Dilemmas in risk assessment

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Perspectives:

Accidents & Safety
- Industry
- Occupational safety
- Medical services
- Transport
- Energy etc.

Themes
- Terminology and concepts
- Risk assessment
- Risk estimation and evaluation
- The Risk Matrix
- Concluding

Risk

Varying definitions
- depend on area of application

Possibility of loss or injury

Someone or something that creates a hazard

Risk = Probability x Consequences

Sometimes dogmatic, but usually more sophisticated

Risk ~ Risk value ~ Theoretical effects

IEC, 2000:
The risk concept always contain two elements: the probability of the occurrence of a dangerous event and its consequences

Risk = Expected value of an undesirable outcome.
The values can be number of injuries, lost lives, money etc

International Atomic Energy Agency (IAEA, 2007)

$$R = \sum p_i C_i$$

p_i is the probability of occurrence of scenario ***i,*** and
C_i is a measure of the consequence of that scenario

There are several other fields with variations on the definitions

There is tendency towards broader and more general definitions

"Risk is the *effect* of uncertainty on objectives"
ISO & IEC, 2009

An *effect* is a deviation from the expected
– positive and/or negative

Risk assessment ~ Safety analysis ~ Risk analysis
- here it is used in a general meaning

It can include:
- Hazard identification
- Estimation of risk
- Evaluation of risk
- Identification of potential improvements

Many different situations:
- A specific installation (workplace, train station, hospital ward etc)
-
- Many units, where data and statistics are available

My starting point:

Risk assessment is a useful methodology,
which is very essential for design and operation of advanced and potentially dangerous systems

A large set of methods and theories are available

However, there are several difficulties that must be handled with care

Probabilistic risk assessment
Highly advanced, much literature, many recommendations
e.g. - *uncertainty analysis* related to data, methods and models

Problems and dilemmas:

Frequency estimates are uncertain. Rule of thumb: factor 10

Misleading if uncertainty interval is not shown and considered

The result is affected by assumptions - can be misused

The result is difficult to check, but not impossible

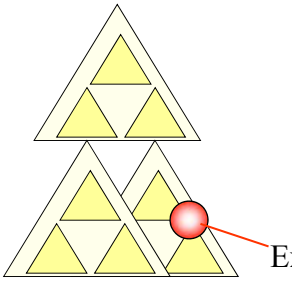
- Well defined process
- Independent analysis of the same object
- Check after incident or accident

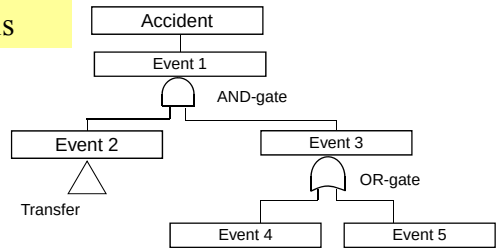
Case 1: A bench mark study

Eleven different teams analysed the same ammonia plant

The largest differences in the results were a factor of around 10 000 for certain estimated values for personal injuries

Case 2: A Fault Tree Analysis

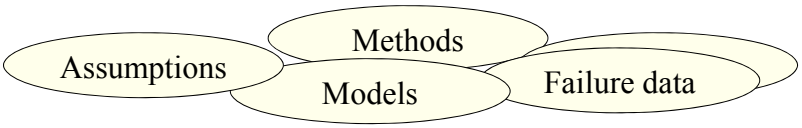




Expected occurrence of failure

Possible validation:
Prediction 1 / 1000 years ~
- in reality 2 events over 3 years ~

Analysis of infrequent events is difficult



Case 1: Differences in methods, failure data, assumptions about operators actions, and release mechanism
Several assumptions were different

Case 2: Human actions and computer control system contributed to the failures
The assumption was a technical system without humans and computers

Evaluation

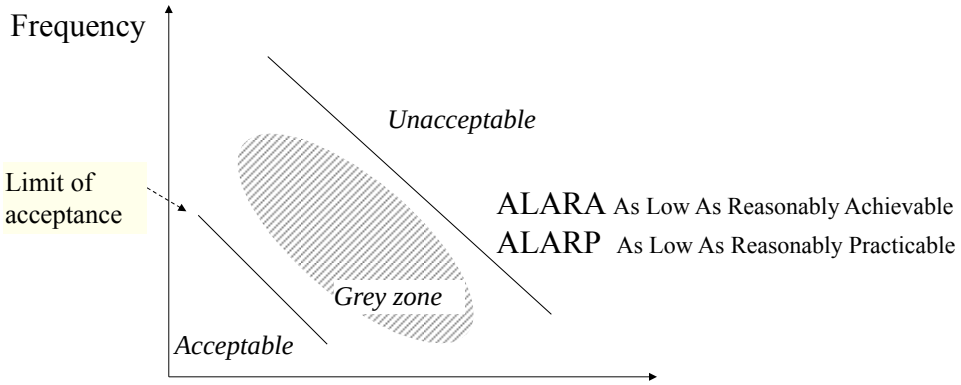
- *judgements of the tolerability of identified hazards, problems, and system safety properties.*

Many principles for evaluation and decisions concerning risk.

Cost / benefit analysis:
Principle - a risk is acceptable if it is balanced by a larger benefit

Whose costs and whose benefits?
- Different parties
- Now or in the future
- Individual or public interests

Evaluation of risk in a quantitative perspective



Arbitrary logarithmic scales

Evaluation of risk with a quantitative approach

Misleading if uncertainty interval is not shown (=)

Only probability considered - Disregards most other aspects

Who decides the limits, and how?

In many systems, most hazards come in the grey zone

Risk matrix - the most common method for risk evaluation

Recommended by

Arbetsmiljöverket - *Swedish Work Environment Authority*

MSB - *Swedish Civil Contingencies Agency*

Socialstyrelsen - *National Board of Health and Welfare*

Transportstyrelsen - *Swedish Transport Administration*

? Strålsäkerhetsmyndigheten - *Swedish Radiation Safety Authority*

Risk matrix 1

Semi-quantitative method
Probabilities and consequences are classified in categories

Frequency	Consequence			
	Minor	Medium	Large	Catastrophic
Frequent				
Probable				
Remote				
Unlikely				

Unacceptable

Acceptable / Tolerable

Each cell is associated with a risk severity

Risk matrix 2

The same problems as with quantitative evaluation above

Basic problem - it looks so simple and self-evident
Not necessary to reflect

Typically used without referring to any manual or guideline
Often based on implicit assumptions supposed to be shared by everyone

Typically used without clarifications
- motivation for estimated values
- origin of scales for probability and consequence
- criteria for tolerances
- who decided the criteria

Risk matrix 3

Uncertainty in estimations - gives erroneous decisions

An event can result in a range of potential scenarios with varying C and p
Usually only one scenario is taken, and without comments

Several "minor" hazards can add up to a serious problem, but still be "acceptable"

Risk matrix 4

Common misunderstanding: A large consequence is (automatically) related to a low probability

As if it is a law of nature (it is not). I call it wishful thinking.
This can be really dangerous!

This is based on a mix-up of a general statistics,
with the situation at the studied object which can be very risky

What's Wrong with Risk Matrices? (Cox, 2008)

Perspective: Mathematical and logical qualities of RM for risk management decision making.

Severe criticism e.g.:

Poor resolution. Comparing randomly selected pairs give low correctness
Identical ratings can be assigned to quantitatively very different risks ("range compression")
Errors in assigning ratings.

If not handled with care: The result from a Risk matrix can '*be "worse than useless" leading to worse-than-random decisions*' (Cox, 2008)

General problems with risk assessment

1) To not use it
A systematic risk assessment should be compulsory in all hazardous activities

2) Complacency (as a group characteristic)

- Part of explanations in many accidents
- If no accident has occurred - *"everything is OK"*
- Risk assessment confirms the expectations
- Early warnings are ignored

General problems 2

Quality and validity is hard to check
- By the "customer"
- By persons at risk
- Lack of quality guidelines for risk assessment
- Scope and aim - too narrow or too wide

Unsuitable definition and modelling of the system e.g.
- Only technical
- Insufficient systems perspective
- Interfaces missed
- General features are overlooked

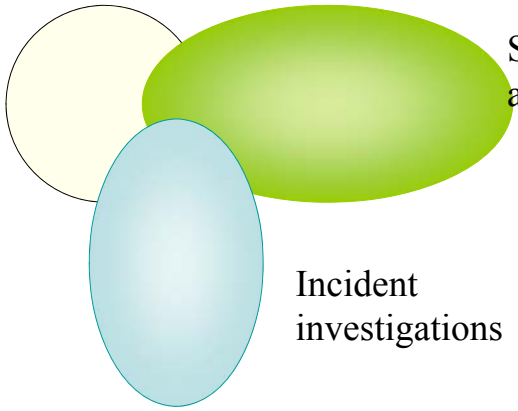
General problems 3

- Systems change (equipment, people, organisation, technical solutions)

Time dimension
- Often undefined & short time perspective (1, 5 or 20 years)

- §§ Requirements to analyse before changes.
  This is difficult and
  often done too late

Steps towards improvements



Steps towards improvements

Incident investigations with a systems perspective

- Handles quite easily organisations, and also informal routines
- Risk assessments can be checked in relation to the incident
- Less based on assumptions - coming closer to reality
- Existing problems are easier to discuss and handle than potential problems

Concluding

There are many dilemmas and potential problems in the use of risk assessment

The ethical perspective:

Avoid these when they are known or can be anticipated.

It is a shared responsibility between analysts, risk owner and authorities to do this.

Concluding 2

Risk assessment can be very useful
But with poor quality, it might be useless (or worse)

I do not know how common these problems are in the radiation field

- but it is a challenge to reduce the ones you have and to avoid the rest