Safety:

a short RoSPA guide to core concepts

version 2

Acknowledgements

In preparing this guide thanks go to:

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More to follow

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1) Introduction

Safety needs careful thought and discussion to arrive at decisions that are balanced, fair and effective. But all too often the quality and outcome of dialogue about safety issues can be impaired because the different parties involved do not share a common language about safety and a common understanding of core concepts and precepts.

This guide, which is a short introduction only, has been prepared by RoSPA to help promote a disciplined approach to the use of some of key terms and ideas that surround safety decision-making. It is intended specifically as an aide-memoire for opinion formers, educators, political representatives, decision makers and other professionals. It draws together a number of fundamental assumptions and ways of thinking about safety and risk which we hope readers will find interesting and which will prompt them to venture further into the subject (see suggested reading list at annexe one).

2) Safety and accidents

Safety is a basic human need, arguably as essential as shelter, clothing or food (if not more so). Before we can accomplish any endeavour successfully we need to try and ensure that we will not suffer or cause unacceptable harm. Yet in practice this is never easy.

Whatever the area of activity, at home, on the road, at work or in leisure activities, dangers are not always foreseeable or sufficiently understood and precautions often fail, prove to be inadequate or are simply not implemented.

Every year in the UK there are over 14,000 deaths as a result of accidents and over 5 million A&E level injuries. Accidents can ruin lives and wreck families. They also impose a massive financial burden on individuals and the community. But the fact that there are not even more accidents testifies to the fact that, whether as individuals, families, communities, work organisations or indeed as a whole society, we are taking steps daily to spot hazards, assess risks and take measures that enable us to stay safe.

Yet, even though we may have good information about hazards and sophisticated analytical tools, we can never forecast the future precisely. Absolute safety is thus an impossibility. We just have to weigh things up in the most appropriate way and make the best choices we can.

Risk is inevitable; accidents are not.
Accidents happen because they are not prevented.
The majority can be prevented quite easily by adopting proportionate safety measures.

3) Assessing risk

Whether we are conscious of it or not, as individual citizens or as part of wider social groups we have no option but to engage in risk assessment.

We all have to make sound judgements about matters as mundane as how to cross the road safely or handle hot liquids in the kitchen or we may be challenged to form opinions about matters as complex as the safety of nuclear power.

Much as we might like other people to make these judgements for us, risk assessment is something we all have to engage in.

In fact we assess risks whenever we have to act prudently in the face of relative uncertainty, be it tackling questions of safety or making choices about matters as diverse as finance, career moves, relationships or politics. The way we do this in practice however varies a good deal, from using 'gut feel' through to systematic evaluation of available evidence.

4) Safety decisions

It is often claimed that safety is just common sense, yet assessing risks adequately and making sound decisions about safety issues is never easy. Often decisions designed to prevent accidents give rise to fiercely differing reactions.

Here are some examples of personal decisions about safety. Opinions will vary as to which are sensible and which are unsound.

never traveling by air;
not using hands free mobile phones while driving;
always taking children to school by car;
not eating vegetables that have been grown with artificial fertiliser;
giving up smoking;
eating five portions of fruit/vegetables every day;
always cooking chicken at gas mark 5 for at least 20 minutes per pound plus 20 minutes;
always peeling carrots before you cook/eat them;
keeping your fridge at least 5 degrees centigrade or under;
always washing your hands after going to the lavatory;
always wearing a cycle helmet;
not drinking more than 21 units of alcohol a week (men), or 14 (women);
always wearing a respirator/mask when cycling in the inner city;
not giving your child the MMR (mumps, measles, rubella) jab;
only using a registered electrician;
not using the Channel Tunnel;
never riding motorcycles;
never driving at night.

And here are some examples of public decisions about safety issues that have been made – or might be made - by Parliament or safety authorities. Again opinions will vary as to which are justified, which are inadequate and which are 'over-the-top'.

banning the private ownership of hand guns;
compulsory child car seats;
the Dangerous Dogs Act;
banning polyurethane foam in furniture;
expanding the UK Nuclear Power programme;
48 hours as a maximum working week in the EU;
fitting interlocks to passenger train doors;
all seater football stadia;
Criminal Records Bureau checks for all nursery staff;
licensing outdoor activity centres;
raising the motorway speed limit to 80 mph;
banning all new uses of asbestos;
security screening of all visitors to the Houses of Parliament;
allowing cycling on the pavement.

Then there are legal safety limits, for example:

80mg/100ml blood alcohol concentration for drivers;
17 years as a minimum age for car driving;
0.05 fibres/ml air as clearance level following asbestos work in buildings;
1.6 mm minimum tread depth for car tyres;
taking a break after 30 minutes work at display screen equipment;
having toe boards and guard rails in place for all work on scaffolding; or
20 milliSieverts maximum annual radiation dose for workers.

Inevitably there will always be debate about exactly where safety limits are set.

Views on safety vary. What seems reasonable to one person or group may not seem so to others.

For example, those whose activities create risks for other citizens may consider the precautions that they take are adequate. On the other hand those who are put at risk may take a different view, particularly if they derive no benefit from the activities concerned.

People who may be excessively 'risk averse' (for whatever reason) can often advocate taking safety measures which are wholly disproportionate. And arguments that risks, however small, are unacceptable can be used as a device by those who oppose change or as a convenient excuse for banning things or not taking action.

Some common problems
And challenges…

Mixing up hazard and risk
Risk management or risk elimination?
Abuse of the precautionary principle?
How tough should we be (belt and braces)?
Action at source versus personal protective equipment and training?
Primary, secondary, tertiary safety solutions?

5) The need for a common language

Too often dialogue about safety is unproductive or even highly fractious because those involved are 'talking past each other' or do not share common definitions or assumptions. For example, safety decision-making raises some fairly fundamental questions:

What do we mean by an accident?
What do we mean by risk?
What approaches should we adopt to risk control?
What do we mean by 'safe'?
Can or should all accidents be prevented?
Must some level (or kinds of) of accidents always be accepted?
Who decides?
And how do we know they're right?

In RoSPA we call the ability to engage with, articulate and apply these ideas 'safety and risk literacy'.

Further problems and challenges…

Exaggerated perceptions of risk?
Over-simplifying accidents?
Condemning human error?
Shallow investigation?
More or less regulation?
Safety and politics?
Knee jerk reactions?

The sections which follow explore core definitions, concepts and ways of thinking which we regard as not just useful but essential to enable people to make sound contributions to safety decision making.

6) What do we mean by an accident?

This question gives rise to endless debate. Some people say that the term 'accident' can only really be applied to truly random events devoid of human content. For example, being struck by lightning. They argue that all other kinds of adverse event involve human failings of some sort and should not be described as 'accidental'. Others say the term 'accident' can be any kind of unforeseen event, even ones with a positive outcome. Most however accept its meaning in common useage when applied to unplanned events leading to harm. The term 'accident' can also encompass 'incident', for example, a potentially adverse event which has not caused harm or it may even be used to describe an unsafe act or condition which might have led to an incident or accident.

For the purposes of what follows we want to suggest that an accident is any unplanned, unforeseen, adverse event causing harm or having the potential to cause harm. This is quite broad and it can include, for example, intentional injury where this was not foreseen by the injured party (for example, an assault in the course of a robbery).

7) What do we mean by a hazard?

There is a lot of confusion about terms such as 'hazard', 'danger' and 'risk'. Often risks are described as hazards and vice versa. Generally speaking the term 'hazard' is taken to mean anything that could cause harm. Hazards can be:

physical factors (such as potential or kinetic energy, heat, blast, radiation, vibration etc)
chemical agents (toxins),
biological entities (micro-organisms, animals and people even), or
psychological factors (e.g. stressors).

All human activity involves exposure to hazards. Unless appropriate preventive action is taken (and given sufficient time), exposure to hazards will nearly always lead to accidents.

8) So what do we mean by 'risk'?

'Risk' is a more complicated idea but one which is essential to grasp and use in a disciplined way if one is to engage in serious discussions about safety. Risk addresses the chance or the probability that an accident will happen but it is a little more complicated than that. It describes the chance that an accident will happen with a certain level of outcome. In others words, 'risk = probability x consequence. So exposure to hazards can give rise to risk that can be can be:

high consequence/high probability
low consequence/high probability
low probability/high consequence
low consequence/low probability

On this basis it is useful to describe risk in terms of 'level':

very low risk; (1-2)
low risk; (3-4)
medium risk; (5-9)
high risk; (10-16) or
very high risk (17+)

Semi-Quantitative Risk Assessment

Severity

1. No lost time injury / minor damage
2. Minor injury (less than 3 days off)
3. Reportable injury (more than 3 days off)
4. Major injury / major damage
5. Fatal / Catastrophic

Probability		**1**	**2**	**3**	**4**	**5**
1. Very unlikely	**1**	**1**	**2**	**3**	**4**	**5**
2. Unlikely	**2**	**2**	**4**	**6**	**8**	**10**
3. Likely	**3**	**3**	**6**	**9**	**12**	**15**
4. Very likely	**4**	**4**	**8**	**12**	**16**	**20**
5. Certain	**5**	**5**	**10**	**15**	**20**	**25**

Risks we encounter in life can be deemed:

intolerable
tolerable,
acceptable or
trivial

although, as we shall see, in practice these tend to be difficult and contentious concepts. Nonetheless it gives us a way of scaling our appraisal of risk.

In numerical terms risk of a particular outcome can be expressed on a scale of zero (or virtually zero) to one. (Risk = p x {specified harm})

9) Risk assessment

To many people, the term 'risk assessment' conjures up a complex technical process. Of course some risk assessments are complicated because the situations or systems being analysed are indeed quite complex and there can be many uncertainties. But risk assessment is actually something we practise every day as individuals, often quite unconsciously, for example, when driving a vehicle, negotiating a stairway, doing DIY, cooking and so on. It's about spotting hazards, working out how harm might occur, how likely it is things might go wrong, who might be harmed and how, and how bad the consequences might it be. And the reason we do this, whether the situation is domestic or industrial, is to help us answer basic questions such as:

- are we sure the activity is justified? (For example, is the risk balanced by benefits? Or is there a safer alternative?)
- if so, is the level of risk broadly tolerable? and
- are our control measures adequate and suitable to make it acceptable?
- if not, what more do we need to do?

Risk assessment can be conducted at various levels:

- generic (a broad assessment for general situations); or
- specific (fine tuning a generic assessment to take account of particular circumstances or features of an activity) – but nearly always it will also be
- dynamic (taking account of movement and change).

When assessing risk, having identified a hazard(s), it is often important to understand the spread of outcomes that can follow from an unplanned, adverse event to which the hazard can give rise. The same event or interaction with a hazard can have different outcomes, for example:

near miss;
damage only;
minor injury;
major injury or
fatality(ies).

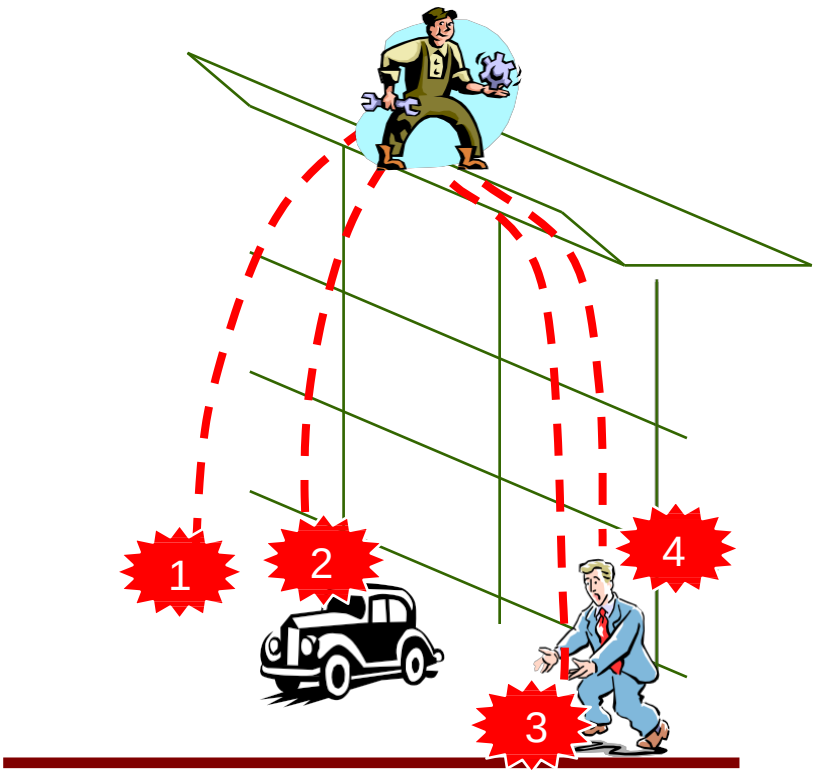
Or the severity of outcome can nearly always be the same (for example, fatality as a result of falling from a great height).

When studying accident data therefore it is important to remember that, very often, for every fatal injury there are likely to be:

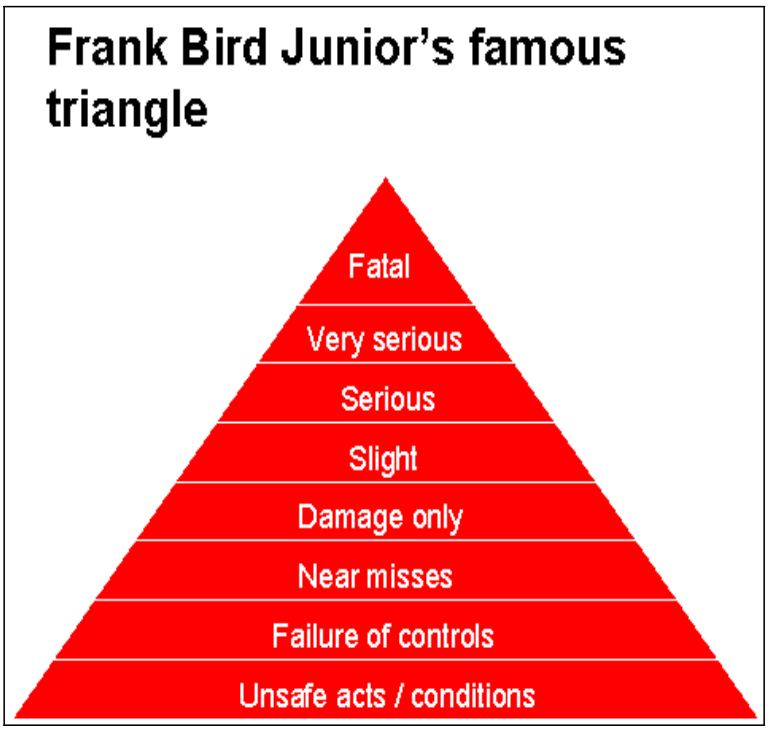
a greater number of major injuries;
even more ‘minor injuries’;
still more ‘damage only’ events;
many more ‘near misses’
and a very large number of failures of control.

Same unplanned event, different outcomes

1. Near miss
2. Damage
3. Minor injury
4. Fatality

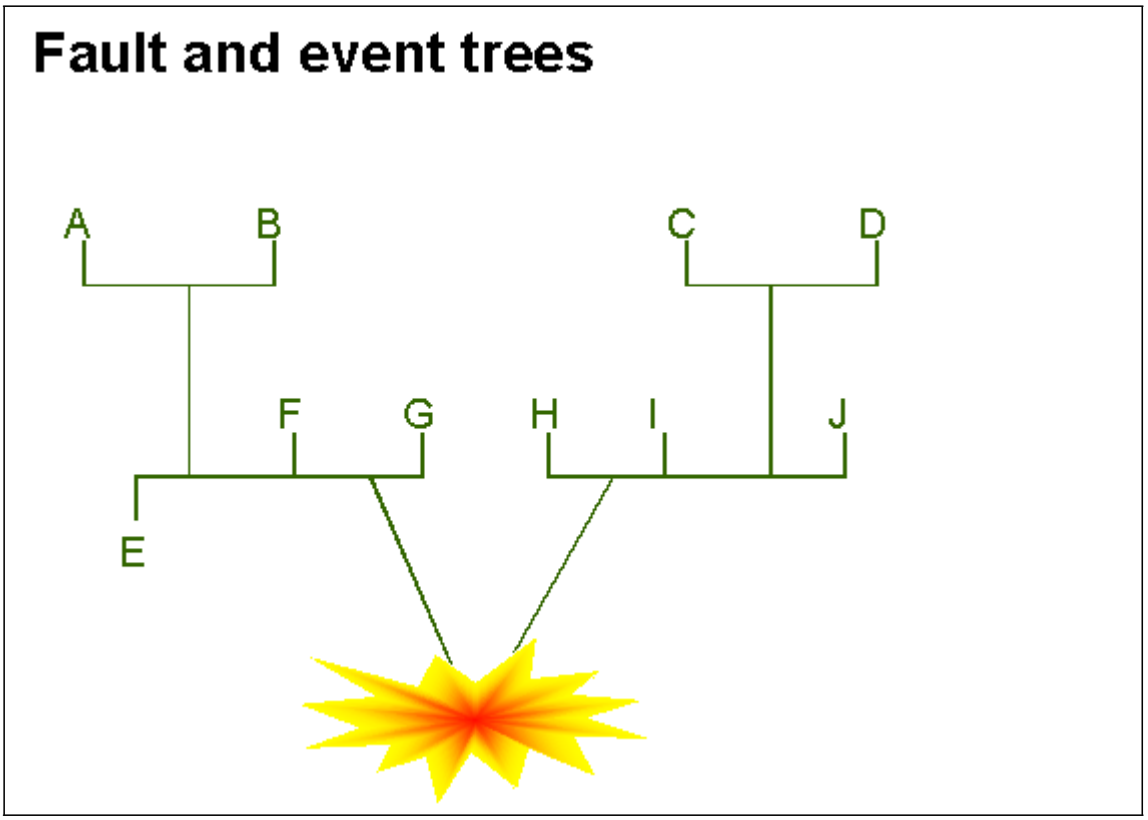


When considering the level of risk to health posed by exposure to harmful agents, again it is important to consider the spread of possible effects. These can include ‘deterministic effects’ (ones that inevitably occur) and ‘stochastic effects’ (ones that occur with increased frequency depending on the extent of exposure).
Having good data and good modeling therefore is fundamentally important to help predict both probabilities of accidents or health effects and the likely nature of consequences if they do occur and to assess the likely effectiveness of control measures. But ultimately quantification of risk should be seen as an aide to judgment not a substitute for it.



10) Understanding causation

Very few accidents are simple and straightforward. Generally speaking necessary and sufficient conditions have to combine to enable a chain of events to occur resulting in an accident, for example, failures of management systems, failures of technology and failures in human behaviour. If any one conditional factor is absent or its interaction with another is interrupted, the accident will not occur.

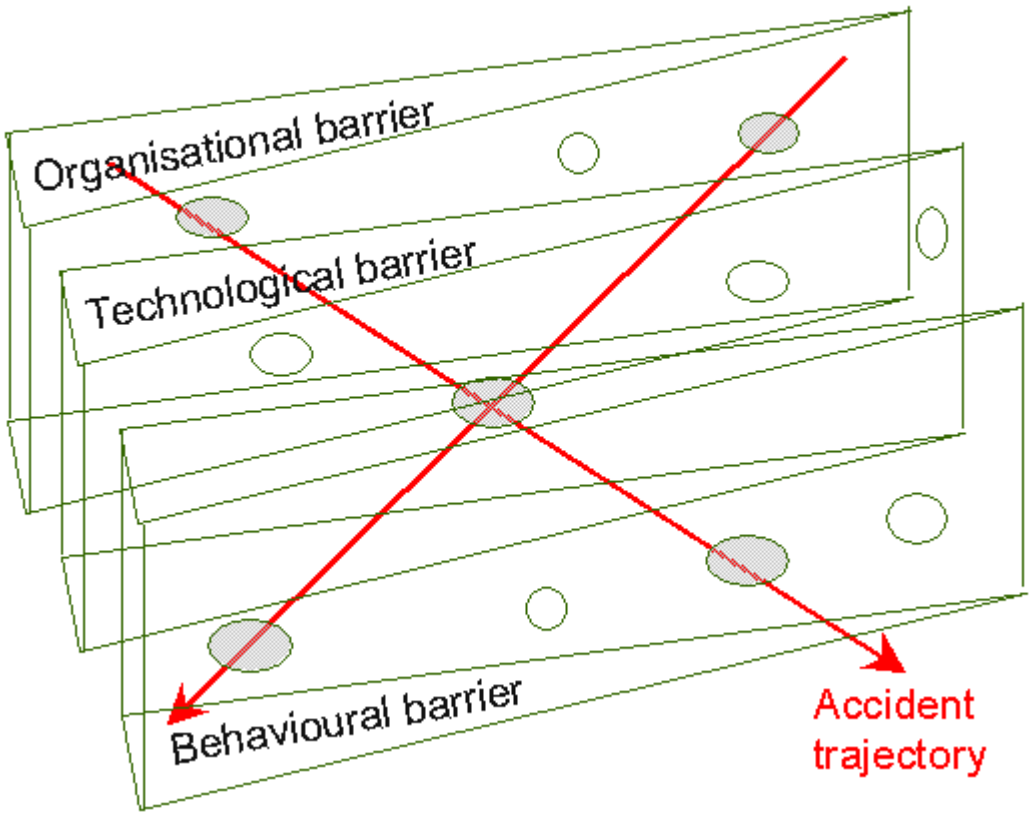


Accident sequences are usually multi-branched and can be understood as tree of conditional factors. When undertaking suitable and sufficient risk assessment and spotting opportunities for risk control it is important to understand how such factors can combine in order to appreciate the chain of events which have to unfold for an accident to happen. In complex systems techniques such as 'Quantified Risk Analysis and Assessment' or 'Failure Modes and Effects Analysis' can be used to help make structured judgments to predict how likely certain kinds of safety failure might be.

Understanding barriers to accidents
(James Reason's 'Swiss Cheese' model)

Three kinds of barrier (with holes in each!)
1. Organisational
2. Technological
3. Behavioural

If the holes line up you have an accident trajectory.



If accidents are investigated systematically, they present unique 'windows on reality' through which vital lessons to improve safety can be learned. But accidents can only yield positive lessons for safety if suitable investigation techniques are applied, including appropriate approaches to: gathering and integrating evidence; testing hypotheses about what happened, how and why; and reaching conclusions so as to be able to make recommendations to prevent recurrence.

When trying to prevent accidents it is important to look at underlying conditional factors as well as the last few failures in the safety chain.

Accidents, even small scale ones, are rarely simple events. Oversimplifying accidents can lead to superficial and ineffective remedies.

11) Understanding the part played by human error

A common failing in safety is to see human error as both the most important cause of accidents and as simply willful negligence and rule or law breaking.

But human error like accidents is complex: Errors can be

UNCONSCIOUS
- slips
- lapses

or

MISTAKES
- skill based
- ruled based

or

VIOLATIONS
- exceptional
- routine
- situational

In accidents different error types can combine (e.g. road accidents where all too often 'violation + error = crash!')

Error types can combine

Eg.

Violation + Error = Crash

Prof Steve Stradling

Errors can be committed by organisations as well as individuals. Poor past safety decisions or internal procedural or goal conflicts can produce latent errors in organisations ('accidents waiting to happen').

12) Hierarchy of control

Understanding the way causal factors combine and the way this determines the level of risk associated with an activity can help us decide what approach to take to risk control. On the whole it is always preferable, particularly where risk levels are high, to opt for elimination (or the maximum amount of control) of hazards at source before simply requiring people to follow specific safety rules and procedures (we call this primary safety) or providing measures to mitigate consequences (secondary safety) - or worst of all, simply ensuring that they have access to emergency and medical services (tertiary safety).

The hierarchy of preferred approaches to risk control (ERICAE)

ELIMINATE
REDUCE
ISOLATE
CONTROL
ADAPT
EMERGENCY ACTION

Generally speaking, the 'safety case' for an activity will be made up of a selection of measures from this hierarchy. For example, if levels of harm are likely to be severe, it is wise to opt for 'defence in depth' ('belt and braces') and not rely on a single method of risk control or a single safety approach which, if it failed, would lead to disastrous consequences.

Examples include suitable combinations of: redundancy, diversity, a variety of techniques, procedures, physical safeguards, alarms and emergency procedures. For high consequence risks effort should be made to select control measures and systems which will be as forgiving of error as possible, fail to a safe condition and protect especially vulnerable groups, for example, older people or young children.

In reality however, hazard elimination - may not always be the preferable solution, bearing in mind practical considerations and overall costs to individuals, organisations or society, including opportunity costs. It can be argued that no control principle is more acceptable than another, as long as the overall outcome is acceptable, bearing in mind that the control hierarchy relates to the effectiveness of the control measure.

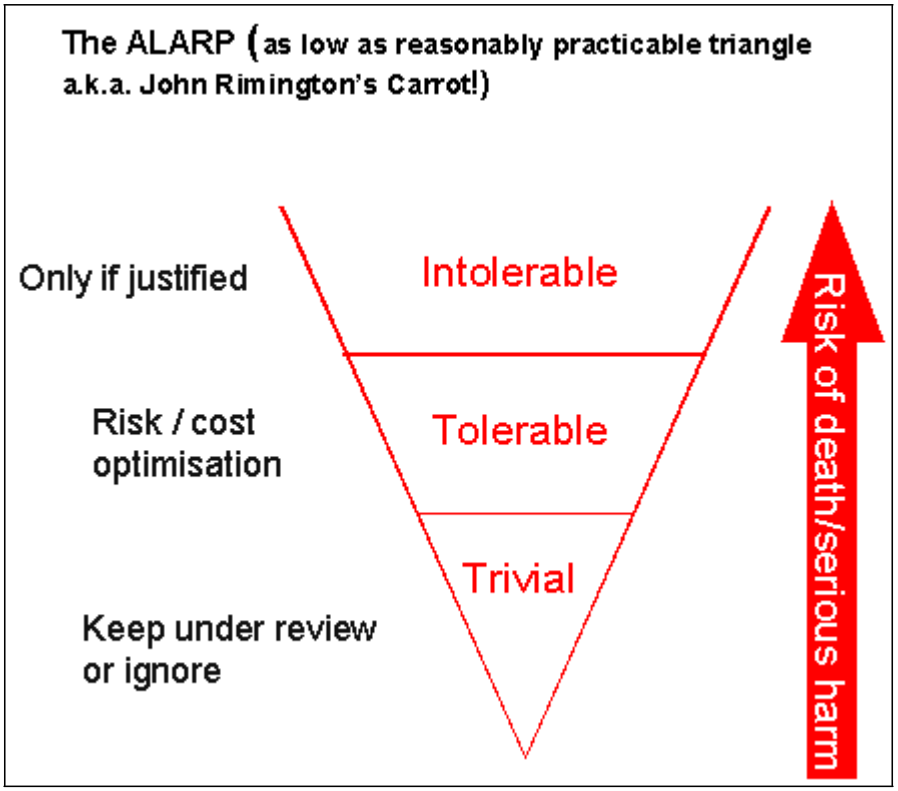
Levels of Safety

Primary (initial integrity)
Secondary (protection)
Tertiary (emergency response)

13) So what do we mean by safe?

This is the most difficult question and one which leads to so much misunderstanding at many levels whenever safety is under discussion. The most important thing to grasp is that 'safe' does not mean that the probability of harm is zero. In this sense, there no such thing as absolute safety which in practice is as undesirable as it is unattainable.

In RoSPA we say *'things should be as safe as necessary, not as safe as possible'*. So by 'safe' we mean justified, broadly tolerable risk that does not exceed risk limits and is controlled to an 'optimised' ('as low a level as is reasonably practicable - ALARP) **level.**



This needs some explanation

Justification: Hazardous activities should not be banned simply because they could lead to accidents but ideally the benefits of exposure to hazards should always outweigh the risks involved, otherwise the activity should be abandoned - even if the risks are small.

Risk limits: Suitable limits should be set as to the maximum level of risk that can be tolerated before an activity should cease.

Optimisation: Below this level, effort should continue to be made to reduce risks until a clear point of diminishing safety returns is reached (risk/cost optimisation). Safety decision makers, whether individual, corporate or societal, have always therefore to tread a difficult path, taking care to ensure that preventive measures are neither excessive - leading to wasted resources or missed opportunities (including education and recreation) nor insufficient (leading to unnecessary risk).

'The Goldilocks principle'

Too much safety? (over-hitting)
Too little? (under-hitting)
Just right! (optimised)

Deciding if things are suitably safe therefore is always a matter of informed judgement based on risk assessment. It has to involve ensuring that the levels of risk are not intolerable and that steps continue to be taken to reduce them, at least until they can be deemed to be broadly acceptable, although in practice this is a contentious and difficult concept.

But how safe is safe enough? And again, who decides and how?

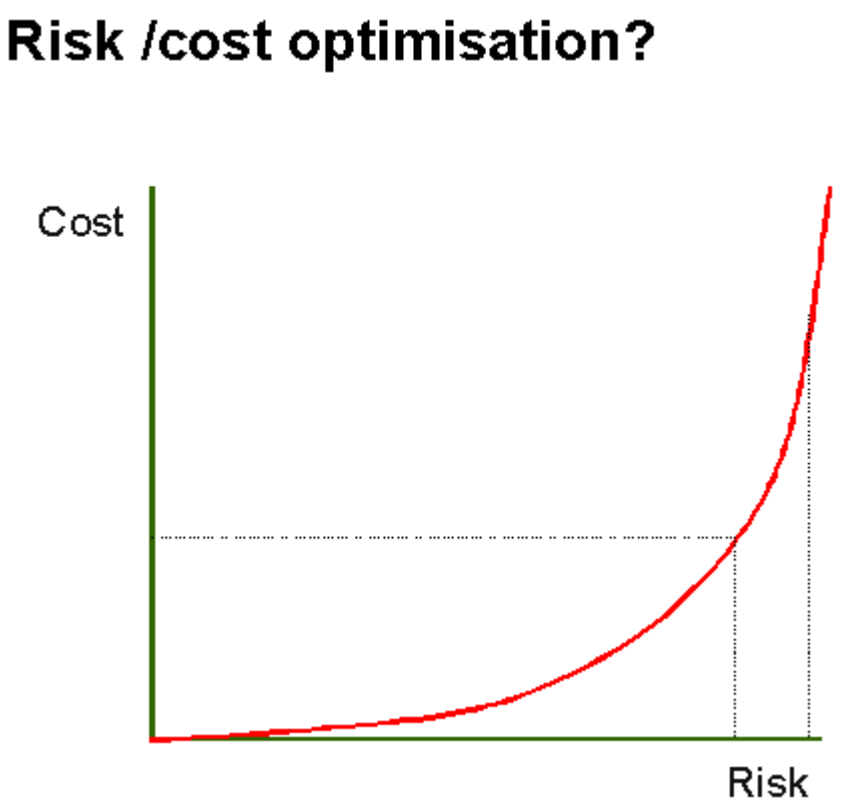
Risk triage

Are risks:

- 'Intolerable' (too high/unjustified?)
- 'Tolerable'? (reduce risk until as low as reasonably practicable -ALARP)
- 'Acceptable'? (ALARP)
- 'Trivial'? (keep under review or ignore)

Balancing risk and costs

The risk versus cost curve (finding the point of diminishing safety returns)



Costs can include money, time, opportunities and other factors.

But remember, the point of balance must also reflect the degree of uncertainty in the assessment process, including confidence in the available data.

Safety and reliability

- If it can happen, it must not matter!
- If it can matter, it must not happen!

	Risk based control plan (after BS 8800)
Risk level	*Necessary action and timescale*
Very low	No further action required. Maintain controls.
Low	Further action is low priority and only justified if cost is low. Maintain controls.
Medium	Reduce risk levels within a specified timescale, taking account of costs. Maintain and monitor controls, particularly if consequences are severe.
High	Substantial and urgent efforts to be made to reduce the risk, with temporary suspension of activity or emergency interim measures if necessary. Considerable resources to be devoted to safety if needed. Very stringent steps to be taken to maintain and monitor controls.
Very high	These risks are unacceptable and the activity should cease until measures are taken which reduce risk to a tolerable or acceptable level. If this is not possible the activity may need to be prohibited.
NOTE	For risks with severe consequences further assessment may be required to increase confidence in actual likelihood of harm

14.) Tackling uncertainty

A major challenge in safety is managing risk in the face of uncertainty. Where data on risk are incomplete but available evidence seems to suggest that significant harm could occur, there is a prima facie case for taking early precautionary action rather than waiting for absolute proof of risk. In this sense, those at risk should always be 'given the benefit of any scientific doubt', although interpreting available evidence appropriately in this context can present many challenges.

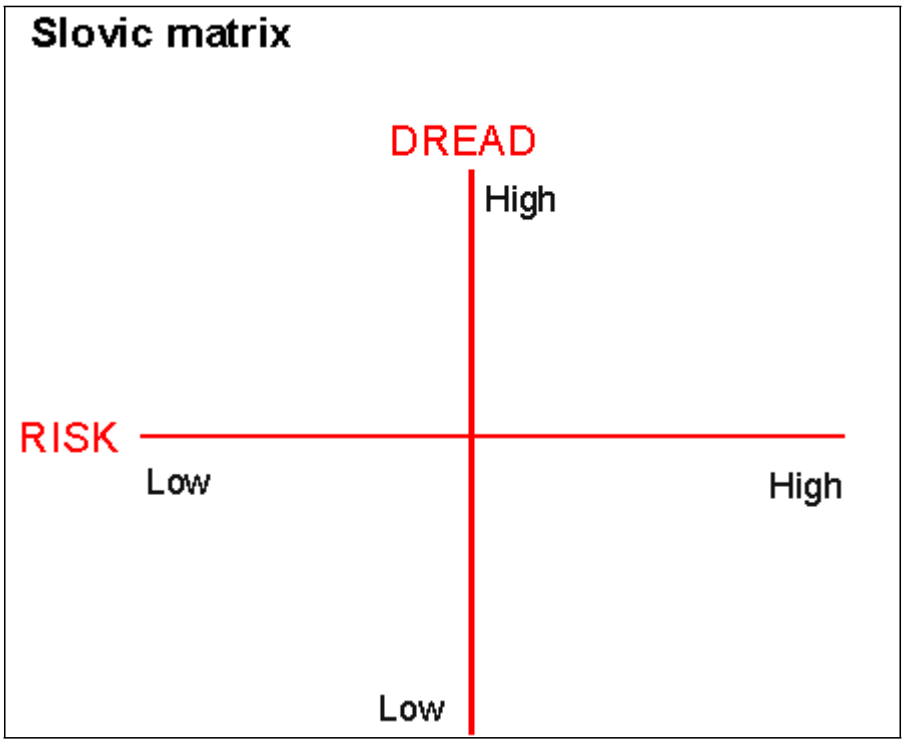
In genera caution in safety decision making should reflect the nature and extent of uncertainty, recognising that being excessively cautious can also impose high opportunity costs.

15) Risk Perception

People's perceptions of risk tend to vary and are likely to be influenced not only by their rational estimates of the chances that harm may occur and its level of severity but by the way they feel about them, for example whether harms are likely to be ordinary or catastrophic, immediate or delayed or affect individuals or society generally and whether the hazards involved are: natural or man-made; familiar or unfamiliar;

controllable or uncontrollable; and whether exposure to them is voluntary or involuntary or involves benefit or restriction. Further key issues in risk perception include whether individuals have had personal experience of the harms involved and whether or not they trust those who are managing risk on their behalf.

Low risk phenomena can evoke high dread and vice versa.



16) Stakeholder decision-making

How safe things (for example, activities or products) need to be (and conversely, how unsafe they can be) before they become unacceptable is essentially a matter of social rather than purely technical judgement and one on which various stakeholders like risk creators, regulators and those at risk, will nearly always have differing points of view.

Those responsible for developing safety decisions need always to work with all relevant stakeholders and the wider public to get the maximum amount of agreement about: how risky things really are; if and how they can be made safe; and how safe they should be made, taking into account people's safety ambitions and perceptions and their views about the time, financial and opportunity costs of achieving specific safety objectives.

Stakeholder perspectives on risk tend to vary.

‘Risk creators’ may: be highly cost conscious; demand ‘beyond reasonable doubt’ evidence; have only moderate safety ambitions; trust ‘experts’; and be confident about data and the efficacy of controls.

‘Risk takers’, particularly where risks are created for them by others, may: demand ‘on balance of probabilities’ evidence; have high safety ambition; mistrust experts; be sceptical about efficacy of controls; be less cost conscious and seek to ban rather than control.

Safety decisions are often a ‘bargained’ compromise so campaigners often pitch their demands at a higher level in order to achieve an eventual solution that they might consider satisfactory.

Safe effort should be prioritised and proportionate

With limited resources do you focus effort on :

a high risk/low exposure problem with a high cost solution?

OR

a medium risk/medium exposure problem with a medium cost solution?

OR

a low risk/high exposure problem with a low cost solution?

For example, in a factory setting and with limited resources, which three of the following would you tackle as a matter of priority?

one experienced person using an unguarded circular saw;
100 staff without ergonomic seating;
5 canteen staff washing up without rubber gloves;
20 staff exposed to more than 90 decibels (noise level) for eight hours a day;
occasional smoking by staff in areas where flammable substances are stored;
frayed asbestos lagging on outside pipes;
inadequate lighting throughout the premises; or
three pregnant women operating VDUs.

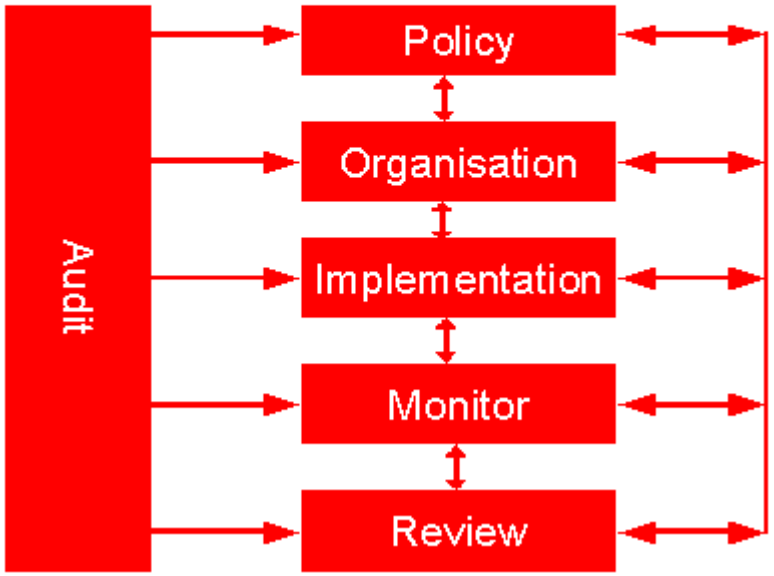
17.) Organisational risk management and safety culture

Having the right risk control measures in place to deal with hazards is always critical but what ultimately assures safety is having an adequate general approach to risk management underpinned by a positive safety culture. This is the case whether it is a matter of a child understanding the need for a systematic way to cross the road or a business having the right policies, people and procedures in place to manage its risks. In all areas of safety, having robust risk management systems in place (backed by positive attitudes) is the key to effective safety assurance, with such systems integrated to the greatest extent possible into all other systems which organisations or individuals may have in place for achieving other objectives. (Safety has to be part of how we manage our lives generally - not a ‘bolt on extra’.)

HSE's five elements of H&S management systems

- Policy
- Organisation
- Planning and implementation (informed by risk assessment)
- Monitoring (active/reactive)
- Review (and periodic audit)

The system elements
HSG65



Safety culture

- Shared perceptions of the seriousness of problems and the efficacy of solutions.
- Shared values and commitment.
- Consistently safe behaviours.
- Corporate emotional intelligence.

18.) Some concluding thoughts

So what's the case for safety?

Firstly, that from a moral standpoint safety should always come first. Human life is to be cherished and should not be seen as an inevitable part of the price to be paid for any kind of undertaking.

Secondly, that safety is ignored at our peril. What is sufficiently safe is always a matter of judgement but if reasonable and practicable levels of safety are sacrificed in pursuit of other personal, organisational or social objectives, the latter are likely to be diminished by the effect of harms which could have been avoided.

From an economic standpoint investing time, money and effort in reasonably practicable measures to manage accident risk ensures efficiency, promotes sustainability and is usually preferable to simply opting to bear the human and financial costs of accidents when they occur.

In short, optimised safety pays substantial dividends!

People have both a duty to act responsibly to protect themselves and others and conversely a right to expect to be 'safe' when exposed to other people's activities. Wherever necessary and appropriate, this right needs to be guaranteed by law. The more control 'risk creators' have over their activities, the greater the moral (and possibly legal) obligation they should be under to protect those who may be exposed to these and/or to provide them with suitable and sufficient information so that they can make choices about risks.

In short, safety is vital but as accidents and subsequent safety policy discussions show, getting it right isn't always so easy…

A common language and shared understandings can help.

Roger Bibbings
Occupational Safety Adviser
14th December 2012

Further reading:

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