the transcript.

There were a number of issues raised and discussed that are worthy of further exploration. These included:

- Moral arguments surrounding the differing "rights" of individuals, enterprises and the state to cause potential harm to third parties.
- The case for a common Value for Preventing a Fatality or varying it according to the economic status of the potential victims and factors such as life expectancy and health.
- The wide variations in approach to safety in the transport sector between road, rail, marine and air.
- The potential conflicts between a "Zero Tolerance" approach to accidents and Cost Benefit Analysis
- Societal attitudes and the influences on them. Strategies for communication and dialogue.
- The threats posed to technical investigation and prevention of accidents by over zealous criminal investigations.

We will canvas the opinions of participants and others before initiating any further action. The views and opinions of readers of this report will be welcomed.

John N Turnbull FREng

Leader, Risk Project

The Economics and Morality of Safety: a seminar

Chairman: **Mr John Turnbull**

Panel: **Ben Alcott** **Tony Bandle**
John Broome **Colin Dennis**
Deborah Grubbe **Michael Jones-Lee**
Gordon Lawrence **Jeremy Western**

John Turnbull: Thank you all for coming to this event. It is the latest in the Royal Academy of Engineering's Risk programme. When we began the programme, we grossly underestimated the level of interest in the topic and the breadth of its implications. It has turned out to be quite a major programme. Indeed, I have to apologise to you if the change of location has caused any inconvenience this evening, but we underestimated the number of you who wished to participate in this evening's discussion.

Tonight's issues are how far we should go in the quest for safety, and what are the drivers behind that quest? We know that absolute safety is unattainable and so we have to draw the line somewhere. Are the accepted methodologies mutually consistent?

As you know, ALARP is at the heart of UK practice and, but "reasonably practicable", is open to a wide range of interpretations. Best Available Technology is another methodology, which is perhaps more favoured on the continent and, perhaps significantly, by the media. But this approach raises major economic and political problems, as the NHS and Highways Agency will testify.

Cost Benefit Analysis has a reassuring quantitative ring about it. Economic values may be estimated for property damage and business interruption but this is far from easy. Furthermore, what price loss of reputation? But how do we approach human injury or even fatality? If we can envisage real potential for fatalities as a result of our operations, then what steps should we take to minimise this? Clearly, legal and economic drivers apply but do other social and moral drivers also come into play? Can we in any way justify the acceptance of the potential for personal injury as a result of our operations or product? Is it acceptable to put a value on life in order to evaluate this or are we morally obliged to do everything within our power to avoid loss of life?

The UK media played out these issues in respect of rail privatisation. Dividends were seen to be at the expense of investment in safety. The Pentagon recently placed an urgent order for more body armour for troops in Iraq, following US public pressure that this was not an area for cost saving.

NICE has the almost impossible task of approving new drugs and treatment in the UK, using a balance of cost and efficacy. As we have just seen, those decisions are challenged in the courts and by the media.

So these are not issues that will go away and, on the contrary, decision-takers will be subject to ever increasing public scrutiny. We need to be sure that our house is in order. If we each employ different methodologies, we need to be clear why this is the case, and be able to justify doing so.

A subsidiary question, which we may or may not have time to address this evening, is where we, as individuals or enterprises, derive the right to make these decisions on behalf of the community. Is it by reason of regulation set by a democratic government or regulation set by professional institutions? Or is it just unspoken acceptance by the community? In the UK, we engineers are not generally licensed to operate by any publicly accountable body.

It is intended that this should be an active seminar with as much participation from the floor as possible. To get things underway and stimulate discussion, we have assembled a distinguished and talented panel. But we have given them an almost impossible task. Despite the seriousness and complexity of the topic, we have asked them to give you the key issues, as they see them, in five to six minutes each. This is in order to allow you, the audience, adequate time for discussion and exchange.

Our panel consists of regulators at both the national and sector level, experts in both economics and morality, and, by no means least, front line operators from the railway, petroleum, civil aviation and the nuclear power industry. Without further ado, let me move on to our first group of three speakers who will set the scene in terms of UK regulation, the economics of safety, and the moral and philosophical issues behind the management of safety.

Let me first call on Tony Bandle, to talk to us about UK regulation.

A regulator's view

Tony Bandle

Head, Risk Policy Unit

Health & Safety Executive

Good afternoon, everyone. Thank you for giving me the opportunity to provide a flavour of the regulator's view. I would like to provide you with a feeling of what it is like to be a regulator in the modern world – a world where we have left behind some of the certainties of absolute regulation and requirements. It is a world where there is a much greater expectation of stakeholder and public involvement, and much more accountability; and where, generally, we have to deal with much more complex systems, technology and fast-moving changes in both the workplace and the workforce.

There is still plenty of certainty about and a point I should make at the outset is that there are still a great many traditional safety issues which are not being dealt with very well. This results in excessively high levels of accidents and injuries, many of which are very obviously preventable – and yet there are plenty of good practice, good guidance and good standards around to prevent this.

I would like to discuss the world of greater uncertainty into which we are moving, where we are dealing with emerging new technologies, and with having to take account of aspects of public safety as well as worker protection. I have chosen to deal with this using four headings to illustrate the sorts of issues that we are faced with; which we have to trade-off and balance.

"The Juggler"

This could be any one of a number of the regulators around, although my experience is obviously with HSE. We have to perform a juggling act between the statute, the regulations and the guidance on which we are required to regulate and enforce, and indeed help to prepare in terms of regulatory packages. There are also the codes, instructions and quality manuals that flow from that, to give the consistency that we owe to duty holders and also our accountability to the public and to the politicians.

On the other side, we have a whole range of expectations. We have the worker expectations. There are business' expectations in terms of being able to make a reasonable profit and carry on their business and develop their new technologies, and yet be provided with an adequate degree of public assurance.

We increasingly have partner and stakeholder expectations because many of the things that we need to deal with these days we cannot do on our own. We require the wider health and safety community to do them. In some cases, sections of that community perform rather better than we can. There is also a greater expectation of accountability, even beyond that, out to the public.

I will return to the question of public expectations in a moment. We also have the political and parliamentary expectations and, having just appeared before

two parliamentary inquiries, both concerning risk and the handling of risk, I am only too aware that there are parliamentary and political expectations about how we behave and operate, and our accountability to the public and the politicians.

The discretionary balance

Under this heading I want to discuss the balance we have to strike as a regulator, in the discretionary way in which we operate. Ultimately, of course, there is the legal system - with the courts and judicial review and the House of Lords - that will make the decisions. However, for much of what we do, we actually have to make discretionary judgements, concerning concepts such as 'as low as is reasonably practicable' or, as it is sometimes expressed, 'so far as is reasonably practicable'. It also involves weighing the costs and benefits, and taking into account issues like efficiency and effectiveness.

Most people are aware that there are devices and instruments that we use to do that. There is *The Tolerability of Risk*, and there is our famous – or perhaps infamous – document, *Reducing Risk, Protecting People, R2P2*. At this stage, I should perhaps say that these are very much aids to decision making and they are not algorithms where you can put numbers in at one end and get answers out at the other. They are about informing judgements, and helping to make weighted and balanced decisions about how far to go with something and when to call enough enough.

The still calm voice

Then, of course, we have to be on the side of the angels. We have done some research and we know for a fact that an important part of our existence depends on our ability to continue to have public trust, a large part of which is about whether we are seen as representing the public interest in an objective, unbiased and fair way. However, as we all know, there is not one public, but there are several very differentiated publics. We also know that people react emotionally to certain situations, so that we can have peaks of public concern, public alarm or public expectations – but how do we cope with those? They are very temporal but we have to deal with them.

There is the whole issue of perceptions, which is still a relatively unresearched area. I feel that this is particularly important where, perhaps, some of the more traditional, rational, risk-based approaches need to meet the sorts of models and approaches that are being suggested by the social researchers. I am not sure even now that we really understand what drives perceptions, or that we know particularly well how to take those into the decision-making process.

Within this, we have the confounders. We all know about media amplification – we can actually sometimes have media attenuation. Believe you me, there are things that we would like the workforce and the public to take more seriously, but they do not seem inclined to do so. There is a question about how much 'education' we should attempt, or how much we should accept the situation and work with it.

There is then the whole issue of single interest groups, or pressure groups. How do you take them reasonably into account when you are decision making, and particularly when you are making high level policy and recommendations

to ministers about packages of legislation or how to deal with new and emerging issues?

The Arbiter

Finally, there is this point about where we sit – where we position ourselves as an organisation – and that is also a reflection of the political climate at the time. On the one hand, there is a push for a totally free market environment, where things will sort themselves out anyway. Alongside that, there are mechanisms like self-regulation – although not in its entirety. We need to consider corporate and individual rights. And then there is the so-called compensation culture. Whether it exists or not is not of importance to me, but the perception exists, and we need to address that.

On the other hand there is the alternative model, which is full state intervention. What we have is something between the two. There is thus a very difficult balancing act to strike in terms of where responsibilities lie, and how far to go. How much do you protect individuals and groups? This is a very difficult balance to strike.

I hope I have given you a flavour of the issues without getting into the detail of how we address them. I would, however, like to return to the point I made earlier, which is that we have many models, and many tools and techniques to help deal with these issues but, at the end of the day, they are not the final determinant of the decisions we make. We have to rely on having a very professional, knowledgeable and evidence-based organisation that is closely in touch with both its duty-holders and its wider stakeholders, in order to make what we believe – most times – are sensible decisions, and sensible risk management decisions.

Thank you very much for listening.

John Turnbull: Thank you very much, Tony. We will no doubt hear later whether you have elicited sympathy for the lot of the regulator.

Let us now hear from Professor Jones-Lee from Newcastle, who has made a name for himself by putting economics into the safety equation.

Safety economics

Professor Michael Jones-Lee

University of Newcastle Business School

I shall be brief and to the point: my wife often requires me to do that and I shall try to comply.

My basic premise is that, in most circumstances, safety can be improved – but only at a cost. We can install overhead lighting on all stretches of motorway, and we have installed train protection warning systems. We can build flood protection barriers. We can install pollution attenuation devices in production plants, and so on. However, these are all at a cost in terms of real resources or time or trouble. This strongly suggests that, if decisions concerning safety improvement are to be taken on a rational, systematic basis, then we require some means of associating values with safety improvements, so that values can be weighed against costs, in reaching a balanced decision.

Of course, we can set the issue aside and simply proceed on the basis of hunch, intuition or good sense, but that will almost certainly lead to inconsistency and inefficiency in the allocation of resources. There is ample evidence that this was the case before public and private sector decision-makers confronted the problem of safety evaluation head on.

But how do we arrive at values of safety? We could, of course, do the evaluation in terms of eggs or sausages, or doctors or nurses or schoolteachers, but money is a useful unit of account – but it does not have to be in terms of money. However, I will talk about monetary evaluation because that is a convenient unit of account.

In a civilised society, it is natural to require that the values that we use in this sort of decision-making should, in some sense, reflect the preferences and wishes and, more particularly, the strength of preference of those members of the public who will be affected by the safety improvement decision concerned. A natural measure of a person's strength of preference for goods or service is the maximum amount that he or she would be willing to pay for it. That is a clear reflection of what the goods or service is worth to the individual, relative to other potential objects of expenditure.

This is, of course, conditioned by the individual's ability to pay, but that seems appropriate because that is a reflection of the ultimate overall constraint on society's resources. So those of us who advocate this approach try to estimate so-called 'willingness to pay'-based values for safety. We need some sort of unit with which to work, and that is the so-called "prevention of a statistical fatality".

Let me suppose that we have a safety improvement that would afford each and every person in a group of 100,000 a one in 100,000 reduction in the risk of death during the coming year. That safety improvement might prevent no fatalities, with a probability of about 0.38. It might prevent one with a probability of 0.38. It could prevent two, with the probability of 0.38 divided by

two, and so on. However, the mathematical expectation of the number of fatalities that will occur, or, if you prefer it, the arithmetic mean is precisely 1. We refer to that as the "prevention of a statistical fatality". But it is vital to appreciate that it is essentially a large number of very small risk reductions.

Now suppose that the people in this room are representative of the larger group and are, on average, willing to pay £15 per head for the safety improvement. The aggregate willingness to pay, or the aggregate value, of preventing the statistical fatality is then simply 100,000 times £15, which is £1.5 million. We refer to that £1.5 million as the value of preventing a statistical fatality. That is approximately the figure that is currently used by the Department for Transport and also the Rail Safety Standards Board, and it is the figure recommended by HM Treasury.

One of the problems – apart from the difficulties of estimation – is that the first thing to notice is that VPSF (the value of preventing a statistical fatality) has not surprisingly been truncated to VPF (the value of preventing a fatality). That leads many people to the totally incorrect conclusion that it is the value of a life, or the price of a life, but it is not. In no remote sense is it meant to be the sum that any person would accept in compensation for the certainty of their own death. For most of us, no finite sum would do the trick. Nor is it meant to be the maximum sum that a person would pay to prevent their own death – for most of us, that would be everything that we could afford and we would borrow and borrow. It is not, not, not the price of a life.

What are the other problems? VPSF will clearly depend on the income of those affected. The willingness to pay is clearly dependent on ability to pay and so, if strictly applied, that approach would give you a lower VPSF for Bethnal Green than it would for Chelsea, Kensington or wherever. That is not on, and the Department of Transport does not do that, but it applies a uniform value. However, if you asked it to defend its application of a uniform value, other than handwaving and saying that it was fairer, they would be pushed – as I have been challenged for a great many years.

John Broome is a very good friend, but we have had a fundamental disagreement in this area for a very long time. He suggested to me recently that a way of defending the common value is by treating everybody's reduction in risk as socially providing a common gain in social welfare. If you make a few additional assumptions about how safety is financed, for example in the public sector, by a proportionate tax, and if you make further assumptions about the relationship between willingness to pay and ability to pay, you actually end up with a theoretical defence for the common value applied to all income groups.

The final problem is whether we use the same value across the board. Should road and rail use the same value? Should we apply the same value to road accidents and large-scale rail accidents, fires in public places and so on? If you paid attention to the media and the press, your conclusion would be, 'No way! There should be huge values for rail, where big accidents can occur.' Well, we have done research on this and we put it directly to people. We said, 'Would you prefer to prevent 30 separate road fatalities, or one single rail accident with 30 deaths?' The modal or major answer from members of the public, randomly

selected, is no, they would not prefer a higher value. So, for many circumstances, I would say that there should be a common value. For rail trespassers and suicides, OK, a reduction may be acceptable.

My final two points are brief, and they are two very important 'no-nos'. The VPSF, or VPF, is not, not, the price of a life, but it is the value of a large number of small risk reductions.

The second no-no is that cost benefit analysis, using VPSF, is not the final answer. It is input but, in addition to that, educated and sensible good judgement is also required.

Thank you very much.

John Turnbull: Thank you for that. Clearly, from the body language, you have the audience counting their pennies and wondering how much they would be willing to pay. You promised us that Professor Broome would strongly disagree - although I am sure there will be no physical conflict between you, but just an intellectual one.

Safety philosophy & morality

Professor John Broome

White's Professor of Moral Philosophy

University of Oxford

I am just a humble philosopher and I am honoured to be invited to speak to such an intimidating group of engineers. I am glad to see at least that you are not all wearing your hard hats, as I rather expected you might.

I thought yesterday that you would simply treat me with contempt if I did not have a PowerPoint presentation. I therefore found PowerPoint on my computer and this is my first attempt with it. Perhaps you could reserve your contempt for Michael, who is an economist.

Most of us regularly impose risks on other people – you do that every time you drive a car down the street because you might have a sudden stroke and kill somebody. That is inevitable. We therefore impose risks, which raises the question as to which risks it is morally permissible for us to impose on other people.

I do not think many people would reasonably be absolutist about that – although perhaps some philosophers would. However, not many people would say that you simply may not impose any risks on other people, because that would interfere too much with ordinary life. We would all have to stop driving cars and in fact we would not even be able to ride horses. I therefore take it that we have to be less than absolutist. This means that it is sometimes permissible to impose risks, and what determines whether that is so, is bound to be a matter of weighing the risks in some way or other against the benefits that arise from imposing those risks. We therefore need to weigh risks against benefits.

This is something that is very commonly undertaken in a formal quantitative way. It happens in Cost Benefit Analysis, or Risk Benefit Analysis as it is sometimes called. Cost Benefit Analysis compares the badness of a risk with the benefits that can be derived from imposing that risk on people. The methods of Cost Benefit Analysis are in general controversial and they have been argued over for a long time. They are especially controversial when it comes to matters of life and death, because the way this is usually done, as Michael has said, is to assign a monetary value to life. He was cautious in explaining exactly what he was doing about that but, in some way or other, money becomes attached to the preserving of life and some people find that horrifying and offensive – which is grounds for controversy.

Michael is a practitioner, whereas I am just a theorist, sniping from the protection of an ivory tower. However, as a matter of fact, on the general idea of weighing risks against benefits – and these are risks to life and risks of death against benefits – he and I are on the same side. What I am about to say now is actually to support him, rather than criticise him.

I see nothing wrong with the idea of weighing the risks of death against benefits. In principle, I see nothing wrong with the idea of valuing people's

lives in terms of money. Michael and I have disagreements about how that should be done in detail but not over whether it should be done. I agree that it should be done and I will say something about why I agree.

First of all, the value of a person's life is a quantitative matter. Some people's lives go better than those of others - some people have better lives than others. One of the things that helps to determine how good your life is, is how long it goes on for. For most of us, having a longer life would be better than having a shorter life. If you expose somebody to risk by driving down a street and, as a matter of bad luck, you kill her, then what you have done is to deprive her of the rest of her life. That may be a big deprivation or it may be a comparatively small deprivation. If she is young, with a full life ahead of her, it is a very big harm that you have imposed on her. On the other hand, if she was not very far from death in any case, then it is a much smaller harm that you have imposed on her. The value of life is a quantitative matter. Some people suggest that life has an infinite value but it does not: it has a finite value and it is a matter of quantity. That is one point.

The second point I would like to make is that the value of a person's life is comparable, or commensurable as philosophers often say, with the value of mundane things such as chatting to your friends or having a holiday. It is plausible that some sorts of goods are not commensurable with each other. To give a philosopher's example, pleasure on the one hand and justice on the other are both good things, but many philosophers believe that they cannot be weighed against each other. They cannot be balanced against each other in any way and they cannot be measured on the same scale.

So some goods are incommensurable with each other but that is not so with the good of life and the mundane goods that come in life. This is because what you lose, if you lose your life, is the sort of mundane goods that you have in your life. If your life is shortened by a year, what you lose is your annual holiday and all the fun you would have during that year – the chatting to friends, and so on, that you would have during that year. In fact, the value of life is nothing other than the value of the mundane goods that occur in it and so there is no problem with commensurability between life and other goods, and they can be measured on the same scale. If they can be measured on the same scale, it does not much matter what the units are that you use in the measurement – and so it does not do any harm to use money, for example, as a unit of measuring life against other goods. For technical reasons, as a matter of fact, I prefer a different unit, which is the year of life but, to a first approximation, money is fine so far as I am concerned.

There is nothing outlandish about the idea of weighing risk in people's lives against other benefits. Cost Benefit Analysis, or Risk Benefit Analysis, does that, and it is perfectly justifiable in doing so. So that supports Michael.

That is the end of what I wanted to say about that, because I would now like to say something really rather different. Suppose that you have done a Cost Benefit Analysis for some engineering project that you have. Suppose that you have done it correctly and correctly weighed the risks against the benefits, and suppose that the answer that comes out is that this project is worthwhile: that is, the overall benefit of doing it is greater than the badness of the risk that it

imposes on people. Let us suppose that you have done that. Does that mean that it is OK for you to go and do the project? No, it does not. This is perhaps the most important point I want to make. Just because the benefits exceed the badness of the risk, it does not follow that it is OK to do the project.

If you think about it, that should be obvious. Just because a project is beneficial on balance, that does not mean that you should go ahead and do it. It does not even follow that it is morally permissible for you to go ahead and do it. Suppose the project harms somebody, and harms them badly. Suppose it destroys somebody's house. Now suppose that it is generally beneficial – perhaps it builds many houses for other people, but it destroys this person's house. Is it OK to knock down her house, just because you have worked out that the general benefit is positive? No, it is not – you cannot go around knocking people's houses down, just for the sake of the general benefit. That is not something that we can do.

If you were a government, you would be in a slightly different position. Governments are in a morally different position in this respect. They are representatives of the people, which gives them a certain sort of authority in doing harm to some people for the sake of benefit to others, or for the sake of the general benefit. That is not an unlimited moral permissibility – government cannot do just anything to us, just because it turns out that doing that would be for the general benefit. Furthermore, if it does harm us, it generally owes us compensation. But at any rate it has more in the way of authority to impose harm on people for the general benefit than do private individuals or companies.

It is true that even private individuals and companies have some entitlement to impose harms on other people. For example, I am allowed to mess up your flower bed when I jump from my burning house, if that is in order to save my life. That is a harm I do to you, but it is evidently worth it because it saves my life. However, situations like that are strictly limited and private individuals and organisations are not generally allowed to harm others significantly for the sake of the general good. The same goes for risks as well as actual harms. It would be entirely immoral for a private company to impose significant risks on other people, just because doing so would be generally beneficial.

In the case of a private company, I can say something more to reinforce that point. Remember that it is the job of a private company, if it does something that is generally beneficial, to try to capture as much as it can of the general benefits for itself. It generally sells its beneficial services, rather than giving them away, and it tries to get hold of the benefit it creates, as much as it can. Thus, most of the general benefit will turn out to be the benefit of the shareholders and the managers. It is entirely reprehensible for it to impose risks on other people just for the sake of its own shareholders and managers.

That is my main message – that a Cost Benefit Analysis or a Risk Benefit Analysis is not enough. If you show that your project is generally beneficial, then that is something worth knowing, but it does not entitle you to go ahead with the project and impose risks on other people. Something more is needed. Let me briefly say something about what more.

Just what risk is a private company morally entitled to impose on other people for the sake of the general benefit, including its own benefit? I would like to be able to answer that question properly but, fortunately, I have run out of time – fortunately, because I do not actually know the answer. This area of moral philosophy is not very well developed and it certainly needs working out.

Let me say just one thing. It is pretty clear that a private company is entitled to impose some risks on other people and only an absolutist would think not. Thus, a company is allowed to send its delivery vans around the town, for example, even though sometimes they will kill somebody. That is a permissible risk for a company to impose on other people. I take it that that is on the same general principle as makes it permissible for me to mess up your flower bed in the course of escaping from a fire to save my life. It seems to me that the idea of gross disproportion is the appropriate criterion – or, at any rate, the beginning of an appropriate criterion in that case. The cost to me of not messing up your flower bed is that I lose my life, which is grossly out of proportion to the harm done to you by my messing up your flower bed and that is why I am allowed to do it.

Gross disproportion is a matter of weighing benefits against costs but it is not the weighing that appears in a cost benefit analysis. A Cost Benefit Analysis finds out whether the benefits are greater than the costs or the harms. A calculation of gross disproportion is finding out whether the benefits are much, much greater than the badness of the harms and that is an entirely different matter. As I am sure you know the idea of gross disproportion is already embodied in law, as seems appropriate.

Thank you very much.

Questions & Answers

John Turnbull: As you will have observed, the seminar is structured such that we have had our opening three speakers dealing with the general issues surrounding the subject, and they will be followed by four speakers who will address the workforce – the real place where it happens. We have a few minutes available in the programme if there are any points of clarification or dispute that you would like to raise.

Philip Thomas (City University): I very much enjoyed all three speakers and I agree completely with Professor Broome and indeed Professor Jones-Lee that a value needs to be put be ascribed to preventing a fatality. At City University we have developed a methodology which we think achieves this in a completely non-subjective way.

I have a question for Professor Broome. I note his distinction between the risks that a private company can impose, and the risks that a government can impose. What effect would this have on the transition, for instance, of the CEGB to Nuclear Electric? Has the height of the hurdles they need to clear been raised by that simple change of ownership?

John Broome: It is certainly true that private companies can get the government on their side. One can obtain permission through a government to impose harms on other people. That is the way of appropriating to yourself the authority that is invested in the government. I am assuming that the government gains its authority through a political process in some way or another. It will be entitled to say, in certain circumstances, that certain risks or harms imposed on other people are permissible and merited, and this will allow a private company to go far beyond what would be permissible without the authority of the government behind it.

I was over-simplifying when I said that private companies cannot do this at all, but they need the authority of the political process if they are to do more than impose minor risks on other people, such as sending their vans around the town.

John Turnbull: I do not know whether Professor Evans is in the room, but certainly Railtrack – privatised – was set a much higher hurdle by you and I than dear old British Rail. That is the reality of the situation, is it not? Certainly, John Humphrys thought so.

Chris Elliott (Pitchill Consulting Ltd): I am an engineer and a lawyer. On the issue about the difference between government and private industry, right at the beginning Tony mentioned that the duty what was reasonably practicable and, if you cannot do what is reasonably practicable, you should not be in the business. That is fine if you are in a free market with competing companies, and the ones that are not safe, should not be doing it. The four speakers we have to come all are from industries, but in some sense are part of the national infrastructure. In some cases they are publicly funded.

You mentioned NICE at the beginning. I have been told this by NICE. They use the life expectancy, or quality adjusted life year (QALY) approach that John Broome mentioned. They work out the value, how much life it will give you, and then divide one by the other, and they then rank them in order of bang for buck, cost effectiveness, and go down the list until the budget runs out. But that is quite different from doing everything that is reasonably practicable. If you demand that publicly funded industries do all the necessary financing, you are taking away from government and Parliament the control of the budget. There is a fundamental difference between free market competing companies and a highly regulated national infrastructure capability and yet, in some cases, we demand that the reasonably practicability test be applied as well, for example, the railways, and yet the budget is set by government.

John Turnbull: I have a question for Professor Jones-Lee. I have had a career in an international company and you have mentioned the problem of different values being placed on life in a wealthy and a poor part of town. What about a company operating in both China and California? How would they deal with this?

Michael Jones-Lee: There is an argument that says that, in some sense, an altruistic organisation in a developed country should apply the same values to the inhabitants or occupants of a less developed country as it does to itself. The argument against that is that if you spend, say, £1.5 million per statistical fatality prevented in a very, very poor country, then the hard fact is that if you put it to the occupants of that country whether they would rather have the £1.5 million spent on something else such as food, clothing or education, I bet you they would say yes. Thus, your altruism is actually what economists would call Pareto sub-optimal. It is inefficient and you are over-larding the egg in relation to what they would really want.

Alan Powderham (Mott MacDonald): Since we have raised the issue of inconsistencies, and we have begun by discussing raising the bar for private companies compares with public ones, and then the issues about California and China, there is a much greater disparity that surely influences the moral issues, even within the UK. I have been flipping through an article after Hatfield. I do not know whether the facts are quite accurate, but there is a 100:1 difference in the accident rate between railways and roads and yet we are persuaded – through the government and public pressure and perceptions – to spend about 150 times more on rail safety. Furthermore if we went for the best train protection system, that would equate to about £2 billion per life saved, while for certain road expenditures the amount is more like £100,000. A huge disparity seems to exist there, which seems to dwarf raising the bar between public and private sectors and this surely needs some rational debate if we are to move forward here.

John Turnbull: Thank you for that. I am sure that we will come back to the question of road versus rail. We were very keen to have the Highways Agency sitting on this platform but, somehow, they were busy – digging up the road in my village, I think.

Deborah Grubbe, BP operates in California and China as BP. How does BP square the circle on the issues of safety, costs and morality?

The oil industry

Deborah Grubbe

Vice President, Safety & Industrial Hygiene, BP plc

Good afternoon. It is a privilege to be here and, as you can tell, I am not from this land. However, I am a product of your university system, having been a Winston Churchill scholar at Cambridge University a number of years ago. Today, I would like to talk about BP's strategies and management practices, and how we are working to build a safer future.

You might find my remarks rather idealistic, but that is deliberate. You might find that they are not practical but I can tell you that, after a 27-year career in the DuPont company, running global operations, one can put safety first, one can make it work, and it makes you money and keeps you in business. It gives you the licence to operate.

BP's group values

BP's core values are very clear: no accidents, no harm to people and no damage to the environment. That is what we are looking for and we are working to develop a statement of what we are looking for, in words that speak to the positive. My over-arching message today is – safety, first and always. There is risk in everything that we do. There are some consultants out there who will say that you cannot really put safety first and that you have to put safety equal because, after all, you could stay in bed. I do not know about you but, if you have cared for elderly parents, you will find that staying in bed can create hazards that are as life threatening as getting out on the roads and driving an automobile. We are working with everyone who works with BP or comes in contact with us – our key suppliers and our contractors – to raise their level of education and awareness, so that they can also work with this notion of safety first. Managing safety and working safety is a condition of employment.

With the introduction of our Code of Ethics earlier in 2005, there has been a direct tie made between some of the most sacred safety rules in BP and the notion that one actually performs them. And yes, it is unfortunate but, in my experience, safety is a unique balance of the carrot and the stick. Therefore, if there are transgressions that appear to be serious or even minor, there is a definite disciplinary procedure for enforcement – and this is not only for the workforce - but it is also for managers, because everyone is in the same boat when it comes to safety, which is rather egalitarian.

Let me talk about what good safety practice requires. This is the same whether it is BP, or the DuPont company I have also been on the NASA Aerospace Safety Advisory Panel for two and a half years and I can safely say that these are the kinds of things that NASA is also looking at.

Committed leadership is absolutely key. If you do not have your leadership on board, or if they do not believe what you are thinking about and what you want to do, and if they are not actively participating in it, then that is a major

fault. Safety is not something for somebody else. It is not an intellectual discussion – with all due respect to my colleagues – but it is where the rubber meets the road.

Do you make decisions around money, priorities, what the organisation is going to work on, or what you talk about? Do you make those kinds of decisions and think, 'Well, it is OK for me to make these decisions because I am not the one who will get hurt.'? My view would be that one has to question the morality of that kind of comment.

You must have educated and competent personnel. Safety, at some levels, is a very inexact science. As a chemical engineer, I see that in some ways it is a balance between the science of engineering and the science of human attitudes and behaviour. There are a great many psychosocial things in which I find myself becoming involved, for which my university education did not prepare me.

One must integrate safety operations and do that with management systems – systems that are supported and actively run by management. A piece of what you would look for in a management system would be issues such as whether there is an audit process. Is the audit process supportive and helpful, rather than a 'gotcha!' kind of process? Is it an audit process that helps learning?

Does the system have no tolerance for deviance? Are you looking for things that are wrong all the time? Are you trending? Are you also looking for things that go right and examining those? Your system must also be able to deal with complexity. This is not an easy world and, while we try to simplify it greatly to aid our understanding, that is good only up to a point. Once there is a fundamental understanding, we must dive relentlessly into the details and make sure that we understand the complexities because, as every engineer knows, the devil is in the detail. There needs to be continuous attention to those details, followed up by a relentless pursuit of communications. If you look at many of the major incidents that have occurred over the years, a lack of communication, and poor communication leading up to the incident and during the incident, have been factors.

Safety first – BP's approach

We at BP believe that all incidents and injuries are preventable and we are working towards that. There are no economic or other trade-offs, although I am sure that some of you in the audience may disagree. In the end, that is where it has to be: no trade-offs. Yes, there are not unlimited capital budgets, and you can never make anything perfectly safe and so, as Tony Bandle said, how can you find the right balance?

Safety must come first and you must have efficient operations with good mechanical integrity, to ensure that your operations are efficient and productive. This is just good business and, as one of the largest companies in the world, that is our obligation to the communities in which we operate. We must work hard all the time and be diligent. However, the 100,000 employees of BP are human also, which means that we must constantly be diligent, and constantly re-dedicate ourselves to the concept of safe operations.

Many transformational changes go into building a strong safety culture. We are doing some studies now that say that there are good correlations between some of the responses to questions in our annual employee surveys, and how safe a site really is. Interestingly, this boils down to the relationship between all workers and their respective supervisor. This mirrors some work that was done in the United States in the early 1990s that showed that while we can talk about the money and we can talk about the kit, there are other key determinants such as relationships, respect and trust, which one cannot ignore.

The cost attached to this future goal is an investment. My prior firm conducted a study – and I do not know whether it was published – but for every dollar that was invested in safety, the DuPont company claimed they saved \$4 to \$5. I do not know about you, but I think that is a pretty good return.

The safety of everyone depends on a common commitment. People who know me say that I am very passionate about safety, and I agree. I come by it very honestly. My father was a high-voltage electrical lineman and, if he did not work safely, he did not come home. If his buddies did not work safely, my dad did not come home. At six years of age, I was conscious enough to remember these things and started to learn about dangerous occupations. When I found myself a number of years later graduating with a degree in chemical engineering, I wondered how to incorporate these values taught to me by my father. Safety means that while you cannot see electricity, you cannot smell it, but just always remember that it lies there, waiting for you to make a mistake.

Thank you.

John Turnbull: Deborah, thank you for that.

Let us now move on to the rail business. I know that Colin Dennis's ears will have been burning during earlier parts of the discussion.. While we are waiting for him to take the podium, let me just say that throughout my career in the oil business, we looked to Exxon as a model of how to manage safety and, in the petrochemical and chemical business, we looked to DuPont. I always found it interesting that the correlation between safety and profit was very positive: profitable companies are safe, unsafe companies not only hurt people but they do not make money.

The rail industry

Colin Dennis

Head of Risk Assessment

Rail Safety & Standards Board

Some of the things that have already been said will be repeated in my presentation as we go through, but I hope this will just reinforce some of the points that have been made.

Principles

I want to talk about the principles behind safety decision making that we use in the railway industry and I will put that into context as of the overall risk levels on the railway and the backdrop against the decisions that we have to make.

I will go on to some developments that we are thinking about in the area of safety decision-making and wrap up with a few conclusions.

First, in relation to the overall underlying principles for safety decision-making, railway companies clearly have to reduce risk, to a level that is as low as is reasonably practicable – and that is the legal duty, about which we have already heard today. That is enshrined in the 1974 Health & Safety at Work Act.

The railways are quite a complex system particularly in the area of financing: Where does the money come from? Chris Elliott mentioned earlier that it is a combination of the public money, through public subsidy to the railways, as well as the money coming in from fare-paying passengers, through the ticket office. Therefore, what is reasonably practicable must reflect the social duty to deliver a railway that society demands, and pays for through public subsidies, as well as the commercial duty to the shareholders and customers. In addition to that, we must be conscious of all the other stakeholders who are involved within the railway, live by the railway or interact with the railway in some way. This is a very complex area to deal with.

What is ALARP?

The overall philosophy of reducing risk to a level that is as low as reasonably practicable is well known and has already been discussed. The whole essence is a matter of balancing the cost of safety enhancements with the safety benefits that it produces. However, it is not only the safety benefits that we have to consider, if we can convert risk reduction into a monetary value, through using the value of preventing a statistical fatality (VPSF), as Mike has explained. There are also other benefits, such as direct benefits relating to the cost of accidents that we actually avoid, and the physical damage that occurs during accidents. The cost of public inquiries, for example, is very significant in the overall equation of costs to do with accidents.

Performance gains can be a significant area for the railways. Safety decisions are not just safety decisions in their own right but they are a part of overall business decisions and we have to consider the performance elements as well. Indeed, there are indirect costs associated with avoiding loss of reputation,

because an accident may not cause many fatalities but the associated reputation issues can nevertheless be quite significant.

On the cost side, we need to take an holistic view, ranging from the cost of designing the project, to the equipment itself, to installation and testing, training, and very importantly considering whether there are any risk increase factors associated with installing the equipment. Putting in a new train protection warning system, for example, might incur a considerable amount of work, for track workers to go out on the line to install the equipment on the line-side. That has to be taken as a disbenefit, because they could be subjected to an increased level of risk. Operational maintenance costs need to be considered, as well as any loss of performance that might be derived from the modification. So we must do all that is reasonably practicable to reduce risk. This was the principle enshrined from the famous *Edwards v. National Coal Board [1949]* case.

How are we doing?

To put that into context of where we are in relation to the overall risk, most of you will be familiar with the HSE's Tolerability of Risk criteria and the ALARP triangle, which we have come to know and love. This looks at individual risk in terms of the probability of fatalities per year, and splits that into three sections of the unacceptable risk, the tolerable risk and broadly acceptable risk. For passengers, the boundary between unacceptable and tolerable is a 1:10,000 per year probability and for broadly acceptable it is 1:1 million. If we are operating in the tolerable region our aim must be to reduce risk to a level that is as low as reasonably practicable.

Where are we currently? Passenger individual risk on current estimates is about 1:160,000 per year. We relate this to a typical commuter travelling 450 journeys a year by rail, with a distance on average of about 30 miles. Bearing in mind that we have about 1 billion passenger journeys per year, that translates to about 14 fatalities a year on the railways. In comparison to roads, which were mentioned earlier, I would say that fatalities are much more than 100 times fewer. But a better comparator is the individual risk, 1:17,000 being the average figure for road users. So, in terms of passenger individual risk, the railways fare well in comparison to roads being a factor of 10 lower.

The workforce is another key area. We have a slightly different criterion for the band between unacceptable and tolerable, namely 1:1000 per year. I have a couple of groups of workers for whom I have figures. There are about 15,000 train drivers within the industry who currently have a risk of about 1:16,000 per year, which compares fairly well with the average construction worker. At the moment, our group with the highest level of risk is that of track maintenance workers, out on the track, keeping the infrastructure in good working order. There are about 30,000 full-time equivalent track workers per year, and about 1:7,000 is their current level of risk, which is approximately comparable with typical scaffolders, roofers or tilers in the construction industry. Thus, while we are operating quite well within the tolerable region for the most exposed groups of individuals, clearly we are not down in the broadly acceptable region and so we have to make safety decisions concerning what is reasonably practicable.

Current views

What are our current views on safety decision making? About two years ago we set up a project within the industry, led by RSSB, to look at the whole way in which safety decisions are made within the industry and this became known as the Safety Decisions Programme. We are looking at establishing the need for consistent safety decision making across the industry as well as within government. The industry is made up of a large number of different companies, but they have to make consistent decisions and these also have to be made within the context of government policy, for us to be confident in the decisions that we are making.

As Mike mentioned earlier, the Road and Rail Safety Project Appraisal should share the common willingness to pay based value of preventing a statistical fatality, for the typical rail passenger and road user. Mike also indicated that this currently stood at about £1.5 million per fatality prevented. One of the safety decision making tests that has been enshrined, coming from the original *Edwards v National Coal Board* [1949], as well as in documents like *R2P2* which was mentioned, is the fact that the cost should be grossly disproportionate to the benefit.

As part of the research work that we have been doing, we believe that there is no justification for a test of gross disproportionality between the cost and benefits. If you believe that the values of preventing a statistical fatality have been derived from genuine willingness to pay, then there could be no justification for a grossly disproportionate expenditure, relative to the actual benefit. What is required is a proportionate approach, but we also have to be cautious that, in any Cost Benefit Analysis, or quantitative assessment, there will be uncertainties associated with that analysis. You have to take those uncertainties into account in that equation.

In thinking about the overall risk and safety decision making, we also need to take into account societal concerns. This would be both national societal concerns as well as local issues. What do our stakeholders actually think of the decisions that we are making?

Should all exposed groups be considered to be the same? Is it right that the expenditure to prevent trespasser fatality should be the same as that for preventing passenger fatalities? That is a key question. If there is someone voluntarily taking a short-cut across the railway, knowing that they were exposing themselves to risk, should we really be putting the same amount of money into preventing those types of fatalities as passenger fatalities, or indeed passengers in multi-fatality accidents?

We should not just manage fatality risk but we also have to consider the whole plethora of major injuries and minor injuries that exist within the railways. We currently weight major injuries and minor injuries, with 10 major injuries being the equivalent to one fatality, and 200 minor injuries being equivalent to one fatality, to help in the Cost Benefit Analysis assessment, taking into account injuries as well as fatalities. We are working to see whether there is a good and robust justification for those weightings to be used within the Cost Benefit Analysis framework.

Making safety decisions

Last year, we issued a document which is available on our website, called *How Safe is Safe Enough?* This gives an overview of how safety decisions are made on Britain's railways and I would recommend that you should read it following this evening's presentations, because it contains some good information on the way in which decisions are made. As part of that, we are developing a framework for safety decisions to provide this consistent approach to decision-making across the industry. This varies from routine decisions, such as platform staff despatching trains every day at some stations, to the complex decisions such as the installation of an automatic train protection system, which would be a multi-billion pound project. Lying between those, there is a whole range of increasing complexity and novelty, some uncertainty and the overall scale.

We believe that there is a framework that can be developed, based on some work that was done by the UK Offshore Operators Association in the mid-1990s, to establish guidelines on the types of decision making you may use, depending on the type of decision involved. That is from platform staff despatching trains, using codes, standards and rules specific to that, because you cannot have them doing a Cost Benefit Analysis every time they despatch a train. It is taking into account good practice, professional judgement and qualitative analysis as the decisions become more complex, turning to quantitative analysis as an input to decision making, to help you make the decisions, and taking into account corporate social values and ethical responsibilities as part of the overall package. You have to be aware of what your stakeholders require. As I said earlier, all these decisions are a part of overall business decisions and they are not just safety decisions – they have to be taken within the context of your overall business.

Conclusions

In conclusion, the railway industry is taking a proactive approach to managing safety risk to a level that is as low as is reasonably practicable. There is a need for consistent safety decision making across our industry and in government. The cost of safety enhancements should be proportionate to the benefits and not grossly disproportionate to them. We have set up a comprehensive Safety Decisions Programme, which has been established with the aim of producing a consensus view about how to make safety decisions across our industry. Finally, a consistent and proportionate decision-making framework will enable us to be confident in the decisions that we taken.

If you would like further information, please look at www.rssb.co.uk. Thank you.

John Turnbull: Thank you, Colin.

We have now heard two fundamentally different approaches. On the one side we have statistics that say that there will inevitably be accidents, and we even will not do certain things because we estimate the costs to outweigh the safety benefits. We have heard another approach which talks of zero tolerance – that we will not tolerate accidents. Gordon Lawrence, where does the Nuclear Power industry sit in this debate, given that – hopefully – the Government is going to see sense and build a few nuclear power stations? We are all waiting with bated breath to hear about that.

Decision making on nuclear safety enhancements

British Energy's approach to the use of Alarp

Mr Gordon Lawrence

British Energy

Good afternoon, everybody. I shall be talking to you this afternoon about British Energy's approach to decision-making on safety enhancements to ensure the risks from nuclear accidents are ALARP. The ALARP principle has been in use within our company and obviously within the industry generally for many years now. This is firmly based on going back to the HSE Tolerability of Risk approach and, more recently, enforced by R2P2, which takes that principle and applies it across a wide range of industries.

We have been using ALARP for many years now. We revised the guidance that we had for applying it as a result of considerable experience in the 1990s, from considering retrofitting enhancements and safety systems required by modern standards to operational nuclear power stations. This gave us a good deal of interesting experience, which we have taken into account.

An enhancement is not reasonably practicable when ...

You will therefore see a number of similarities between what I am about to say, and what other speakers have said. However, there are also some differences and I will try to tease those out as we go along.

Just to ram the point home, the ALARP principle is that we will implement risk reduction measures until further enhancements are not reasonably practicable. That is the test: it is until the point at which there is disbenefit, which is when time, trouble and cost are in gross disproportion to the risk reduction gained. As previous speakers have said, this is easy to do, as long as both sides of the balance are in the same units. Unfortunately, however, they are not, and this leads to the problem.

Quantitative assessment

One approach is to convert them all into money. We have a cost benefit approach within our guidance, which involves evaluating the disbenefits as a cost to the company – and I will talk about that later. We quantify the benefits as a reduction in accident costs. From that, we can calculate the cost benefit ratio, you apply disproportion and, lo and behold, out comes the answer. Qualifying the benefits: reduction in accident costs

It is worth pointing out a difference. Most of what we are talking about here are very infrequent but very severe accidents. This is a particular difference between our applications and the applications that Colin has just been talking about in the rail industry. We are mostly looking at enhancements that will reduce the frequency of such severe accidents, so that we can evaluate the reduction in accident costs by looking at the reduction in frequency, which is

the product of the reduction in frequency times the cost of that accident, times the residual life of the plant.

Qualifying the benefits: accident cost

The accident cost is evaluated by three main contributors: the societal health effects, including the statistical value of a life, which the previous speakers have mentioned; costs of agricultural restrictions – food banning and so on; and also evacuation and relocation if that applies. As you might imagine, this cost calculation is somewhat stylised and we only use it in the context of this particular application.

So we can now complete the CBA: but ...

We can now complete the Cost Benefit Analysis, and produce an answer. However, there are uncertainties. There are uncertainties in the accident cost – as I have said, it is a stylised calculation – and there are uncertainties in the frequencies. We are talking about very low frequency accidents and we do not have a big statistical population so that we can prove the numbers – thank goodness.

The qualitative factors

Albert Einstein is quoted as saying "Not everything that can be counted counts: Not everything that counts can be counted"

Qualitative factors – the benefits

We have qualitative factors in our methodology as well and we split these between the benefits and disbenefits. Benefits are things like reduces dependency on operators, improves separation and segregation, improves single failure tolerance. I will not go through the whole list but I am sure that you would recognise many of them as being the kinds of issues that you look for when designing enhancements or when improving safety systems.

Qualitative factors – the disbenefits – during implementation

More interesting, perhaps, are the factors that apply on the disbenefit side. In our approach, we split consideration of the disbenefits between the implementation phase of an enhancement and the completion phase, because different factors to apply to both phases, or the same factors apply but they apply in different ways.

Colin earlier mentioned the issue of implementing modifications on operational plant, in his case railways, while in our case this involves operating power plant. There are significant issues to do with risk to the implementers. There are issues to do with going in and modifying very complex interactive systems. Sometimes the technology is novel and has not been tried before. Again there is a long familiar list.

An enhancement is not reasonably practicable when ...

Returning to the test of whether disbenefits are disproportionately higher than the benefits, in British Energy we rely on careful consideration of all the qualitative factors, using a quantitative calculation as one of the inputs to the decision making – although by no means a dominant contributor. We consider the qualitative factors, which are considered by experienced nuclear professionals, who understand the nature of the underlying issues and make

decisions on that basis. I am not saying that this is easy – yes, there are differences of opinion and there are debates but, having identified the qualitative factors and gone through this in a systematic way, we can then have debates about those specific judgements rather than considering the issue on gut feel or prejudice.

Summary

In summary, we have an approach which acknowledges the high uncertainty in accident costs and frequency. The difficulty is that many of the issues relating particularly to disbenefits are very difficult to quantify and so we have a decision-making process which is primarily based on qualitative factors but we use quantitative assessment as an aid to judgement. The approach is reliant on engineering judgement by nuclear professionals. It is a systematic approach within a consistent framework, allowing judgements to be shared. Thank you.

John Turnbull: Finally, we turn to civil aviation and we shall hear from Ben Alcott. I have to say that, in our years of looking at risk, risk assessment and management, if you read the Academy reports, you will find that the civil aviation industry emerges as a benchmark, an example of best practice in many respects, in the field of risk assessment and management.

The civil aviation industry

Ben Alcott

*Head of Safety Investigation & Data Department
Civil Aviation Authority*

I will spend the few minutes allocated to me by giving you some context around safety strategies and management practices from our point of view at CAA.

The Civil Aviation Authority

I could quite easily stand here and tell you many things about aviation and how important it is to the UK economy and how safe it is but, in the context of what we are discussing today, I have decided to start elsewhere. CAA is entirely funded by the industry we regulate, which is relatively unusual for a regulator and – I think you will agree – it is an interesting slant on the economics of safety. This leads to quite an interesting dynamic between us, and the industry that we regulate.

We obviously have statutory obligation and the industry wants and also expects a level of professional advice. Safety is obviously our No. 1 priority, and hopefully theirs too, but we have a remit that is linked to this, which means that we have to do this in a way which allows industry to operate as effectively, as efficiently and as innovatively as it possibly can.

Conflicting pressures on a regulator

It is certainly no bed of roses. Just as you have heard from others already, there are many conflicting pressures and things we have to balance. For us, it is one of the ways that the economics and morality of safety meet in really practical terms. We see a 'healthy' friction between the safety regulator and the regulated industry, and the balance of autonomy and prescription which determine where risk, and finally the moral obligations, lie.

That balance is constantly being reviewed and it is constantly shifting, and it involves a dialogue between us and the industry. Whether we have got it right or not depends. I suppose we could go so proscriptive as to ground the entire aviation fleet, but that would not really meet with the wishes of the public or of the business. On the other hand, we could go entirely the other way and leave it completely to market forces but, once again, I do not think that would meet with the moral obligation that the public feels we have to keep them safe.

The main difficulty for a safety regulator is that the success is measured by nothing happening, and so it is sometimes very difficult to determine how far you are away from that.

Safety strategies and management practices

In terms of the safety regulation group specifically, everything we do is really driven by our high level goal, and there are two points I would like to pull out of this for you today. First, there is a statement on partnership with industry and, secondly, about continuous improvement.

In partnership with industry – in aviation – we very much believe that an adversarial approach to our regulation would be counter-productive. The UK safety record, which is one of, if not, the best in Europe, really speaks for itself. Secondly, when it comes to driving continuous improvement, we really cannot envisage a time when we would say, 'That is safe enough – we are not going to do any more!' Technologies that were pie in the sky 20 years ago are now freely available and we are implementing those – so who knows what we will be able to achieve in 20 years' time?

If we go on from this, it may be more towards asking how we sustain this level of safety that we have now decided is enough, for less cost and greater operational advantage.

Safety strategies ...

To put that into practice, we use a number of safety strategies. Right through the industry, we approve the people and organisations that can really impact the final outcome of safety. We use systematic, numeric analysis, very much at the certification stage and before a product ever goes into service, to try to determine whether we feel that it will meet the safety standards that we require. More recently, we have used much more in the way of human hazard analysis, which has been developed a great deal at CAA and which asks the designer to consider how that component or product will have to interface with the human, right through its service life.

Once the product is out there, we use a variety of techniques, including things like the safety barrier model – which you may have seen as the Swiss cheese type of model. This looks at what our defences are in place, right up to a catastrophe. What are the holes in those defences and what can we reasonably do to try to plug those gaps before the holes line up, the barriers are lost and we end up with the catastrophe.

We have an obligation to understand what the impact of our regulation is. We do high level Cost Benefit Analysis, and also benefit analysis without the cost. We do regulatory impact assessment – more and more as we are becoming involved with the European Union. RI is becoming more and more a part of our business.

However, as Tony Bandle said at the beginning, the outcomes of these are not the final determinants. These are the things that we put into our framework for our decision-making, but we then bring our professional judgement and the industry's professional judgement, and many other factors too, before we make a decision on whether to change a regulation or add new regulation.

...and management practices

In terms of our management practices and how we implement that, we have to engage with the industry we regulate. A good relationship with that industry, based on mutual respect and a clear understanding of each other's position is essential for us. We are not on site with the industry 24 hours a day, seven days a week and, since much of what we are trying to convey in terms of safety is culturally based, we have to have a high level of trust between us and the industry.

We have to be proportionate. Risk is an inherent part of life, as many of the previous speakers have said, but there is a world of difference between the level of safety that we would demand for you and me buying tickets to fly to New York, and the level of safety we would ask for if someone had built their own single-seat aircraft in their garage and wished to fly it. In fact, in that case we would be more interested in the safety of the people on the ground, perhaps, rather than the safety of the pilot.

We promote a just culture. Since 1976, the CAA has run a mandatory Occurrence Reporting Scheme, where we have asked industry to submit to us the quite low level incidents that are happening in the industry. We have given a guarantee that we will not take punitive action against those people who report to us, except in cases of gross negligence. We expect industry to behave in the same way and to use that data with us for continuous improvement. This is absolutely vital because as a regulator, without information and data about what is really happening on the ground, it is extremely difficult to know where to put what are quite scarce regulatory resources. We need the industry to believe that they can talk to us about what is happening in service, and that that information will be treated confidentially in a professional manner. We can then work towards the 'let us not let this happen again' type of scenario.

Finally, we need to plan for safety. As a regulator, we are in a unique position to be able to capture data from around the world – from the UK picture and the European picture – and to distil that into something that we in the industry can agree is a way forward for safety improvement.

The economics and morality of safety

To summarise, with regard to the specific issue under discussion today, risk cannot be zero. If we want air travel, there will be a risk. However, we think we have got the balance right, when we really reflect the norms and values in our society, in terms of risk versus caution. Our job, as a regulator, is to transfer those norms into what is quite a highly technical and complex environment. However, we must not forget that in society there is more than one public. Society and the public at large are the people who will be the final arbiters of that, in the way they react to the industry and perhaps even in the way they vote.

Lastly, I have an apology – especially to all those aviation enthusiasts – that I have not left you with a picture of an aeroplane. That is extremely remiss and it will not happen again! Thank you.

Open forum

Discussion and questions to the panel

John Turnbull: I have made a note of some points that have arisen. There is the question of the difference between hurdles set for government organisations and private organisations, which plays to a point made by Tony on the lack of understanding of the public perception of risk.

I heard this most brutally illustrated when comparing the civil aviation business with the healthcare industry. It is said that the NHS kills 20 people a day with infections and a further between 20 and 60 a day due to other mishaps. On confronting a health professional with this, he said, 'Of course, you see, we only do it one at a time, whereas a 747 crash kills 300 at a time, and that affects perceptions of what is happening.'

Then I was not convinced by your body language that you all quite bought into the concept of a statistical fatality versus a real one.

This issue of gross disproportion is something that maybe we should explore.

I am still intrigued by the difference between different types of person – not just in terms of life expectancy, as John Broome illustrated, but also as to whether they are a trespasser, a worker or a paying passenger. That strikes me as an issue worthy of exploration.

During the discussion, I wondered whether we were focusing too much as safety as an add-on – retro fitted devices that make things safer, as opposed to the built-in safety. There is the issue of simplicity versus complexity. In this context. I am thinking of the Channel Tunnel, where we added so much safety kit that it became inoperable and still today you are not allowed to take flash photographs, lest you stop the train.

I said I admire the civil aviation business and Ben Alcott touched on an issue that strikes me as crucial. That is the level of incident reporting and the willingness of a pilot to say, 'I set the flaps wrongly on that take-off', and to write a report to say that he made a mistake. This is a culture that one does not see throughout industry.

Those were the points that struck me but, no doubt, you will have many others.

Gordon Masterton (President, Institution of Civil Engineers): My day job is with Jacobs, and I guess that, as a company, we are very much in the zero tolerance philosophy for safety.

My point relates to the last point about the climate and culture for people to be prepared to discuss incidents. The biggest risk to companies is being run by people who are not risk-aware – especially high risk industries, of course, such as nuclear, oil and transportation. If the risk of prosecution becomes so significant in senior management positions in these industries or in any other,

then do you run the risk of the risk-aware people turning their back on accepting promoted positions because they are concerned about increasing their personal risk profile? Have we got the balance right between carrot and stick?

Post-Hatfield, I was very worried about that because there were many individuals who were prosecuted but, eventually, the charges were dropped – which was three or four years after a very painful process that they went through.

Following on from that, will a corporate manslaughter act actually assist or change the perception of risk of accepting very senior management positions in these industries?

John McDermid (University of York): First, could I take you back to this question of government versus companies, and their ability to pose different risks. That presupposes that a government really reflects the values of society and I would question that as an assumption. As voters, we have very limited choices and I suspect that we get to vote between two things we did not want, and so I very much question whether we can say that a government can pose more risk than companies. I would like a comment on that.

We have also been talking all along as though we know how to quantify risk. I have worked a great deal with the aerospace industry but my background is with software. Most of the cost to do with software is in finding out where the problems are: reducing the risk is cheap because it usually involves a relatively small change to the code that might cost a few thousand pounds, but it might cost you millions of pounds to find the risk. However, before you invest the money to find out, you do not know whether you will find anything and so you do not actually have a basis for making a judgement.

It strikes me that, in my discipline, which more and more controls our complex systems, actually applying ALARP is exceeding difficult. Although it is easy with hindsight, it is very hard upfront. With the sort of technology that we are dealing with, it is extremely difficult and I would be interested to hear people's views on that.

John Turnbull: I will ask John Broome to revert once again to this issue of government and the common good, and private companies grasping for profit.

John Broome: I was not so much commending the government for harming people for the sake of the general good, as the other thing – which is condemning companies for doing it. We are talking about a case where some people are harmed for the sake of benefit to other people. The default position – the position from which we should start when thinking about that – is that you cannot do it. You cannot go around harming some people just because that would be more beneficial to other people.

There is the famous case that philosophers talk about, which is what should happen in a hospital, where someone has been admitted for some kind of operation or another, but where there are five people in the hospital needing

organs. One needs a liver, another needs kidneys, and another needs a heart and so on. You could benefit those five by killing this person and distributing his organs around – but you cannot do that.

The main point is that, simply figuring out what is best overall is not enough to justify us in doing something. I did not really go much beyond that, except in issuing that as a warning. However, I said that there must be some political process that makes this legitimate in some circumstances because, otherwise, society would not develop. More or less anything that happens in society is bad for some people and good for others and so there must be something that makes this morally permissible.

One part of that is the political process. We authorise governments to have charge of coercion. They can do things to people and they can make people do things they do not want to do. Sometimes they are entitled to do that for the sake of the general good and so we have this political process which makes this possible, but private individuals do not have that. If a company is going to harm some people for the benefit of others, then it needs to obtain its authority to do so from somewhere or other – and this will come from the political process, somehow or another. So it will come through the government.

I do not want to say that the government has unlimited authority or even that we should trust the government to be doing this right because, of course, we cannot.

Peter Broughton (Peter Fraenkel Maritime Ltd): I used to work very much in the oil business and so I have a good deal of empathy with what Deborah said with regard to the targets for safety, and also with the point that was made by Mr Masterton. The last project I was involved with was with Philips Petroleum Company and it was a major decommissioning project in the North Sea. After going through that exercise, I came to the conclusion – with all the facts at my disposal – that I would not take on that type of high-risk project or project management because there was too much downside to it. There is a disincentive for people to evaluate what they are doing, the consequences and what could happen. There is a real problem to get people to do some of these rather dangerous jobs.

Another point that would improve safety is a great deal more transparency as to what is going on in the various industries. On the particular project that I worked on, we introduced a safety philosophy which was very proactive – and I am sure Deborah would agree with it – and it encouraged people to report near miss incidents, for example, by giving payouts. People could report as many near misses as they wanted to, and they would receive payouts on a monthly basis. Only by following that sort of learning curve do you really understand what is going on.

Another point – which I have not heard today – concerns all the tools and procedures that are available to manage safety. We have talked about many philosophical issues but there are many rigorous tools. The gentleman from the Civil Aviation Authority touched on some of these things. With HAZOPs and HAZIDs, we regularly sit down and discuss hazardous operations and

hazard identification in every procedure executed, and that is the only way to capture and deal with some of the things that can potentially go wrong in these major projects.

John Turnbull: I like your point on transparency and that is why I love the Civil Aviation Authority – I cannot help coming back to that, because they are so transparent.

Andrew Evans (Imperial College, London): There is a somewhat inexplicable difference between road safety - preventing accidents on the roads - and preventing accidents in most of the other sectors from which we have heard presentations tonight. However you define 'as low as reasonably practicable' – if, having done your analysis, you conclude that something is reasonably practicable, then none of the sectors represented by the speakers would not do it. Colin Dennis was very explicit and said that if they interpreted the law as saying, 'Well, this is what the Health and Safety at Work Act says', they would then have to do it. Pleading poverty, or the fact that we did not have a big enough budget, would not be accepted as a reason for not doing it. In road safety, on the other hand, it is routinely accepted. The distance to which people – or local authorities – will go in implementing safety measures is constrained by their budgets and by their staff, and that is perfectly accepted. That is a rather striking difference.

The road/rail issue has been raised. It is true that the most expensive rail safety measures, latterly, have been of the order of £10 million per fatality prevented, while the road ones are probably a little more than £100,000, so that there is perhaps a factor of 50 between them, but not more than that.

On a general point, in this discussion it seems important to distinguish trade-offs between safety and costs where we are actually on what the economists would call the efficiency frontier, where you cannot have more safety without actually sacrificing some costs. When you are inside that frontier you can have both. Many accidents are caused inside the frontier - where it is not that the wrong judgement that has been made but it is just that some error has been made within the organisation. That is an important distinction.

David Andrews (University College, London): I was going to say that there is another industry that operates rather like the road industry in its disregard – almost – for life, and that is out at sea. Historically and still today, there has been a disregard for the lives of fishermen, for example. There are also the incidents associated with ro-ro shipping which needed big disasters before something fairly obvious was done.

I would be interested to hear people's views on whistle-blowers, which one inherently thinks is a good idea. However, sometimes a little knowledge can be a very dangerous thing and it seems that there is quite a conflict between a desire in good companies to listen to whistle blowers, and people who are being just plain malicious.

Mike Robertson (Risk Solutions): I would like to ask the panel collectively to give a response to how they think societal concern should be taken into account in safety decision making. Colin touched on it in terms of what RSSB

are doing for the rail industry. Colin showed the tolerability of risk framework which the HSE has provided but, of course, he omitted societal concern from the risk axis. I would quite like to hear the regulator's perspective on that first, and then the panel's views on whether it should be up to government to decide what societal concern is and what should be done about it, or whether it should be left to private firms to try to invest that in their safety decision making process. I would be quite interested in a global firm like BP, which has a different range of cultures, as well as different societies within those countries, to undertake that.

John Turnbull: Could you elaborate on what you think societal concern is?

Mike Robertson: I could give you my answer but I would like to hear the panel's answer.

John Turnbull: I just wondered what you mean by societal concern. I will tell you what is in my mind. With regard to this question of road versus rail, there is this technology that consists of cameras and speed measurement devices, which are intended to improve safety. However, like fishermen going to sea, driving a car is such a romantic, heroic thing, that we have to paint these devices yellow. We defeat the whole object of the exercise. So society is totally unconcerned about road deaths. Is that the sort of thing you mean?

Mike Robertson: I am not sure that that statement is actually true. It is what you mean by societal concerns, which is actually the loaded question. I am particularly looking at Tony here. If you understand what you mean by societal concern, then how do you measure it? And, if you can measure it, how do you take account of it in your safety decision making process?

Tony Bandle: I indicated in my opening presentation that one of the things we need to try to take account of is – and I used the phrase – ‘societal expectations’. There are two levels on which you need to do it. One is on the policy-making level and the other is operationally.

At a policy making level, it is an issue about the nature of the regulatory regime that you put in place, or do not have in place, and this is influenced by a number of factors. Any social researchers here will know very well that the approach we use is to take the psychometric model that has been provided by people like Slovic, and this has had a great many years of people trampling all over it, and it has been reasonably robust. This has essentially said that there are four or five axes on which you can represent broad public concern in terms of dread, the degree of control, your confidence in the regulator and your trust in the track record of the industry and so on.

When you are making policy, whether you do it implicitly, or more explicitly – and, as Mike knows, there are tools around to help you do it more explicitly – you bring that into your judgement. However, I will not try to pretend that you can do that with any degree of accuracy or quantitatively. These are merely indicators to you that you might expect a particular type of regime or perhaps a harsher regime in some areas than you would in others.

I will try to illustrate that with an example. If you had an emerging technology,

and you did enough market research with people to find out where their concerns lay, you might well find out that that technology was going to be developed in an industry which, in the public's opinion, had a pretty poor track record. You might therefore look to a commissioning regime which will require higher standards of safety management systems and all the rest of it.

On the other hand, there might be something inherently "difficult" about that technology – and the obvious one that comes to mind goes back to my previous history, with radiation protection and the whole of the nuclear and radiation issues. There are some interesting nuances around that as well as what people perceive as being radiation. But we do not have time to go into that now. You might actually decide that your legislation is much more about the immediate control measures and you might want that to be dealt with in a very controlled way.

In genetic engineering, we have had to put resource into understanding what the public expects, and indeed what the industry expects in terms of public reassurance. This is because, in some cases, those technologies could not be developed without that degree of public assurance, and we have therefore opted for a regime which is partly about enclosing the products and partly about a commissioning regime which keeps quite a close oversight on this. Hopefully, we have also done this in a regulatory way, which will allow that regulation to be adapted, as our understanding of that technology grows and improves. That is my take on societal concern.

There is another dimension to that, which is the societal risk one and which I do not particularly want to explore because it is a hornets' nest. However, operationally, we have made the decision that societal concern in most cases is too big an issue for an individual company or group of companies to deal with and so it should be dealt with at the regulatory level. For certain industries, where there is a very clear risk beyond their sites, which is related to large number of people potentially being wiped out, we have said that they need to take that factor into their equation when they set the standards of expenditure on safety. They need to include that in their safety cases, and I think that is quite reasonable.

John Turnbull: Deborah, BP sets great store by its perception in society and its interaction with the community. What does societal concern mean in the oil business?

Deborah Grubbe: I have only been in it for 10 months but I will give it my best shot.

There are multiple factors and it is very difficult to give one answer that fits around the world. It depends where the development is going on or where the actual infrastructure is located. It depends on the level of education of the population, and the level of education and rigour of the processes of the government, and the people in the government. You may have a population that may not understand or have a depth of understanding, if you are in a very remote area. There is a different level of understanding than if you are in Southern California. In a remote area there may be a government that may be corrupt, or there may be other issues and factors in play, so that it is very difficult to say that 'It is always like this', depending on the location.

It is therefore incumbent upon companies like BP and our peers to develop consistent policies and to operate in a consistent manner, no matter what the environmental aspects that we find. This means that we work with the local populations and with the government and we offer goods and services that the populations say that they need to better their society and to try to be a net positive contributor.

John Turnbull: Mike, could you just say a few words on how you see societal concern. You tell us that you are measuring it pretty accurately.

Michael Jones-Lee: I was going to say that societal concern is a hornets' nest but I am perhaps more inclined to say that it is a container in which there are many difficult issues. However, to be simple about it, I would view societal concerns as, in some sense, captivating or capturing those issues that you will not necessarily pick up in a straight willingness-to-pay exercise – the concerns about children, or about old age pensioners and indeed the whole issue of equity and fairness. One way of caricaturing it is to say that, in some sense, when one does an empirical willingness-to-pay exercise, one is asking people to wear a 'self-interested' hat, whereas when considering societal concerns, you are asking them to behave as citizens. I will not say more than that.

Roger Short (Atkins Rail): On the question of societal concern, I wonder whether one important factor is not so much the source of the concern in society, but the target of the concern. When it comes to questions of road safety, the responsibility for safety on the roads is very diffuse. It is diffused among all the road users, as well as the Highways Authority and so on. Thus, whilst society may be very concerned, say, about the safety of children crossing the road, the societal concerns have no specific targets to aim at. In industries like railways, nuclear power and aviation, however, safety is the responsibility of a fairly small and identifiable group both within the industry and in the regulators of the industry. They will certainly feel themselves to be the target of societal concern and they are therefore likely to react to that in the way they make their safety decisions. It may be the target rather than the source of the target that accounts for the difference in response in the different industries.

John Turnbull: Yes, I know many mothers who are so concerned about the traffic on the roads that they drive their kids to school.

Richard Williams (Mott MacDonald Limited): I have a point to make on the earlier issues about legislation that could be brought in, and the impact of prosecuting people. I would suggest that the Royal Academy could well have a good influence on the government in this area. There is the point that the gentleman made about the fact that he would not want to participate in a high risk project. That means that we will have more fools than wise managing industry if more legislation is introduced. That is a very strong argument. I think leadership will prevail but, at the same time, it will probably produce an industry that is very moribund and where innovation is extremely limited as a result of that sort of legislation. I think it will be very damaging, but that is just a view.

The question I would like to raise, possibly for Professor Broome, builds in the last point. So far, nobody seems to have mentioned the distinction that I have

found in this road/rail question. I have spent 30 years in the rail industry and so I have thought about it a little. There is the fact that often, where the individual is taking the risk, their tolerance to failure and risk is very high. In other words, they will take risk. Whereas, when it is a body or organisation taking risk, they demand an unreasonable amount of safety protection.

I would like to build on that a little further. Is this a very British thing that we are talking about tonight, in the context of the discussion here? For example, when you go to Germany and observe people crossing the road, they will say, 'Of course, I do not cross the road when the light is red. I stand still and then, when the light is green, I cross the road.' Then there are others who will tell you that people are sometimes hit by car but it is logically correct because they crossed on red. So does some of this societal concern and behaviour actually also have a good deal to do with society in terms of being British?

John Turnbull: Before you address that question, John Broome, could I just come back to the first point which is an important point? Ben, coming back to civil aviation, you seem to have avoided the situation that we have in the rail industry now, where an accident is immediately the scene of a crime. It is roped off and the police take over and, as an investigator cannot get there until the police have done their thing. How has the Civil Aviation Authority avoided that?

Ben Alcott: If we had someone here from the Air Accident Investigation Branch, they might argue that this is something they face on quite a regular basis – especially with private pilots' accidents, which we obviously see more frequently. It is probably true in the public transport arena – partly because it is such a rare event and such a catastrophic event that even the police will want to stand back and let the professional accident investigators become involved.

In talking to the AAIB, however, they occasionally do have problems – depending on the police force and the culture within it, which can quite often determine what will happen when the AIB investigator arrives.

John Broome: I was rather worried because I thought I was being asked whether being British makes a difference, and I will not try to answer that.

I just have one simple thing to say. When I said that private companies may not impose risks in the same way as governments do, I was talking about imposing risks on people who do not choose to take those risks. Things are quite different when people are able to decide, or when they have some role in deciding whether they take on a risk – when they decide whether to drive, or to buy a plane ticket from a company whose safety record they can look at. That enormously complicates the issue, and that now raises the question about when is it right for us to take risks ourselves – and that has quite different answers. I was talking about the simple case of risks that are being imposed on other people by private companies and, of course, private companies do that. As I say, they send their vans around the town and they may kill somebody.

David Newland (University of Cambridge): I would like to take up the earlier point about Britishness. It has puzzled me for a very long time that the attitude that we take in Britain to nuclear power – and when I say we, I mean society in Britain – is completely different from the attitude that the French take to

nuclear power. We have come from the same starting point but we have reached the point where, in France, something is fully accepted as the natural part of human activity. In my experience, the French are very happy with what is happening while, in Britain, we have been tremendously nervous of nuclear power for many years and this has affected politicians. The result is that our energy policy, in the view of some of us, has been distorted for too long.

I do not want to go into that, but I would like to ask the panel to comment on the fact that the people in one country can have a whole different view and perspective on risk from people in another country. This is not just the Third World but it is the West, and two countries that are only 25 miles apart.

John Turnbull: We will keep that in mind in case we have time at the end for the panel to comment on that. But I see that here are many other points you want raise from the floor.

Len Porter (Rail Safety & Standards Board): I spent a long time in the oil and gas industry before entering the rail industry and I would like first to make a comment about societal concern, with respect to Shell, who had the unfortunate incident with Brent Spa. Shell did virtually everything they could – they did everything right in terms of risk analysis and environmental impact assessment and decided what they would do with Brent Spa. Then, however, the media became involved and stirred up the public to such an extent that they lost about 25 per cent of their revenue in Germany and other parts of Europe. This caused them to change their mind completely, and Greenpeace were very much a part of the stirring up, in terms of the media. Thus, you could actually link societal concern in this case to the media.

The RSSB has done a great deal of research during my time in the rail industry into issues of societal concern and stakeholder values generally. We have concluded that societal concern is very often a product of the media. That is a key point that I would like to make.

Secondly, moving into the rail industry, I would like to pick up on both the oil and gas presentation and indeed the presentation made by my colleague, Colin Dennis. There are lessons from the formal inquiry reports - the accident investigation reports. This is something that the RSSB facilitator did on behalf of the industry until very recently and it has now been picked up by the Rail Accident Investigation Branch, although we still do some work in that area. Broadly speaking, if you separate the output into some broad areas, you find that the people in the rail industry failed to specify their work very well, and they failed to plan. They failed to communicate effectively and there is a lack of competence normally associated with the accident. Those things, normally speaking, are at the heart of most of the accidents.

Many of those words were in Deborah's presentation. We call this a safety issue but, if you look behind that and you fail to plan, and you fail to specify your work properly, and you catapult from requirements definitions straight to installation and commissioning to operation, then you will do a bad job. If you fail to communicate effectively and you have poorly competent people, then it will affect your business because these are business decisions.

At the heart of all the arguments safety is definitely not a bolt on – as several of the speakers on the panel have emphasised – and it is very fundamental to business. The Safety Decisions Programme that we are running, and the very essence of the research that we are conducting, would lead me to believe that this is not a Safety Decisions Programme but a Business Decisions Programme. It is just a decisions programme, full stop.

That is just a comment but I wonder whether any panel members would want to respond to that.

John Turnbull: They will, in due course.

Bob Malcolm (Ideo Limited): I do not have much of a problem with rationality, usually, but I have a huge problem with statistics. I would like to pick up the point that John McDermid made earlier about not being able to get the numbers right. I am not talking about where we can get figures, such as on rail and roads, but I am talking about the very low probability and very high consequence accidents.

I have been peripherally involved in looking at the decision making of authorities over GM foods, the introduction of the Basel Accord in the financial industry, and even more peripherally over the foot and mouth outbreak. In every case, in sectors which were not familiar with concepts like HAZOPs, they effectively took an inventory analysis approach to it and they missed out swathes of possibilities and therefore probabilities. The numbers were frankly wrong in almost every case.

John Broome makes the point that governments have the authority to make decisions and to impose disbenefits, in fact, but I would argue that the government is not very well informed, in general, because of this – because the experts are not. The governments obtain their authority through a political process, but who runs the political process? Us, the public – and are we well informed? I have a constant problem with that, not with the rationality, but the process that we think is rational is not really rational.

Ian Dalling (Unified Management Solutions): We should perhaps think about whether there is a distinction between risk management and overall management, or is all management risk management? We need to be conscious of what we are really trying to optimise. All too often – as in the conversations earlier – we are talking about the number of deaths, but are we really not trying to optimise happiness in society? If we look more in that direction, we will probably satisfy society in general to a higher level.

We now very often hear how life is being extended as opposed to the quality of the life, which particularly upsets me because I would prefer a higher quality of life and have it be much shorter. We have to take account that the media, and people's so-called irrationality, is a part of life. Organisations have to deal with that – with respect, it is not the theoretical structures that come out of think tanks and universities or whatever. I do not know whether there is any sympathy with that view.

Stefan Tietz (SB Tietz & Partners): Everyone here will know about BATNIEC and ALARP. The alternative to ALARP has always been BATNIEC and I do not need to spell that out because everyone knows. Is it actually reasonable to believe in ALARP, or is ALARP cheating most of the time, because economic considerations are quite unavoidable?

John Turnbull: I am sorry, floor, but we need to finish there. I will give each member of the panel a brief opportunity to respond to outstanding issues.

Jeremy Western: I am slightly over-awed because Gordon did such a good job for the nuclear industry, but I am from British Energy too. There are a number of themes. I spent much of my career in the CEGB at the Sizewell inquiry and then subsequently in the privatised industry – all the time on safety.

Summarising my thoughts following what I have heard today, mentioning things about the public sector when I was in the CEGB compared with the private sector, it does not always go the way you might think. The CEGB readily agreed to spend a great deal of money on the Sizewell design, to take it to a completely different position beyond the world standard for a pressurised water reactor. It did so because it could afford to and it would not be hit very seriously, and it wanted to get through a public inquiry.

In the private sector, money is looked at rather differently. Does that lead to less or better safety? Actually, it is often better to look very critically at bolting lots of things onto complex designs, as the private sector probably would have done more, and go for more consistency and commonality of design. That is just a reflection of a little experience of public versus private.

On the attitudes of senior people and risk of prosecution in relation to safety, I have seen many different people at the top of our company and it seems to be absolutely crucial that leaders in high hazard industries have the imagination and the competence to understand what their technology can do. I went to Chernobyl after that accident and I saw what happened there, and it does make a difference. The truth of it is that, certainly in the nuclear industry, most of the safety issues are carried out below that leadership level, so that the leaders are there to create the right organisational culture for safety, and to make sure that people know the direction in which behaviours are being encouraged. So they have an enormous impact on culture and not so much on detailed safety decisions.

Societal risk and societal concern are big issues in the nuclear industry. I would explain societal concern as being when society pushes you to go beyond what you and the regulators believe is a sensible balance. That is perfectly legitimate because we are in a democratic society and, if that is what society wants, then there must be a way to take that into account.

My concern is where the regulator tries to take it into account, on top of the normal processes, because this leads to a great deal of uncertainty for people like us, in trying to work out what the regulator needs.

There are many interesting issues and this is a fascinating area. I would like to thank the Royal Academy for creating this debate.

Ben Alcott: I will start once again with the issue of societal expectation and concern. There is certainly an expectation, as we have discussed at length tonight, around the purchase of a ticket and the expectation that, with that in your hand, you have a reasonable chance of reaching the other end of your journey.

As for societal concern, some of this is media-driven – although not in its entirety. As a regulator, we have an obligation to explain our decisions to the public, either to allay that concern or to go along with them. We certainly do not implement everything that society has wished us to at the time. A good example from the aviation industry would probably be the fact that we decided not to mandate smoke hoods after the Manchester accident, despite huge public pressure to do so. Our view, from the research we had done, was that more people would perish in trying to fit them during the accident than would if they just tried to get off the aeroplane. Nevertheless, there was huge pressure at that time for us to go down that route – but in the event we resisted it and explained the reasons behind it.

The challenge for us as an industry in the future is on the culture side. On the design side, we have been very successful in terms of designing engines and aeroplanes that very rarely fail. The challenge in the future will be along the lines of the human interaction with that product from the moment it leaves the factory to the moment when it finishes its service life. That is where we are concentrating much of our effort. We have this problem of having to deal with low accident rates and how to cope with the fact that the worldwide accident rate for aviation at the moment is around 0.2 per million flight hours. That is incredibly low and it includes some of the accidents that we see in some of the Third World countries. If you just take Western Europe, the figure is even lower than that, so we have to deal with this concept of very low rates and how to push that further. This really brings us back to the culture and the human interaction in the field.

Michael Jones-Lee: I would like to make just two points, which have been raised in the last few minutes. The first related to human happiness and quality of life. It is very important to stress that, contrary to the popular conception of economists as people who are really only interested in money, we are actually really interested in maximising social well-being. The willingness to pay approach to the evaluation of safety is an admittedly imperfect attempt to capture people's views about their own well-being.

The second point that interested me, and which arose late, was the media issue. The role of the media in the whole safety area is very interesting and complicated. Some people would argue that it is media hype, and media hype alone, that has driven the whole business of the road/rail disparity. Well, is it really? I am not so sure, but I am quite certain that, in some degree, it is responsible.

My two points to underline are, first, that economists are concerned about well-being and about meeting people's preferences, and the second point would be in relation to the media.

Tony Bandle: I will outdo Mike, because I actually have four points – but I will make them quickly.

1. Just because something is liable to prosecution does not mean that people will be prosecuted. If you look at the track record of my organisation, you will find that the people we go after are either the ones who have criminal intent, or the ones who are so incompetent that they deserve to be prosecuted.
2. We have talked a good deal about some quite intellectual issues but someone from the floor raised the question whether this is just about good management – and I think it is. A point to convey to people is that if we could only have a reasonable standard of what I would call sensible risk management across all sections of industry, we would make huge improvements without being bound up in the business of whether it is ALARP or not, and all the rest of it.
3. I remember Baroness Onora O'Neill's point at one of the Reith lectures, which fits in with some of the research we have done ourselves: do not rubbish the public, because they are very capable of making some very sensible decisions. You are the public and we can make some very sensible, rational decisions. We have conducted a number of exercises where we have involved people in decision-making in some very complex technical areas, and they come up with some very sensible conclusions. They are part of the decision-making process. I will not deny that the media has a hand in stirring things up, or keeping some things damped down that ought to be stirred up, but they are not at the root of the issue. What we are talking about here are people's preferences and, if we ignore those, then we are not doing justice to the democratic process or, in my case, my role as a regulator.
4. My final thought is that it is quite interesting, in a debate like this, that I am not aware that we have any social researchers here at all. It is a great pity that there is not a greater meeting of social researchers, engineers and technicians in these sorts of discussions. I am sorry – I now see that we have one or two here but, on the whole, we do not have many and that is a great shame.

John Broome:

This is something that I have wanted to say for an hour or so, because it is very important. There are always trade-offs. However safe you are, you could always be safer. You could always find ways of making yourself safer. It may be very expensive, but you could always do it. What stops you doing it, therefore, is that, in the end, it is not worth it. If you are to do this properly, you have to be aware of that. You have to balance the costs of being safer against the benefits of being safer and, if you are not doing that balancing, then you are not working out properly how safe you ought to be.

Deborah will have the chance to respond to this, so I shall say one more thing. If indeed it is true of DuPont that, for every dollar it spend on safety, it made \$4 to \$5, this means that DuPont is not spending enough on safety. It is not even spending enough to maximise its profits, and it is certainly not spending

enough if you take into account the external effects – that is to say, the effects on other people. How has it got itself into this position? Well, this is just speculation, but perhaps it has the wrong attitude. Perhaps it thinks that what it should do is to be as safe as possible and it does not concentrate on those trade-offs that it really needs to make.

Deborah Grubbe: I will pass on the DuPont comment, other than to say that DuPont sells safety and it is one of the largest safety consulting businesses in the world.

I would like to address the notion of cultural differences, although I will not touch the Britishness comment – because I do not consider myself an expert on that. However, family-based cultures in my experience, both in BP and DuPont, see differences in safety and how it manifests itself in the workplace, due to the nature of the family relationships being carried into the workplace and creating a workplace family.

On the second point, on the media question, while the media may stir things up, it is a common problem for both of our nations that our public is relatively uneducated in the finer points of scientific knowledge. This causes other issues. I happened to have dinner with the former head of Greenpeace and I asked him what was their methodology – and the methodology is really very simple: a large amount of emotion and a tiny amount of fact, whereas for engineers, it is the other way around.

Lastly, there is the notion of risk being an inexact science, and I can only offer an example. When the first quantitative risk analysis was done on the space shuttle in the late seventies, the model predicted that there would be one shuttle incident, or one shuttle lost, in 100. After Colombia, when the model was re-run with the new data, it predicted that there would be roughly two shuttles lost in 100, which is exactly what had occurred. When the press got hold of this, they said, 'The shuttle is less safe than it was in 1979!', which is why we have to educate those people. All of you know that that the shuttle was no less safe, but that we just knew more and could do a better job. Thank you.

Colin Dennis: It appears I almost have the last word. Within the context of the railway industries, and of the other industries represented here today, it is very important that we recognise that safety decisions have to be made on a day-by-day basis and we cannot shy away from that. The need for some structured framework with some criteria about how to make those decisions is a very important aspect. The absolute worst situation would be to have no criteria and nobody to make a decision, because the safety definitely does not improve. The work that we are doing to bring into the kind of work that Mike is doing, on valuing and preventing fatalities, and the whole framework process, will help us in that decision making process.

A comment was made about keeping society happy and, in relation to the railways, if you ask society and particularly the passengers who use railways for their perception of the railways, it is not about safety but it is about whether the trains turn up on time, and whether they are a clean and pleasant environment in which to travel. Safety is not a concern. However, these issues are all inextricably interlinked, because it is the whole perception of the

companies and the operators and the way in which the trains are run, which gives a good image of a good organisation, and therefore one in which you can have confidence that it is managing safety well.

John Turnbull: I shall not attempt to sum up these proceedings, except to say that this is really the story of my life. I slave away to organise a technical seminar in which we will have an exchange of engineering views, statistical models and safety technologies, and it descends into this wishy-washy cultural, societal, making-people-happy stuff.

To be serious, this plays to an important theme which has been running around the room, and it is that – as technical people and engineers – we do not communicate at all well. If you rely upon John Gummer and his daughter to explain food safety, you are in trouble. We experts really must have the courage to put our heads above the parapet. From my earliest days, I was trained to run a mile if I saw a journalist. But that was the most stupid advice that could ever have been given: Journalists need material and they need copy, because they live off it. If we refuse to talk to them, and if we refuse to express ourselves, we get what we deserve in return.

A very big thank you to you all for a very active discussion – which could have gone on much longer. Please join me in thanking this panel.

Close of Meeting

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