Lecture 8 - Risk Management Fundamentals – Student Notes

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1.1 Introduction

The confusion often surrounding decisions about safety can be clarified by refining the definition of the term "safety." In essence, safety refers to the judgement of how acceptable a particular level of risk is. Risk itself is understood as the likelihood and potential severity of harm to human health. Therefore, something can be considered "safe" only if its associated risks are deemed acceptable. This interpretation stands in contrast to simplistic dictionary definitions that portray safety as being completely "free from risk," a condition that is essentially unattainable—only those no longer alive face zero risk, as noted by Bandle in 2009.

Since absolute freedom from risk is impossible, absolute safety cannot be guaranteed either. Instead, safety exists on a spectrum defined by varying degrees of risk. This foundational principle of safety management has significant implications. For example, it challenges the demands made by the media or the public for absolute guarantees of safety in areas like nuclear power or air travel. Instead of asking for absolute safety, the more appropriate question is, "Is it safe enough?"

Answering this question requires addressing several critical aspects of safety and risk management, including:

- How can we measure safety?
- How can we determine the safety of a workplace or work activity?
- How safe is safe enough?

To tackle these questions effectively, we must critically examine the concepts of risk, risk assessment, and risk management.

1.2 Acceptability of Risk

The terms hazard, risk, and safety are often used interchangeably, but they have distinct meanings. A hazard refers to something with the potential to cause harm. Risk, on the other hand, involves the likelihood of harm occurring due to exposure to a hazard, combined with the potential severity of the harm. In essence, risk is defined as:

Risk = Probability × Consequences

The consequences of risk can impact individuals, specific groups (e.g., businesses), or society as a whole, making risk a broad statistical measure encompassing the chances of hazard exposure and the resulting adverse effects.

In workplace contexts, safety is achieved when risks—quantified through hazard analysis and severity likelihood—are either eliminated or effectively controlled. A probability-consequence diagram can illustrate levels of risk (e.g., high, medium, or low), which can guide decision-making.

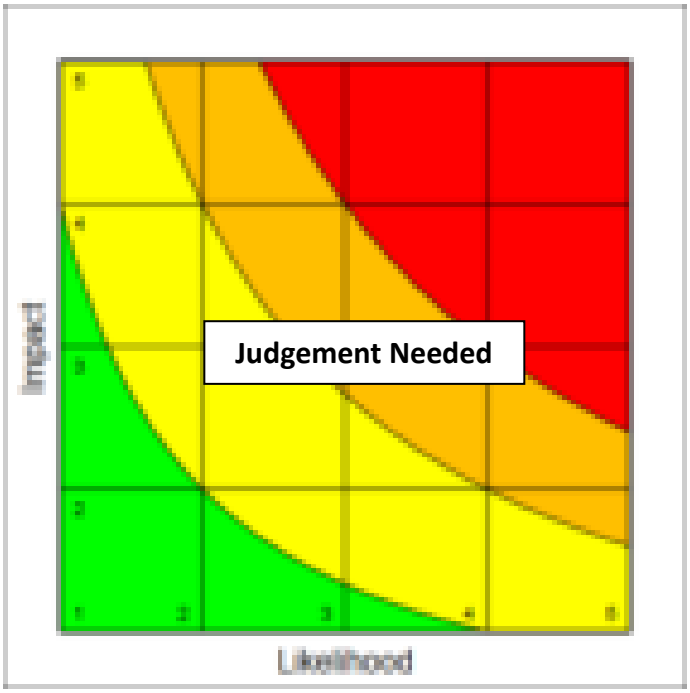

Figure 1: Probability/Likelihood – Consequence/Impact diagram

However, how individuals, groups, and nations respond to risks depends largely on their perceptions. Studies like that of Slovic, Fischhoff, and Lichtenstein (1981) have shown that public perception of risk often diverges from actual statistical data. For example:

- People tend to overestimate the risk of rare events (e.g., botulism or tornadoes).
- Common risks (e.g., heart disease) are underestimated.

The media heavily influences public perception, often amplifying fear around lesser-known risks (e.g., nuclear power) while downplaying everyday dangers (e.g., road travel). Political pressures also affect risk decisions, especially after significant but rare incidents.

The Council for Science and Society (1997) concluded that *The acceptability of risks cannot be derived from a scientific study of quantified probabilities, cost and benefits, only. The human factor influences the analysis at every point. However, fairness in decisions and effectiveness in risk controls can be approached by using scientific methods, among others, provided that the diversity of human interests, values, and perceptions of risks is continually respected and factored in.*

While value clashes around risk may seem irreconcilable, negotiation and compromises often address conflicts where interests overlap.

Read: https://www.hsph.harvard.edu/wp-content/uploads/sites/1273/2013/06/RISK_IN_PERSP_JUNE2003.pdf

1.2.1 Risk Profiling

Risk profiling is a systematic approach that helps organisations identify and prioritise their main health and safety concerns. While many people have experience with risk assessments, the process of measuring and analysing risks is often subjective. It depends on the analyst's expertise, the available information, and the priorities of the task.

The purpose of risk profiling is to collect data that supports both qualitative and quantitative evaluations, enabling organisations to determine whether a risk is acceptable or needs further attention. A well-developed risk profile considers:

1. The nature and level of threats the organisation faces.
2. The likelihood of adverse events occurring.
3. The potential cost and disruption associated with each type of risk.
4. The effectiveness of current controls in managing these risks.

This process allows organisations to allocate resources effectively, focusing on the most critical risks while ensuring appropriate control measures are in place.

1.2.2 Understanding the Assessment of Risk

Risk assessment, a concept formalised in EU Directive 89/391/EEC, Cap 424, new Cap 646 and L.N. 36 of 2003 among others, is a process humans naturally engage in during everyday decision-making. For instance, when crossing the road or driving, we instinctively evaluate risks and decide on safe actions. At work, however, risk assessment is a more structured process that requires identifying hazards in tasks, reflecting on potential dangers, and implementing appropriate controls.

Despite its importance, risk assessment is sometimes misunderstood or misused. It is occasionally reduced to a "tick-box" exercise, especially when conducted by individuals lacking a full understanding of the process or its purpose. Overuse or poor implementation can lead to complacency, undermining the effectiveness of risk assessments as a tool for hazard control.

To ensure meaningful outcomes, risk assessments must follow a structured and logical approach. However, pitfalls often arise, such as:

- Misinterpretation of risks.
- A failure to align the assessment with the actual work environment.
- Over-reliance on generic templates.

A successful risk assessment involves:

1. Systematic identification of potential hazards.
2. Accurate estimation of the likelihood and severity of harm.
3. Implementation of proportionate control measures to reduce risks.

By adopting a deliberate and informed methodology, organisations can avoid the common pitfalls of risk assessment and ensure its effectiveness in maintaining safety.

1.3 Understanding Hazards and Their Consequences

Failures in safety systems often reveal that early warning signs of hazards were either overlooked or not addressed due to the absence of a systematic approach to identifying and analysing hazards. Therefore, hazard identification should be an integral component of any safety management system.

Key activities in hazard identification include:
1. Investigating accidents and illnesses to understand their root causes.
2. Conducting systematic safety analyses and product testing.
3. Undertaking epidemiological surveys to assess trends and risks.

Once hazards are identified, defining the conditions of exposure is essential. This helps assess the adverse effects of the hazard, as the severity of these effects typically depends on the degree of exposure. Combining hazard identification with exposure assessment leads to an overall risk estimate.

The next step involves risk ranking, where hazards are compared and prioritised. This prioritisation highlights the most significant risks that are likely to impact the greatest number of people. A quantitative assessment of risk is often the most reliable method for generating a clear hierarchy of priorities.

Reflecting on various techniques for hazard identification and evaluating their strengths and weaknesses can help organisations select the most suitable methods. Effective hazard identification strategies contribute significantly to improving workplace safety and preventing potential incidents.

1.4 Obtaining Information

Effective hazard identification, risk evaluation, and control measures depend on the availability of reliable and accurate information. A variety of internal and external sources can provide the necessary data, but it is crucial to assess these sources critically to avoid conflicting or duplicated efforts.

Internal sources of information might include:

- Workplace inspections and audits.
- Accident and incident reports.
- Employee feedback and health records.

External sources could encompass:

- Industry standards and guidelines.
- Research studies and scientific data.
- Regulations and reports from health and safety authorities.

While external information provides valuable benchmarks and insights, it should be seen as a starting point rather than the sole basis for decision-making. For example, desk-based research can highlight probable conditions and comparable standards, but it must be supplemented by direct observations and workplace-specific investigations.

Identifying the strengths and limitations of each source is crucial to making informed decisions. For example:

- Internal sources offer specific, relevant insights into the workplace but may lack broader context.
- External sources provide context and comparison but may not fully address unique organisational challenges.

The process of gathering and analysing information should be ongoing, with practitioners updating and refining their data sources over time. This approach ensures that safety decisions are well-grounded and adaptable to evolving workplace conditions.

1.5 Cost versus Benefit

The goal of safety management is not to eliminate all accidents—an impossible task—but to reduce risks to an acceptable level. Determining this level involves key questions:

- Who decides what is "acceptable"?
- Should cost considerations influence these decisions?
- How do we know when a risk level is low enough?

The concept of "reasonably practicable" is central to safety management. It requires balancing the cost, effort, and inconvenience of implementing controls against the level of risk reduction achieved. Beyond a certain point, further safety measures yield diminishing returns, making them impractical or excessively expensive. However, this principle does not imply complacency; risks must be reduced to a level that is as low as reasonably practicable (ALARP).

The ALARP principle is achieved by adhering to industry standards, codes of practice, and relevant laws. While this approach is often qualitative, it can be quantified through methods like hazard analysis and probabilistic risk assessment, especially for complex or high-risk scenarios.

The tolerability of risk further defines acceptable thresholds. Risks may be considered "tolerable" if:

1. Reducing them further is impractical.
2. The cost of mitigation is disproportionately high compared to the benefits.

These decisions rely not just on scientific analysis but also on ethical considerations, fairness, and societal values. Risk control measures should aim to align with these principles while ensuring legal compliance.

1.5.1 Cost Benefit Analysis (CBA)

Cost Benefit Analysis (CBA) is a key tool used to determine whether risk control measures are justifiable. The principle of "reasonably practicable" requires weighing the cost and effort of implementing controls against the level of risk reduction they achieve. This balance is illustrated in scenarios where:
- A significant risk, such as the potential for limb loss from a machine, justifies the expenditure on safeguards.
- Minor risks, such as a small cut, may not warrant significant spending on additional controls.

Figure 2: Balance of risk and control

CBA helps identify this balance point, often referred to as the optimum risk-cost ratio. Organisations can use industry standards, best practices, and safety guidelines to gauge whether their measures are proportional to the risks involved.

The HSE (1997) describes a point, known as Point A, beyond which further investment in safety measures no longer produces a worthwhile return. This point is reached when additional controls fail to significantly reduce risk while continuing to incur costs. The concept applies to measures ranging from single safety procedures to comprehensive safety management systems.

Examples of costs factored into CBA include:

- Direct control costs: Safety equipment, training, inspections, and audits.
- Failure costs: Lost time, damage to equipment, accident investigations, and production losses.

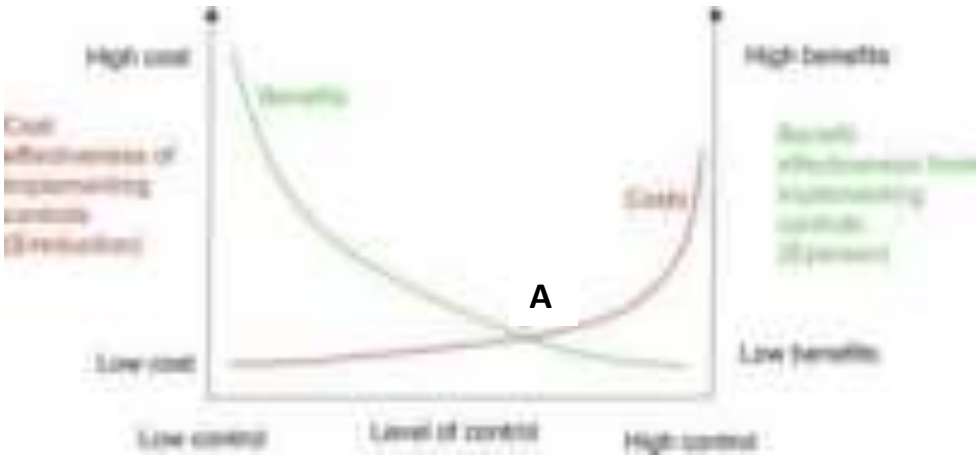

Figure 3: Costs of a control programme

CBAs are particularly helpful in cases where decisions are unclear or in the absence of established guidance. However, they should be viewed as part of a broader evaluation framework rather than a standalone decision-making tool. Importantly, costs should not merely be proportional but must avoid being "grossly disproportionate," ensuring risks are reduced as low as reasonably practicable (ALARP).

1.5.2 Economic Risk Criteria

Economic risk criteria provide an objective framework for evaluating the potential financial impact of workplace risks and determining whether these risks are acceptable. This analysis assesses:

- The cost of accidents or damage (e.g., injury compensation, equipment repairs).
- The frequency of these losses.

- Whether the cumulative impact is tolerable.

While insurance may cover some costs, such as injury claims or equipment damage, other losses, including production downtime or material wastage, can be more substantial and may not be insured. Understanding these costs in advance is essential for informed decision-making.

One method of economic risk evaluation involves using historical company data to estimate current accident-related losses. These losses can then be plotted on an economic risk histogram to visualise patterns and predict future risks.

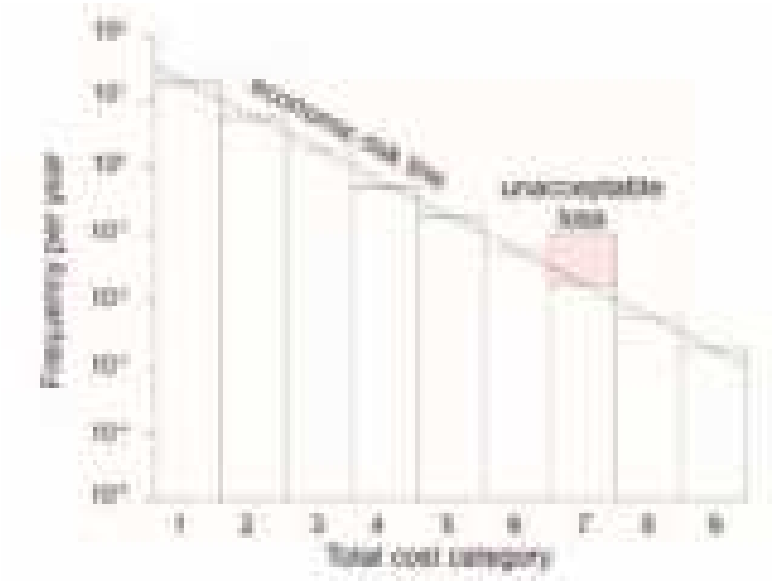

Figure 4: Economic risk histogram

For example, if an accident is estimated to cause €1 million in damage and is expected to occur once every 1,000 years, the annualised cost is €1,000. In this case, spending up to €1,000 annually on preventive measures is economically justifiable, while exceeding this amount might not be.

Additionally, monetary valuations for injuries or even human life are often used, though there is no universal agreement on these figures. However, industry standards, such as the use of fixed guards on machinery, can help ensure risks are reduced to negligible levels without incurring unreasonable costs.

Economic risk criteria complement other risk management strategies, providing valuable insights into the financial implications of accidents and control measures.

However, they should be integrated into a broader analysis to ensure a balanced approach to safety and cost-efficiency.

Read:

HSE principles for Cost Benefit Analysis (CBA) in support of ALARP decisions

https://www.hse.gov.uk/enforce/expert/alarpcba.htm

1.5.3 Tolerable Risk

The concept of tolerable risk refers to risks that we are willing to live with in order to gain certain benefits, provided they are effectively controlled and regularly reviewed. Importantly, tolerability does not mean the risk is acceptable in the sense of being negligible or ignored. Instead, it reflects a pragmatic balance where the risks are managed as low as reasonably practicable (ALARP).

The concept of tolerable risk, managed to be As Low As Reasonably Practicable (ALARP), is integral to risk management across various industries. While the UK's Health and Safety Executive (HSE) formalized this approach through the Tolerability of Risk (TOR) framework, other European Union (EU) countries and Malta have adopted similar principles, though their applications and regulatory structures may differ.

European Union (EU):

Within the EU, risk management practices are influenced by both EU-wide regulations and individual member state policies. The European Commission has developed a Risk Management Framework to guide the transport of dangerous goods, emphasising harmonised risk estimation and decision-making processes. This framework introduces governing principles and objectives, along with guides for risk estimation and decision-making, aiming to establish recognised, traceable, and high-quality risk assessments.

Additionally, the European Maritime Safety Agency (EMSA) has explored risk acceptance criteria and risk-based damage stability, drawing comparisons with frameworks like the HSE's TOR. This indicates a trend towards adopting structured risk management approaches across various sectors within the EU.

Malta:

In Malta, risk management frameworks are shaped by both EU directives and national regulations. Organisations such as EY, PwC, KPMG and other firms offer services to help businesses develop comprehensive governance, risk, and control frameworks. These services include assessments of current structures, processes, and controls, assistance with enterprise-wide risk management, and tailored training for boards and senior management.

While specific references to the TOR framework's direct application in Malta are limited, the principles of managing risks to be ALARP are embedded in the country's adherence to EU regulations and the services provided by consulting firms. This alignment ensures that Maltese industries maintain risk management practices consistent with broader European standards.

In summary, although not necessarily in an official form, the concept of tolerable risk and the ALARP principle are recognised and applied across EU countries, including Malta. Although the UK's TOR framework serves as a foundational model, each country adapts these principles to fit its regulatory environment and industry needs, ensuring that risks are effectively managed in pursuit of societal and economic benefits.

The Health and Safety Executive (HSE) defines this concept through the Tolerability of Risk (TOR) framework, originally developed for industries like nuclear power. According to this framework:

- The maximum tolerable risk for workers in any industry is set at a 1 in 1,000 chance of fatality per year.
- For the general public exposed to industrial hazards, this threshold is reduced to 1 in 10,000.
- Acceptable levels, such as for communities living near nuclear power plants, are much lower, often at 1 in 1,000,000.

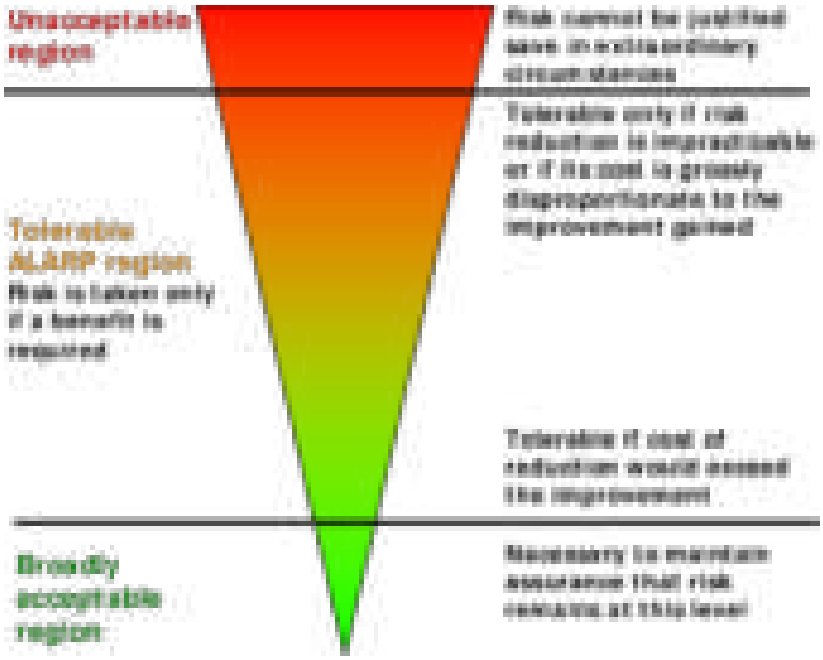

Figure 5: HSE framework for the tolerability of risks (HSE, 2001)

This framework provides clear boundaries between acceptable, tolerable, and intolerable risks. Risks deemed intolerable must be mitigated regardless of cost, while tolerable risks require ongoing management to keep them within acceptable limits.

The Enforcement Management Model (EMM), also devised by the HSE, is a related tool that ensures decisions about risk enforcement are consistent, transparent, and proportional. This model helps regulators assess when and how to intervene based on the tolerability of risks.

Ultimately, tolerable risk reflects the complex interplay of ethical, economic, and social considerations in safety management. It recognises that while some risks are inevitable, their management must prioritise fairness, control, and the minimisation of harm to an acceptable level.

Read: ALARP "at a glance"

https://www.hse.gov.uk/enforce/expert/alarpglance.htm

1.6 Risk Evaluation

Risk evaluation is a critical step in safety management, building on the principles of acceptability and tolerability of risk. This process involves assessing the relationship between exposure to a hazard and its potential outcomes. The goal is to determine whether risks are at acceptable or tolerable levels and to implement measures to reduce them where necessary.

For routine, low-risk activities, a simple evaluation approach may suffice. However, when activities become more complex or involve higher levels of risk, a structured and robust methodology is required. This ensures that failures can be predicted or reviewed systematically, providing greater objectivity in decision-making.

Risk evaluation also considers the cost, time, and effort required to mitigate risks. The challenge is to balance these factors while achieving meaningful reductions in risk. Advanced techniques for risk evaluation can assist in this effort, particularly in high-risk industries like petrochemicals or nuclear energy.

The following outline specific tools and methodologies that elevate risk evaluation to a more formalised level. These include:

1. Hazard and Operability Studies (HAZOP).
2. Hazard Analysis (HAZAN).
3. Failure Modes and Effects Analysis (FMEA).
4. Fault Tree Analysis (FTA).
5. Event Tree Analysis (ETA).
6. Probabilistic Risk Assessment (PRA).

These techniques, often used in combination, enable organisations to predict potential failures, evaluate their impact, and identify appropriate controls. By adopting these methods, safety practitioners can ensure that risk evaluation is not only thorough but also aligned with best practices.

Note: These techniques will be discussed in slightly more detail during our Lecture 15, ‘Risk Assessments’, and comprehensively in other modules during the second year.

1.7 Human Reliability

Human reliability examines how human behaviour and decision-making influence the safety and performance of systems. Since individuals have unique characteristics—shaped by their personalities, physical traits, and cultural backgrounds—their perception of risk and responses to hazards vary. These variations can lead to human error, a significant factor in workplace incidents.

Human error is considered a contributing cause in 80-90% of major accidents. Examples include:

- Operators failing to recognise or respond appropriately to early warning signs.
- Poor system design that complicates tasks for workers.

Major disasters, such as the Flixborough explosion (1974) and the Bhopal chemical leak (1984), illustrate how errors in system design, operation, or maintenance can lead to disastrous outcomes. In both cases, temporary modifications to industrial processes without thorough safety reviews played a central role in the incidents.

Human reliability analysis aims to quantify the likelihood of human error and incorporate it into overall risk assessments. Techniques include:

1. Task Analysis: Breaks down tasks to identify potential error points and evaluates how these errors might impact the system.
2. Performance Shaping Factors (PSFs): Considers conditions such as stress, workload, and environmental factors that influence human performance.
3. Recovery Factors: Recognises the ability of individuals to detect and correct their own errors before they escalate, an important aspect often overlooked in analyses.

Probabilities are assigned to human errors using statistical data or expert judgment. For example:

- In complex, high-pressure situations, human error rates are higher (e.g., 1 in 10 under stress).
- Routine tasks have lower error rates (e.g., 1 in 1,000 for familiar activities in a controlled environment).

Organisations can better understand the interplay between human performance and system safety by systematically including human reliability in Probabilistic Risk Assessment (PRA). This holistic approach ensures that both technical and behavioural factors are considered in risk management.

Note: PRA and other methods of RA will be further discussed in slightly more detail during our Lecture 15, 'Risk Assessments', and comprehensively in other modules during the second year.