ADDRESSING ISSUES IN THE DESIGN AND USE OF RISK MATRICES IN PROCESS SAFETY

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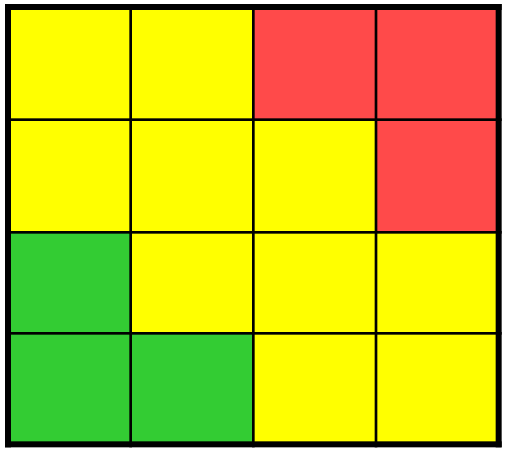

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RISK MATRICES IN PROCESS SAFETY

- Used to rate and rank risks
  - E.g. in PHA
- No standards
- No validation
- Apparently simple (deceptive!)
- Easy to use (incorrectly)
- Many pitfalls

CONTENTS OF PAPER

- Issues with risk matrices
  - Framework is flawed
  - Must be calibrated
    - Hazard scenarios or hazardous events
  - Do not address risk uncertainties
  - Use subjective judgment
- Guidelines for design
- Guidelines for use

ISSUE 1 - FLAWED FRAMEWORK

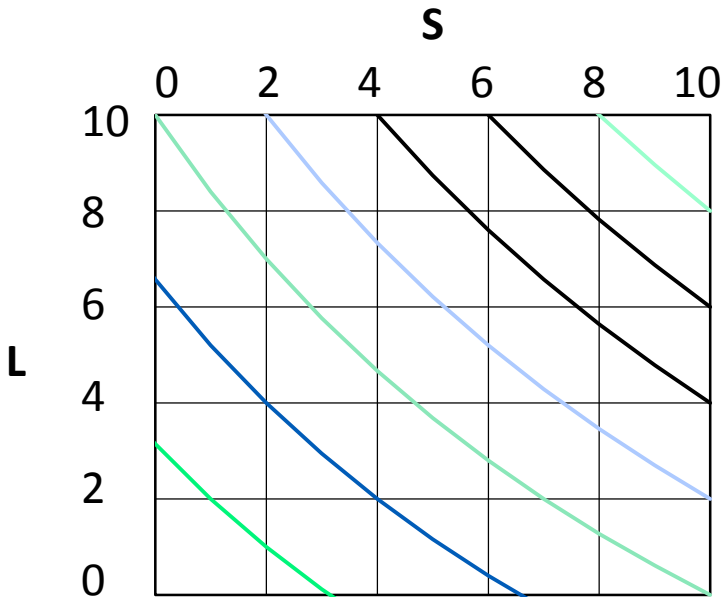
- Underlying assumption:
  - Cells in risk matrix define ranges of risk values that are mutually exclusive
    - Except N x M = M x N
  - Not true!

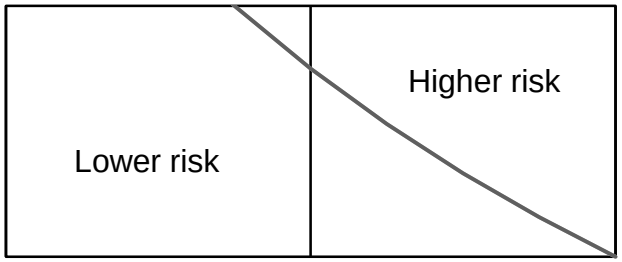
L/S	1	2	3	4
4	*4*	*8*	*12*	*16*
3	*3*	*6*	*9*	*12*
2	*2*	*4*	*6*	*8*
1	*1*	*2*	*3*	*4*

L = Likelihood S = Severity

FLAWED FRAMEWORK (CONTD.)

- S's and L's are defined by ranges of values
- R = S x L
- Linear axes are a problem



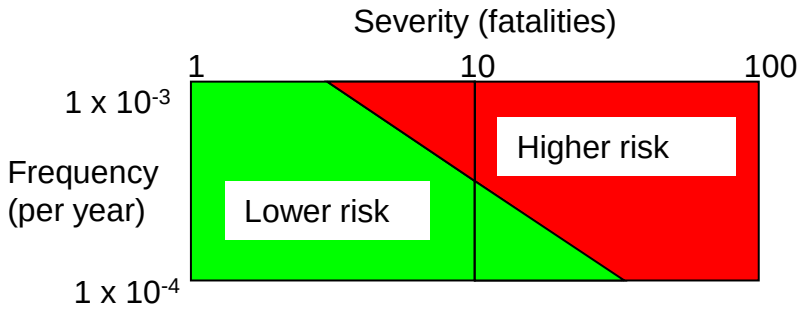


ADDRESING FLAWED FRAMEWORK

- Use logarithmic axes

Risk Level	Meaning
I	Unacceptable
II	Undesirable
III	Acceptable with controls
IV	Acceptable as is

L \ S	1	2	3	4
4	IV 10	II 6	I 3	I 1
3	IV 13	III 9	II 5	I 2
2	IV 15	IV 12	III 8	II 4
1	IV 16	IV 14	IV 11	III 7



ISSUE 2 - MATRICES MUST BE CALIBRATED

- Many companies calibrate risk matrices
  - Adjust required risk reduction measures with reference to risk tolerance criteria
  - Allocate risk tolerance criteria to hazard scenarios

L\S	**1**	**2**	**3**	**4**
4	*4*	*8*	*12*	*16*
3	*3*	*6*	*9*	*12*
2	*2*	*4*	*6*	*8*
1	*1*	*2*	*3*	*4*

- E.g. facility individual fatality risk tolerance criterion = 1×10^{-4} per year

EXAMPLE OF A RISK MATRIX FOR INDIVIDUAL RISK

Severity level	Meaning
1	First-aid case
2	Lost-time injury
3	Hospitalization
4	Fatality

Likelihood level	Meaning (Frequency per year)
1	≤ 5 x 10^{-5}
2	≤ 5 x 10^{-4}
3	≤ 5 x 10^{-3}
4	≤ 5 x 10^{-2}
5	≤ 5 x 10^{-1}

Severity level / Likelihood level	1	2	3	4
5	1	2	3	4
4	TR	1	2	3
3	TR	TR	1	2
2	TR	TR	TR	1
1	TR	TR	TR	TR

TR = Tolerable risk

Numerical values in the risk matrix denote required risk reductions as negative exponents of powers of 10. Thus, 3 equates to a required risk reduction of 1 x 10^{-3}.

EXAMPLE OF A RISK MATRIX FOR GROUP RISK

Severity level	Meaning
1	One fatality
2	≤ Ten fatalities
3	≤ 100 fatalities
4	≤ 1,000 fatalities

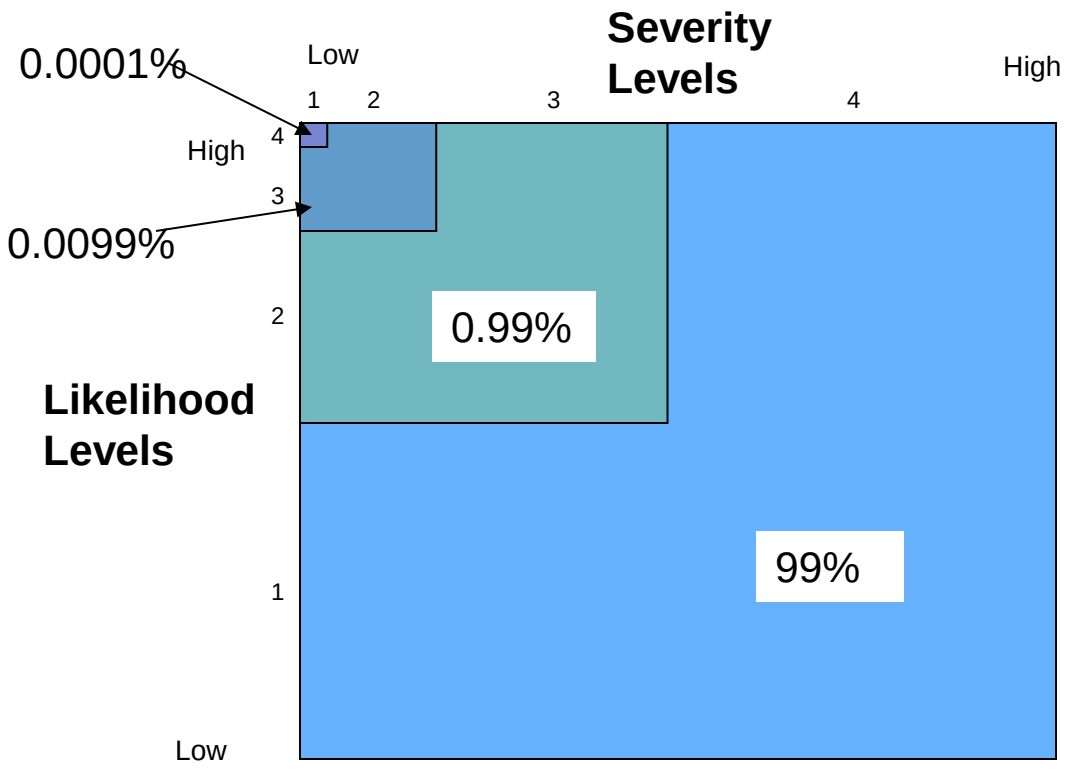
Likelihood level	Meaning (Frequency per year)
1	≤ 1×10^{-8}
2	≤ 1×10^{-7}
3	≤ 1×10^{-6}
4	≤ 1×10^{-5}
5	≤ 1×10^{-4}
6	≤ 1×10^{-3}
7	≤ 1×10^{-2}

Severity level / Likelihood level	1	2	3	4
7	3	4	5	6
6	2	3	4	5
5	1	2	3	4
4	TR	1	2	3
3	TR	TR	1	2
2	TR	TR	TR	1
1	TR	TR	TR	TR

TR = Tolerable risk

Numerical values in the risk matrix denote required risk reductions as negative exponents of powers of 10. Thus, 3 equates to a required risk reduction of 1×10^{-3}.

ISSUE 3 - RISK MATRICES AND UNCERTAINTIES



Note: Conceptual, not to scale. Levels are intended to differ by orders of magnitude.

ISSUE 4 - SUBJECTIVE JUDGMENT

- Risk ranking is a subjective process
  - Depends on analyst opinions
- Subject to psychological factors
  - Heuristics and cognitive biases. E. g., people
    - Underestimate the probability of an event they have not experienced
    - Overestimate the probability of an event they have experienced
- Many such biases affect risk ranking

KEY GUIDELINES FOR DESIGN

- Severity and likelihood levels
  - Overall ranges
  - Number
  - Definitions
- Risk levels
  - Number
  - Assignment
  - Decision requirements

CONCLUSIONS

- Risk matrices are deceptively simple
  - Numerous pitfalls exist for unwary users
- Guidelines have been provided for their design and use
- Provide only an approximate estimate of risk
  - Use with caution and common sense
- More quantitative methods may be merited
  - LOPA and QRA