Study-Based Risk Analyses Variability

– Issues and Opportunities

Manuel (Manny) Marta, P.Eng.
Process Safety Specialist (retired)
manny.marta@gmail.com

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Contents

Useful Definitions & Clarifications

- “Quantitative Risk Analysis (QRA) - The **art and science** of developing and understanding numerical estimates of the risk (i.e., combinations of the expected frequency and consequences of potential accidents) associated with a facility or operation” [1]

- “QRA will never make a decision for you – it can only help increase the information base you draw on when making a decision.”[1]

General Objectives of Study-Based Risk Analyses

- It's useful to clarify objective(s) of the risk analysis
  - **What risk question of interest is being analyzed and for what purpose?**

- Objectives (Fit-for-Purpose)
  - Which lifecycle stage
  - Screening or final decision (ranking, absolute risk)
  - Internal/ external information use
  - Sensitive issue or not
  - Simple or complex risk situation
  - Potential high severity consequences or not
  - Regulatory use or not

- Minimize the gap sufficiently (see "Objectives") between amount and quality of knowledge originally available and judgment needed by an accountable decision-making individual/ group

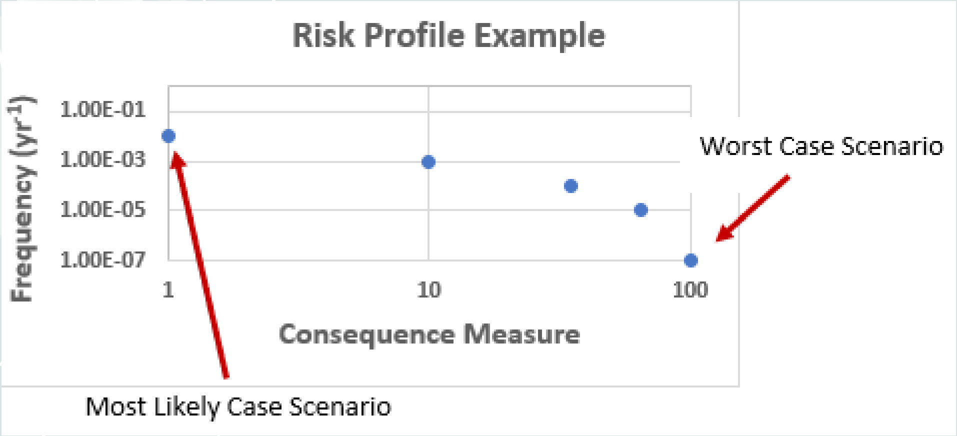
- "Define analysis objectives so results will satisfy the particular decision-making requirement." [1]

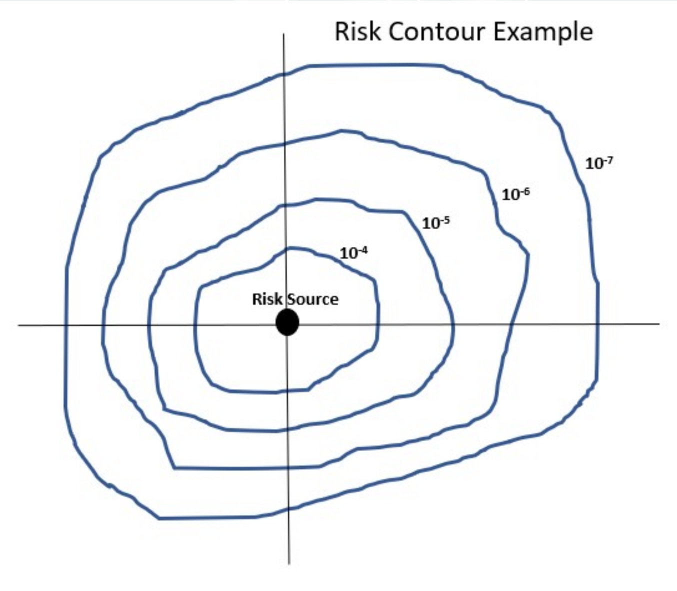
Historical Observations on Risk Analysis Variability

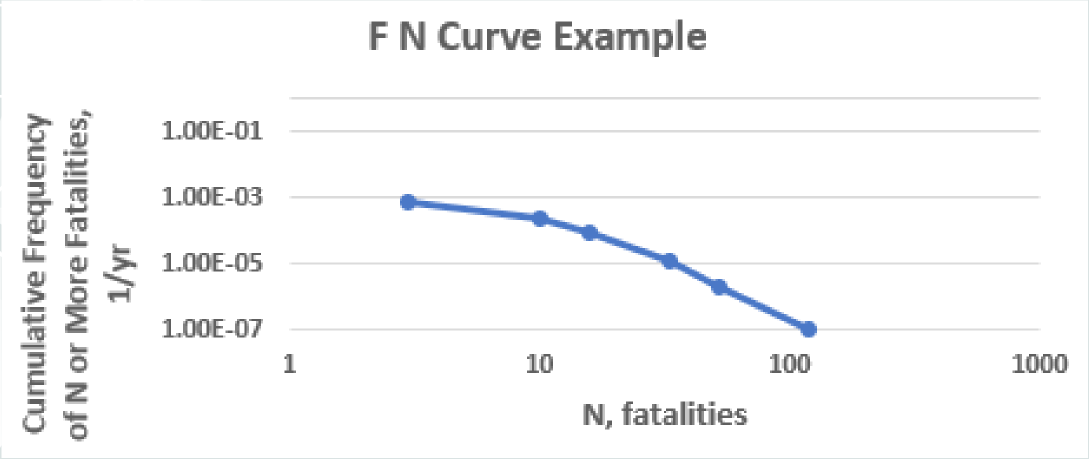
- “The art of making wise decisions is the hallmark of successful management and **requires both pertinent information and good judgment.**” [1]
- Decision-makers must appreciate that QRA is **both an art and science, not a pure or exact science**.[1]
- **Analysts use different approaches/ methodologies when looking at the same risk problem.** Some examples below.
- Examples of general analytical approach for risk analyses
  - Qualitative, semi-quantitative, quantitative
- Examples of how scenarios are analyzed
  - Deterministic (e.g., worst credible case, most likely case)
  - Stochastic analysis for frequency & consequences (e.g., Monte Carlo simulation)
  - Environmental risk analyses done by environmental practitioners - Stochastic analyses for consequences
  - Selected multiple scenarios from a risk source for aggregate or cumulative risk determination

Historical Observations on Risk Analysis Variability (Cont'd)

- **Examples of Different Presentations of Risk Information**







Historical Observations on Risk Analysis Variability (Cont'd)

- **Analysts using different models when looking at the same problem**
- Examples of various consequence models
  - Blast overpressure – TNT, TNO Multi-Energy, Baker-Strehlow-Tang, Computational Fluid Dynamics[3]
  - Jet Fire – API 521, Shell, TNO [4]
  - Fireball [5]
    - Example of uses from reference
      - TNO model – for estimating a fireball's diameter, duration and surface emissive power in the downwind location
      - CCPS solid flame model – for estimating surface emissive power from fireballs in the crosswind location and incident thermal radiation power absorbed by the target located in the fireball's diameter
      - Roberts point source – for estimating incident thermal radiation from fireballs one diameter away and elevations of fireballs

Historical Observations on Risk Analysis Variability (Cont'd)

Examples of Different Consequence Models That Are Used (Cont'd)

- Different toxicity exposure and effect analysis approaches [6]
  - Emergency Response Planning Guidelines - ERPG 1, 2, 3
    - Max. airborne concentrations below which exposures up to 1 hour results in different health effect severities.
  - Acute Exposure Guideline Levels - AEGL 1, 2, 3
    - Airborne concentration above which exposure for a specified duration results in different health effect severities.
    - Each level with five exposure periods – 10 min, 30 min, 60 min, 4 hrs, 8 hrs
  - Toxicity Effect Probit Functions (Probit - Probability Unit)
    - Probit functions can provide an estimate of the percentage of people who may get a specific adverse response to a particular chemical exposure [12]
    - "….different organisations derive different probit functions for the same substance"[7]

Historical Observations on Risk Analysis Variability (Cont'd)

- **Analysts using different data sources/ data when looking at the same problem**
- Some examples of published data sources
  - CCPS Guidelines for Process Equipment Reliability with Data Tables (PERD) [8]
  - OREDA Offshore Reliability Data Handbook [9]
  - Failure Rate and Event Data (FRED), HSE, UK [10]
  - Component Reliability Data for Use in Probabilistic Safety Assessment, IAEA [11]
- In-house data can be combined with industry wide data to help achieve reasonable QRA objectives.[1]
- Care must be exercised to select data most representative of your specific system from the wide range available from various sources.[1]
- Even data from your own plant may have to be modified (sometimes by a factor of 10) to reflect your plant's current operating environment and maintenance practices.[1]

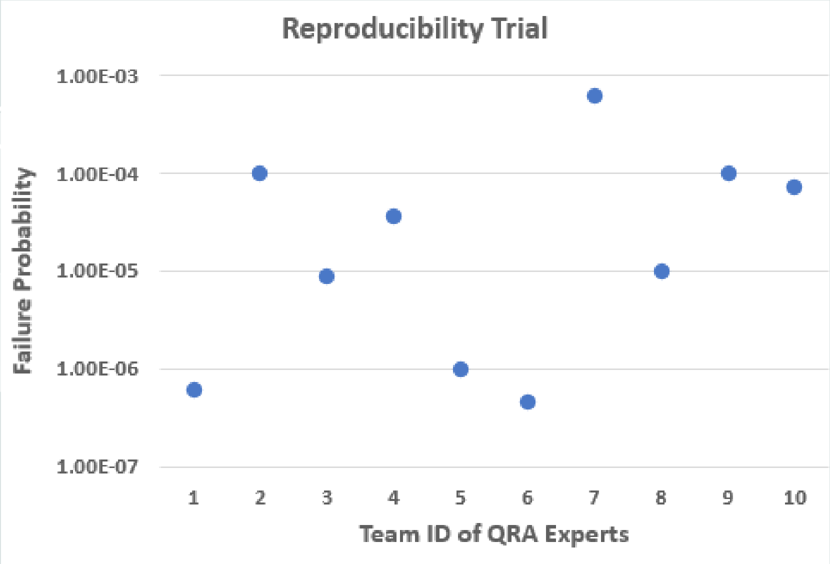
Historical Observations on Risk Analysis Variability (Cont'd)

- **Analysts using different consequences/ measures when looking at the same problem**
- Process Safety People Risk Analyses
  - Common - "Immediate/ imminent" fatality
  - Less common - Health impact
    - Short term reversible
    - Long term irreversible
- Environmental Risk Analyses, can include
  - Ecological, Socio-Economic Effects
    - Different representative consequence measures used
  - Human Health Effects
    - Short term reversible
    - Long term irreversible
    - Usually does not include "immediate/ imminent" fatality from exposure

Historical Observations on Risk Analysis Variability (Cont'd)

- **Analysts using different assumptions when looking at the same problem**
- "Subtle assumptions of analysts performing QRA studies can be the driving force behind the results. Many times, these assumptions are at best arguable, and at worst arbitrary" [1]
- Reproducibility Experiment [1]
  - "Several **expert teams** were given identical systems to analyze (failure probability) using common techniques and a common database. The **analysts were initially given total latitude concerning necessary assumptions, events to consider, data, and so forth**."

    See results below.



Ref [1]

Historical Observations on Risk Analysis Variability (Cont'd)

Use of different assumptions (Cont'd)

- Discussion on reproducibility experiment
  - **Different results** arose from **different** very **basic assumptions** used by various analysis teams
  - When given similar assumptions, results converged within a factor of 5
  - Managers must appreciate the assumptions made (*or sometimes not even documented*) during a QRA are as important as any quantitative result. Decisions made will be crucially tied to appreciation of assumptions used in such studies. [1]

Still, Value Remains for Risk Analyses

- Study-based risk analyses are still valuable
  - Powerful analysis method that can be used to manage risk and improve safety in many industries[1]
  - Provides deeper insight into the risk question of interest
  - Helps understand major risk contributors
  - Reduces degree and quality of uncertainty when decision-makers make their final judgment
  - For Environmental Risk Assessments, provides greater transparency on criteria for making decisions (less “hidden” influence from politics/ activism)
- Still, continuous improvement opportunities exist to help address reproducibility concerns

Consistency Improvement Opportunities

- Taking consistency to the "next level"
  - Part of continuous improvement effort (stepped technology improvement)
- Develop useful guidance
  - Research available industry and regulatory practices
  - Make the guidance consensus based; at the following levels where needed or possible;
    - Level 1 - Guidance within organizations
    - Level 2 - Guidance within industry associations
    - Level 3 - Guidance within professional safety organizations (include/ consult organizations, industry associations)
    - Level 4 – Guidance development with consultation between organizations, associations, regulators (provincial, national)
  - Make it fit-for-purpose
    - Meet required identified objectives of a risk analysis
    - Clarify perspectives - consider stakeholder perspectives
  - Have it peer reviewed
  - As an option, possibly allow a trial period for initial public use and collect feedback

Consistency Improvement Opportunities (Cont'd)

- CSChE Process Safety Management Division Development Efforts Underway
- Guideline for Quantitative Risk Assessment – Risk to People from Chemical Hazards Having Acute Impacts
- Chemical Spill/ Release Environmental/ Ecological Risk Assessment Guidance
  - Part 1 Guidance Manual
  - Part 2 Acronyms and Key Terms
  - Part 3 Environmental Harm Index/ Risk Workbook
  - Part 4 Chemical Spill to River Simple Dilution Model - Determines;
    - Peak concentration in river (for soluble chemicals)
    - Distance downstream to concentration of interest (e.g., toxicity benchmark, guideline)

In Conclusion

1. What has been **your experience** with study-based risk analysis **variability and reproducibility issues?**
2. If feasible, what will it take to create **national consensus based guidance** for all industries for study-based risk analyses?

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