What is risk?
Foundations in Risk Assessments and Management

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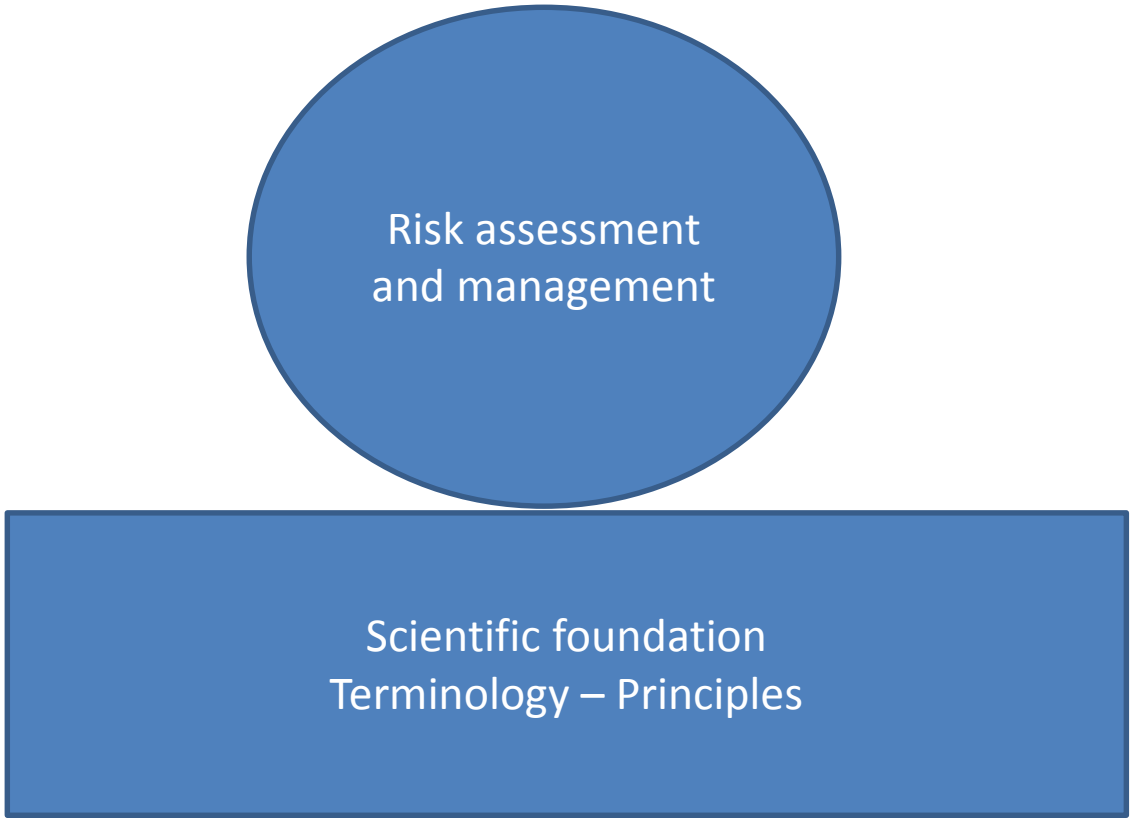
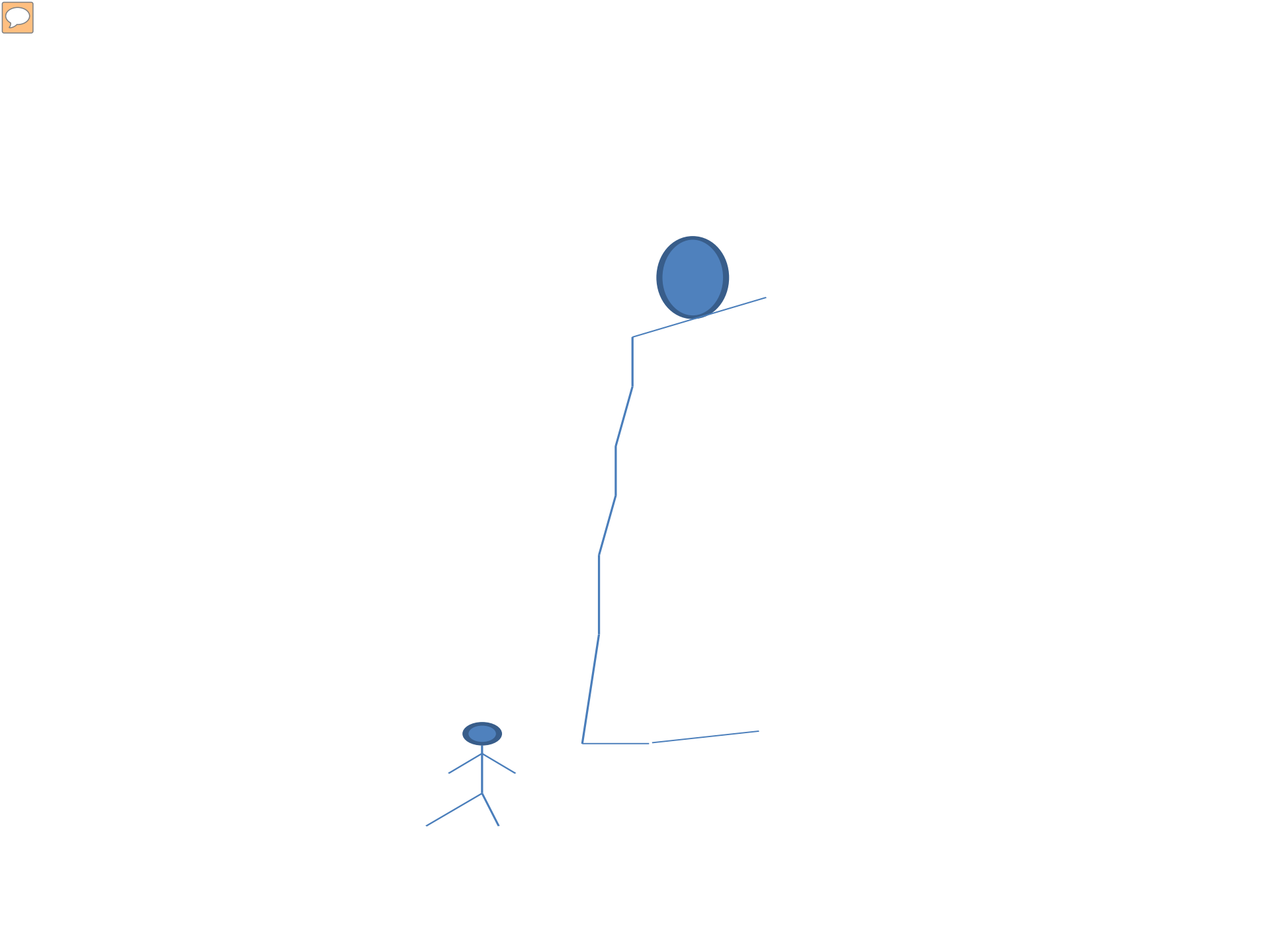
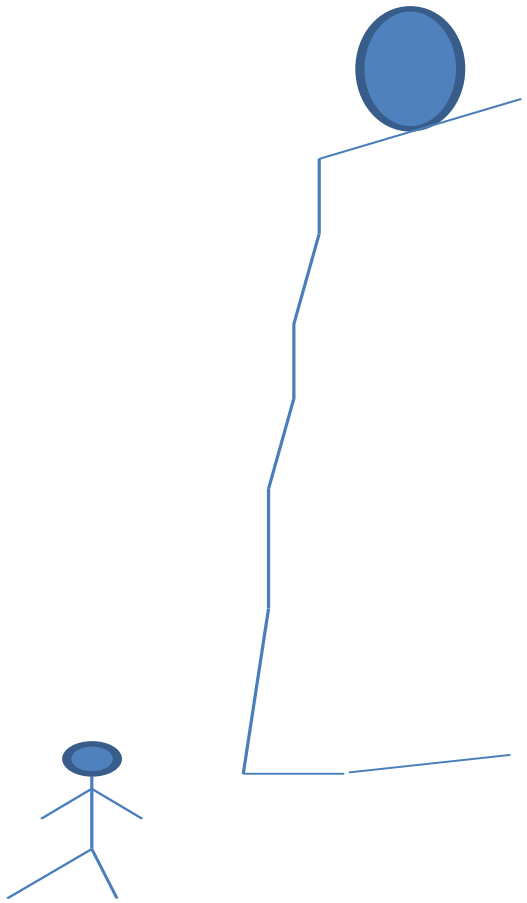

Risk assessment
and management
Scientific foundation
Terminology – Principles





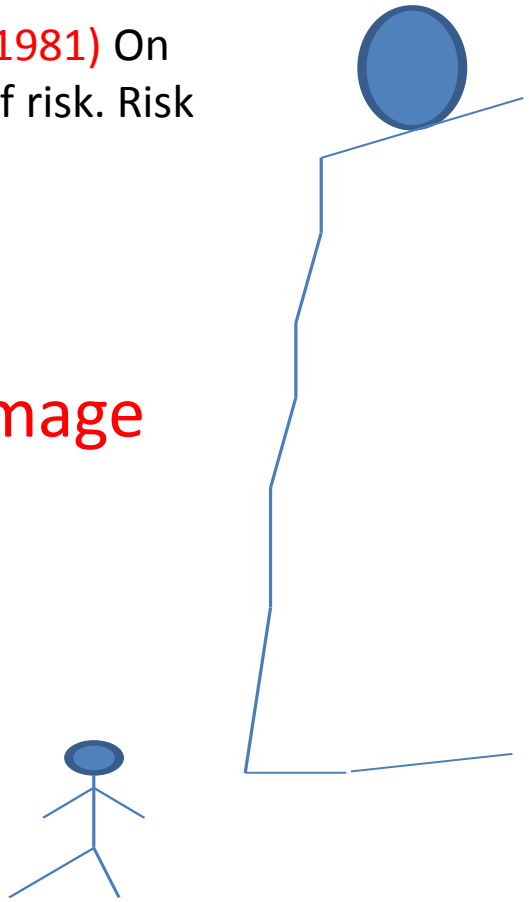
1. Values at stake, consequences with respect to something that humans value

2. Uncertainties

Kaplan, S. and Garrick, B.J. (1981) On the quantitative definition of risk. Risk Analysis 1, 11-27.

Risk =

Uncertainty + Damage



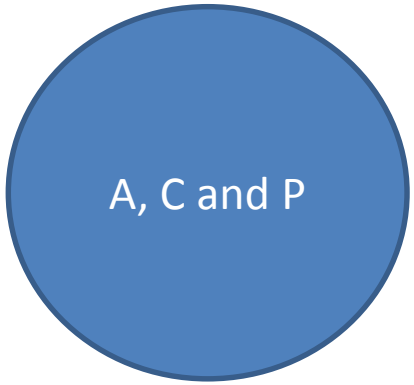
1. Values at stake, consequences with respect to something that humans value

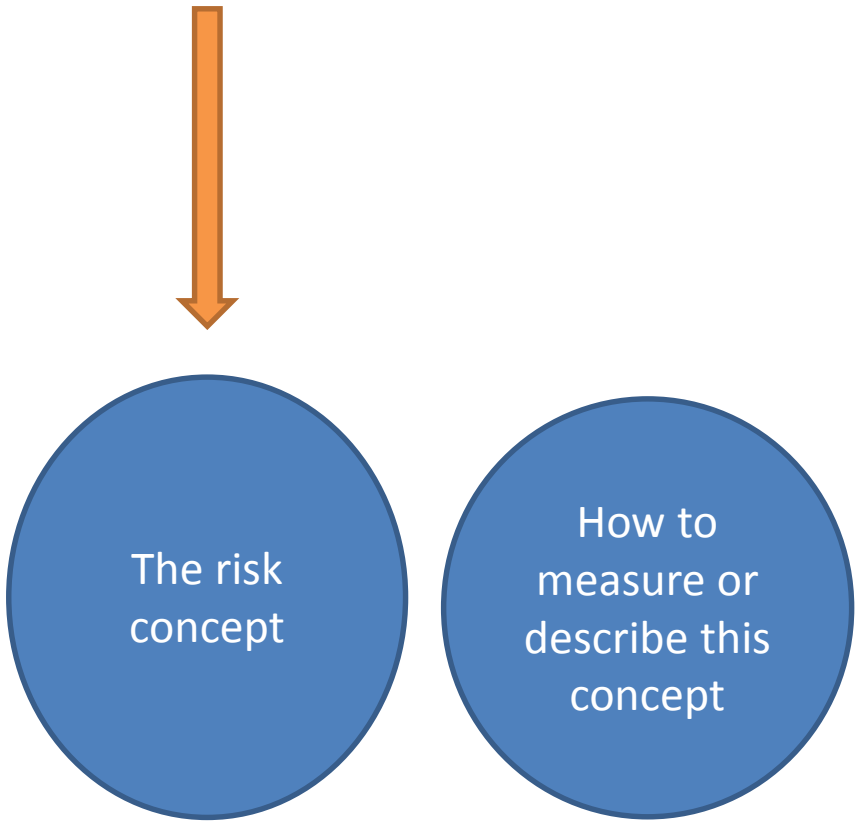
2. Uncertainties

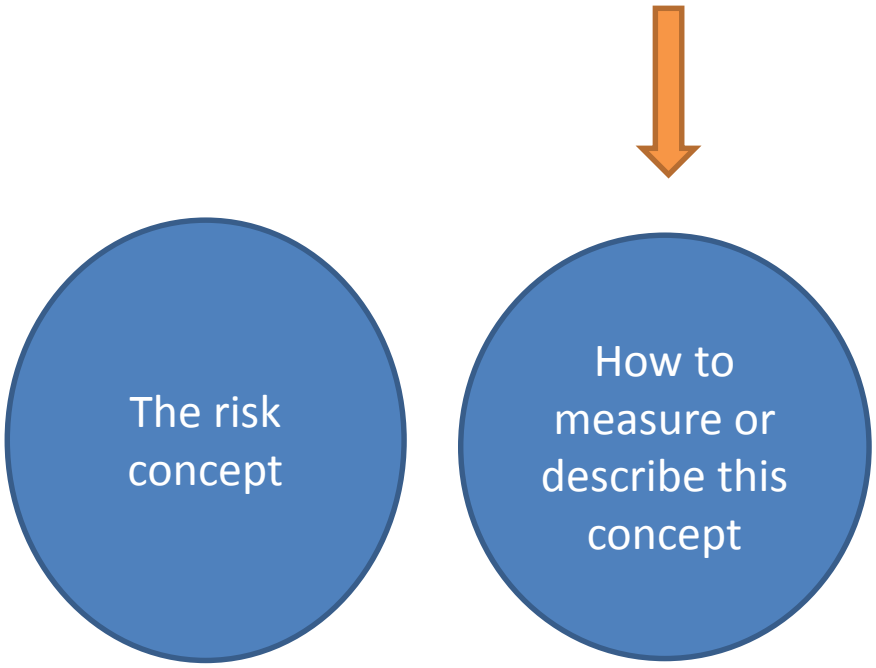
Kaplan and Garrick (1981)

The quantitative definition:

Events/scenarios A, consequences C, probabilities P

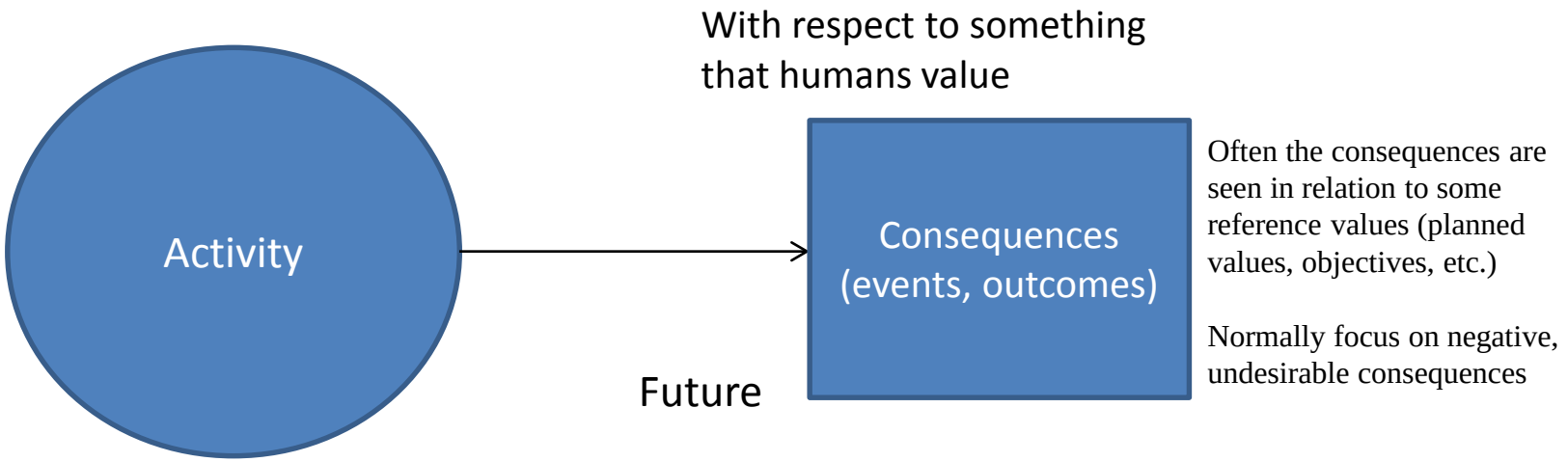



The risk concept
How to measure or describe this concept



Meeting the need of the decision situation

Risk assessment



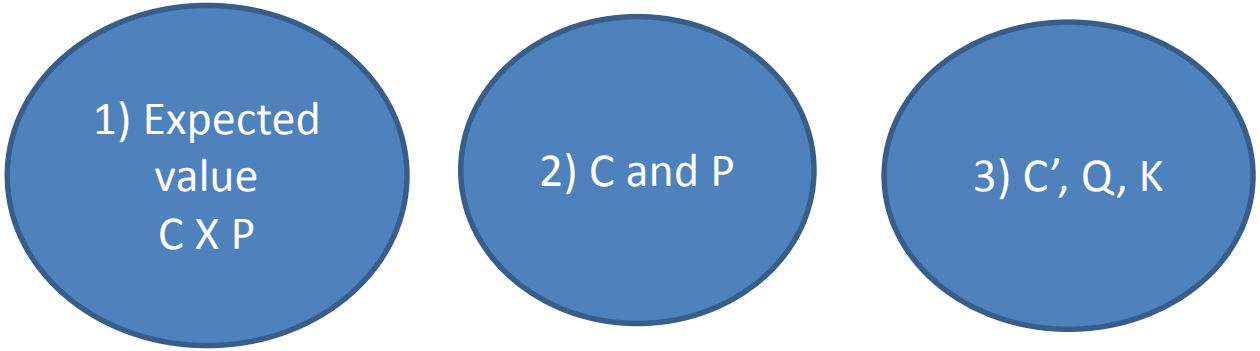
- Risk is the possibility of an unfortunate occurrence
- Risk is the potential for realization of unwanted, negative consequences of an event
- Risk is exposure to a proposition (e.g. the occurrence of a loss) of which one is uncertain
- Risk is the consequences of the activity and associated uncertainties
- Risk is uncertainty about and severity of the consequences of an activity with respect to something that humans value
- Risk is the deviation from a reference value and associated uncertainties

Glossary Society for Risk Analysis (SRA 2015) www.sra.org/resources

How to describe or measure risk?

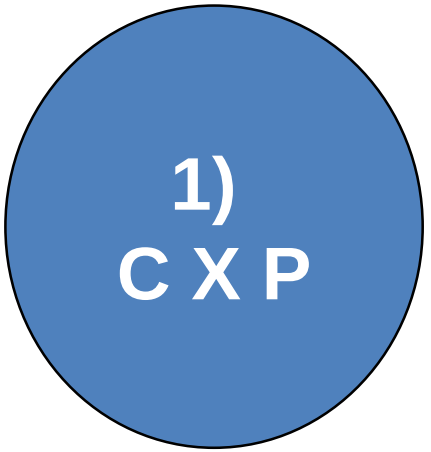
Glossary examples:

1) Expected consequences (damage, loss)
2) The combination of magnitude/severity of consequences C and probability P
3) The triplet (C',Q,K), where C' is some specified consequences, Q a measure of uncertainty associated with C' and K the background knowledge that supports C' and Q



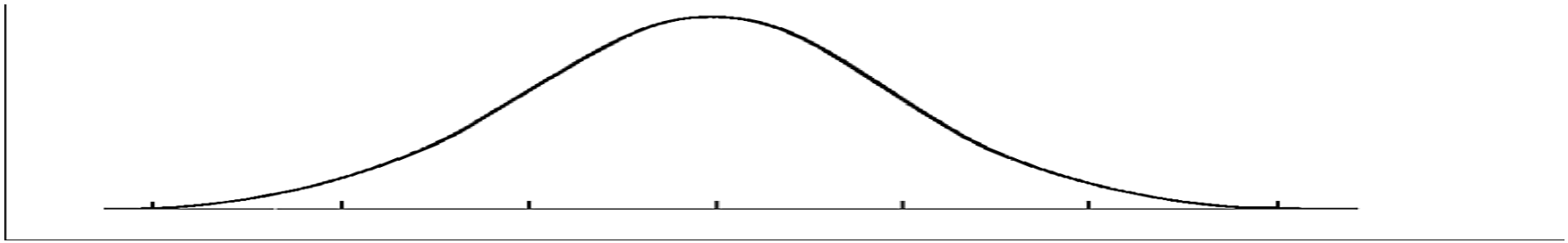
- Risk description = expected loss/consequences

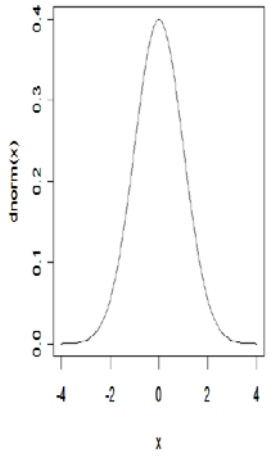
Abraham de Moivre 1711



C: Consequences (loss)

P: Probability





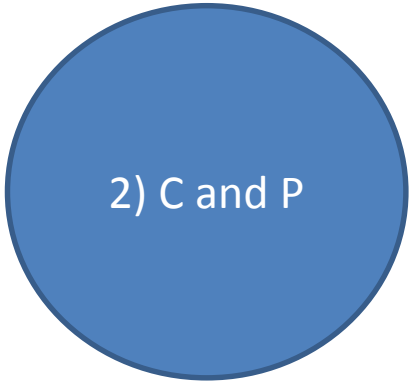
x

2) Risk description= The combination of magnitude/severity of consequences C and probability P

Alternative formulation:

Events/scenarios A, consequences C, probabilities P

Kaplan, S. and Garrick, B.J. (1981) On the quantitative definition of risk. Risk Analysis 1, 11-27.



Same (C,P) but …

A geological expert expresses that the probability that the boulder dislodges from the boulder, hits John and kills him, to be 1/1000000. Her knowledge supporting this number is strong. She has a lot of data available, and insights about the phenomenon.

A lay person assigns the same probability for the event. His knowledge about the phenomenon looked into is very poor.

Should not the strength of knowledge supporting the P be taken into account when considering risk?

John offers you a game: throwing a die

- ”1,2,3,4,5”: 6
- ”6”: -24

What is your risk?

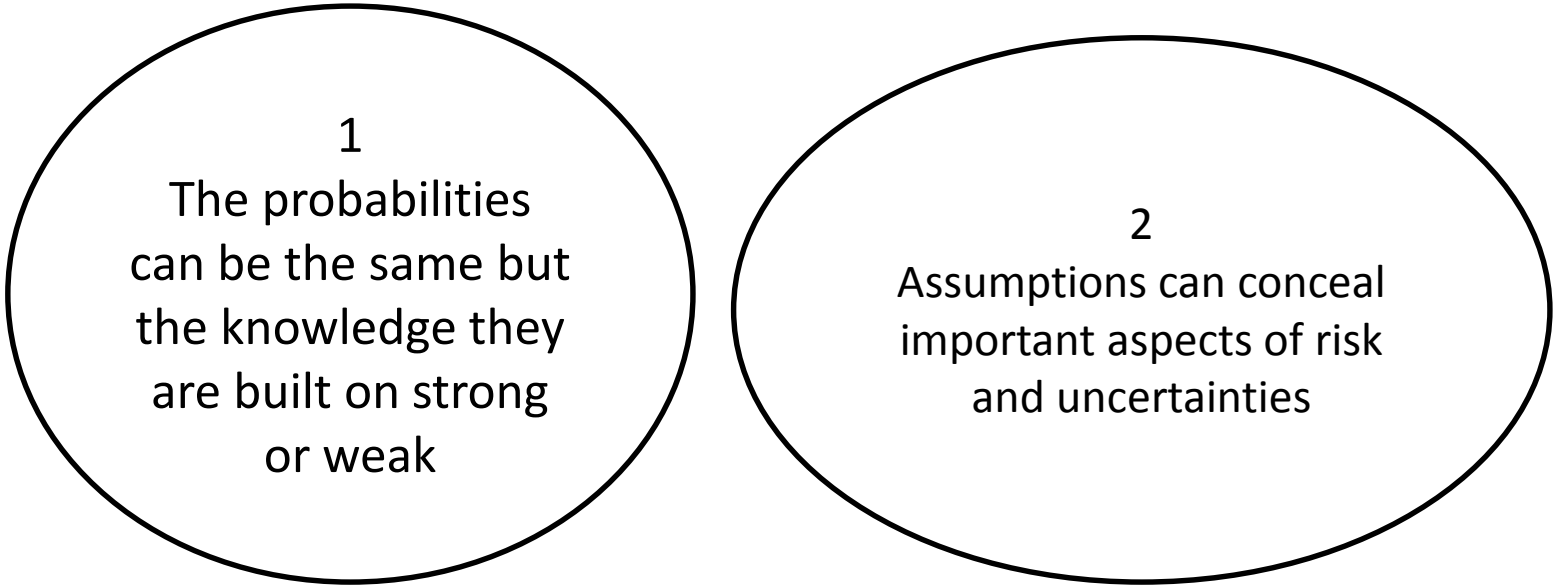
Risk

(C,P):

- 6 5/6
- -24 1/6

Is based on an important assumption – the die is fair

Challenges linked to probability-based risk descriptions



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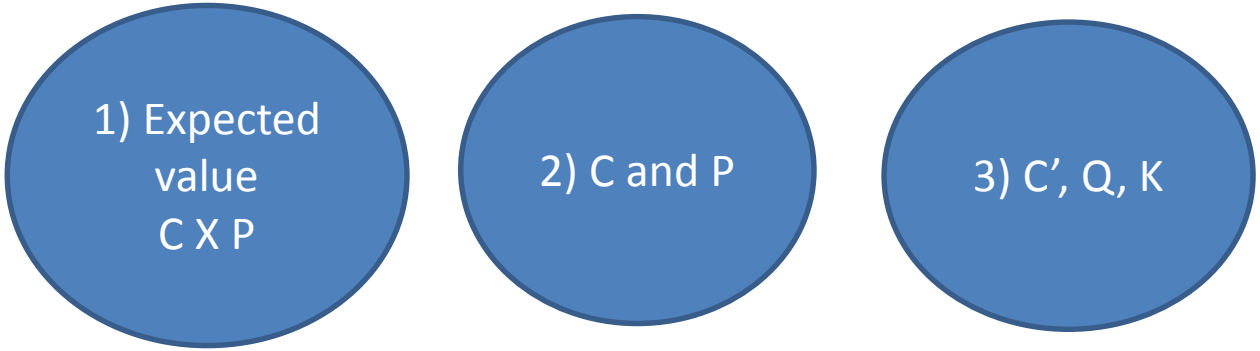

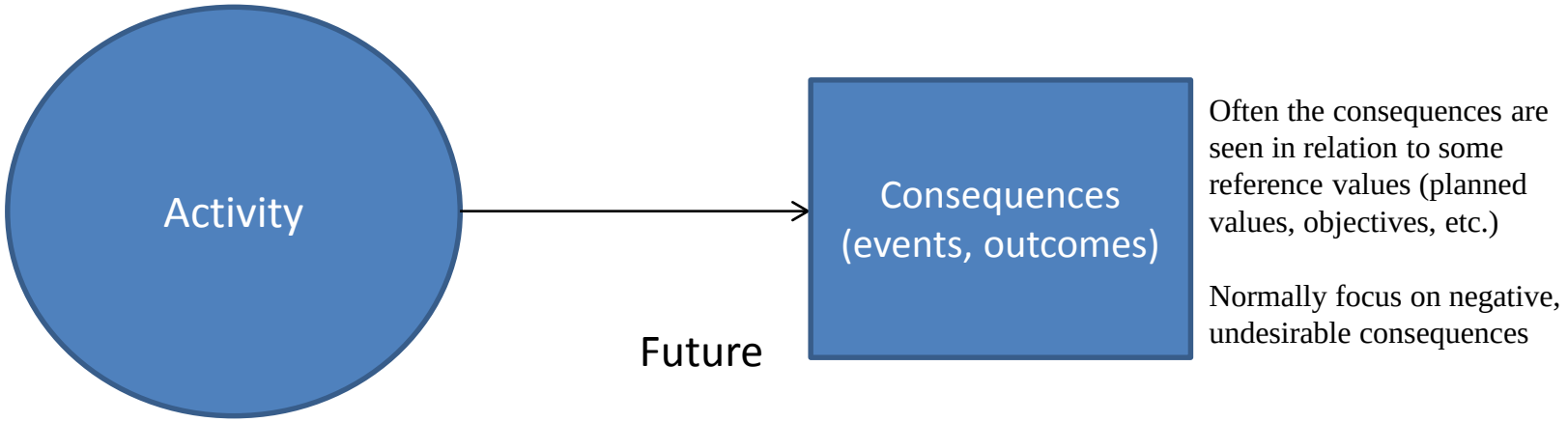

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Glossary Society for Risk Analysis

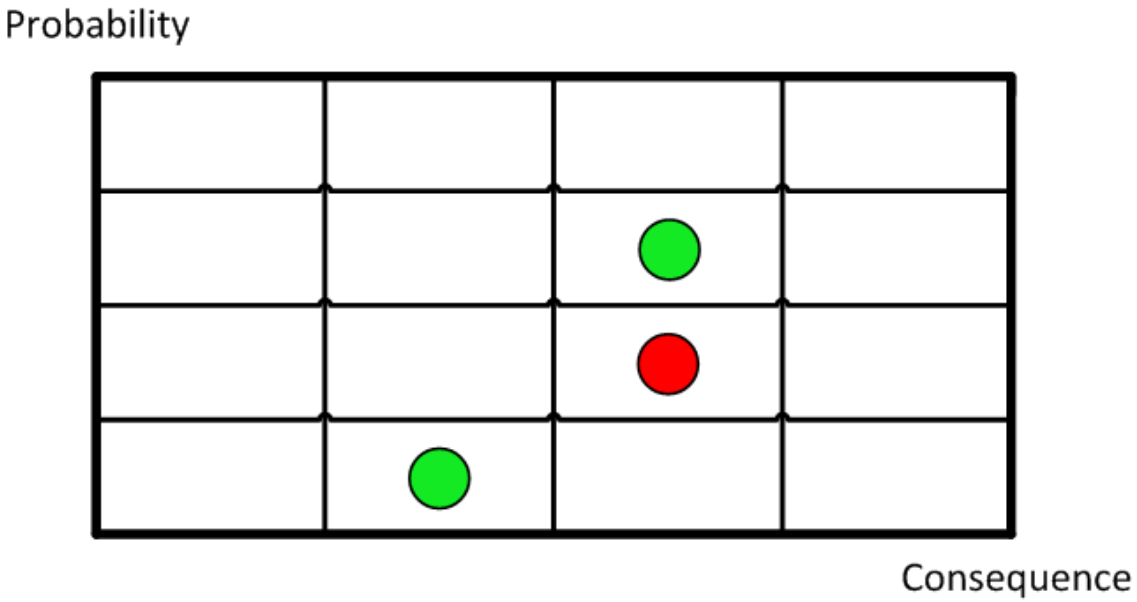
Specify the consequences before they occur, number of fatalities, economic loss (C')

Risk is the consequences (C) of the activity and associated uncertainties (U)

A measure of the uncertainties (Q)

The knowledge K that C' and Q are based on

Q = (P, Strength of knowledge)



Probability

$$P(A \mid K)$$

Knowledge

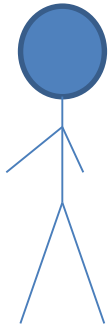
- Poor background knowledge
- Medium strong background knowledge
- Strong background knowledge

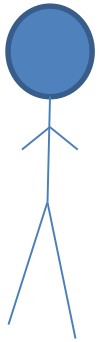
Strength of knowledge judgments:

- *The reasonability of the assumptions made*
- *Amount and relevance of data*
- *Agreement/consensus among experts*
- *How well phenomena involved are understood*

Analysts

Decision maker

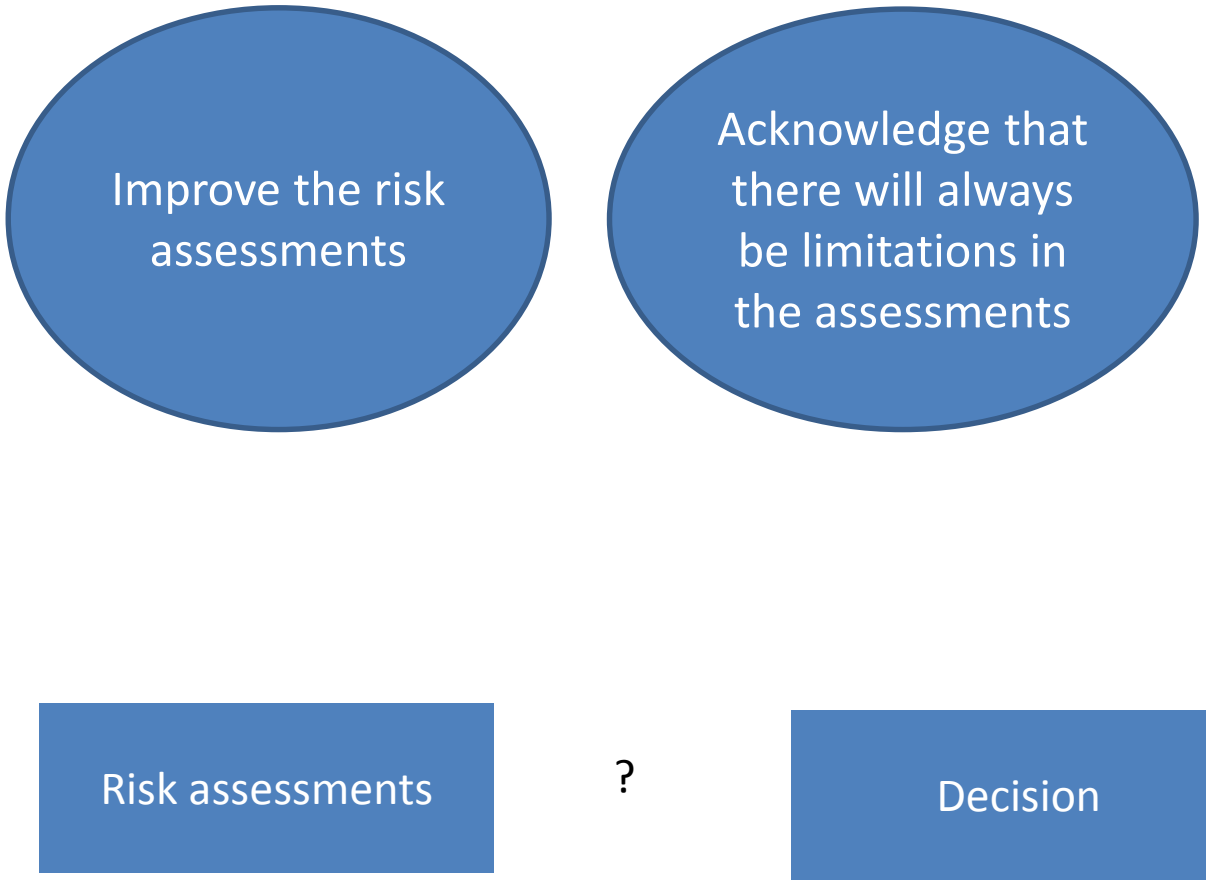




(C, P |K)
«Conditional risk given K»

What about the risk aspects associated with K

Need to face the «unconditional risk» (C,U)

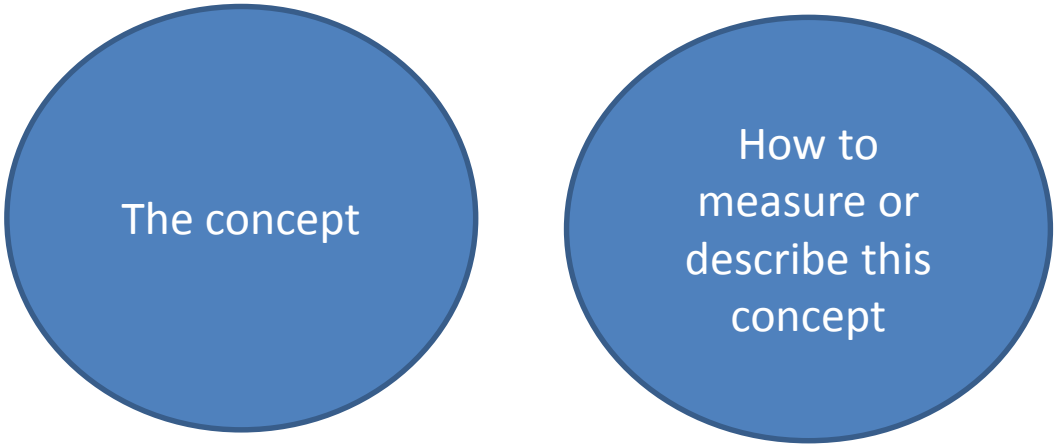

Improve the risk assessments
Acknowledge that there will always be limitations in the assessments
Risk assessments
?
Decision

Risk management

Risk assessments

Robustness, resilience, cautious policies …

Vulnerability



Meeting the need of the decision situation

- The degree a system is affected by a risk source or agent
- The degree a system is able to withstand specific loads
- Risk conditional on the occurrence of a risk source/agent

- Expected system loss given the occurrence of a risk source
- The probability that the system capacity is not able to withstand a specific load (the capacity is less than the load)
- A probability distribution for the loss given the occurrence of a risk source
- (C',Q,K | risk source)

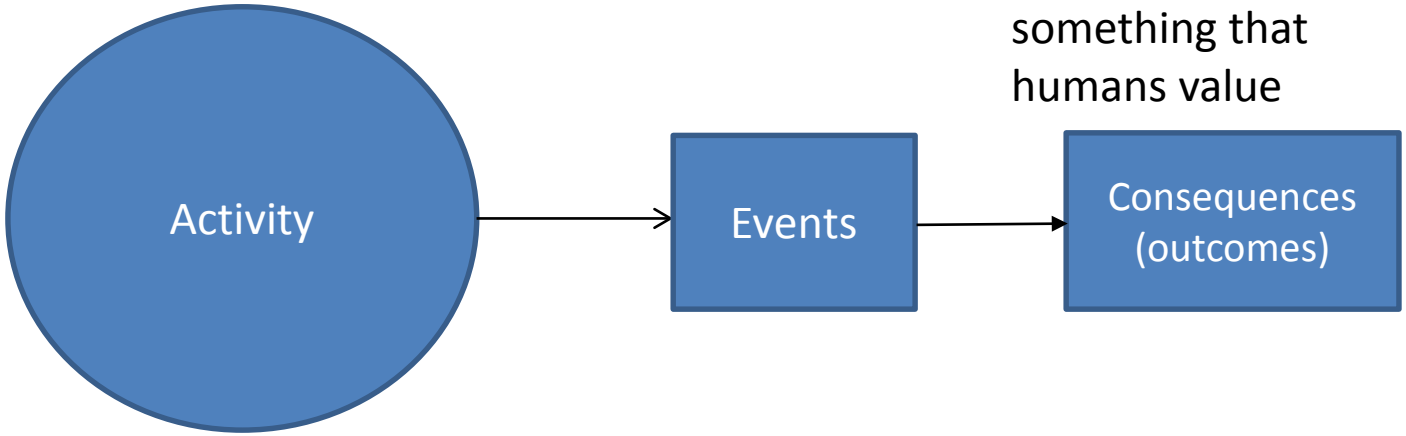
Security

Risk = (Threat (T), Vulnerability (V), Consequences (C))

Risk = (Value (assets), Threat and Vulnerability)

Risk = T x V x C

With respect to something that humans value



Threats, Attacks

Consequences given events

Uncertainties

Uncertainties

ISO Guide 73 / ISO 31000

Risk = the effect of uncertainty on objectives

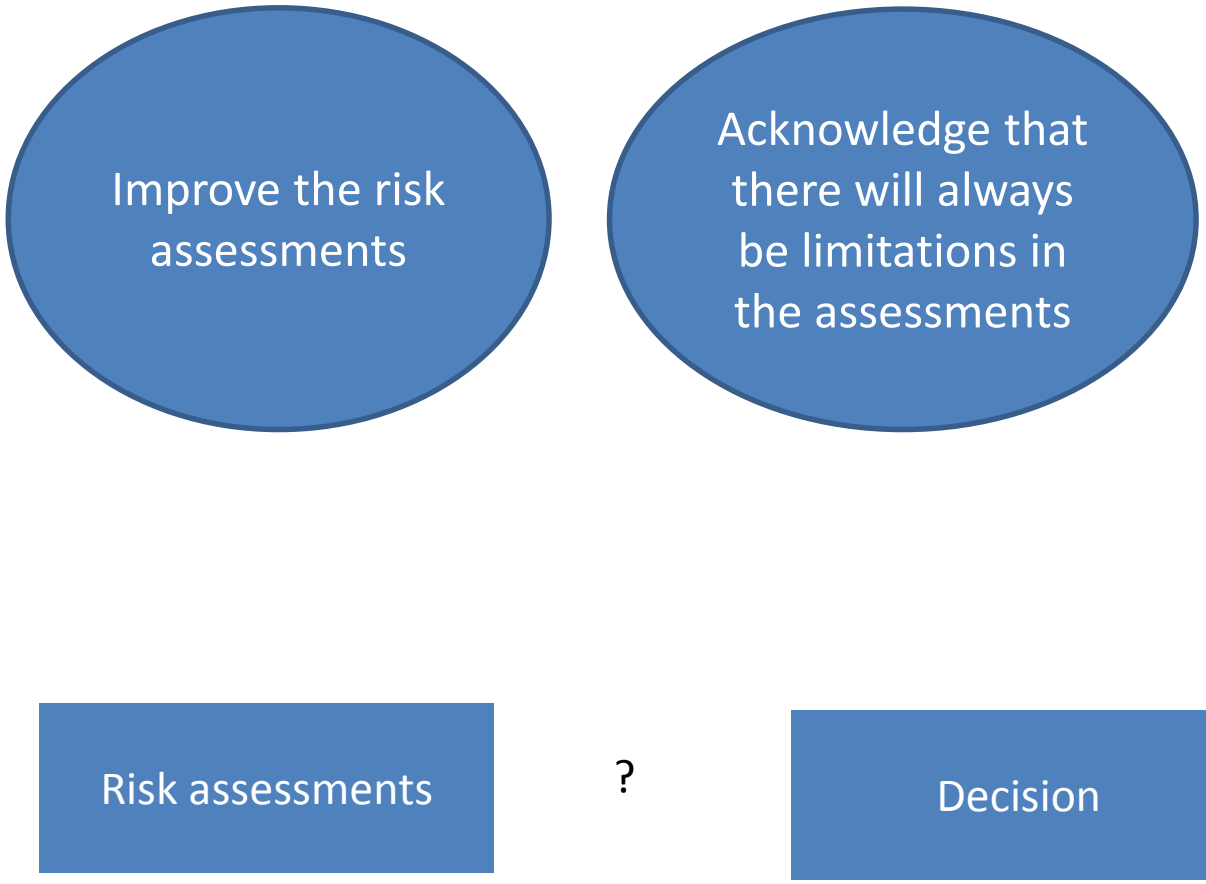
An effect is a deviation from the expected
(positive and/or negative)

- The outcome of an activity is either 0 or 1.
- The associated probabilities are 0.9 and 0.1. Hence the expected value equals 0.1.
- Deviations from the expected mean either the outcome 0 or 1. The outcome is uncertain and the objective is the outcome 0 (zero fatalities).
- ISO definition, risk is “the effect of uncertainty”, i.e. an outcome 0 or 1, “on objectives”, i.e. outcome 0 meets the objective whereas 1 does not.
- The meaning of this is hard to understand

Conclusions

«Current thinking about risk»

1. Risk exists even if we do not measure it. John faces risk even if we do not quantify it.
2. Different metrics can be used to characterise/measure risk. Probability alone is not enough. The knowledge dimension must be given due attention (e.g. using strength of knowledge judgments)
3. Risk assessment informs decision makers


Improve the risk assessments
Acknowledge that there will always be limitations in the assessments
Risk assessments
?
Decision

Extra

Probability (likelihood, chance)

Overall definition

A measure for representing or expressing uncertainty, variation or beliefs, following the rules of probability calculus.

Different types/interpretations:

- Classical probability:

The classical interpretation applies only in situations with a finite number of outcomes which are equally likely to occur: The probability of A is equal to the ratio between the number of outcomes resulting in A and the total number of outcomes, i.e.

P(A) = Number of outcomes resulting in A/Total number of outcomes.

- Propensity/frequentist probability:

A frequentist probability of an event A, denoted $P_f(A)$, is defined as the limiting fraction of times the event A occurs if the situation considered were repeated (hypothetically) an infinite number of times.

The propensity interpretation holds that the probability is to be thought of as a physical characteristic; a propensity of a repeatable experimental set-up which produces outcomes with limiting relative frequency $P_f(A)$.

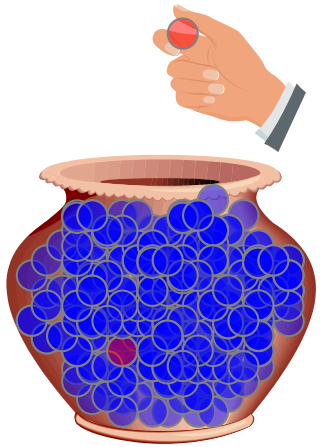
- Subjective (judgmental, knowledge-based) probability:

Reference to an uncertainty standard: The probability P(A) is the number such that the uncertainty about (degree of belief in) the occurrence of A is considered equivalent by the person assigning the probability, to the uncertainty about (degree of belief in) some standard event, for example drawing at random a red ball from an urn that contains P(A) x 100% red balls.

Betting and related type of interpretations: The probability of an event A is the price at which the person assigning the probability is neutral between buying and selling a ticket that is worth one unit of payment if the event occurs, and worthless if not

Subjective (judgmental, knowledge-based) probability

- $P(A|K) = 0.1$
- The assessor compares his/her uncertainty (degree og belief) about the occurrence of the event A with drawing a specific ball from an urn that contains 10 balls (Kaplan and Garrick 1981, Lindley, 2000).



K: background knowledge

Imprecise probabilities

- $P(A) = 0.3$, means $0.26 \leq P(A) \leq 0.34$
- Imprecison interval [0.26, 0.34]

Following the uncertainty standard interpretation this means that the assigner states that his/her assigned degree of belief is greater than the urn chance of 0.26* and less than the urn chance of 0.34. The analyst is not willing to make any further judgments.

* The degree of belief of drawing one red ball out of an urn containing 100 balls where 26 are red and less than the urn chance of 0.34.

- Subjective probabilities P(A|K) can always be assigned
- But the strength of K also needs to be reflected