

The Three Dimensions of Risk

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The starting point – early in 2002

Technics: „The use of technical systems may be dangerous, and may result in injury to persons and property.“

Albert Kuhlmann

Society: „Individuals really do share their thoughts and they do to some extent harmonize their preferences, and they have no other way to make the big decisions except within the scope of institutions they build.“

Mary Douglas

Man: „Without the venturesome, the world would turn a lot more slowly. Think of what life would be like if everyone were phobic about lightning, flying in airplanes, or investing in start-up companies. We are indeed fortunate that human beings differ in their appetite for risk.“

Peter L. Bernstein

R&D activities following this concept

7. Fuldaer Elektrotechnik-Kolloquium 2002

Risiko – Unser Umgang mit der Angst
(Risk – How we are dealing with fear)

<http://www.fh-fulda.de/fb/et/Brett2002/Kolloquium.htm>

Essay

Risikooptimierung kontra Risikobegrenzung – Analyse eines alten und andauernden Richtungstreits.

Automatisierungstechnische Praxis atp (2003) 8, 50-57

(Risk-optimization versus risk-limitation – Analysis of an old and ongoing policy dispute)

The contributions to the colloquium

(contained in the proceedings – in German)

Prof. Dr. Adolf Birkhofer - Munich

Risk Analysis of Nuclear Power Plants

Prof. Dr. Ortwin Renn - Stuttgart

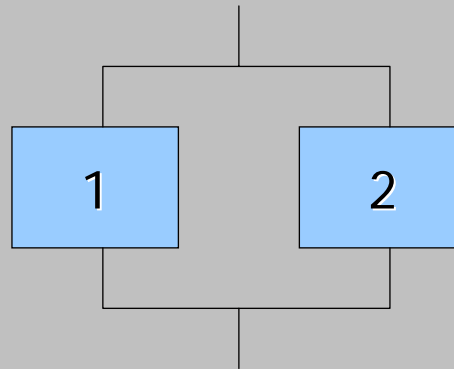
The psychology of risk: On the everyday perception and evaluation of risk

Prof. Dr. Klaus Japp - Bielefeld

Risk cultures: On the difficulties to come to agreements on risky techniques

Technical risk analysis

1oo2-System



Boolean Indicator Variables and Functions

X_1 "Component 1 is defective"

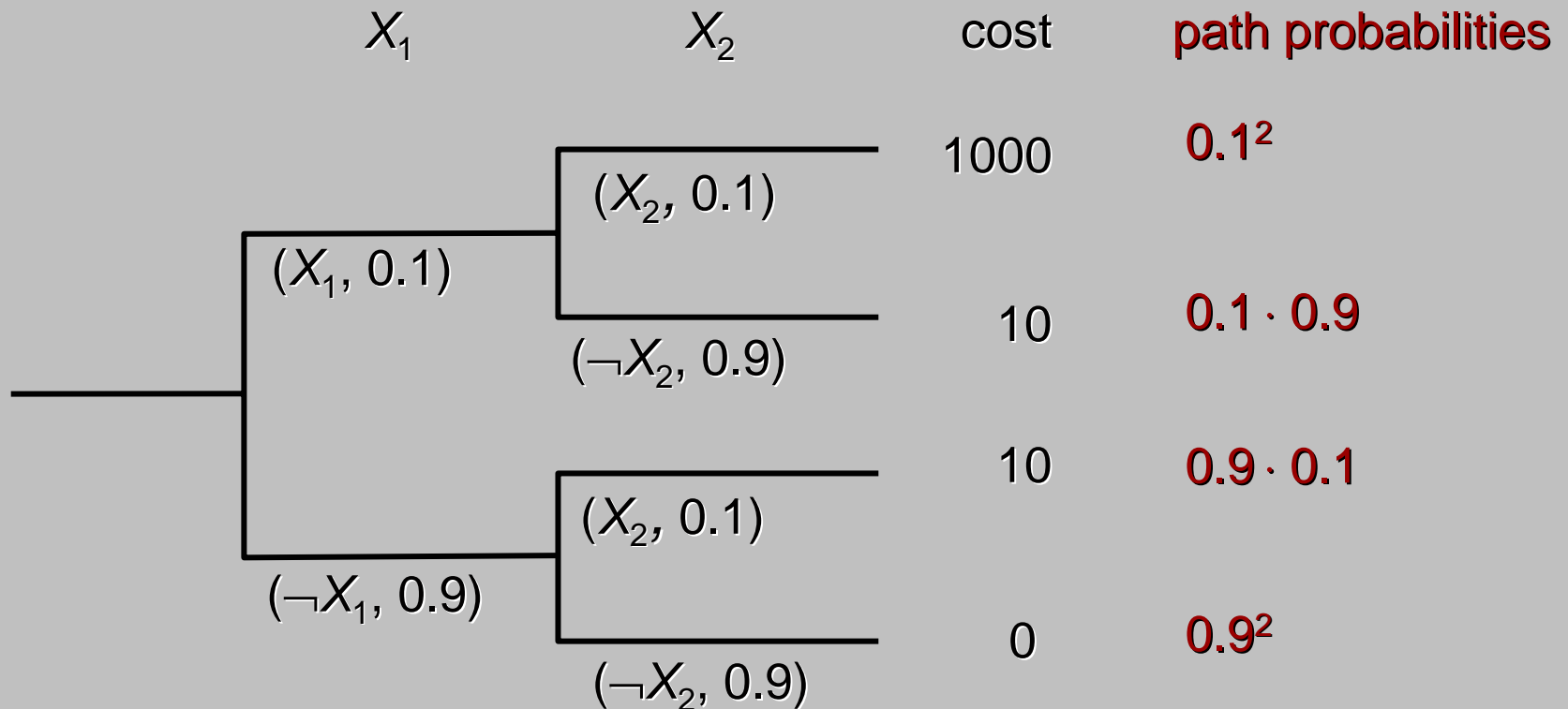
X_2 "Component 2 is defective"

$(X_1 \vee X_2) \wedge \neg (X_1 \wedge X_2)$ "Non-critical system failure occurred"

$X_1 \wedge X_2$ "Critical system failure occurred"

Technical risk analysis

Event Tree of a 1oo2-System



Technical risk analysis

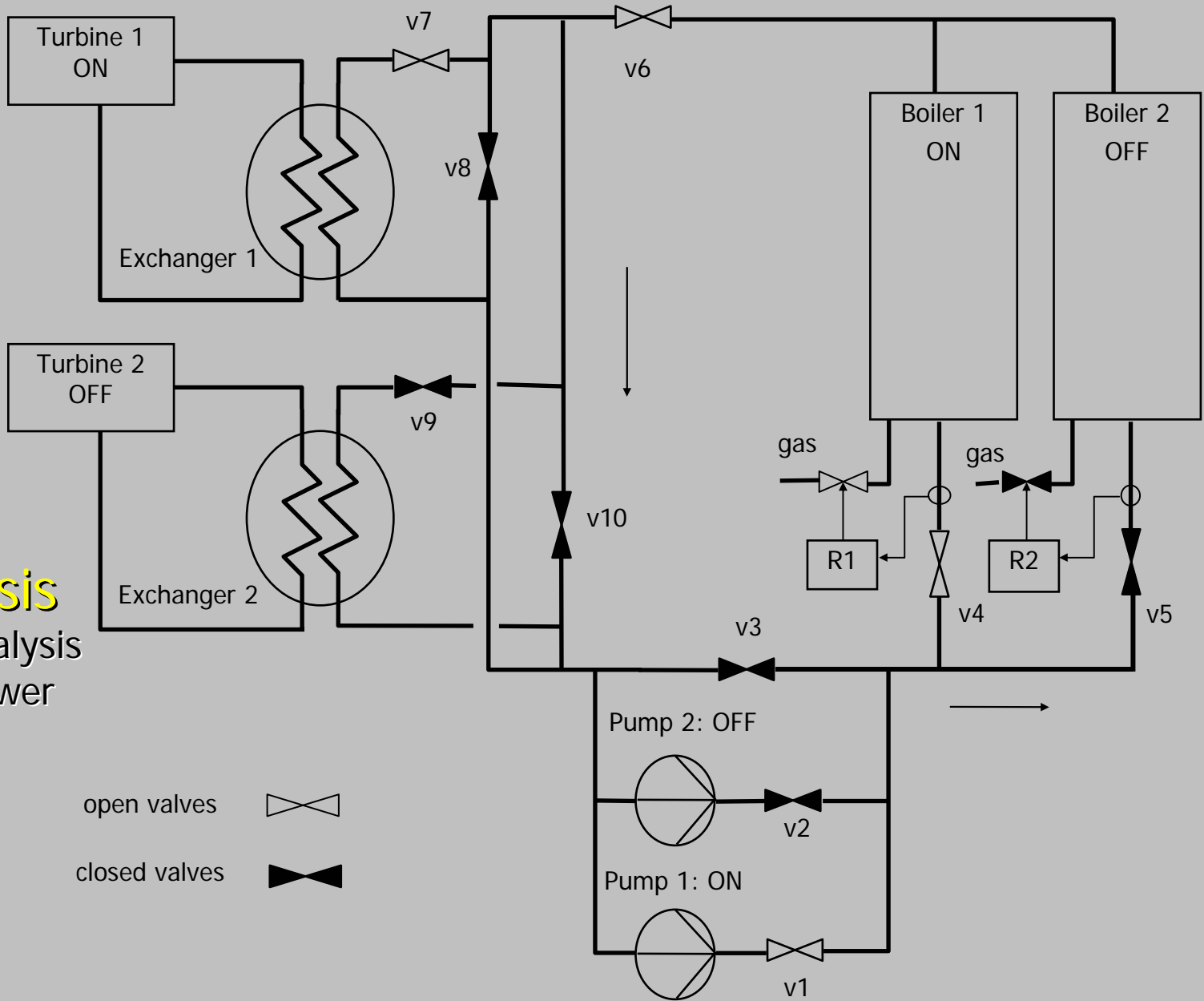
Risk calculation

Objective Risk: Expected Value of Cost

$$\begin{aligned} R = E[\text{cost}] &= 1000 \cdot 0.1^2 + 10 \cdot 2 \cdot 0.09 + 0 \\ &= 10 + 1.8 = 11.8 \end{aligned}$$

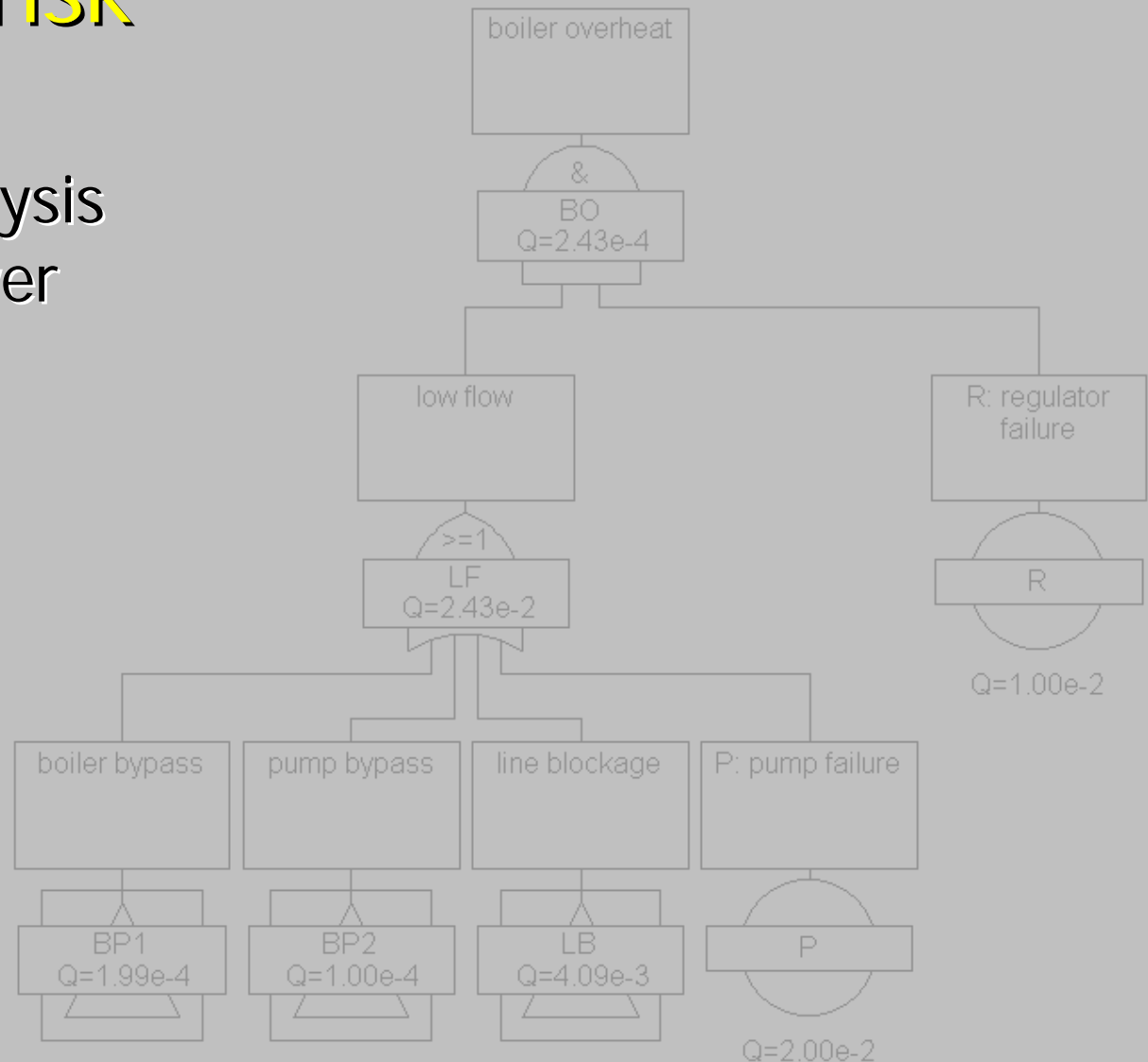
Technical risk analysis

Fault Tree Analysis
(Coal fired power plant)



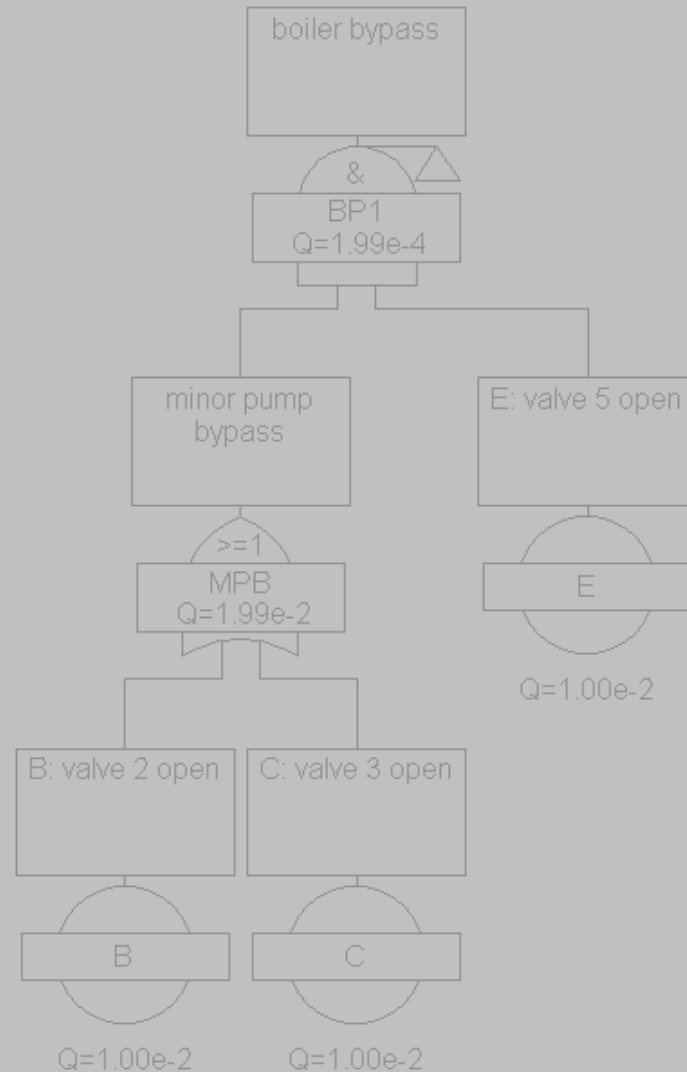
Technical risk analysis

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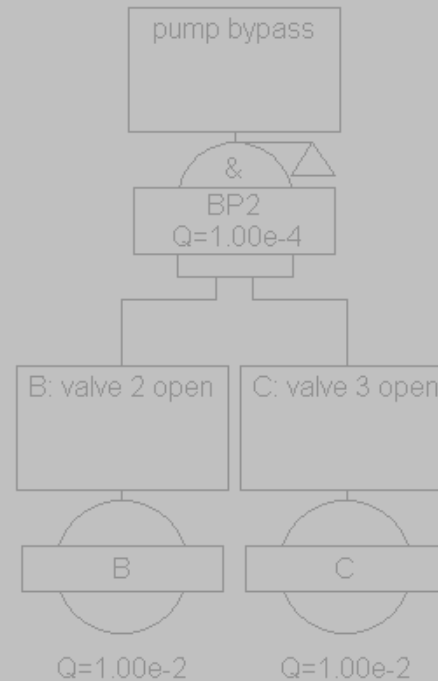
Technical risk analysis

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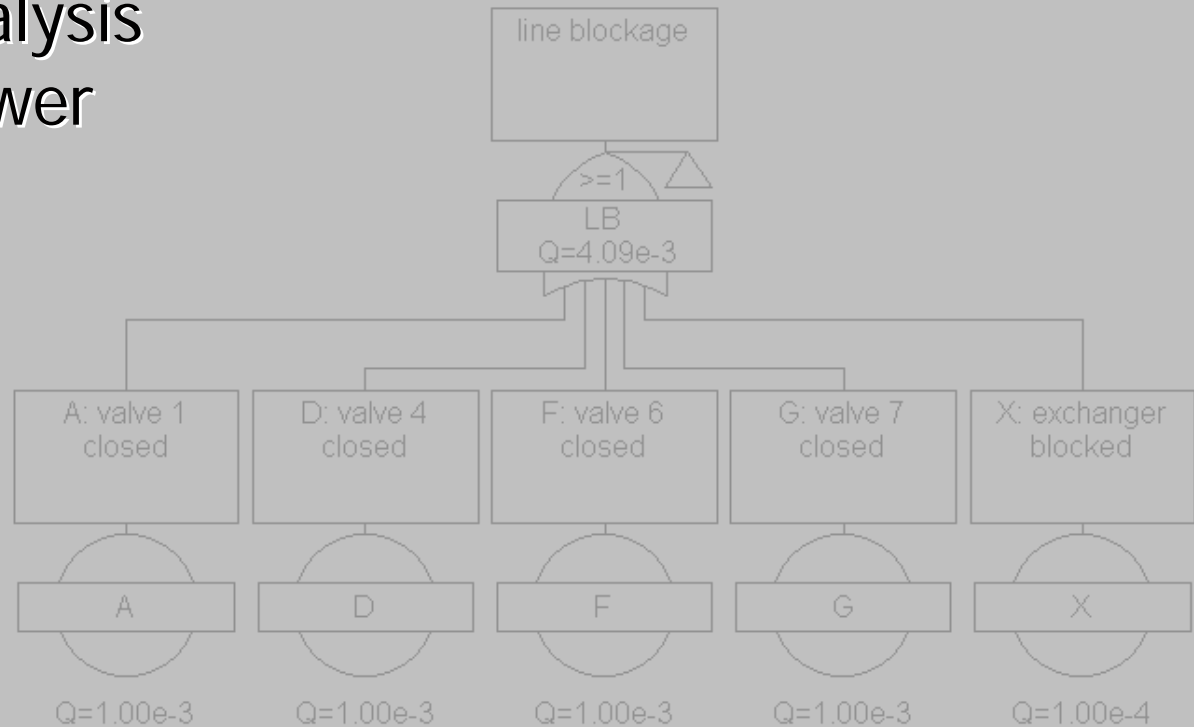
Technical risk analysis

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Technical risk analysis

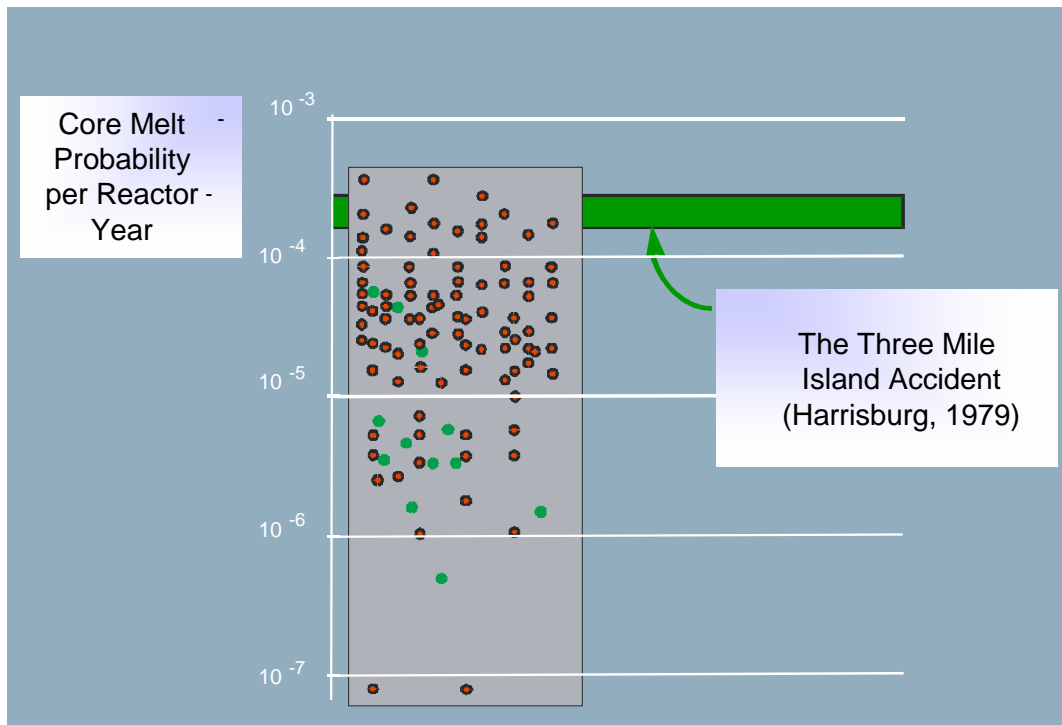
Fault Tree Analysis
(Coal fired power plant)



Technical risk analysis

Nuclear Power

Probabilistic Risk Assessment (PRA) - Results



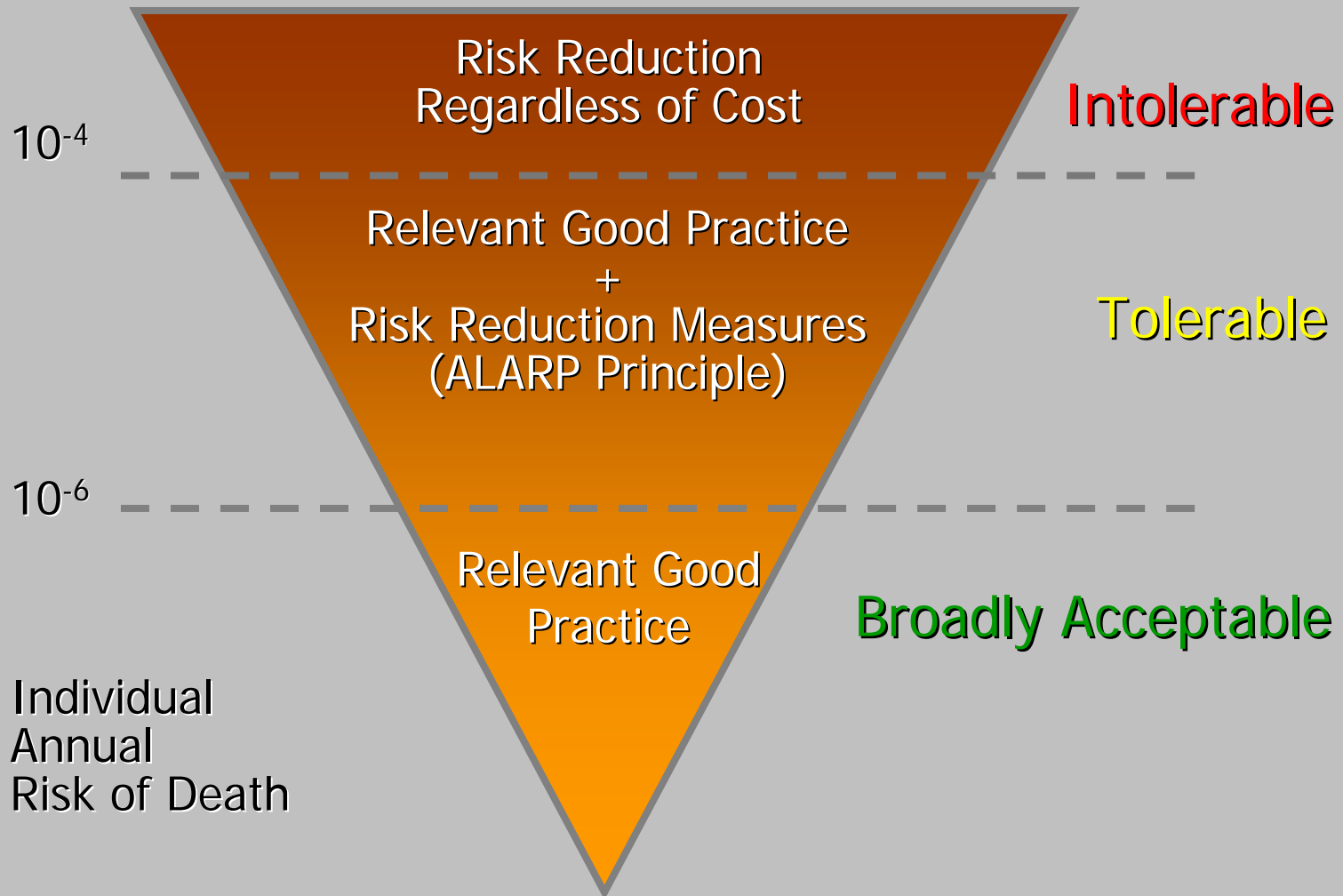
Technical risk analysis

Risk data

Cause of death	Rate per 205,000,000 U.S. Residents	Individual annual death rate
Lightning	107	$5 \cdot 10^{-7}$
Electrocution	1,025	$5 \cdot 10^{-6}$
Motor Vehicle Accident	55,350	$3 \cdot 10^{-4}$
All Accidents	112,750	$6 \cdot 10^{-4}$

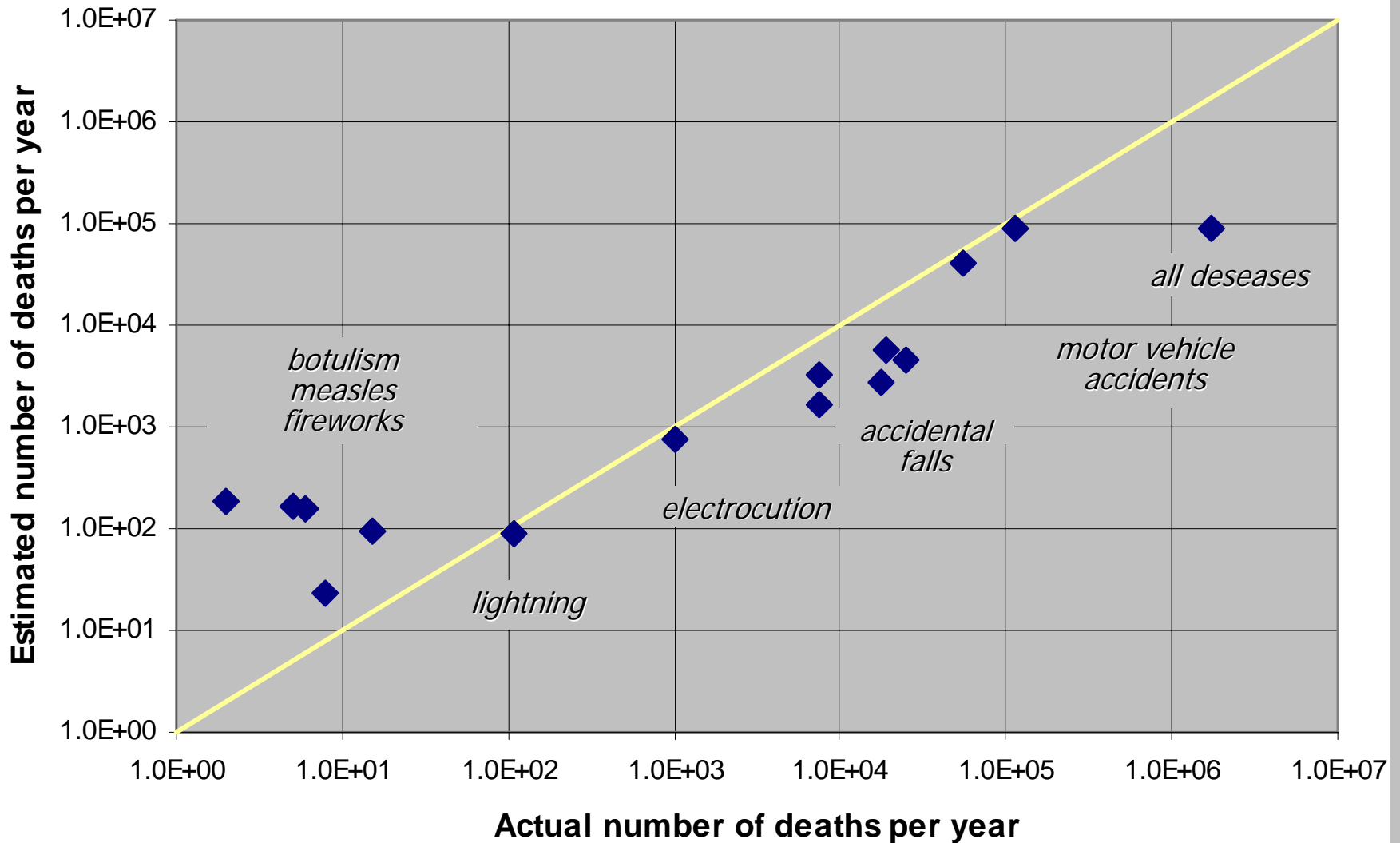
Technical risk analysis

Tolerability of Risk



The psychology of risk

Risk perception



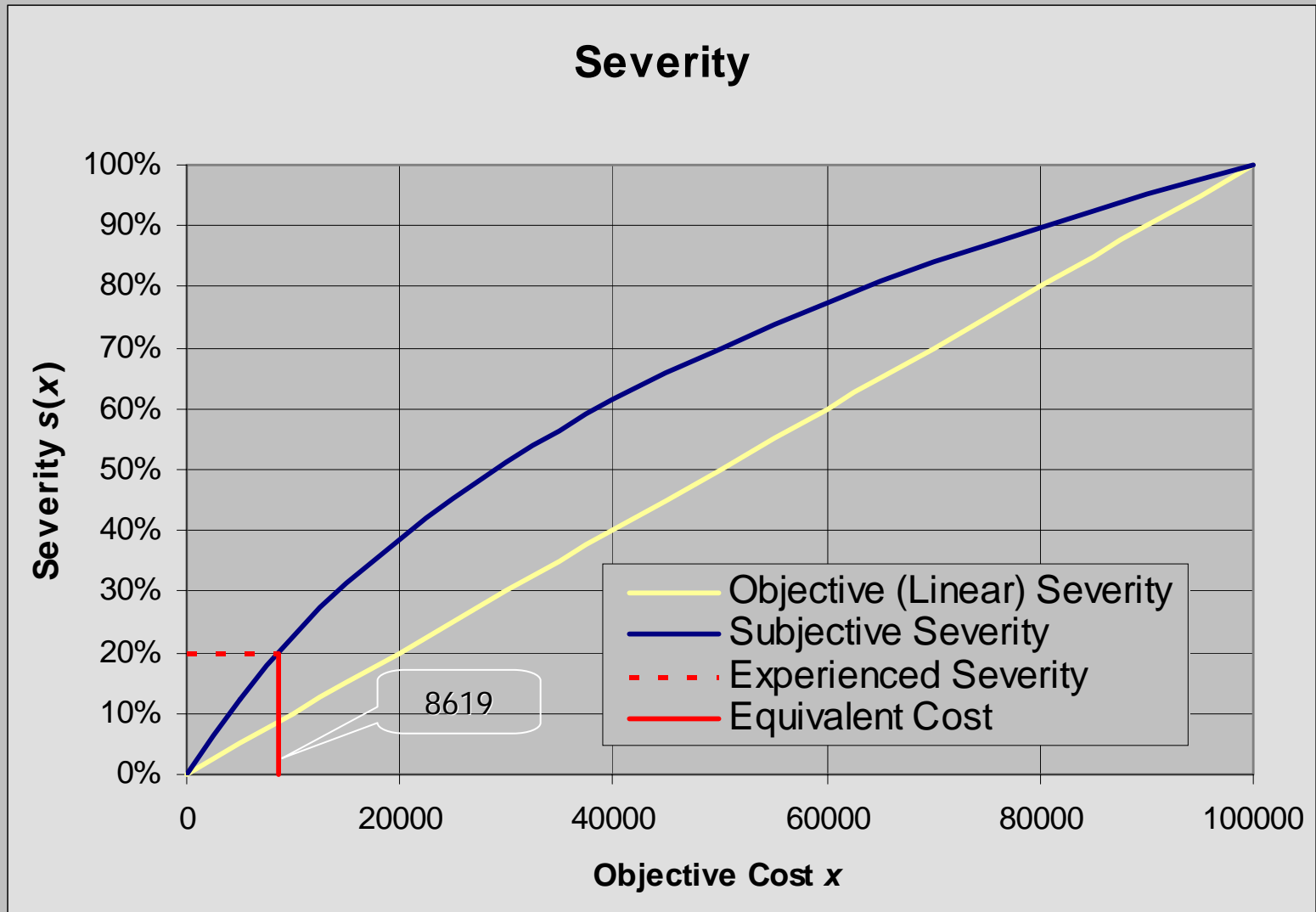
The psychology of risk

Different meanings of the term „risk“

Risk as	Focus on
Immediate threat	Extent of damage
Stroke of fate	To <i>be exposed</i> to danger
Challenge	To overcome danger
Gamble	(Subjective) risk and heuristics
Early indicator of danger	Causality: event (cause) → damage (consequence)

The psychology of risk

Subjective risk



The psychology of risk

Risk acceptance and risk aversion

Objective risk: $E[x] = 20\% \cdot 100000 \text{ €} = 20000 \text{ €}$

$s(E[x]) = 40\%$

Subjective risk: $E[s(x)] = 20\%$

A strictly concave severity function results in the
Inequality of Risk Acceptance

$$E[s(x)] < s(E[x])$$

General principle: *Overweighting certainty*

The psychology of risk

Perception of risk

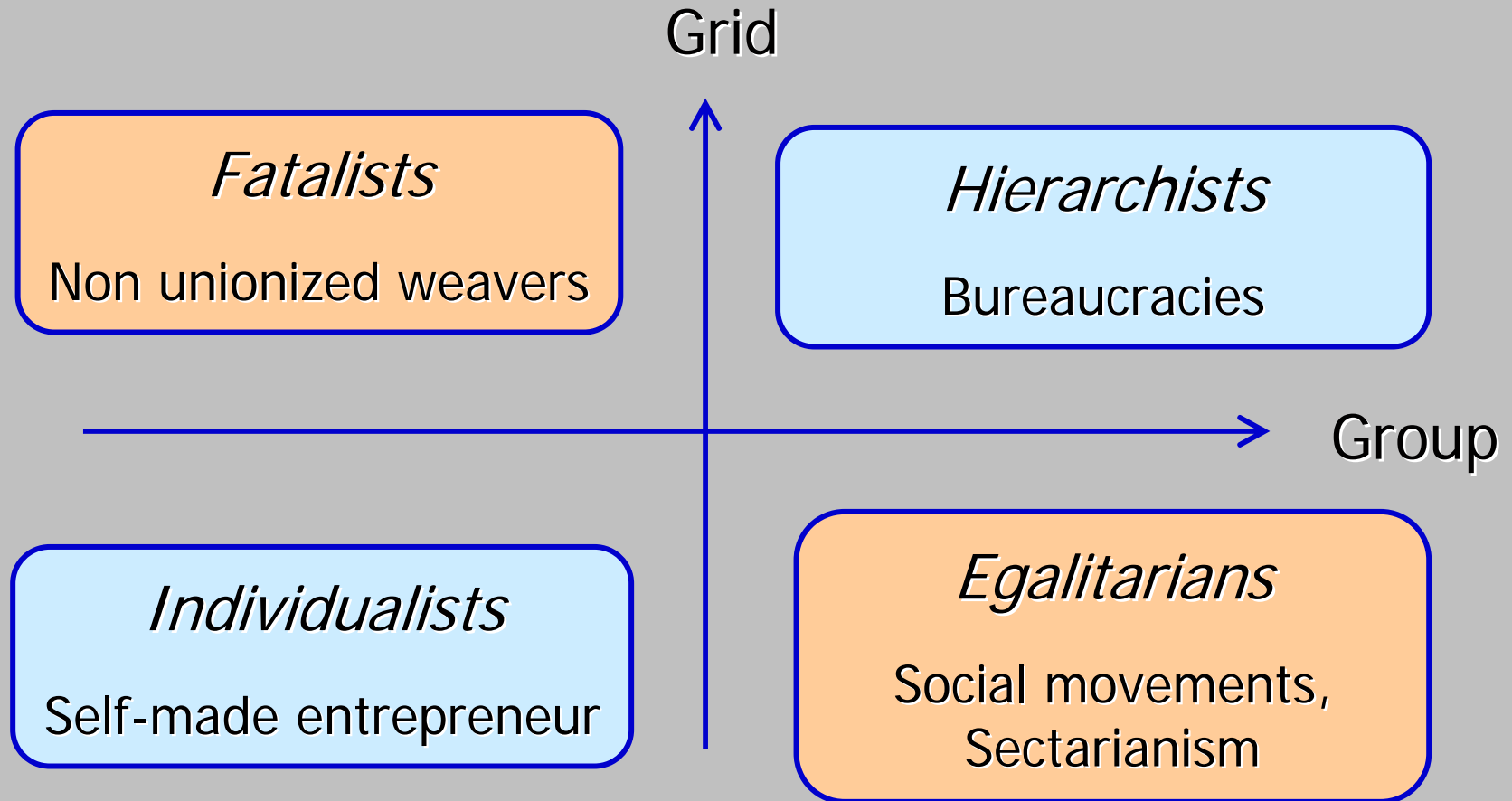
Risk acceptance depends on whether

- the danger is well known,
- the danger is accepted voluntarily, and
- the decision maker has control over the risk

„... human beings differ in their appetite for risk“ (Peter L. Bernstein)

Risk and Culture

The grid-group typology



Risk optimization vs risk Limitation

<i>Risk optimization</i>	<i>Risk limitation</i>
<i>Decision under risk:</i> Choose the least risky alternative	Stipulation for an <i>Acceptable Risk</i> . Safety: Risk \leq Acceptable Risk Danger: Risk $>$ Acceptable Risk
ALARP (As Low as Reasonably Practicable): Risk reduction as far as reasonably practicable	The acceptable risk shall be defined by commissions of experts
<i>Utility based gross disproportion criterion:</i> Risk prevention measures can be left out only if their cost grossly outweighs their benefit	<i>Equity Based Criterion:</i> The risk should be equally distributed (by means of a risk register).

Cultural theory

and the way of dealing with fear

Low Group

High Group

High Grid

FATALISM
No risk assessment at all

HIERARCHY
Philosophy of *risk limitation*

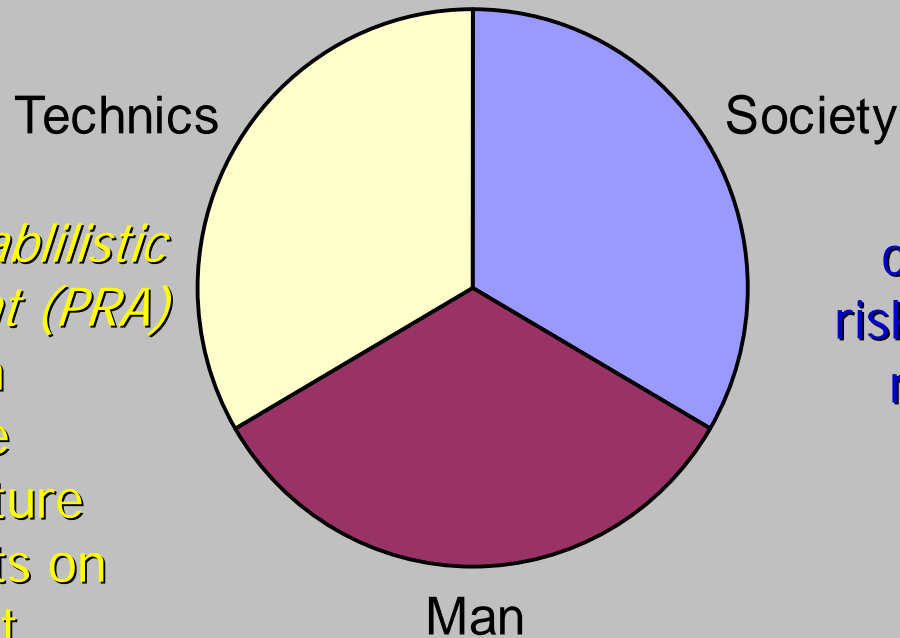
Low Grid

INDIVIDUALISM
Maxim of
risk optimization

EGALITARIANISM
No-risk dogma

Bright cells: Trust in technology
Dark cells: Mistrust of technology

Once more: The Three Dimensions of Risk



Engineer: *Probabilistic Risk Assessment (PRA)* supplies us with estimates of the frequency of future serious accidents on the basis of past experience.

Sociologist: The collective views on risk and technics are related to the four *institutionalized cultures*: individualistic, hierarchic, fatalistic, and egalitarian.

Psychologist: There is no universally valid notion of risk. The identification of generalizable elements of *intuitive risk perception* may help to a better discussion on tolerable risk. The dimensions of intuitive risk perception are legitimate elements of rational politics.