Practical guidance for the Risk Assessment in the framework of Regulation 994/2010 (IE)

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Risk assessment: The Regulation

Article 9: ***Each competent Authority shall make a full risk assessment, on the basis of the the following elements, of the risks affecting the security of gas supply in its Member State by:***

(a) using the infrastructure and supply standards;

(b) taking into account all relevant national and regional circumstances;

(c) running various scenarios;

(d) identifying the interaction and correlation of risks with other Member States.

(e) taking into account the maximal interconnection capacity of each border entry and exit point.

Article 5: ***The Preventive Action Plan shall contain:***

(a) the results of the risk assessment;

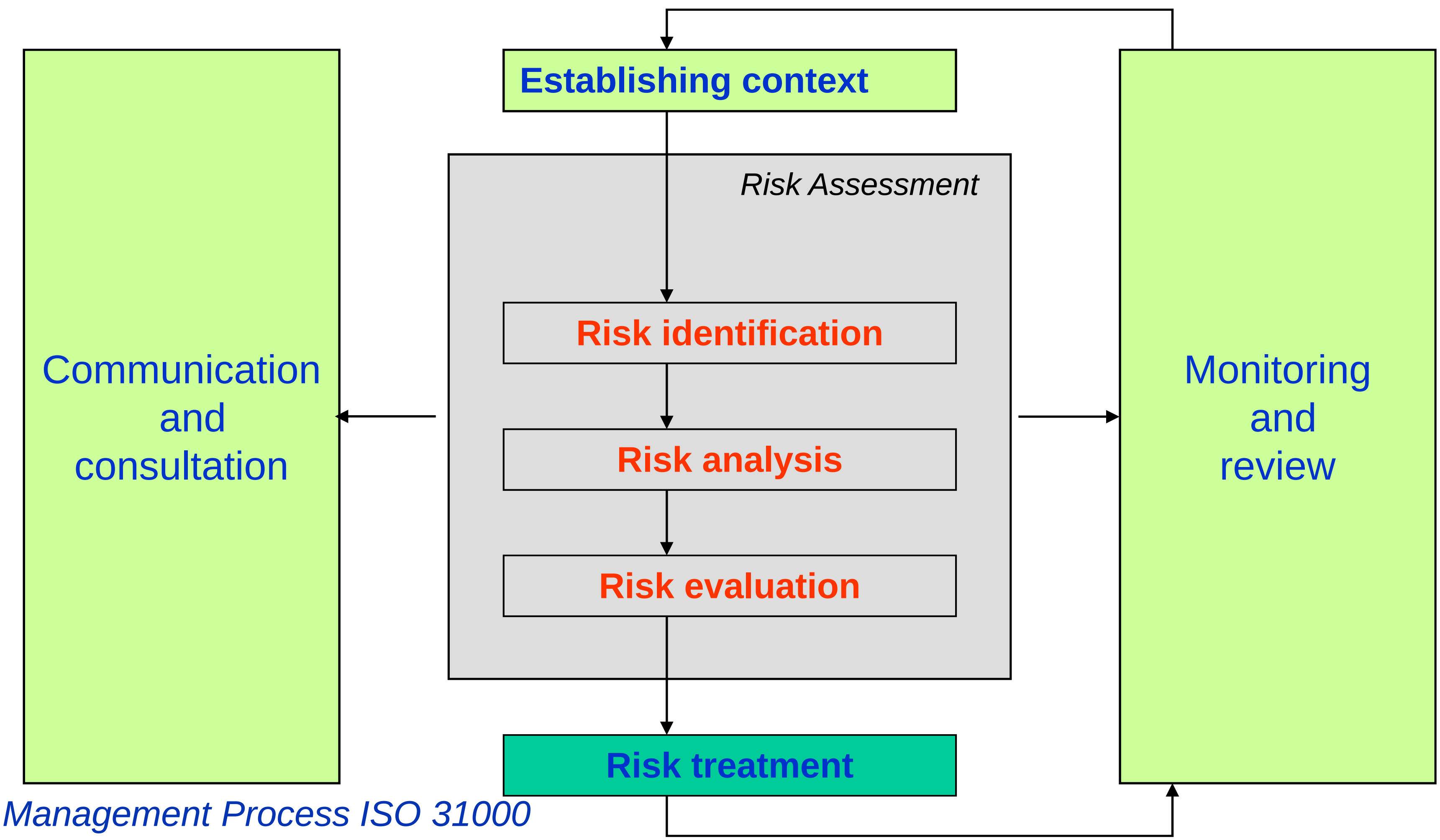
(b) The measures, volumes, capacities and the timing needed to fulfil the infrastructure and supply standards;

(c) the preventive measures to address the risks identified.

Objective of this presentation:

⇒ **Provide guidance for performing the Risk Assessment:**

ISO 31000 - *Risk Management*



Risk Management Process ISO 31000

Risk Management – Risk Assessment Techniques IEC/ISO 31010

ISO 31000: 2009: Risk management — Principles and guidelines

Risk management process

- **Step A**: Establishing context
- **Step B**: Risk assessment
    - **B.1.** Identifying sources of risk
    - **B.2.** Risk analysis
    - **B.3.** Risk evaluation
- **Step C**: Risk treatment

A: Establishing the context

- **Basically this involves two activities:**
  1. Characterizing the system via a set of internal and external parameters
     - Market
     - Gas infrastructure
     - Infrastructure utilization and contracts
     - Institutional framework
     - Regional context
  2. Setting Risk Criteria

Market

The following list of market-related factors is not exhaustive; it only refers to those elements of the market that affects or is relevant to the risk assessment. Both sides of the market are considered – demand and supply.

Demand (average/monthly/peak/seasonal)

- Current and projected gas balance
  - Demand of transformation sector
  - Total final gas consumption
  - Total final gas consumption by sector (industry, transport, residential and commercial)
- Current and projected gas demand in primary energy mix
- Demand from interruptible/protected customers/district heating
- Level of market opening (proportion of market open to competition)
- Customer fuel switching capabilities (industry, tertiary, household)?
- Gas prices?

Supply (average/monthly/daily/peak-seasonal)

- Current and projected gas balance (TPES)
  - Total Production
  - Total Imports (+ number of import sources)
  - Total Exports
- Gas quality (calorific value)
- Number and market share of major energy firms
- Level of supply diversification (market concentration, e.g. Herfindahl-Hirschman Index)

Gas infrastructure

Gas infrastructure refers to the physical infrastructure in place to produce, import, process, transmit, and distribute gas (Capacity rather than flows are taken into account). Gas infrastructure includes the gas transmission network including interconnectors as well as production, LNG, storage transformation and distribution facilities.

Pipelines

- Number of border transmission entry and exit points (pipelines)
- Maximal technical capacity of entry points (+ their country of origin)
- Reverse capacity (by pipeline)
- Number of compressor stations along transmission lines
- Planned investments
- Age/maintenance of pipelines

LNG

Import capacity of LNG facilities

- Maximal technical LNG processing capacity
- Number of LNG facilities[1]
- Cross border LNG capacity/commitments
- Planned investments
- Age/maintenance of LNG facilities

Gas infrastructure (cont.)

Storage

- Maximal technical storage deliverability
- Physical characteristics of storage sites (number/type – e.g. base load/peak load ratio)
- Cross border storage capacity/commitments
- Planned investments
- Age/maintenance of storage facilities

Production

- Maximal technical production capability
- Reserves to production ratio
- Number/type of production facilities
- Planned investments
- Age/maintenance of production facilities

Transformation

- Capacity of gas-fired power generation
- Number of gas-fired power plants
- Planned investments
- Age/maintenance of conversion facilities

Infrastructure utilization and contracts

Utilization

Utilization relates to the volume and direction of gas supplies flowing throughout the system. Utilization differs according to different time periods (e.g. peak/seasonal/daily demand).

Pipelines

- Annual/peak incoming and outgoing flows
- Annual/peak reverse flows
- Annual/peak utilization rate (for each pipeline)

LNG

- Annual/peak import flows from LNG terminals
- Annual/peak send-out flows of LNG
- Annual/peak utilization rate (for each LNG terminal)

Storage

- Annual/peak volume of stocks
- Annual/peak withdrawal rate
- Annual/peak utilization rate

Production

- Annual/peak production
- Actual gas reserves
- Depletion rate

Infrastructure utilization and contracts

Contracts

Supply contracts are an integral part of determining the gas system's flexibility. The duration, type and exact terms of contracts should be taken into account. For pipelines, LNG, storage and production, the following should be taken into account:

- Number and type of contracts (long-term, short term, swap, use of spot market, volume of each)
- Trading
- Flexibility/Liquidity

Institutional framework

In undertaking the risk assessment it is important to make a list of all the relevant stakeholders and the rules governing their activities. This is useful not only in identifying risk but also in being able to better manage unforeseen disruptions to supply (an integral part of the emergency/action plans).

- Stakeholders (e.g. competent authorities, interest groups, government ministries, energy firms, etc)
- Roles and responsibilities
- Regulatory framework (e.g. the institutions and rules governing relations between stakeholders)
- Legal arrangements for security of gas supply (Emergency provisions, disconnection order)
- Level of unbundling (legal, organizational)

Regional context

The regional context draws on similar elements to the national context, but adds certain characteristics specific to the region.

- Infrastructure of common/regional interest
- Regional institutions
- Regional investments
- Regional initiatives

Risk criteria:

Not explicitly mentioned in the regulation

Absolute minimum: The standards (infrastructure and supply)

Importance of defining the system

Definition of measures of damage

- Non-supplied gas to protected customers (evolution over time),
- time during which the lack of gas supply persists, and
- Total non-supplied gas to customers

But not only these.

Classification of Regulation aims

1) Sufficient supply of gas (physical security)

2) Solidarity and co-ordination at regional level

3) Economic approach to security

4) Establishing accountability

5) Environmental concerns

B.1: Identifying sources of Risk

- ***The objective is to identify all relevant sources of risk (i.e. threats and hazards) that may lead to a loss of gas supply.***
- ***Threats imply intentional acts. Hazards are non-intentional.***
- ***These can occur in supplier, transit or consumer states.***
- ***The time horizon for these sources of risk may vary (short, medium and long term).***
- ***Sources of risk can be categorized as follows:***

- **Technical**
  - Hazards (e.g. unintentional failure of infrastructure, ICT breakdown)
  - Threats (e.g. intentional sabotage/attack)
- **Political**
  - Hazards (e.g. civil unrest, war)
  - Threats (e.g. targeted attacks on gas infrastructure, strikes)
- **Economic**
  - Hazards (e.g. gas price volatility)
  - Threats (e.g. commercial dispute, monopolization of market)
- **Environmental**
  - Hazards (e.g. hurricane, earthquake, flood, land slide, etc.)

B.1: Identifying sources of Risk (II)

- ***The key of this step is to make an exhaustive identification of threads and hazards.***
- ***Not being exhaustive in this step may end up in important risk underestimation***
- ***It may be of interest to have different categorizations of sources of risk***

Alternative categorization from the EURACOM FP-7 project for gas systems

Intent	Failure/Accident	Nature	Cascade
Acts of Terrorism Acts of Vandalism Theft (copper/metals) Theft (equipment) Industrial action Targeted Cyber Attack Virus/Trojans EMP Act of War Diplomatic Incident	Negligence Mistake Impact (e.g. vehicle against pylon/pole) Ingress of Water Explosion Disclosure of information (Theft/Leakage) Equipment malfunction or failure Chemical (spillage) Loss, unavailability or turnover of personnel Outdated and un-maintainable technology	Extreme weather conditions Pandemic (Flu/etc) Geological Fire Flood Solar Activity	Loss of power supply/utilities/services Loss of Telecoms Loss of Energy Supply to the Electricity Transmission Network (Interconnector / Generated supply)Loss of 'black start' capability Loss of pumped storage capacity

Techniques to identify sources of risk

Most used techniques to identify sources of risk:

- **Brainstorming**
- **Structured interviews**
- **Delphi method**
- **Check-lists**
- **Failure mode and effect analysis (FMEA)**
- **Hazard and operability analysis (HAZOP)**
- **…**

In general, these techniques may also be used for other purposes.

They may also be used in support of other techniques in the list.

Different techniques may be used for identifying different sources of risk.

Step B.2: Risk Analysis

1. Objectives

- Assess the likelihoods that the hazards/threats identified will lead to a loss of supply.
- Assess the consequences of a loss of supply, e.g. its effect on economy, society and politics.

2. Method

- **Scenario Analysis**
  - Historical
  - Hypothetical (future)
  - Scenarios are built on the basis of likely combinations of likely events that produce, in principle, no negligible damage. Moreover,
    - Normal evolution scenario (most likely)
    - Worst (credible) case
    - Conservative assumptions when deemed necessary or imposed by the Regulation

- **Main components of Risk**
  - Likelihoods
  - Consequences
  - Timeframe

Probability/likelihood estimates

- Likelihood estimates may be either quantitative or qualitative.
- The more quantitative we are able to keep the risk analysis, the more information we may obtain from it.
- The selection of quantitative or qualitative probability scales depends on the quantity and quality of the data available (the larger the quantity of data and the higher their quality, the more quantitative our estimates will be)

⇒ Use of classical statistical inference techniques

These techniques are used to estimate probabilities of events and probability density functions when there are many data obtained under the conditions of the system studied

- ***Maximum likelihood estimation***
- Method of moments
- Bootstrap
- Jackknife

Probability/likelihood estimates (II)

Most frequently used probability distributions, their parameters and their ML estimators

Distribution	PDF	Parameters	Estimators
Uniform	$\frac{1}{b-a}; a \le x \le b$ $0; otherwise$	a: Minimum b: Maximum	$\hat{a} = \min\{x_1,\dots,x_n\}$ $\hat{b} = \max\{x_1,\dots,x_n\}$
Log-uniform	$\frac{1}{xLn(b/a)}; a \le x \le b$ $0; otherwise$	a: Minimum b: Maximum	$\hat{a} = \min\{x_1,\dots,x_n\}$ $\hat{b} = \max\{x_1,\dots,x_n\}$
Normal	$\frac{1}{\sqrt{2\pi}\sigma}\exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right];$ $\sigma > 0$	μ: mean σ^2: variance	$\hat{\mu} = \bar{x}_n = \frac{1}{n}\sum_{i=1}^{n} x_i$ $\hat{\sigma}^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x}_n)^2$
Log-normal	$\frac{1}{x\sqrt{2\pi}\sigma}\exp\left[-\frac{1}{2}\left(\frac{Lnx-\mu}{\sigma}\right)^2\right];$ $x > 0, \sigma > 0$	μ: mean of Ln(x) σ^2: variance of Ln(x)	$\hat{\mu} = \bar{x}_n = \frac{1}{n}\sum_{i=1}^{n} Lnx_i$ $\hat{\sigma}^2 = \frac{1}{n}\sum_{i=1}^{n}(Lnx_i - \bar{x}_n)^2$
Exponential	$\lambda e^{-\lambda t}; t > 0$	λ: inverse of the mean	$\hat{\lambda}^{-1} = \frac{1}{n}\sum_{i=1}^{n} t_i$
Gamma	$\frac{t^{\alpha-1}}{\beta^\alpha\Gamma(\alpha)}e^{-t/\beta};$ $\alpha > 0, \beta > 0, x > 0$	α: shape param. β: scale param.	$\hat{\alpha}\hat{\beta} = \bar{x}_n$ $\frac{1}{n}\sum_{i=1}^{n} Lnx_i = Ln\hat{\beta} + \psi(\hat{\alpha})$ *
Weibull	$\frac{cx^{c-1}}{\alpha^c}\exp(x/\alpha)^c$	α: scale param. c: shape param.	$\hat{\alpha} = \left(1/n\sum_{i=1}^{n} x_i^{\hat{c}}\right)^{1/\hat{c}}$ $\hat{c}^{-1} = \left(\sum_{i=1}^{n} x_i^{\hat{c}} Lnx_i\right)\left(\sum_{i=1}^{n} x_i^{\hat{c}}\right)^{-1} - \frac{1}{n}\sum_{i=1}^{n} Lnx_i$ †
Binomial	$\binom{n}{i}p^i(1-p)^{n-i}$	p: prob. of event	$\hat{p} = r/n$ r=number of times event happens out of n trials
Poisson	$\frac{\lambda^k}{k!}e^{-\lambda}$	λ: Mean n. of events per unit of time, length, surface, etc.	$\hat{\lambda} = r/n$ r= number of events n= sample size (s, m, m^2, etc.)

Probability/likelihood estimates (III)

•Use of Bayesian statistical inference techniques

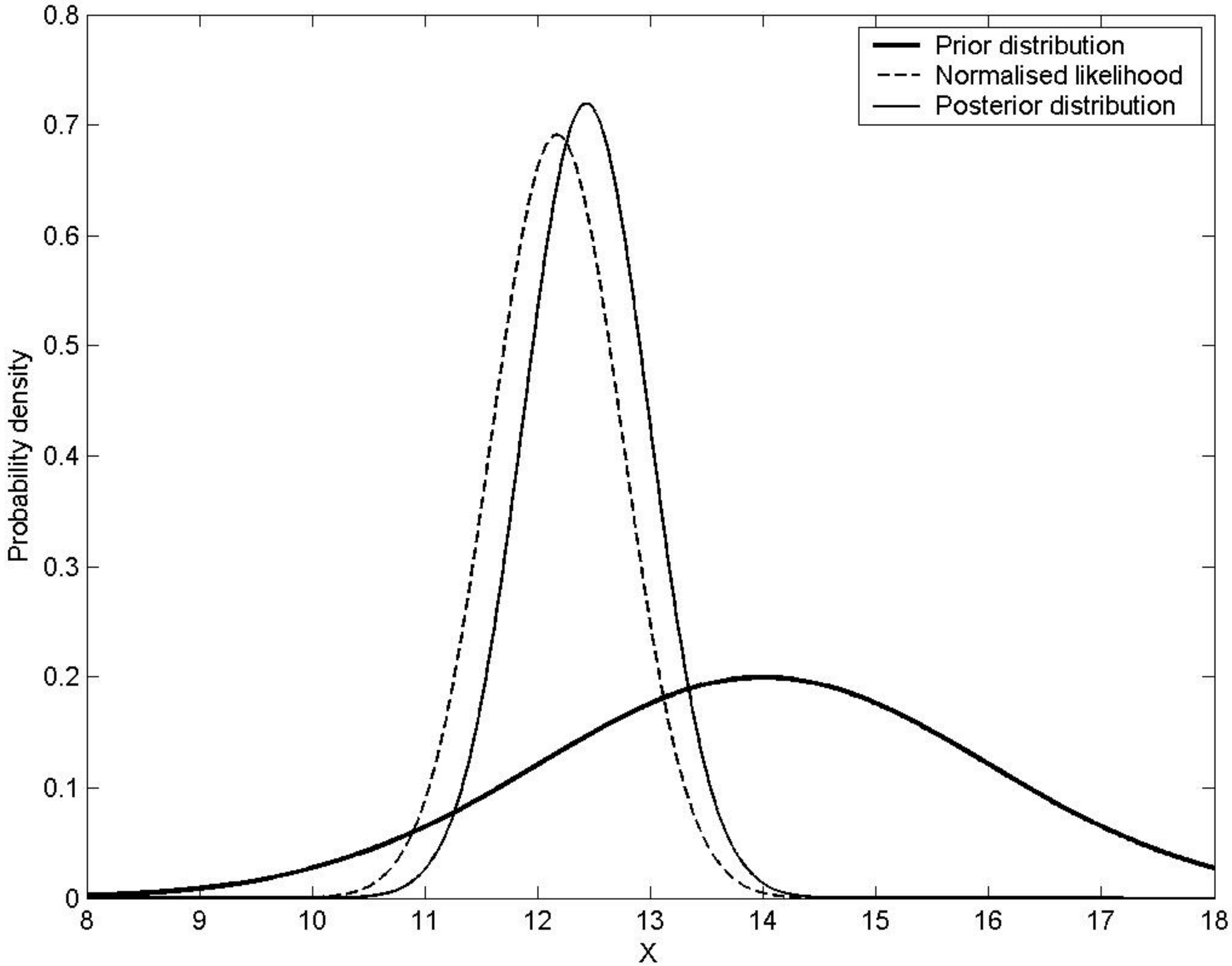
- ➢These techniques are suggested when not many specific historical data are available, but some generic data may be of use.

- ➢This could be the case for example if not much experience has been accumulated about a given facility, but similar facilities are available in other countries, which have accumulated sufficiently long historical records.
  - generic data from similar facilities could be used to create a 'prior distribution', which could be combined with the likelihood obtained from the few historical specific records in order to generate the 'posterior distribution' for the quantity under estimation
  - Key tool to update estate of knowledge ➔ ***Bayes' formula***.

$$\pi(\theta|\mathbf{x},H) = \pi(\theta|H)L(\mathbf{x}|\theta,H)$$

Probability/likelihood estimates (IV)

- Use of *Bayes' formula for Bayesian estimation*.



Use of Expert Judgement (EJ) protocols:

These techniques are suggested when not many data are available.

- Well-known experts would be asked to participate in a structured EJ exercise to provide their estimates.
- Usually, even under severe scarcity of data, experts are able to quantify their opinions in terms of probabilities, which is much more useful than providing soft qualitative likelihood estimates in qualitative scales.
- Need of using structured protocols to avoid biases.

An EJ protocol (phases):

1. Selection of the project team.
2. Preparation of supporting material and definition of the questions to be studied.
3. Selection of experts.
4. Training sessions.
5. Refinement of the questions to be studied.
6. First individual work period.
7. Presentation of individual approaches adopted by the experts.
8. Second individual work period.
9. Elicitation sessions.
10. Analysis and aggregation of results.
11. Review.
12. Documentation.

Probability/likelihood estimates (VI)

- If experts find it extremely difficult to estimate probabilities in a numeric scale, at least a qualitative scale should be used.

- It is desirable to classify events / scenarios according to the qualitative scale. The more classes included in the scale, the better.

In the EURACOM project, the following scale is suggested:

1. **Very low probability** (It is extremely unlikely that the incident will occur – no experience in the gas sector)

2. **Low probability** (It is unlikely to occur – very limited experience in the gas sector)

3. **Medium probability** (It is a likely event – similar accidents have been reported in the gas sector)

4. **High probability** (It is very likely to occur – it has been experienced in most systems in the gas sector)

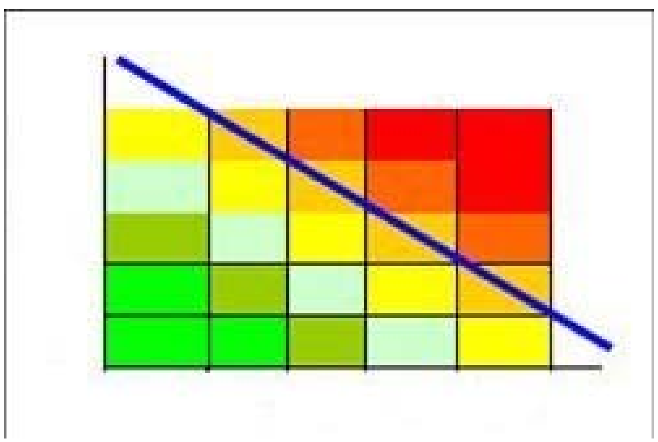
5. **Certainty** (It will happen in the close future)

Step B.3: Risk Evaluation

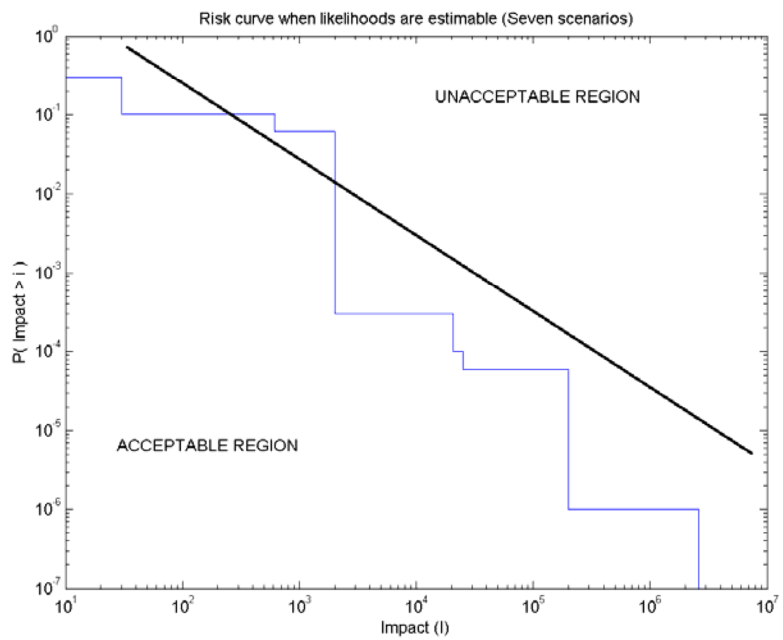
- Risk Matrix

Below are two standard ways of assessing the acceptability of risk by referring to their likelihoods and consequences (qualitative and quantitative).

Likelihood



Consequences



Feedback / suggestions / additions / questions / …

Thank you for your attention!