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Methods of Technical Risk Assessment in a Regional Context

Principles and methods for risk evaluation

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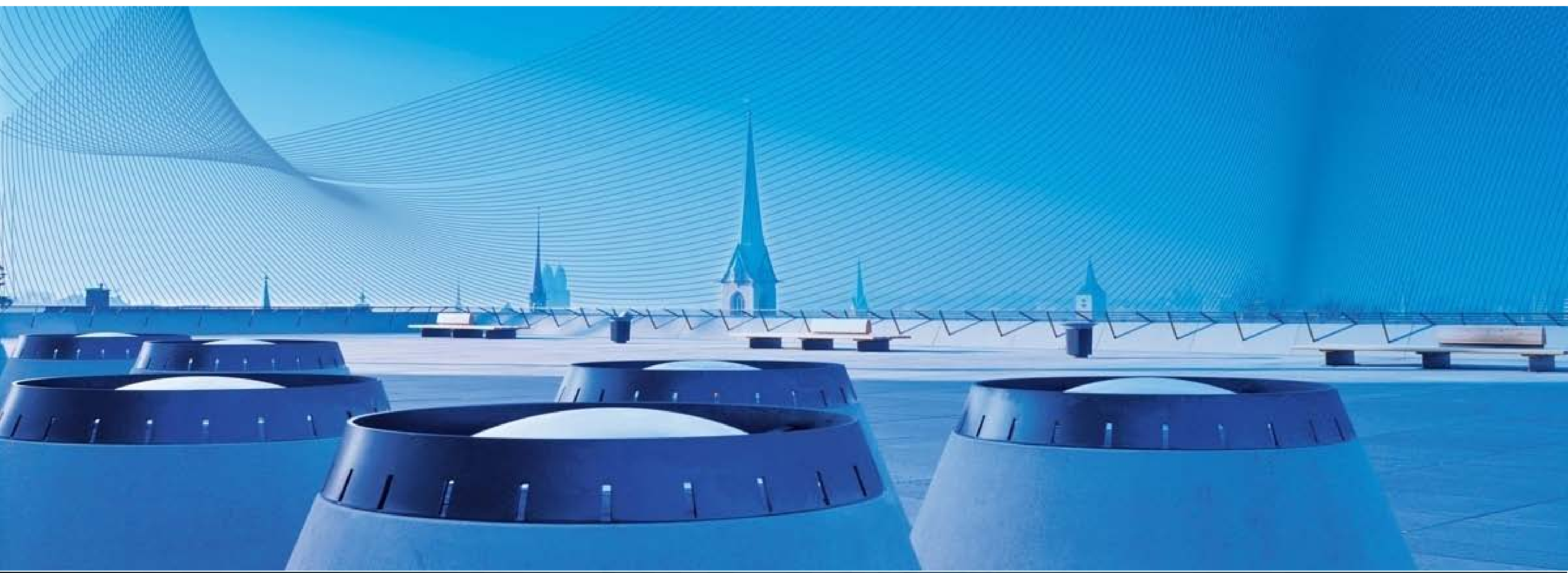


"How Safe is Safe Enough?"

Answers given by internal (industries) or official (ordinances) requirements, e.g.

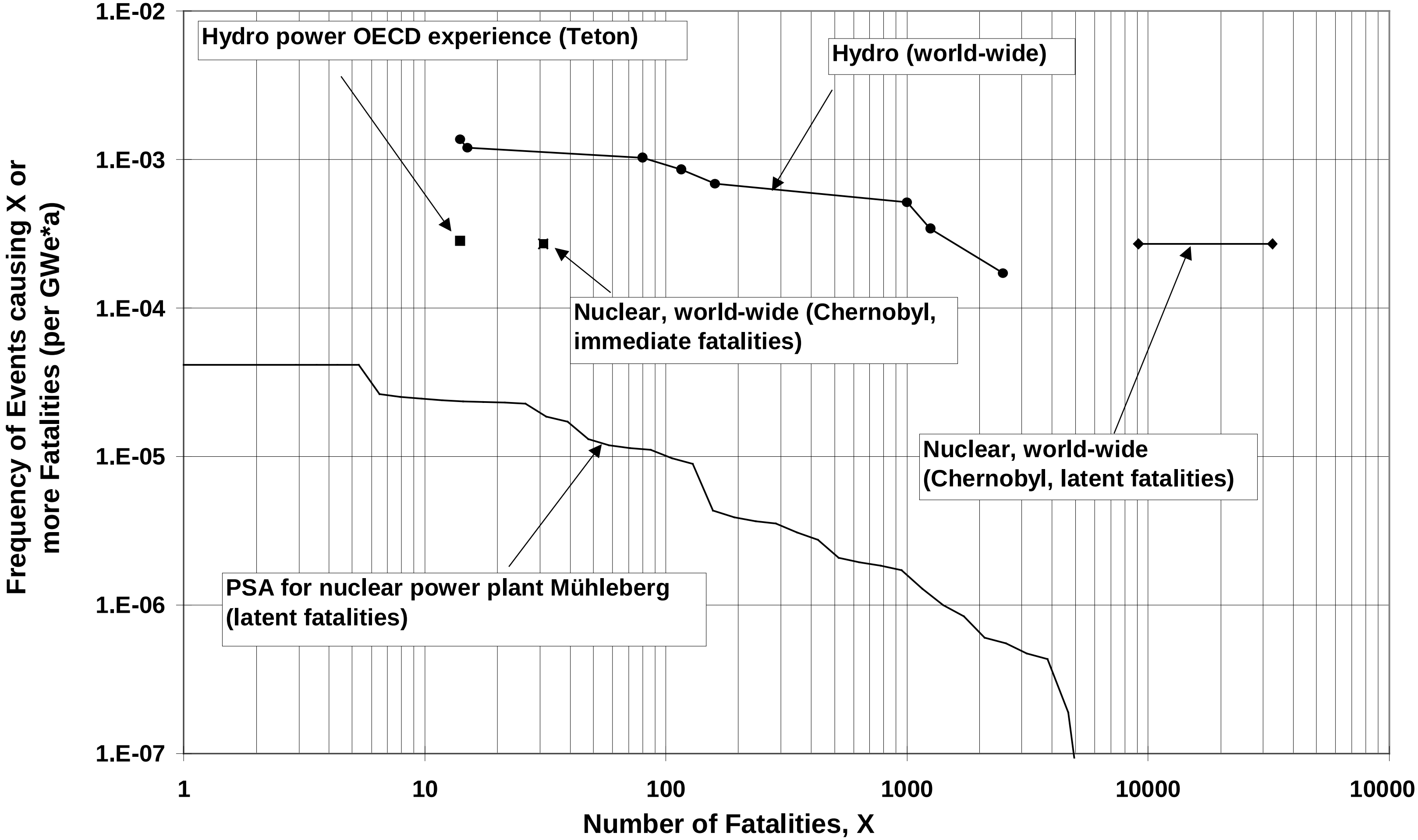
- Undesired event frequencies (e.g. IAEA: Frequency of core melt down $10^{-4}/10^{-5}$ per reactor per year for old / new plants)
- Risks smaller than alternatives (e.g. 1%) or unavoidable (natural) or accepted risks (threshold values/threshold curves – individual or societal, e.g. StFV)
- Exclusion criteria (e.g. max. damage)

Necessity of reasoning (comparison of options, inclusion of economic thinking), e.g.

- Comparison of risk information (F/C-diagrams, e.g. for energy systems)
- ALARP("as low as reasonably practicable) principle, cost-benefit comparison of risk reducing measures
- Cross comparison of the effectiveness of investments made ("life saving costs")

Assessing risks by using F/C-Diagrams

Comparative assessment of energy systems:



GWe: Gigawatt electric

Risk assessment and -comparison

To compare risk assessment results (e.g. F/C-diagrams), the different values (damage indicators) must be aggregated

- Expected value of risk (one or more damage types)
- Risk-value trade-off-models (variance as a measure of risk)
- Damage indicators, or index

Aggregations include basic ethical concepts and aren’t therefore equally accepted.

Rating criteria of the Major Accidents Ordinance (StFV)[1]

Representation of possible damage dimensions

- Hazardous incidents can cause various damages to the population or the environment:
  - Life and health of people
  - Destruction of living environment
  - Property values

- Different damages are measured by a set of damage indicators:
  - n_1, Fatalities [number]
  - n_2, Injured [number]
  - n_3, Polluted surface water [volume in m^3 or area in km^2]
  - n_4, Polluted ground water [loss in man-month]
  - n_5, Soil with derogated soil fertility [area-years in $km^2 \cdot a$]
  - n_6, Property damage [Mio. Fr.]

[1] Störfallverordnung

Rating of damage dimensions

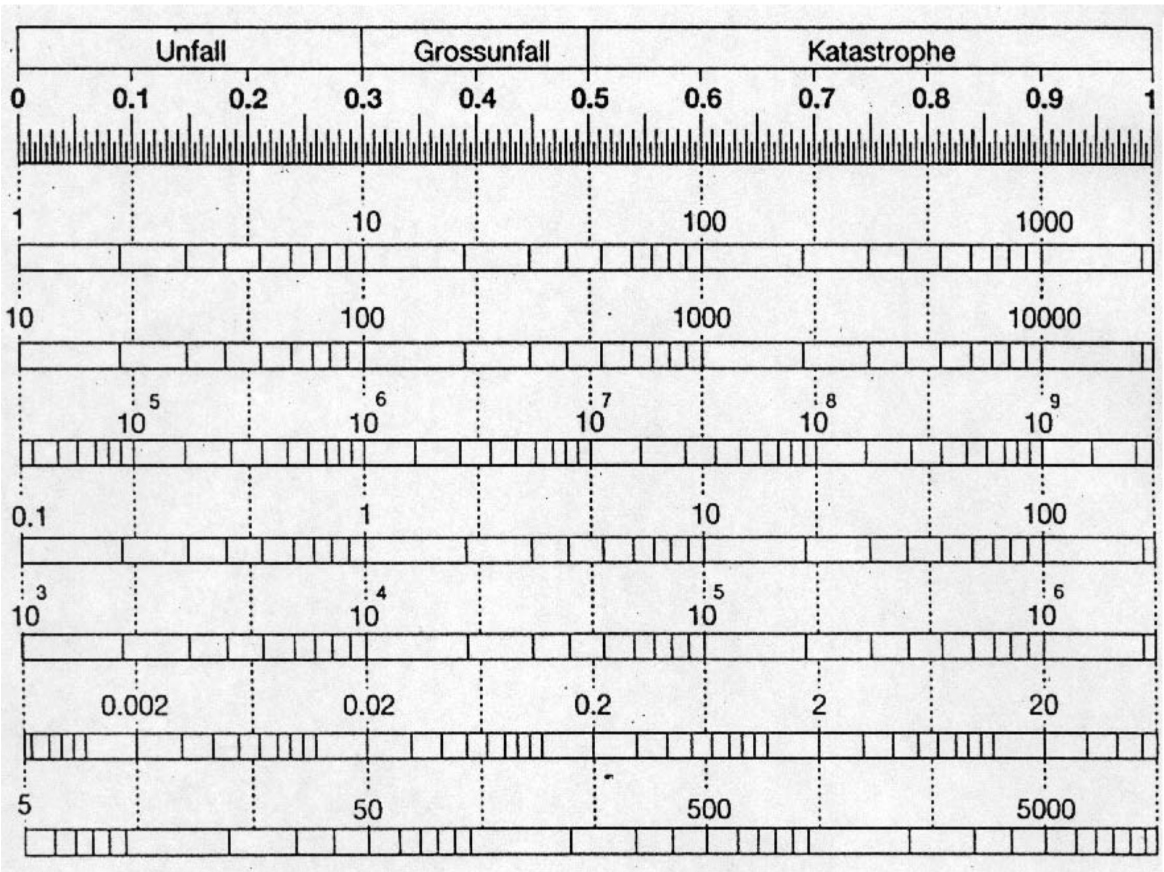
The possible damage dimension of a failure is estimated by the use of damage indicators:

- Damage values between 0 and 1 are allocated to each damage dimension.
- Combinations of damage values are generally not necessary.
- Damage values ≥ 0.3 correspond to a severe damage (Major Accidents Ordinance is only valid for these damage values).
- Damage values > 1 are not to be expected in Switzerland.

Uncertainties:

- In the process of risk assessments the uncertainties of damage dimensions and/or event frequencies must be discussed but need not be laid open.

Damage indicator and corresponding damage values of the StFV



Damage indicator

n_1, Fatalities [number]

n_2, Injured [number]

n_3, Polluted surface water [volumen in m^3]

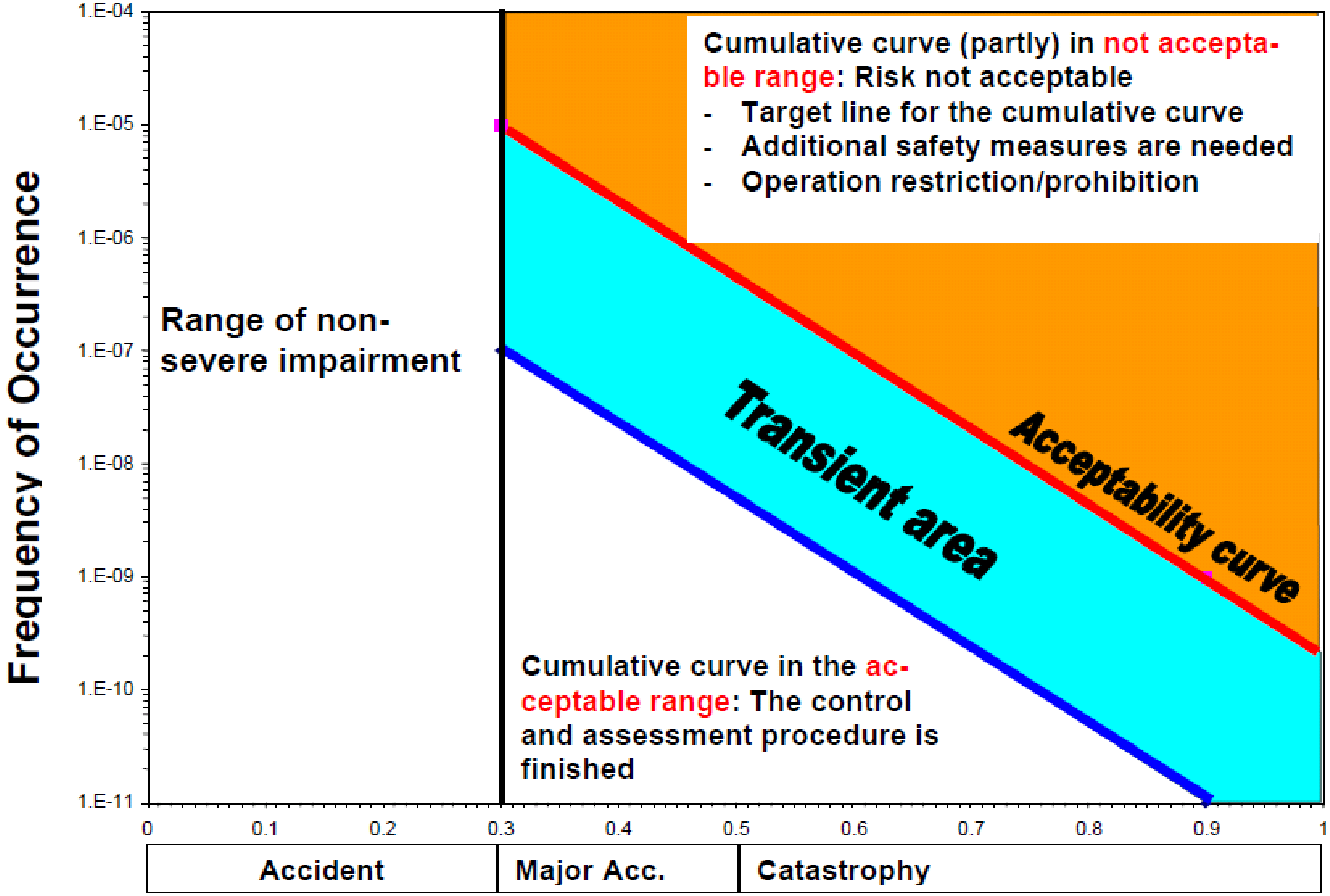
n_3, Polluted surface water [area in km^2]

n_4, Polluted ground water [loss in man-month]

n_5, Soil with derogated soil fertility [areayears in $km^2 \cdot a$]

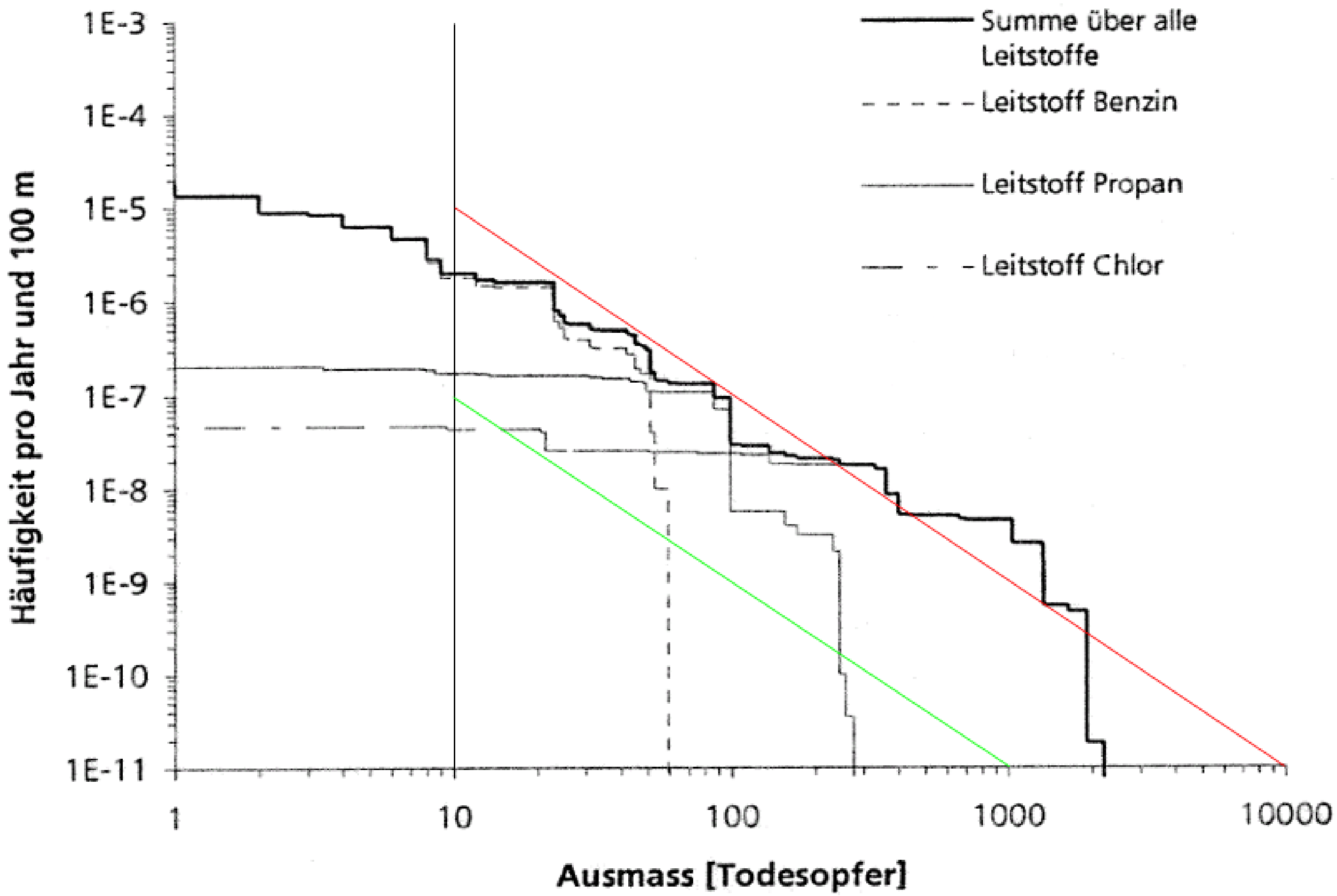
n_6, Property damage [Mio. Fr. index of 1996]

Tolerability assessment of risk (on risk analysis level)

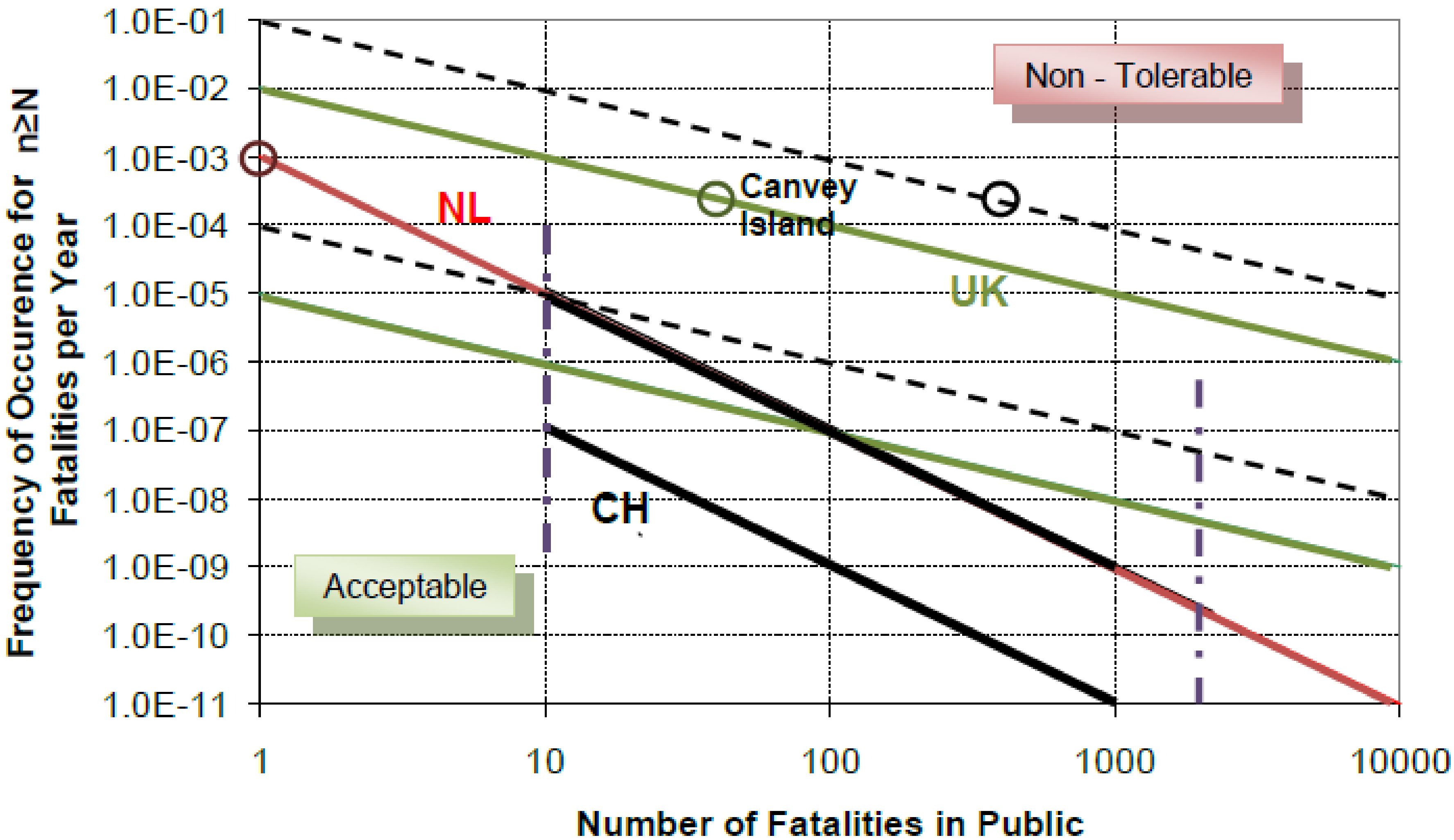


Cumulative curve (partly) in the transient area: consideration of interests
- Target line for the cumulative curve
- Additional safety measures may be needed
- Operation restriction/prohibition if needed

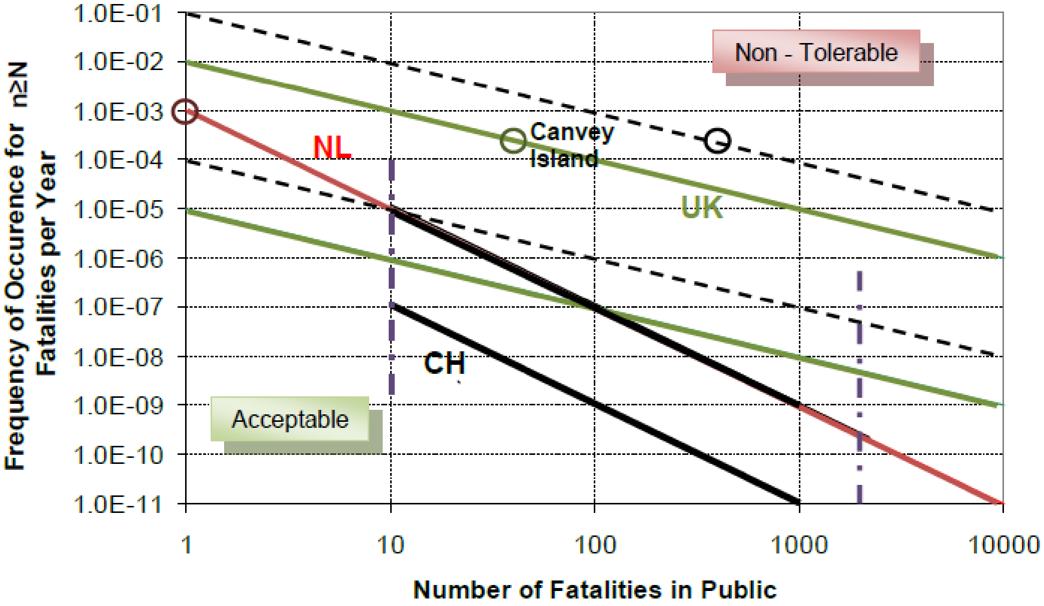
Example: Transportation of petrol, chlorine and propane



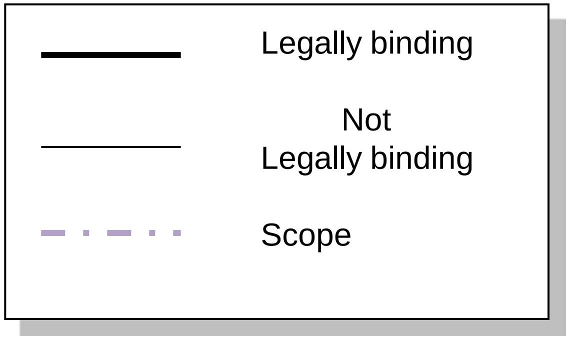
Source: Pilotrisikoermittlung für den Transport gefährlicher Güter, Fallbeispiel Bahn. 1998, Ernst Basler + Partner


Non - Tolerable
Canvey Island
NL
UK
CH
Acceptable
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
1.0E-09
1.0E-10
1.0E-11
1
10
100
1000
10000
Frequency of Occurence for n≥N Fatalities per Year
Number of Fatalities in Public

Comparison of acceptability curves



	Reference Point (○)	Slope of acceptability curves
CH NL	*Based on everyday life risks*	Risk aversion (exponent 2)
UK	Based on the accepted risk of the Canvey Island chemical facility	No risk aversion (exponent 1)



Tolerability of risk

- A band between the point of maximum tolerability (above which a project must be abandoned altogether) and the point of minimum tolerability (below which a risk is so small that the project can proceed without formal assessment).

- A “tolerable risk” is one that society is prepared to live with in order to have certain benefits and in the confidence that the risk is being properly controlled.

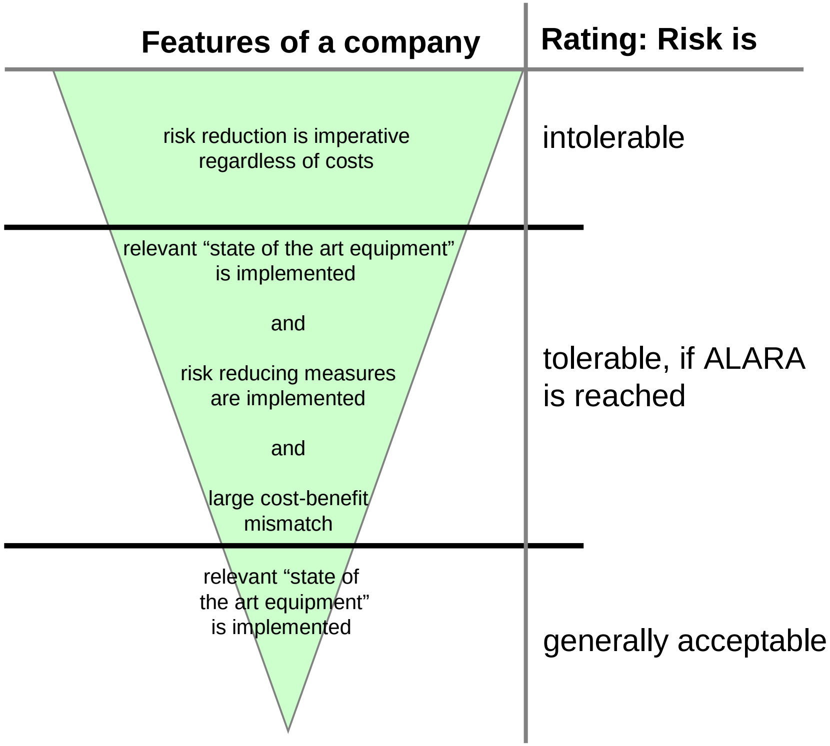
- An “acceptable risk”, which implies that the risk, although present, is generally regarded by those exposed to it as not worth worrying about.

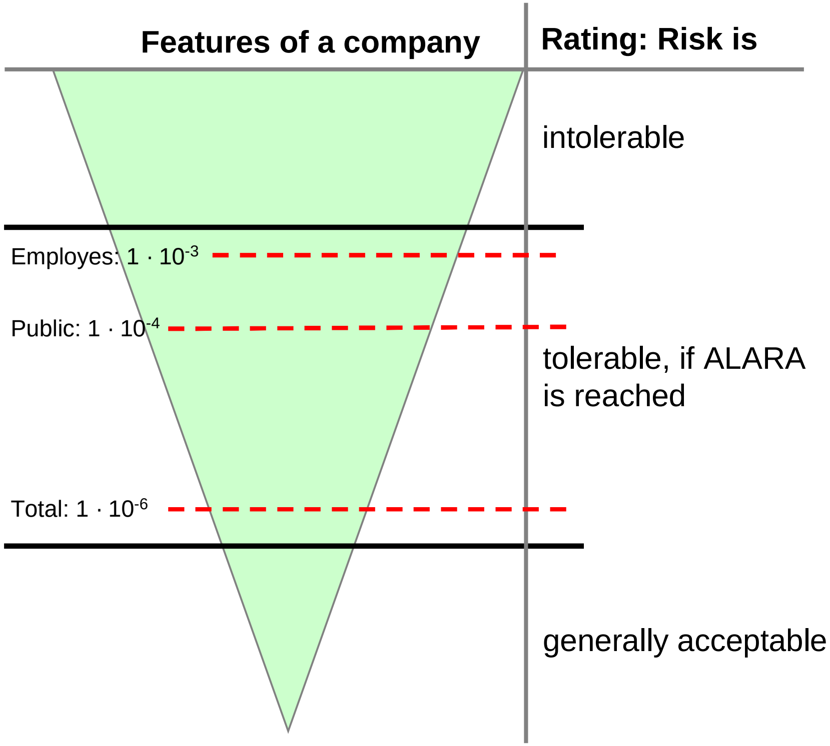
- These different perceptions mean that there is scope for confusion in communicating with the public and non-specialists on risk issues, and great care needs to be taken.

Costs versus benefit as rating scale:

ALARP (As Low As Reasonably Practicable)

The cost-benefit optimum is reached when the ratio between saved accident costs (increased security) and investment in security measures is “reasonable”. The acceptability of the ratio depends on the risk situation.





Concept developed by Health & Safety Executive (HSE), UK

Chain of action when applying the ALARP-principle

1. Identification of influencing factors and available options
Distinguish between quantifiable (e.g. costs, radiation dose) and not quantifiable (e.g. political decision making process) factors

Cost as central factor for:

- Safety measures:
  - Capital expenditure: from planning to operating stage of a facility, installations, equipment, training of personnel, etc.
  - Operational cost: salary, operation, administration, maintenance, reparation, etc.

- Loss expenditure
  - Health damaging effects (lethal or not lethal)
  - Non health damaging effects (e.g. loss of image)

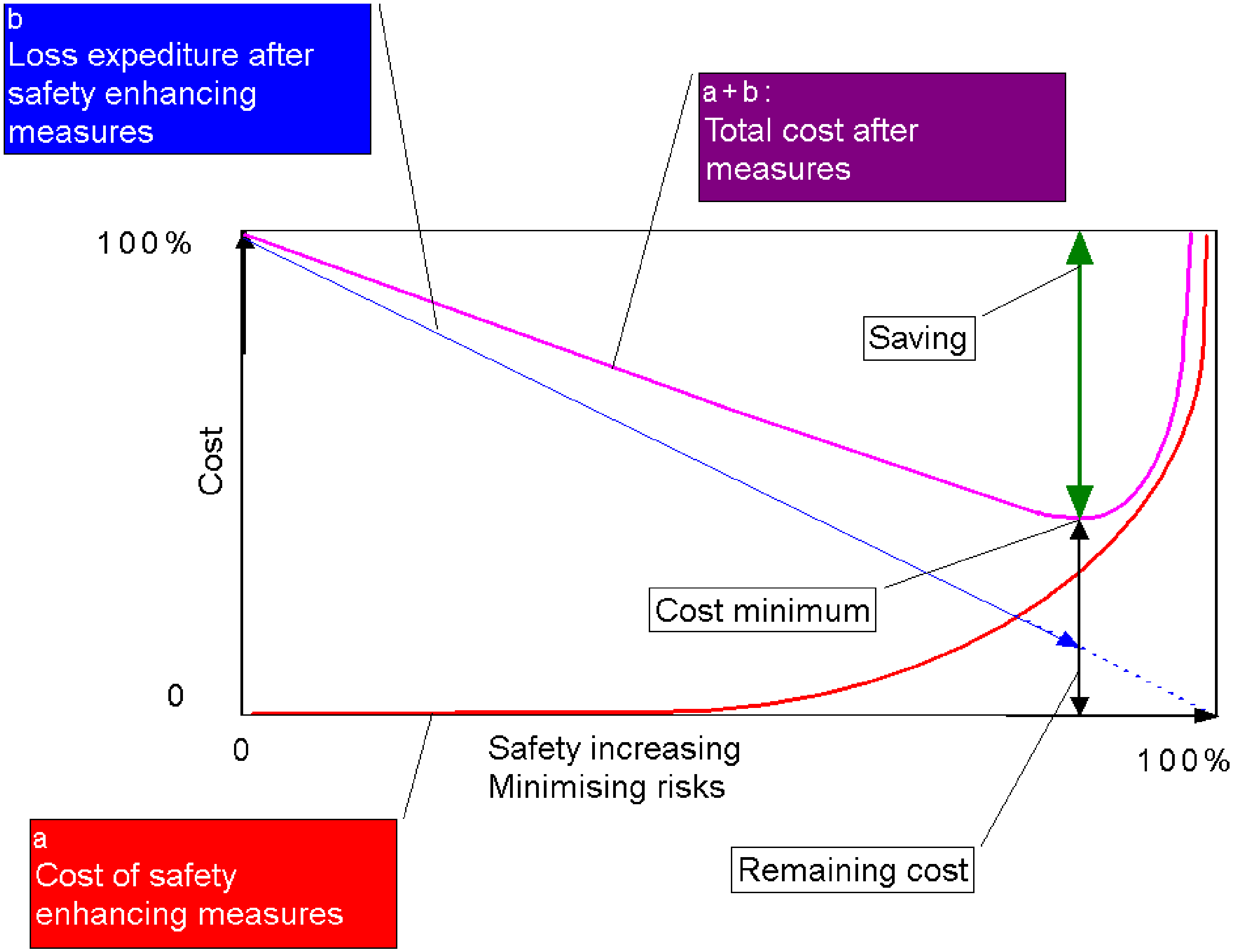
Options are various technical and/or organisational measures for exposition minimiza-tion. They are often derived from the analysis of the influencing factors (e.g. protective equipment).

2. Quantification of the relevant factors

Based on models and simulations

3. Comparison and selection of options

- Simple problems: Intuitive comparison, expert judgment, “best practice”, etc.
- Complex problems: Quantitative, decision aids like the Cost-Benefit Analysis



Cost Benefit Analysis (CBA)

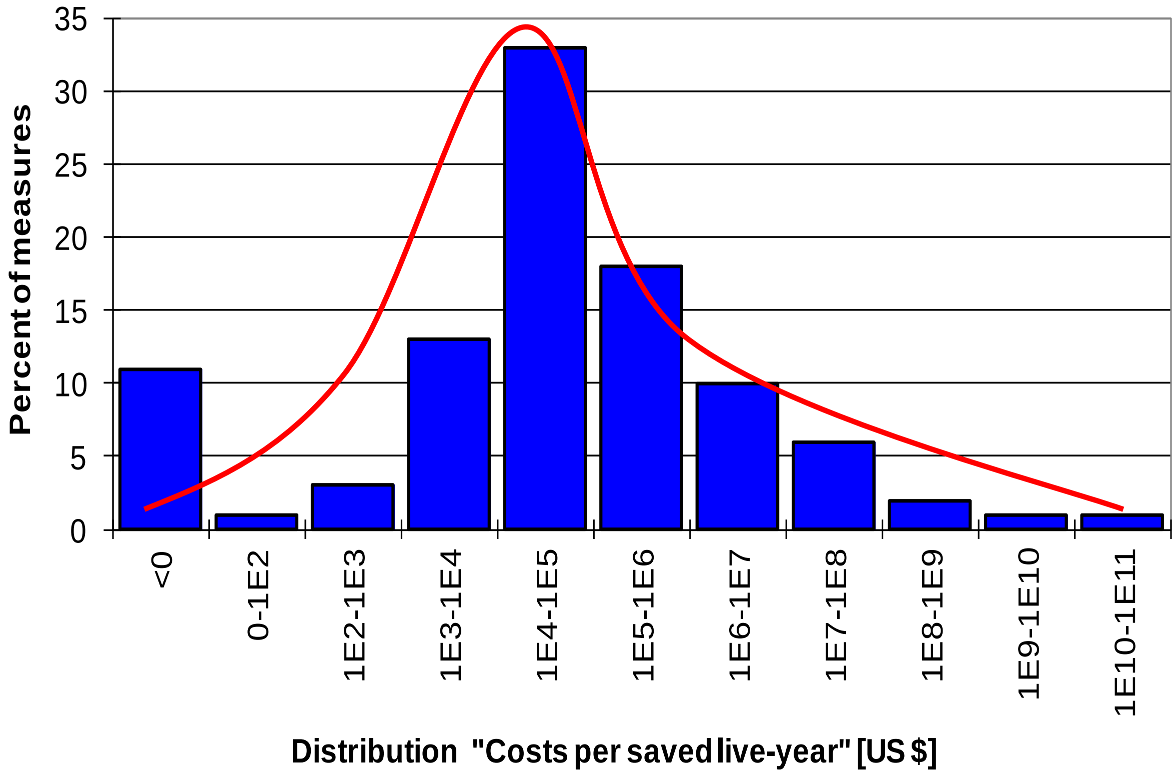
- Originates from the economic theory of welfare.
- Compares the benefits and harm associated with different options.
- All relevant factors have to be expressed in monetary terms, then aggregated to total costs.
- The best option is then the option presenting the minimum total cost.

Costs for safety enhancing measures

To save lives means that we end up with additional life years. The cost of implementing safety measures can therefore be translated into cost of measures per life year.

Measure	Life saving costs (1000$ per saved life)
PAP - Test	25
Mobile treatment of heart attacks	15-30
Security belts on front seats ()	25-110
Flying ban for DC-10	30’000
New regulations for high-rise buildings ()	100’000
Asbestos abatement in schools	Up to 1’400’000
Hydrogen-recombinators in nuclear power plants	3’000’000

Distribution of the costs per saved life [US $]



- 587 measures from different fields (road safety, fire and radiation protection, etc)
- Value < 0: benefit of the measures is higher than its costs

Source: Risk Analysis, Tengs et al., “Cost-Effectiveness of Saving Lifes”

The Major Accidents Ordinance (StFV)

Aim:
The StFV regulates the protection of the public and the environment from undesired events, which can occur in the operation of certain facilities.

Main focus:
- Recording the risks to the public and the environment which result from the handling, storage and transportation of hazardous substances, hazardous waste and micro-organisms
- Risk reducing measures have to be carried out by the owner of a facility or traffic route.
- The owner has to be capable of successfully handling hazardous incidents.
- The authorities control the owners' responsibilities.
- Improve information to the public. The public should be made aware of risks and their implications.

**(slides 18-26 provide additional information - not subject of exams)*

Scope of the StFV

- Facilities which store, produce or use substances, products or hazardous waste in amounts above a defined threshold value.
- Facilities which work with dangerous micro-organisms
- Traffic facilities which are used for the transportation of dangerous goods:
    - Rail facilities
    - Motorways and major roads
    - River and canals (Rhine)

Excluded are

- Facilities which store, produce ore use dangerous substances but the amount of the dangerous substances is lower than the defined threshold value.
- Pipeline networks (for the transmission of liquid or gaseous heating and motor fuels)
- Facilities and activities which are subject of the Radiological Protection.
- Facilities where industrially produced articles of day-to-day use are found (e.g. storing of articles containing PVC)

StFV procedure (chain of action)

Short report:

Provided by the facility owner

↓

Controlled and judged by the authorities

→ **Ended:** If no heavy damages are expected

↓

Risk assessment:

Ordered by the authorities

↓

Provided by the facility owner

↓

Controlled and judged by the authorities

→ **Ended:** If the risk is acceptable

↓

Measurements:

Additionally ordered by the authorities

The short report

The short report of the facility owner is an “estimation of possible impacts to the public and the environment resulting from undesirable events:

- Significant effects outside of the facility area
- Consideration of hazard causes, event sequences and forms of failures in realistic terms
- Oriented more on dimension of damage than event frequency; very low event frequency are no reason to exclude a scenario (worst case thinking).

Estimation of possible impacts to the public and the environment

- Type and amount of possibly released substances
- Release types (e.g. leakage, fire, etc.),
- Type and dimension of released substances (air, water, soil)
- “Worst case” consequences

Risk assessment by the facility owner

The risk assessment is a control mechanism for the effectiveness of the security measures and a basis for rating risks to the public and the environment

Method

How the risk should be assessed is not defined in the StFV:

- If known or generally applied methods are used
  - ⇒ Referencing the source is sufficient
  - ⇒ Giving reasons for the application (without detailed description)

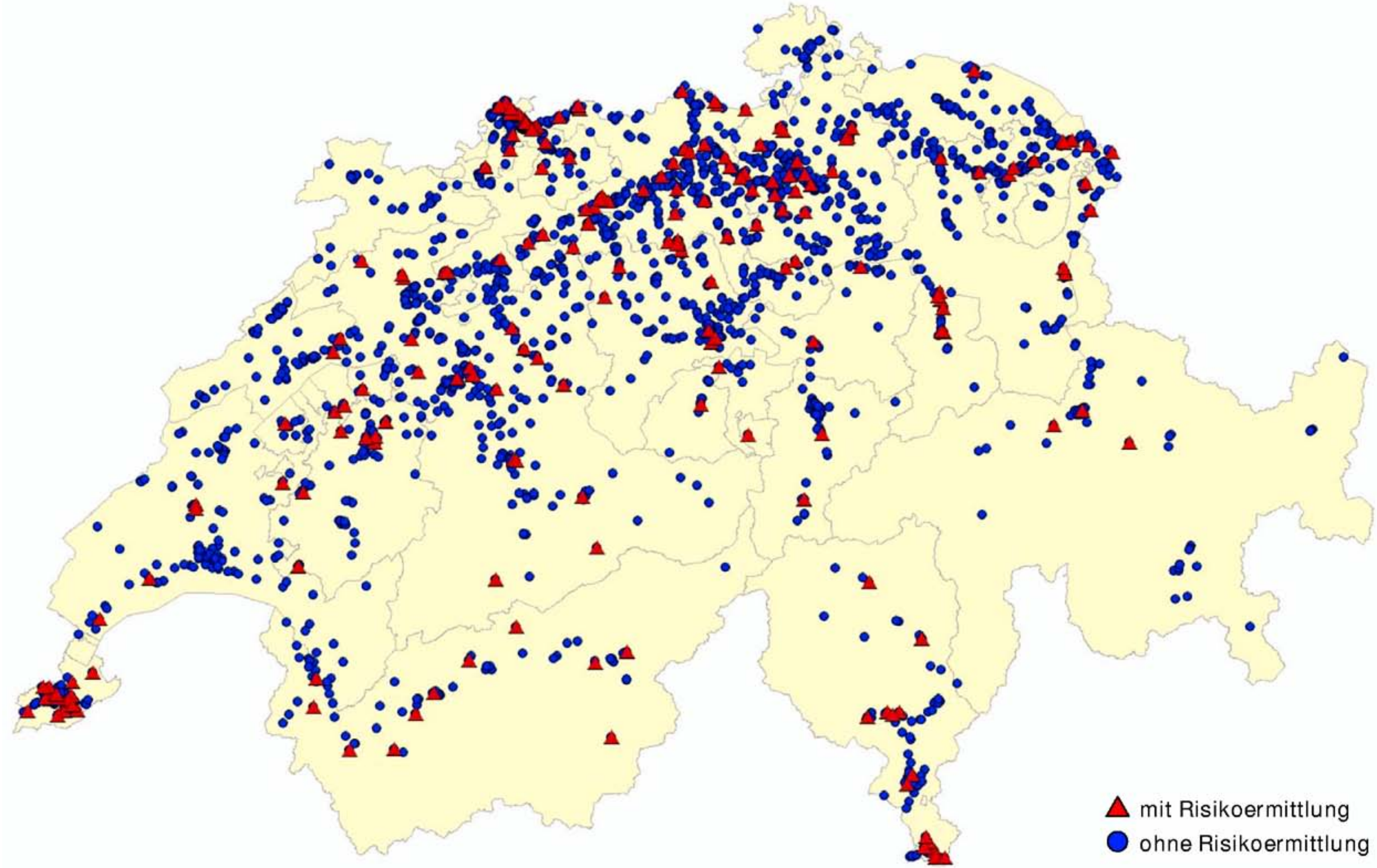
- If not generally accepted methods are applied
  - ⇒ Detailed description is needed (reconstructability)

For the analysis of facilities and hazard scenarios suitable methods are:

- Qualitative, quantitative, inductive and deductive approaches
- Statistical information, event and reliability databases
- Expert judgment

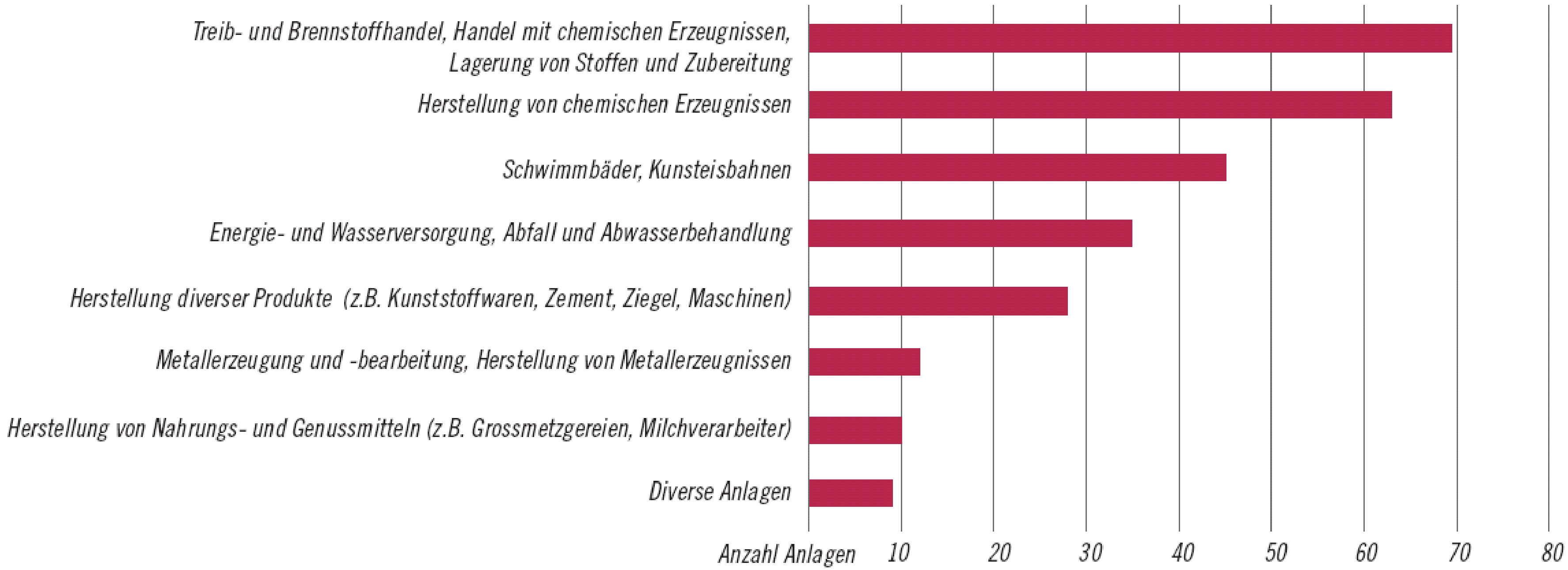
Companies which are subject to the StFV

(End of 2005)



Source: http://www.bafu.admin.ch/aktuell/medieninformation/00004/index.html?lang=de&msg-id=7891

Risk assessment sorted by sector



Source: http://www.bafu.admin.ch/dokumentation/umwelt/00107/index.html?lang=de