

WHY RISK MANAGEMENT ?

1. LEGISLATIVE DEMANDS
2. IMPROVEMENT OF SECURITY AND WORKING CONDITIONS
3. LOSS PREVENTION
4. IMAGE AND COMPANY CULTURE
5. INSURANCE

LEGISLATIVE DEMANDS

1. Not observing of legislation may cause

- financial sanctions
- suspension or limitation of activity
- prosecution

2. Areas regulated by legislation

- technical demands on appliances
- protection of health at work
- fire protection
- chemical substances use

3. Levels of legislation

- laws
- ordinances
- norms

IMPROVEMENT OF SECURITY **AND WORKING CONDITIONS**

- prevention of working injuries and professional diseases**
- improvement of working performance**
- reduction of absences and fluctuation**
- stabilisation of working performance**

LOSS PREVENTION

- **Direct losses**

- production losses (impossibility of production after breakdown or because of prohibition)
- appliance losses
- material losses
- compensation, penalty

- **Indirect losses**

- market losses
- environmental damages (decontamination)
- image losses
- disruption of relations in company

IMAGE AND COMPANY CULTURE

- **Image**

1. Customers
2. Government,
municipality
3. Population
4. Mass media

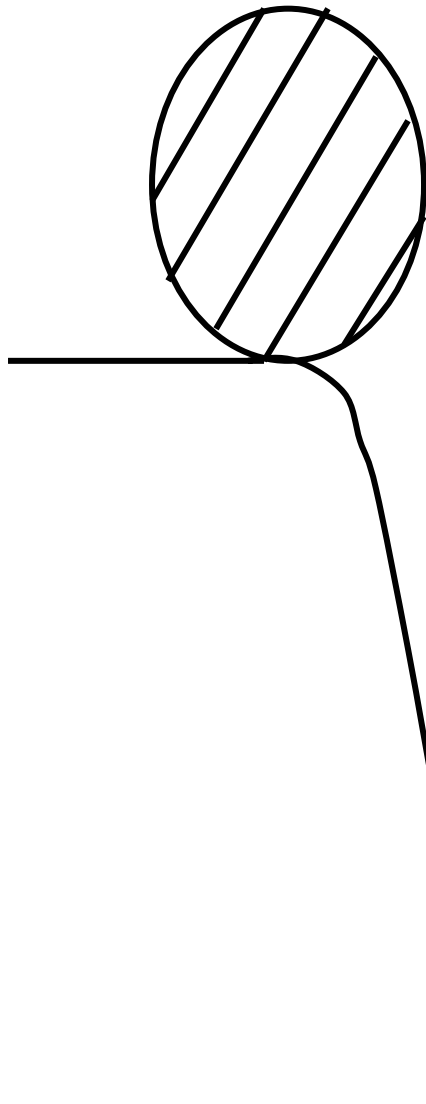
- **Company culture**

1. Confidence of employees
2. Feeling of solidarity
3. Pride on their company
4. Standard use of personal
protective working aids
5. Friendly atmosphere in company

INSURANCE

Building up of security level induces hazard reduction and therefore we can:

- reduce price for the same insurance benefit
- raise insurance benefit for the same price



DEFINITION OF TERMS:

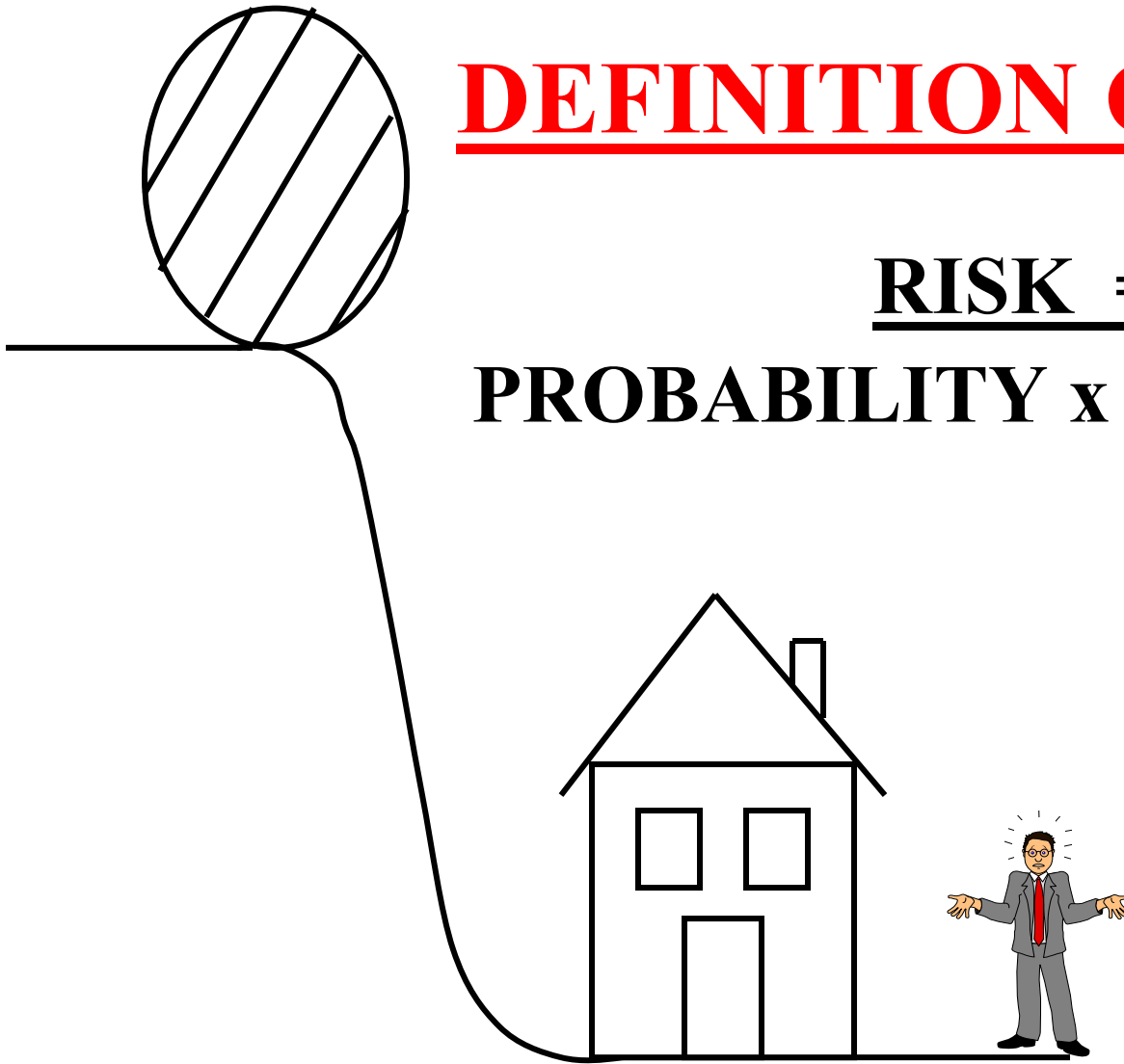
SOURCE OF DANGER

=

**POTENTIAL TO
CAUSE DAMAGE**

DEFINITION OF TERMS:

**RISK =
PROBABILITY x GRAVITY OF
ACCIDENT
(EVENT)**



CHARACTERISTICS OF RISK

Voluntary ↔ Involuntary

Chronic ↔ Catastrophic

Common ↔ Dread

Injurious ↔ Fatal

Known to those exposed ↔ Not known to those exposed

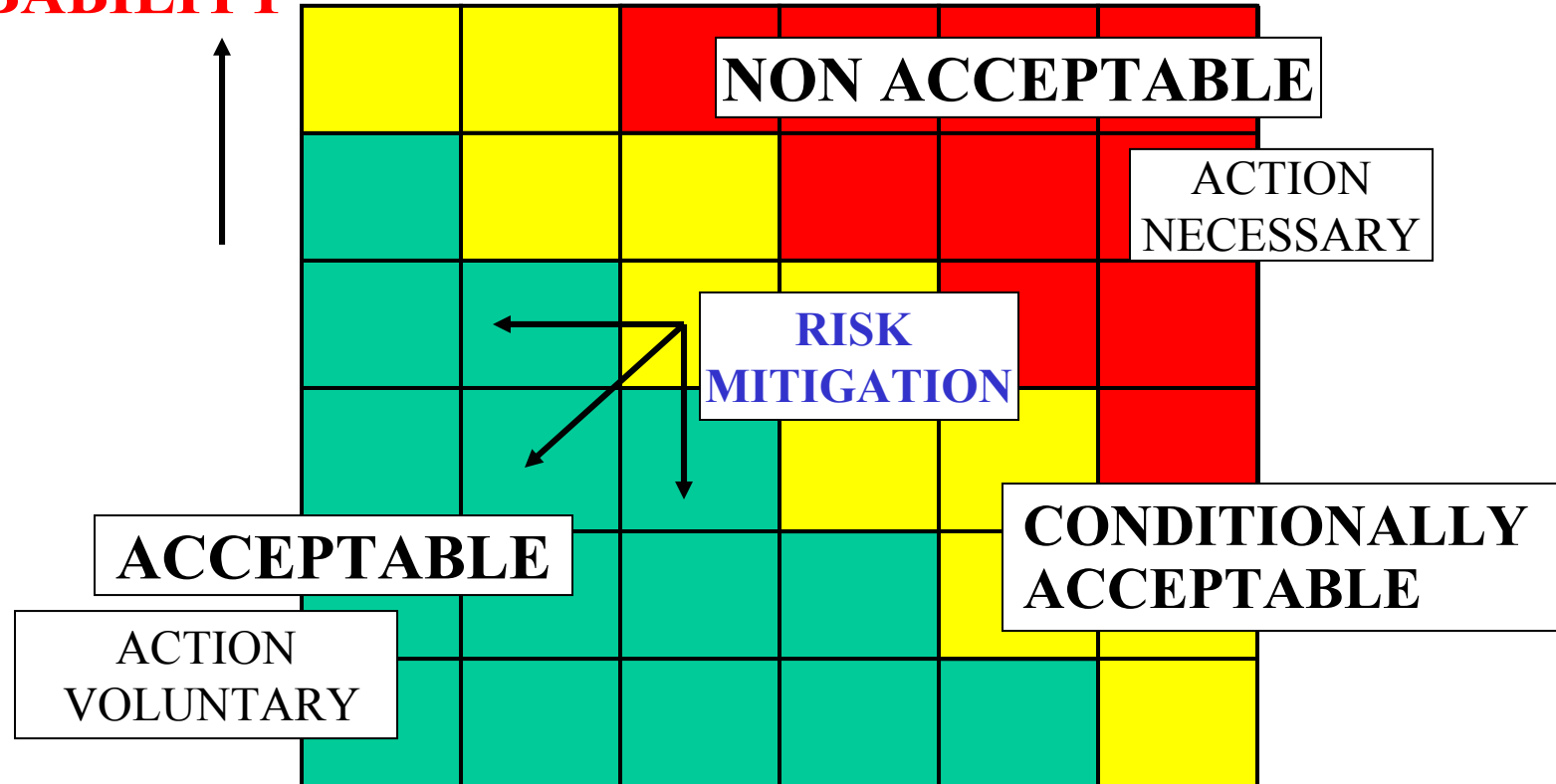
Known to science ↔ Not yet known to science

Old ↔ New

Controllable ↔ Not controllable

ACCEPTABILITY OF RISK

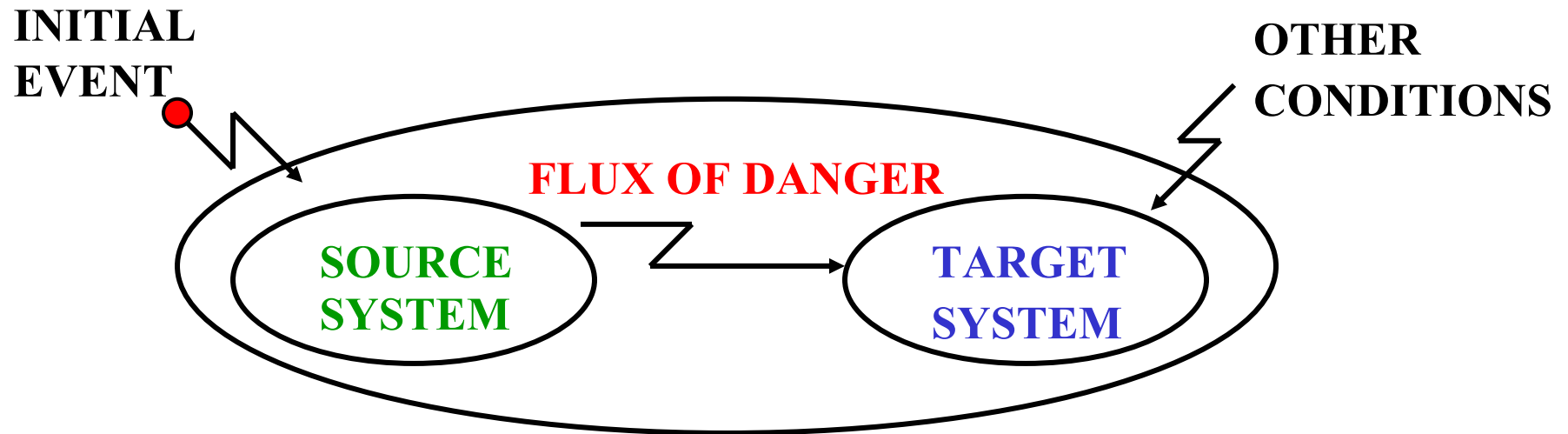
PROBABILITY



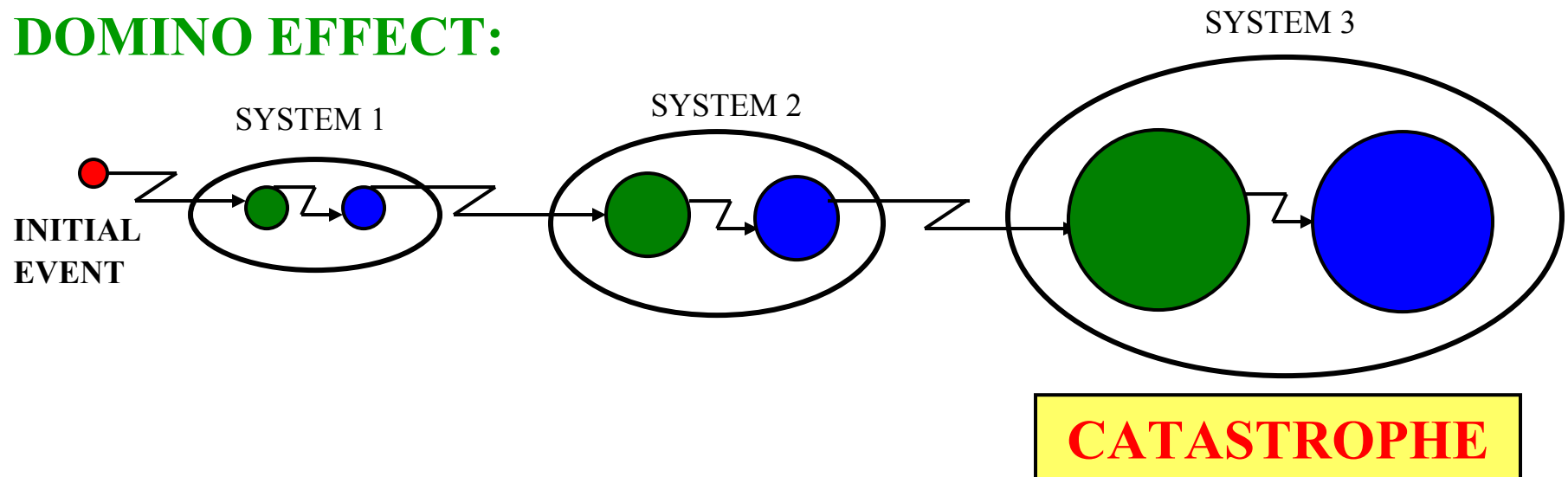
RISK MATRIX

GRAVITY

FLUX OF DANGER - ACCIDENT DEVELOPMENT



DOMINO EFFECT:



FLUX OF DANGER:

- Movement of material
- Flux of energy
- Flux of information

TARGET SYSTEMS:

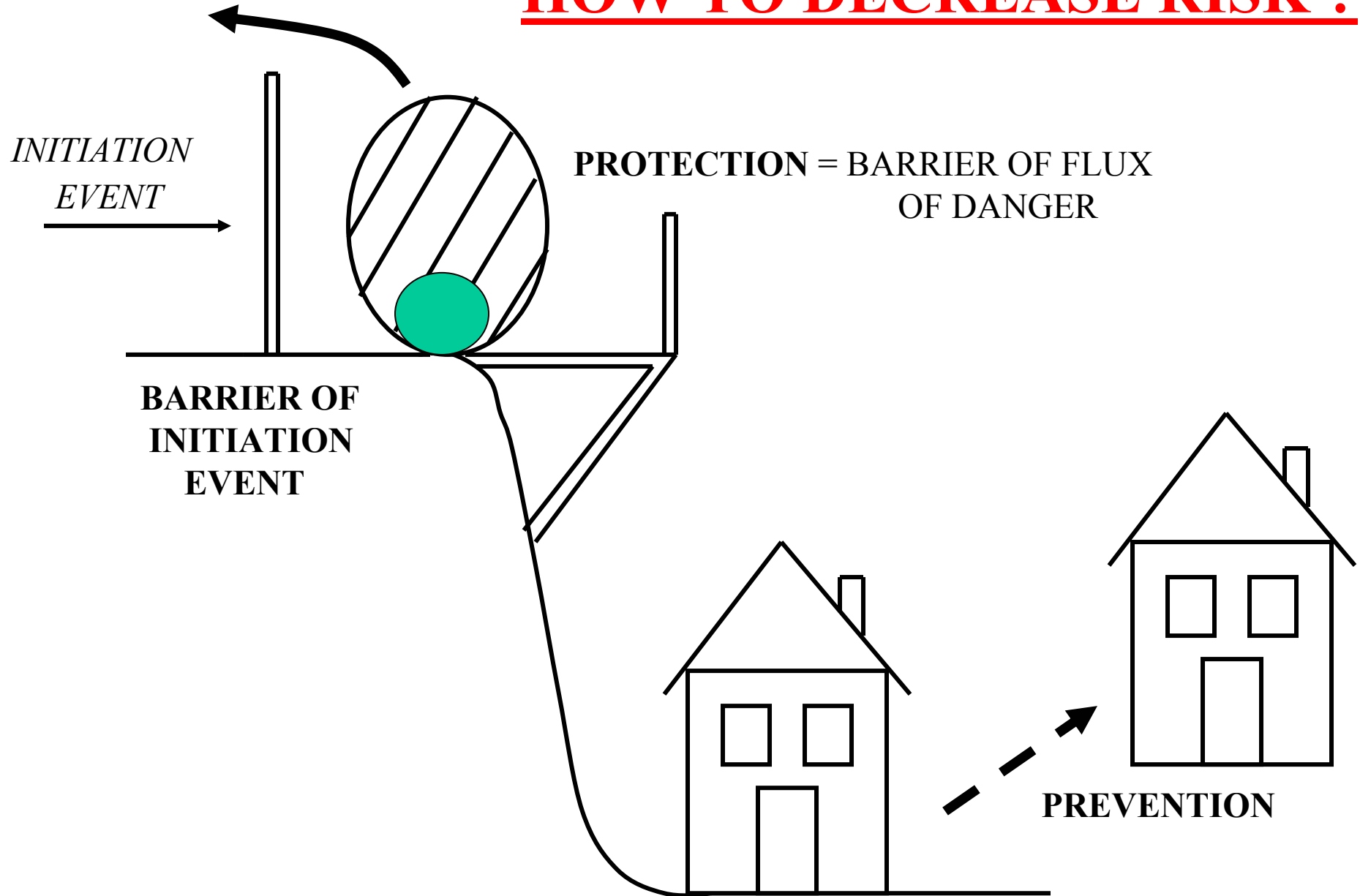
- Workers (employees)
- Population outside enterprise
- Environment
- Installation (material and financial losses)

SOURCES OF DANGER:

- Mechanical (fall, pressure, movement)
- Chemical (toxicity, corrosivity, violent reactions)
- Electrical
- Fire
- Radiation
- Biological
- Human errors
- Active environment (natural, human)

ELIMINATION OR REDUCTION OF
SOURCE OF DANGER

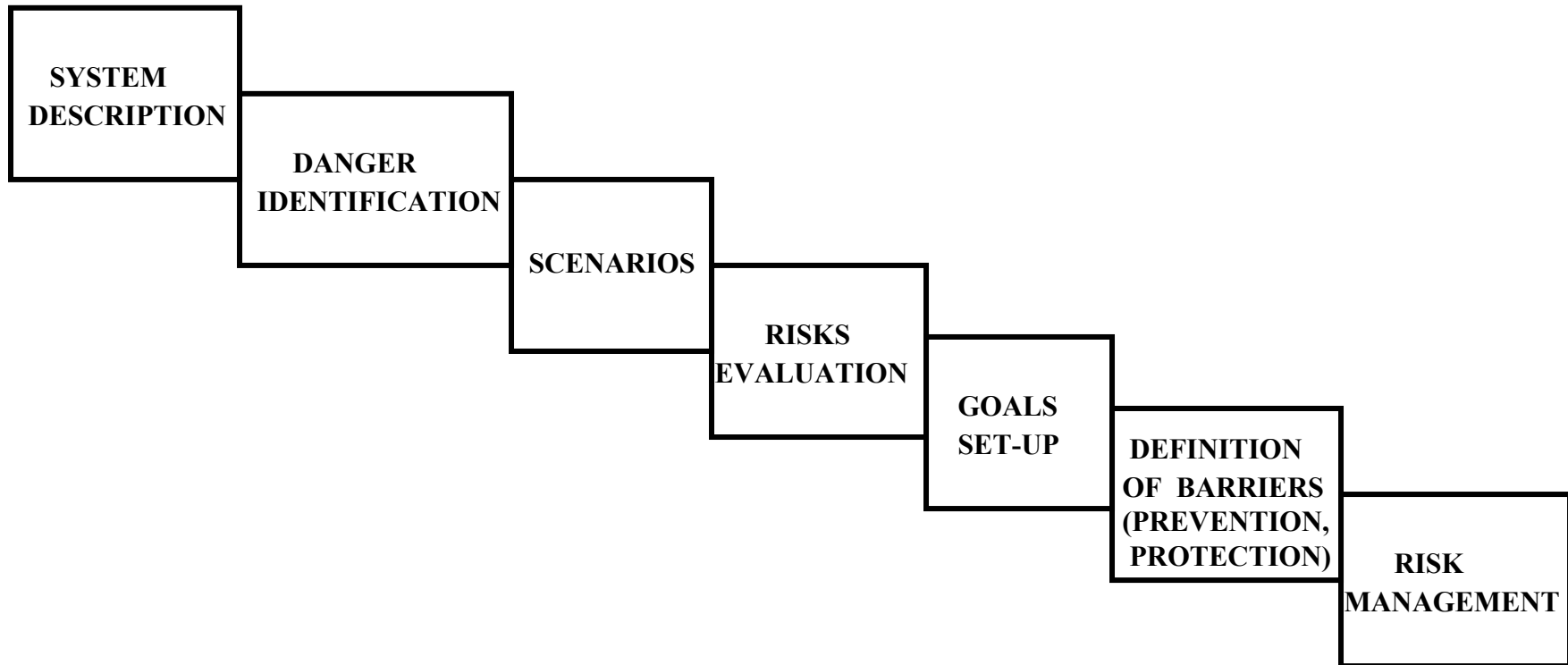
HOW TO DECREASE RISK ?



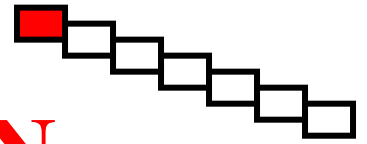
FLUX OF DANGER APPROACH

SOURCE	TARGET	DISCIPLINE
Installation	Employee	<ul style="list-style-type: none">- Occupation health and safety- Ergonomy
Installation	Environment, Population	<ul style="list-style-type: none">-Environment protection-Big accident prevention
Installation	Installation	<ul style="list-style-type: none">-Operation reliability-Loss prevention
Employee	Installation	<ul style="list-style-type: none">-Human errors-Sabotage
Environment	Installation	<ul style="list-style-type: none">-Natural risks-Domino effect (external)

RISK ASSESSMENT AND MANAGEMENT

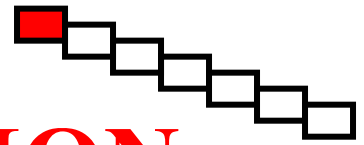


SYSTEM DESCRIPTION



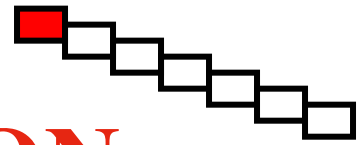
**Necessary information to description of appliance for
needs of analysis and risk management**

- A) Description of technology (appliance in object)
- B) Description of surroundings (natural and social
conditions of appliance location and his immediate
neighbourhood)
- C) Analysis of breakdowns and accidents from past



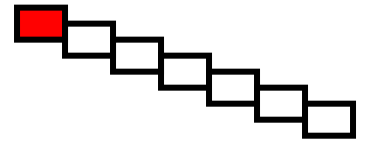
TECHNOLOGY DESCRIPTION

- Type and output
- Connection on surrounding technology (manners of connection)
- Detailed description of operations procedure (normal operation, stand off and start, extraordinary operations)
- Type, physical, chemical, toxicological characterisations of raw materials, intermediate products and products, their quantity in warehouse and consumption
- Wastes, their type, physical, chemical and toxicological characterisations, their quantity and conditions of production
- Media, energy and other commodity supply
- Operating chart of operation
- Description of current security components



EQUIPMENT DESCRIPTION

- General characteristics of the performance (of analysed systems)
History of operation, type and amount of production, relation to other technologies
- Description of working activities in individual sub-systems
General presentation, detailed description of an operation in every phase of a life-cycle of a sub-system
- Media in systems
Raw materials, rare products, products, waste (amount, position)
- Management of a system operation
Description of regulatory elements, description of safety elements, means for decision support
- Supply with media, energy and other commodities
- Performance organisation
- Description of present means for actions



SURROUNDINGS DESCRIPTION

- Meteorological and climatic conditions
- Geological conditions and morphology of terrain
- Hydrology of environment
- Demography of environment
- Surrounding objects and technologies



ENVIRONMENT DESCRIPTION

- **Natural environment description**

Position, description of a relief, meteorology, hydrogeology, hydrology, geology, pedology, nature and landscape

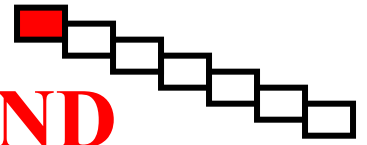
- **Demographic description**

Description of populated areas, places of inhabitants gathering

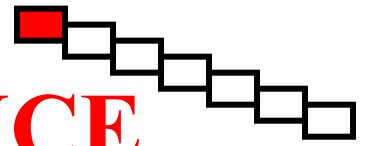
- **System of safety and services**

- **Description of industrial companies and transport infrastructure in the neighbourhood**

ANALYSIS OF BREAKDOWNS AND ACCIDENTS FROM PAST



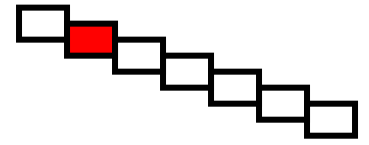
- Description of breakdowns and accidents, which happened on appraisal appliance
- Description of breakdowns and accidents, which happened on comparable appliance at home or abroad
- Received instructions and confirmation of received precautions on appliance



VARIOUS PHASES OF APPLIANCE **EXPLOITATION**

Various phases of appliance exploitation - produce various risks, therefore they must be studying separately

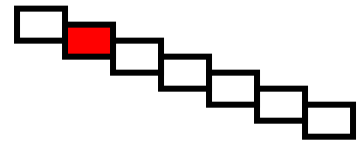
- **Project phase**
- **Construction of appliance**
- **Starting of appliance and operational tests**
- **Standard operation**
- **Service and reparation**
- **Stand off**
- **Dismantlement of appliance and liquidation**



HOW TO IDENTIFY DANGER ?

- **Define sources of danger** : list of sources, their quantity, location ...
- **Define targets, which can be hit**
- **Evaluate existing prevention, protection, check plans and devices**

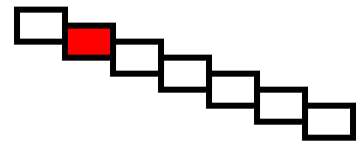
TOOLS : remedial lists, check-lists, index methods
(DOW's F&EI, CEI), empirical experiences



SOURCES OF DANGER

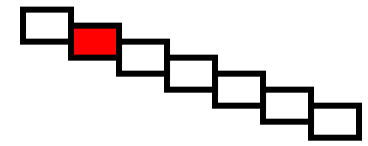
- Sources of danger of mechanical origin
- Sources of danger of chemical origin
- Sources of danger of electrical origin
- Sources of danger of fire
- Danger of radiation and heat sources
- Sources of biological danger
- Human factor
- Sources of danger resulting from surroundings
- Socio-economic sources

DANGEROUS CHARACTERS OF CHEMICAL SUBSTANCES

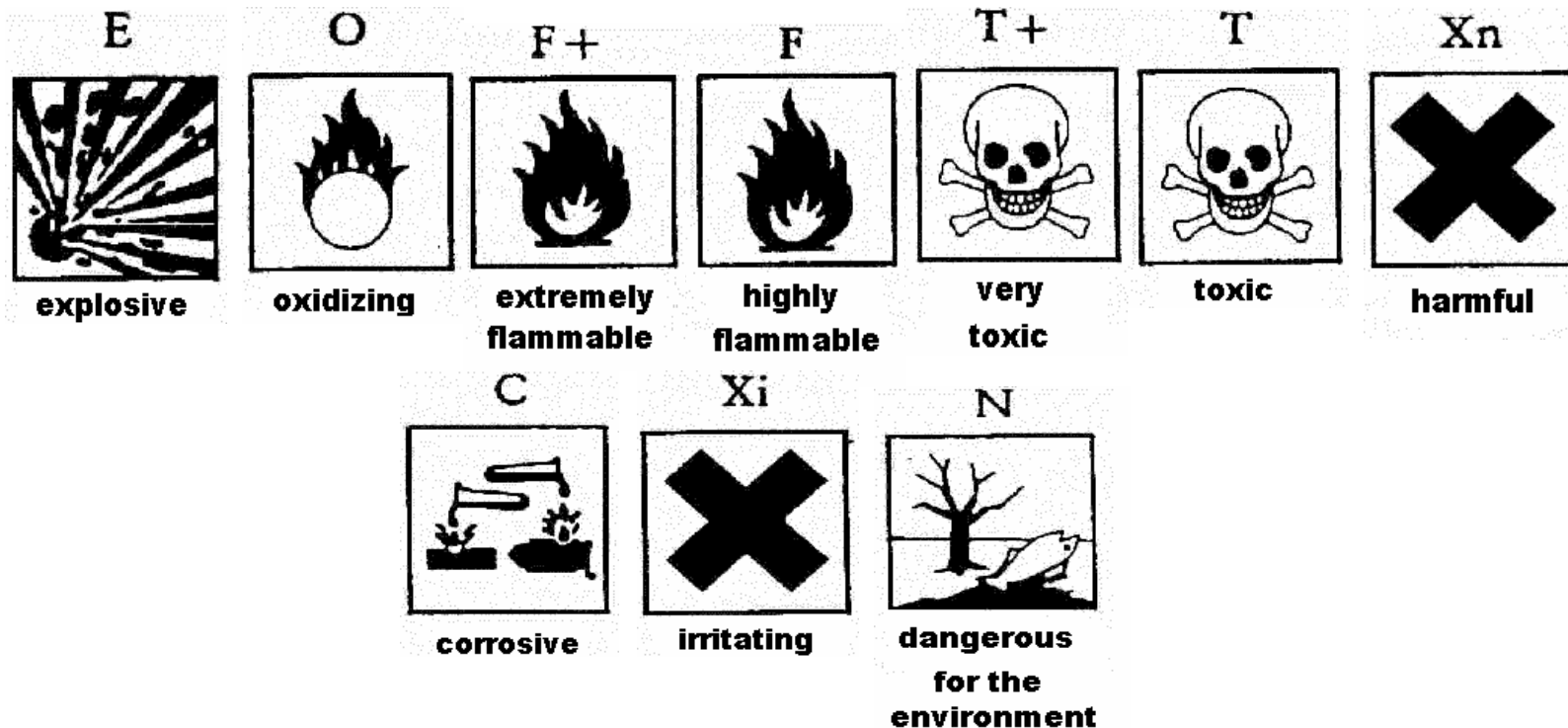


- Danger of chemical reactions - some substances in contact with water, air or other substances can:
 - violently react
 - ignite or explode
 - liberate flammable or toxic vapours
- Danger of explosion of
 - substances themselves (explosives)
 - gases, vapours and dusts in compound with air
 - container of liquefied gases or volatile liquids (BLEVE) and reactors
- Danger of toxicity, ecotoxicity and corrosivity
 - **Toxicity** (induce poisoning, cancer, embryo damage, hereditary disorders, allergy...)
 - **Ecotoxicity** (damage of water, soil, atmosphere quality; plants, animals)
 - **Corrosivity** (damage of skin, eyes, mucous membrane or corrodes materials)

HOW TO IDENTIFY DANGEROUS SUBSTANCE?



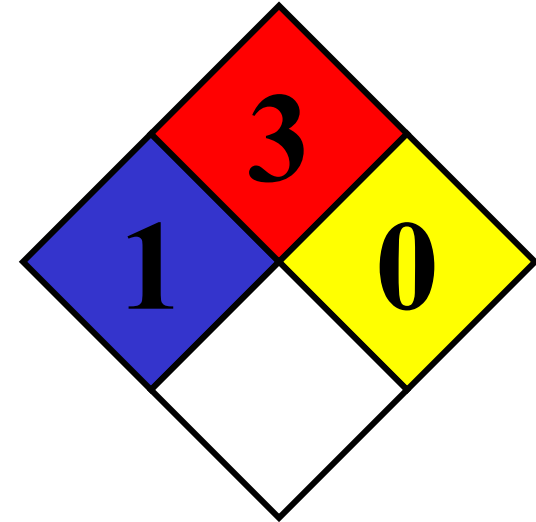
- Symbols of hazard on containers



- R-phrases and S-phrases on containers or in appending documentation
- Safety data sheets
- Literature, databases, information from manufacturer
(if there isn't safety data sheets)

NFPA Diamond

Uses the standard NFPA codes, ranking hazards according to the chemical's reaction to the presence of fire. The red, blue and yellow diamonds use a rating scale of 4 to 0, with 4 representing the greatest hazard and 0 the least. The bottom diamond uses pictograms.



TOP DIAMOND	RIGHT-HAND DIAMOND	LEFT-HAND DIAMOND	BOTTOM DIAMOND
Red:Flash Point	Yellow: Reactivity	Blue: Health Hazard	White: Health Warnings
4 -Below 70°F/ 21°C	4 - Explosive	4 - Deadly	Air - reactive
3 - Below 100°F/ 38°C	3 - Shock and heat may detonate	3 - Extremely dangerous	Water - reactive
2 - Below 200°F/ 93°C	2 - Violent change may occur	2 - Hazardous	Carcinogenic
1 - Above 200°F/ 93°C	1 - Unstable if heated	1 - Slightly hazardous	Radioactive
0 - Non - flammable	0 - Normally stable	0 - Normal material	

INTERNET ADDRESSES

[http: //plumbum.ceu.cz](http://plumbum.ceu.cz)

<http://www.cdc.gov/niosh/ipcs/icstart.html>

[http: //www.atsdr.cdc.gov/hazdat.html](http://www.atsdr.cdc.gov/hazdat.html)

[http: //www.atsdr.cdc.gov/toxfaq.html](http://www.atsdr.cdc.gov/toxfaq.html)

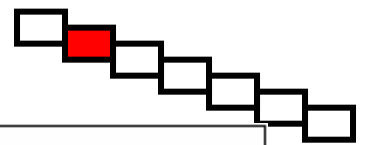
[http: //ehis.niehs.nih.gov/roc/](http://ehis.niehs.nih.gov/roc/)

[http: //www.chemexper.be/](http://www.chemexper.be/)

[http: //www.chemindustry.com/](http://www.chemindustry.com/)

[http: //hazmat.dot.gov/guidebook.htm](http://hazmat.dot.gov/guidebook.htm)

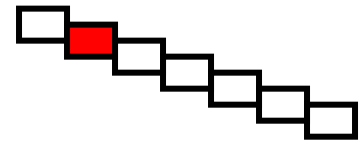
[http: //siri.org/](http://siri.org/)



VARIOUS PHASES OF APPLIANCE EXPLOITATION

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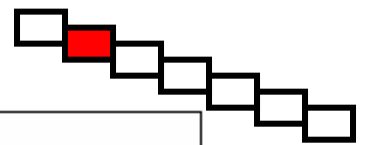
RISK SOURCES LOCATION

- **DESCRIPTION OF A LOCATION :**
 - basic structure of appliance
 - accessibility of appliance
- **MAPS AND PLANS OF:**
 - most important parts of appliance from the safety point of view
 - main store places and production appliances
 - location of hazardous substances and their amount
 - infrastructure (pipes, reservoirs...)
 - distance among individual appliances
 - building and surrounding



TARGETS THAT MAY BE AFFECTED

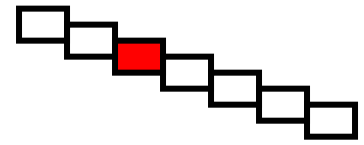
- **EMPLOYEES**
- **PEOPLE OUTSIDE A COMPANY**
- **ENVIRONMENT**
- **APPLIANCE (material and financial losses)**
- **PROPERTY**



Existing protection and prevention means

- **TECHNICAL PRECAUTION** - they are such precautions in construction of appliance, which lead to increase of safety in operation (examples: safety valve, sprinklers, automatic regulation, safety reservoir, double containment...)
- **ORGANIZATIONAL PRECAUTION** - they are precautions in work organisation, regulations, technological productions and procedures (including applicable technical equipment), which lead to increase of safety in operation.

WHAT SCENARIO IS ?



SCENARIO - description of combinations and time sequence of actions, which can cause developing of undesirable event

HOW TO PROPOSE SCENARIOS OF POSSIBLE ACCIDENTS ?

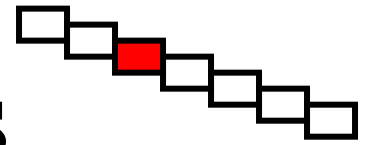
EXPERIENCES FROM HISTORY

METHODS - WHAT - IF

- FAULT TREE
- STUDY OF RELIABILITY (HAZOP, FMEA, AMDEC ...)
- SYSTEM APPROACH - MOSAR, CPQRA

We take into consideration all realistic scenarios to analysis, which can cause significant consequences

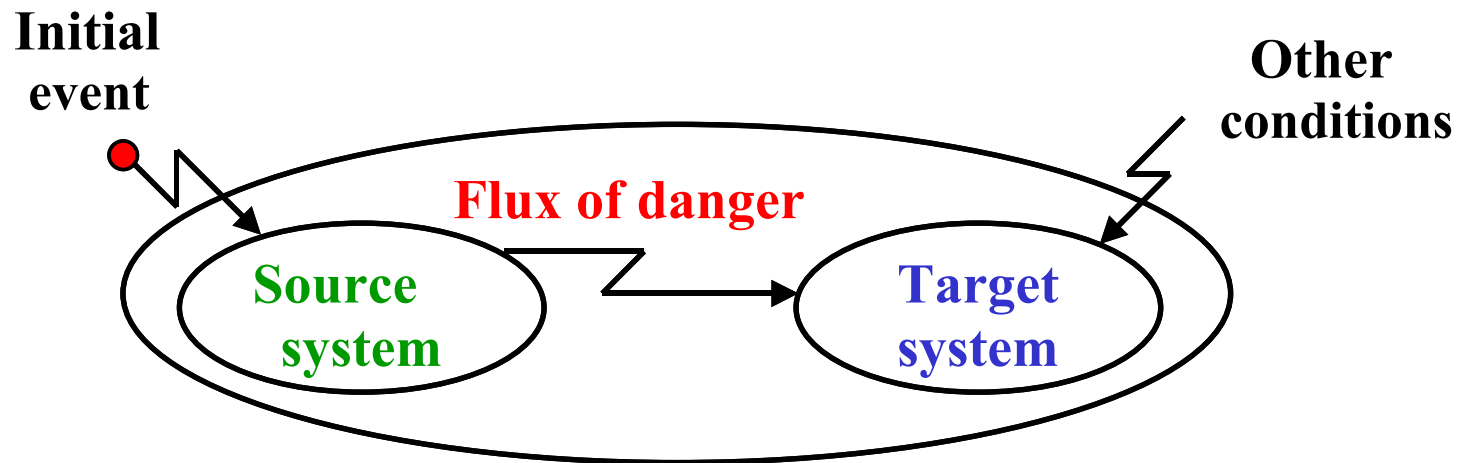
Proposition of scenarios



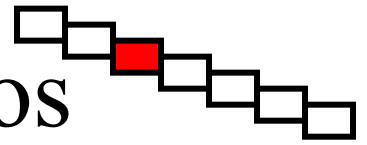
The purpose of this step in the risk analysis is an identification and **description of probable scenarios**, from a development of initial events (causes) to undesirable events (consequences).

A scenario is a description of combinations and time-sequence of actions which can cause development of undesirable events.

Flux of danger = development of undesirable events



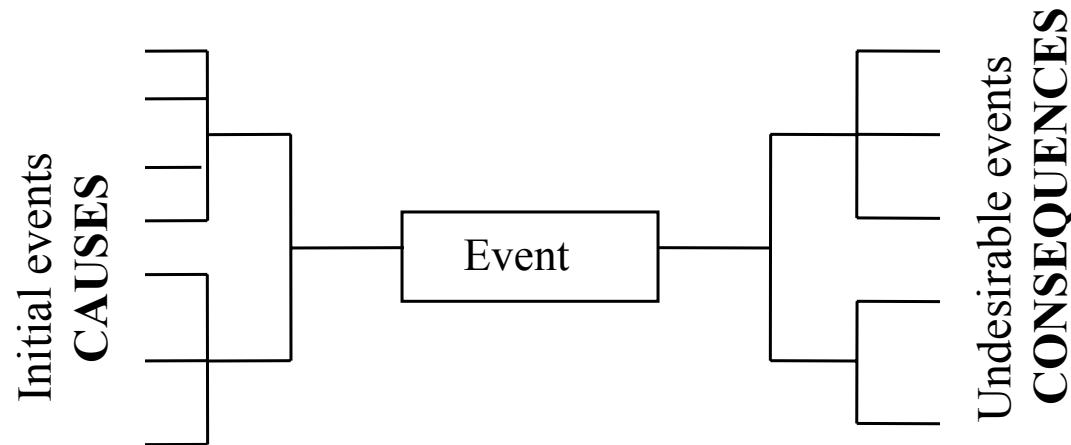
Graphic presentation of scenarios



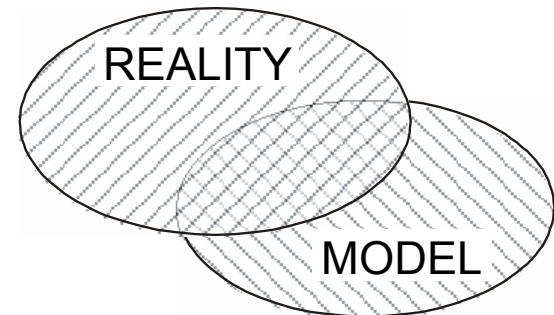
Presentation of scenarios through a **Fault Tree Analysis** supporting of finding of possible causes leading to origination of an undesirable event. **Event Tree Analysis** follows and evolves a possible life cycle of events further.

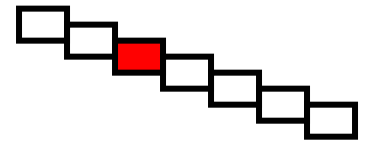
Fault Tree Analysis (FTA)

Event Tree Analysis (ETA)



A reality has ever got some features different for a model and vice versa. The aims of our trying is finding of such a model where these differences are minimal.





Systems

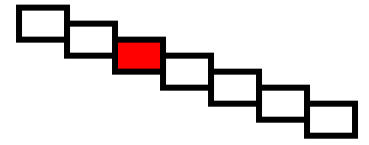
System (sub-system) is defined with its spatial borders, inputs, outputs, functions and time development.

Facilities, technologies, procedures, appliances (system) can be divided into sub-systems according their function or their spatial borders. Every sub-system is defined with similar criteria like a system (borders, inputs...)

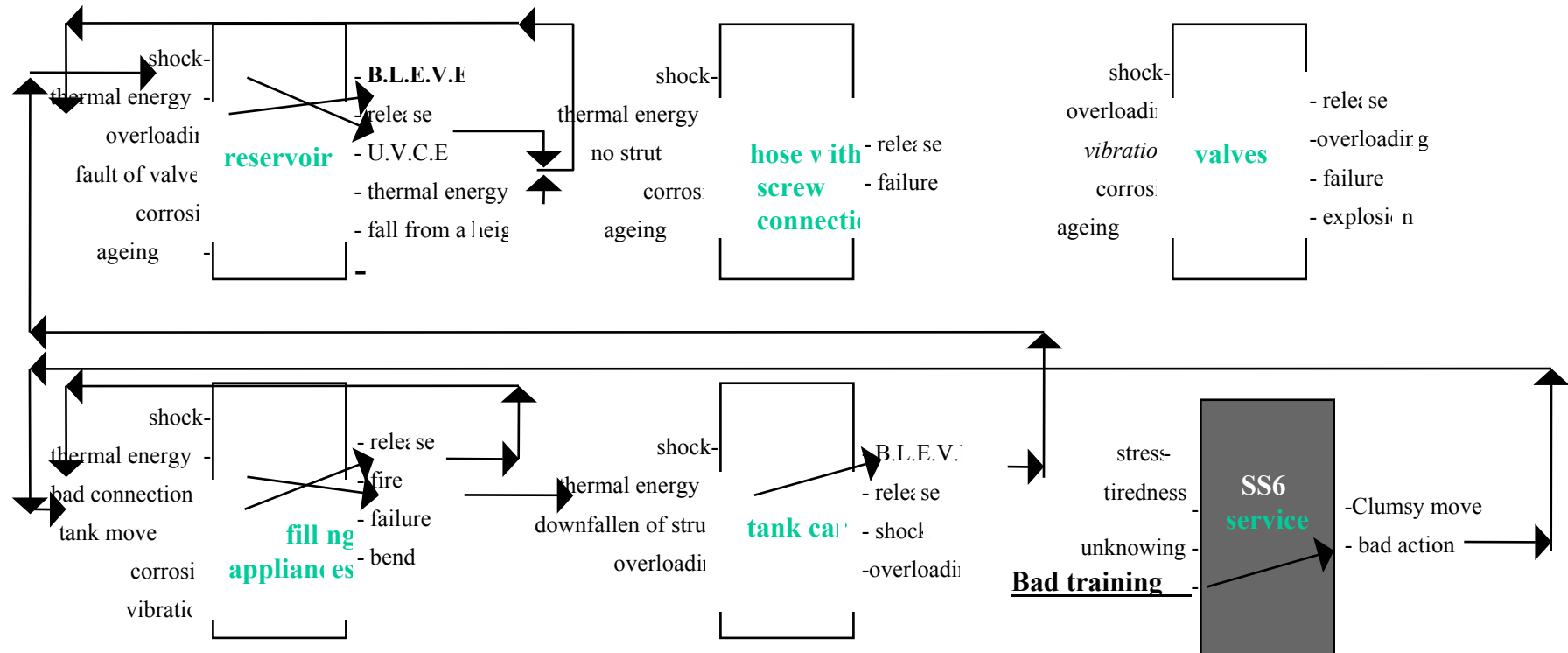
HELP: List of sources of danger.

Systematic procedure of finding of scenarios is based in their searching with a help of a list of sources of danger. Possibilities of its spreading in sub-systems are being probed gradually.

Example of a domino effect



Very complicated scenario may happen in reality through spreading of danger to surrounding sub-systems. A domino effect is created.

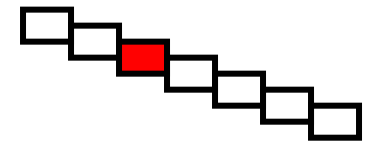


Procedures for proposition of scenaria

Proposition of scenaria of possible undesirable events can be done with the help of:

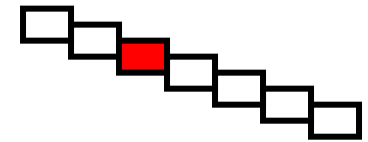
- Historical (previous) experience
 - with a studied system
 - from other similar system
- Partial methods
- Systematic approach

The proposition of scenaria is a **critical step**, because a missing scenario will not be analysed and a not-mentioned scenario devalues results of the whole study (a danger situation).



Overview of partial methods used for an identification or an evaluation of a risk

	Method	Abbrev.
	Relative Ranking	RR
	Safety Review	SR
	Checklist Analysis	CL
	Preliminary Hazard Analysis	PHA
	WhatIf Analysis	WI
	WhatIf / Checklist Analysis	WI/CL
	<u>H</u> azard and <u>O</u> perability Analysis	HAZOP
	Failure Modes and Effects Analysis	FMEA
	Fault Tree Analysis	FTA
	Event Tree Analysis	ETA
	Cause- Consequence Analysis	CCA
	Human Reliability Analysis	HRA

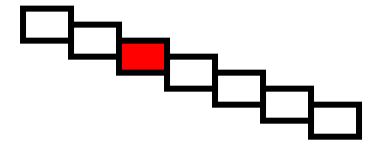


Typical use of partial methods

	SR	CL	RR	PHA	WI	WI/CL	HAZOP	FMEA	FTA	ETA	CCA	HRA
Research + development	-	-	+	+	+	-	-	-	-	-	-	-
Proposition of a concept	-	+	+	+	+	+	-	-	-	-	-	-
Half-operation	-	+	-	+	+	+	+	+	+	+	+	+
Detailed proposal	-	+	-	+	+	+	+	+	+	+	+	+
Setting up	+	+	-	-	+	+	-	-	-	-	-	+
Operation	+	+	-	-	+	+	+	+	+	+	+	+
Develop./Modification	+	+	+	+	+	+	+	+	+	+	+	+
Accident investigation	-	-	-	-	+	-	+	+	+	+	+	+
Examination	+	+	-	-	+	+	-	-	-	-	-	-

+ common use of a method

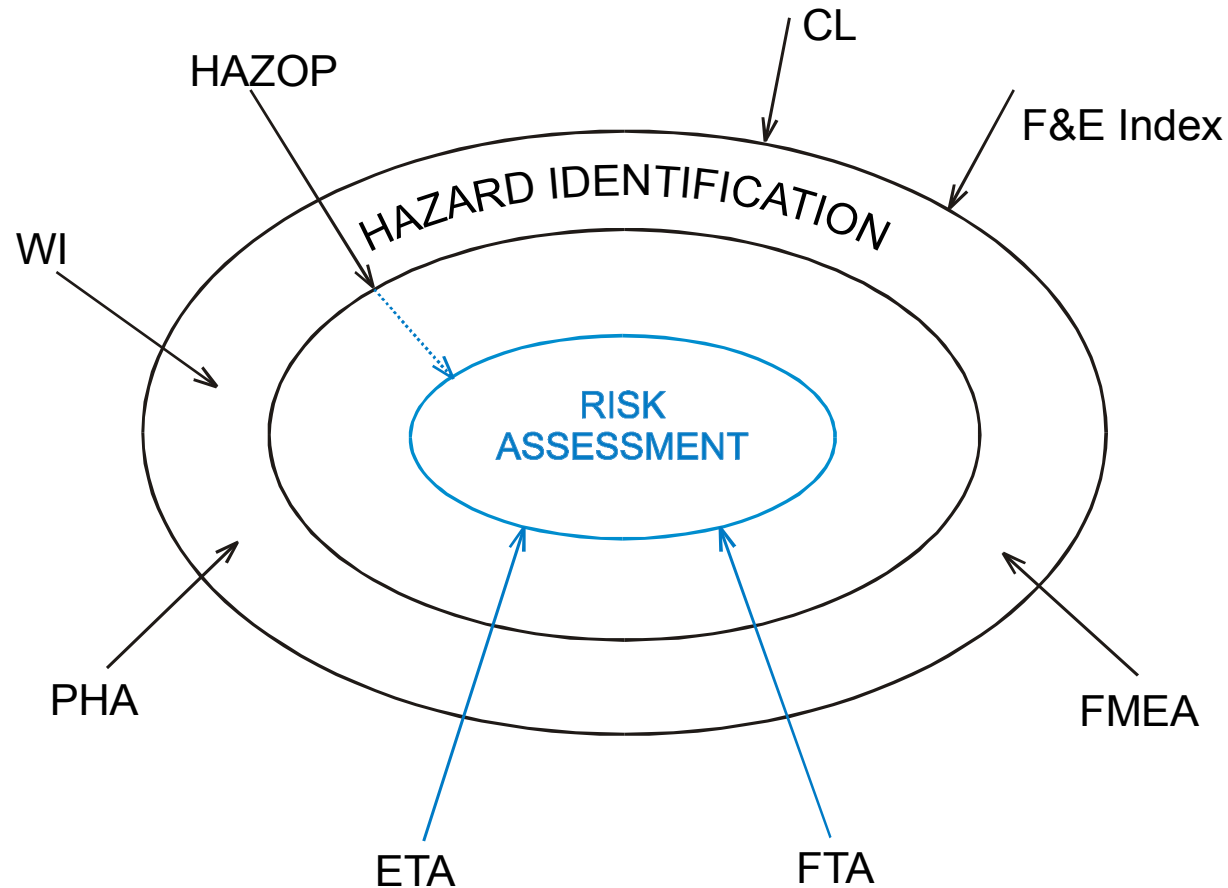
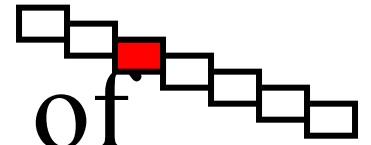
- unsuitable or rarely chosen use of a method



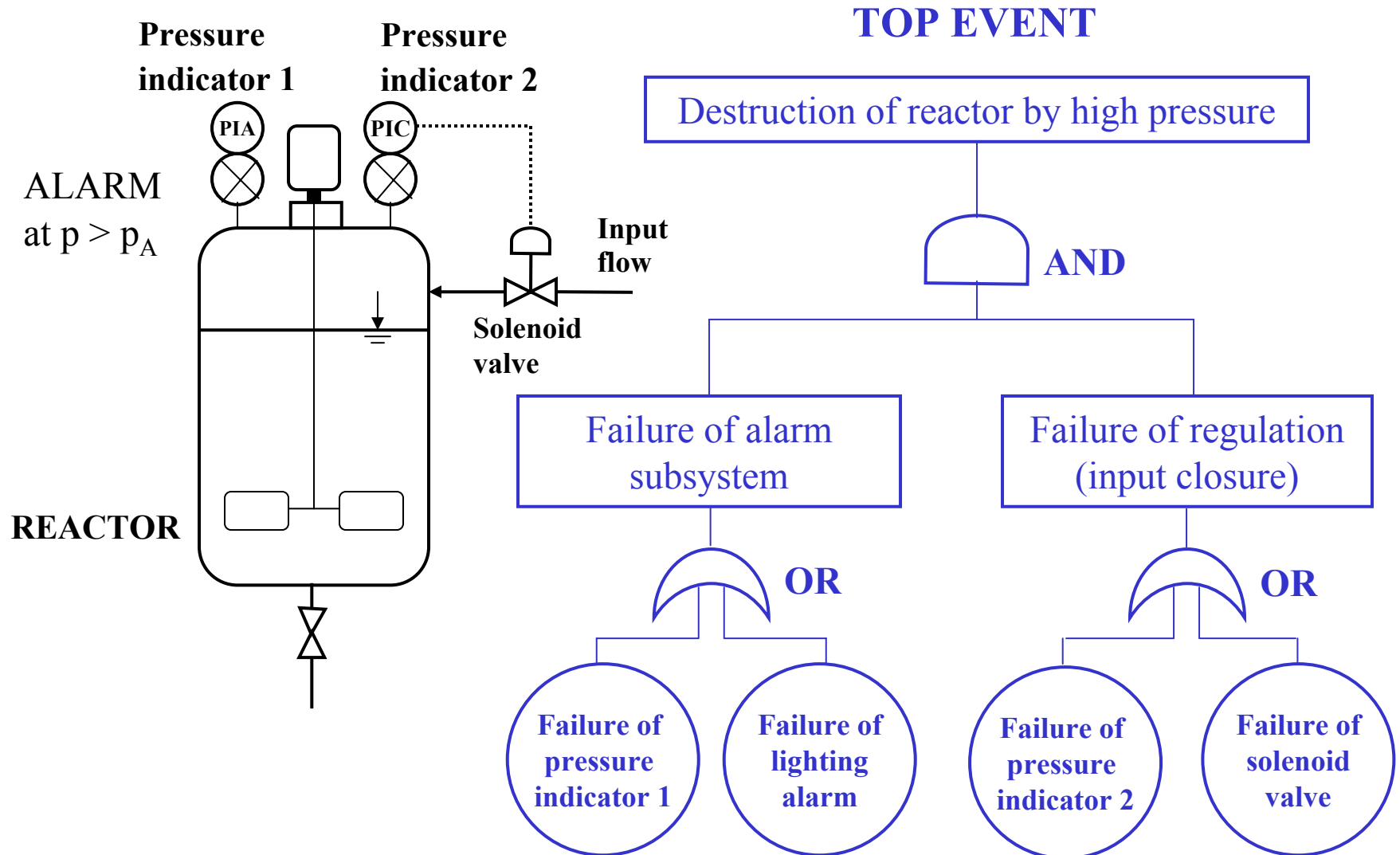
Classification of methods

SYSTEMATICITY	METHOD	APPROACH
Non-systematic methods	Safety Review SR	Screening methods (taxative)
	Relative Ranking RR	
	Preliminary Hazard Analysis PHA	Causal coherence methods
	What if Analysis WI -	
Systematic methods	Hazard and Operability Analysis HAZOP	
	Failure Modes and Effects Analysis FMEA	

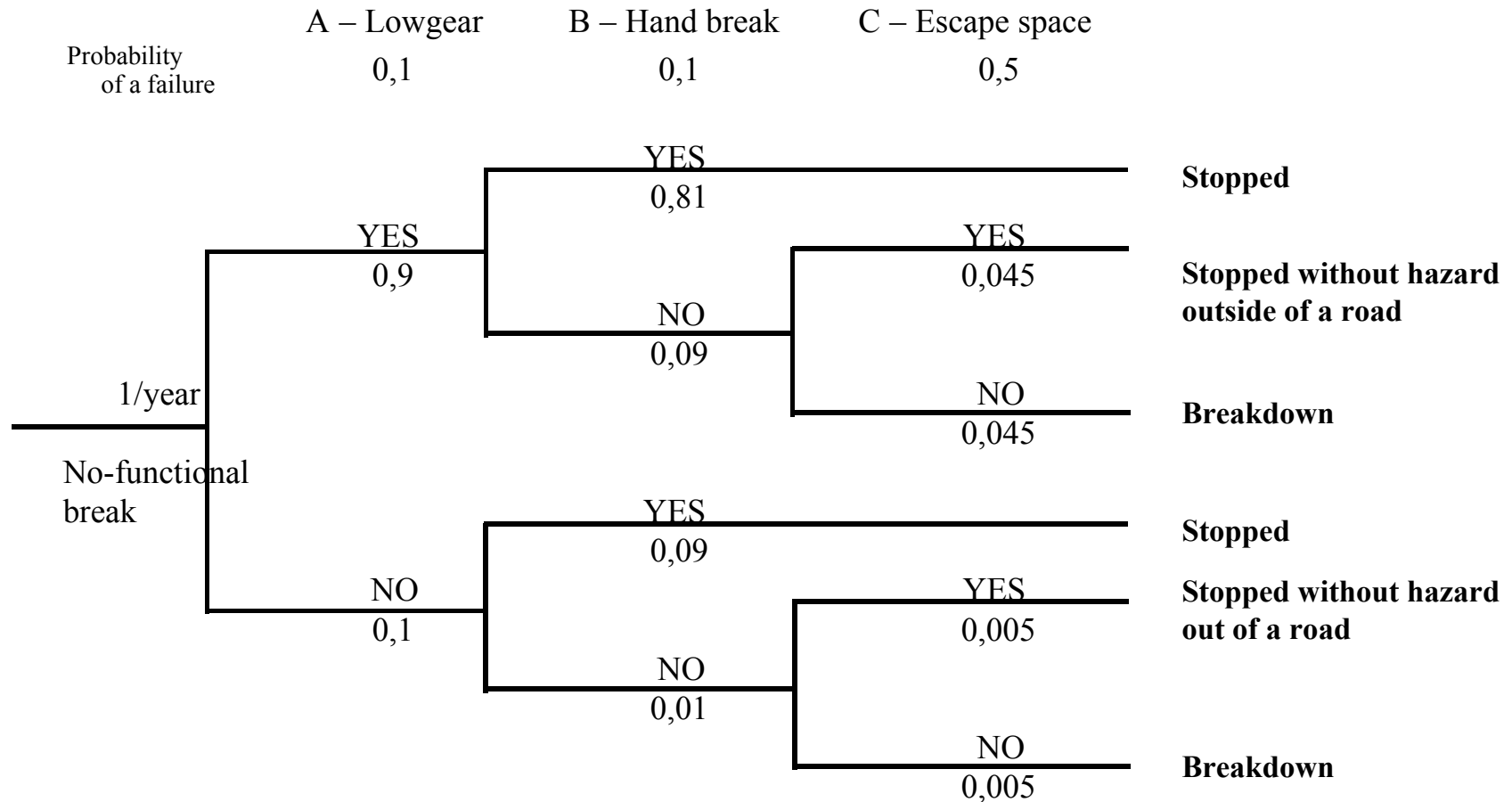
Possibilities of application of methods



FTA - Fault Tree Analysis



Event Tree Analysis



Undesirable event - a breakdown $0,045 + 0,005 = 0,05 \Rightarrow 20\%$

HAZOP - Hazard and Operability Study

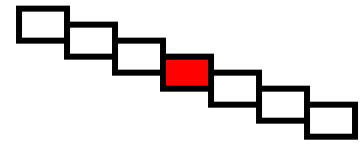
HAZOP – Deviation Matrix

GUIDE WORDS DESIGN PARAMETER		MORE	LESS	NONE	REVERSE	PART OF	AS WELL AS	OTHER THAN
CONTINUOUS OPERATION	FLOW	HIGH FLOW	LOW FLOW	NO FLOW	BACK FLOW			LOSS OF CONTAINMENT
	PRESSURE	HIGH PRESSURE	LOW PRESSURE	VACUUM		PARTIAL PRESSURE		
	TEMPERATURE	HIGH TEMP.	LOW TEMP.				CRIOGENIC	
	LEVEL	HIGH LEVEL	LOW LEVEL	NO LEVEL				LOSS OF CONTAINMENT
	COMPOSITION OR STATE	ADDITIONAL PHASE	LOSS OF PHASE		CHANGE OF STATE	WRONG CONCENTRATION	CONTAMINANTS	WRONG MATERIAL
	REACTION	HIGH RXN RATE	LOW RXN RATE	NO REACTION	REVERSE REACTION	INCOMPLETE REACTION	SIDE REACTION	WRONG REACTION
	TIME	TOO LONG	TOO SHORT					WRONG TIME
		STEP TOO LATE	STEP TOO EARLY	STEP LEFT OUT	STEP BACKWARDS	PART OF STEP LEFT OUT	EXTRA ACTION INCLUDED	WRONG ACTION TAKEN
		BATCH OPERATION						

OTHER PARAMETERS:

Corrosion, Utility failure, Vapour pressure, pH, Heat capacity, Mixing, Flash point, Viscosity, Static charge, Startup – shutdown.

RISK EVALUATION



1) To make the scale of gravity :

- health damages of employees (disease, injury, death...)
- health damages and discomfort of inhabitants out of company
- environmental impacts
- material a financial losses, including indirect
(production losses, image losses ...)

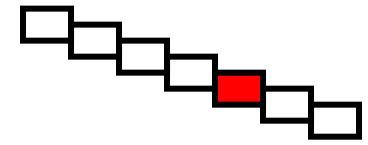
2) To make the scale of frequency in time

expression: for example: 10^{-3} / year \sim once a 1000 years

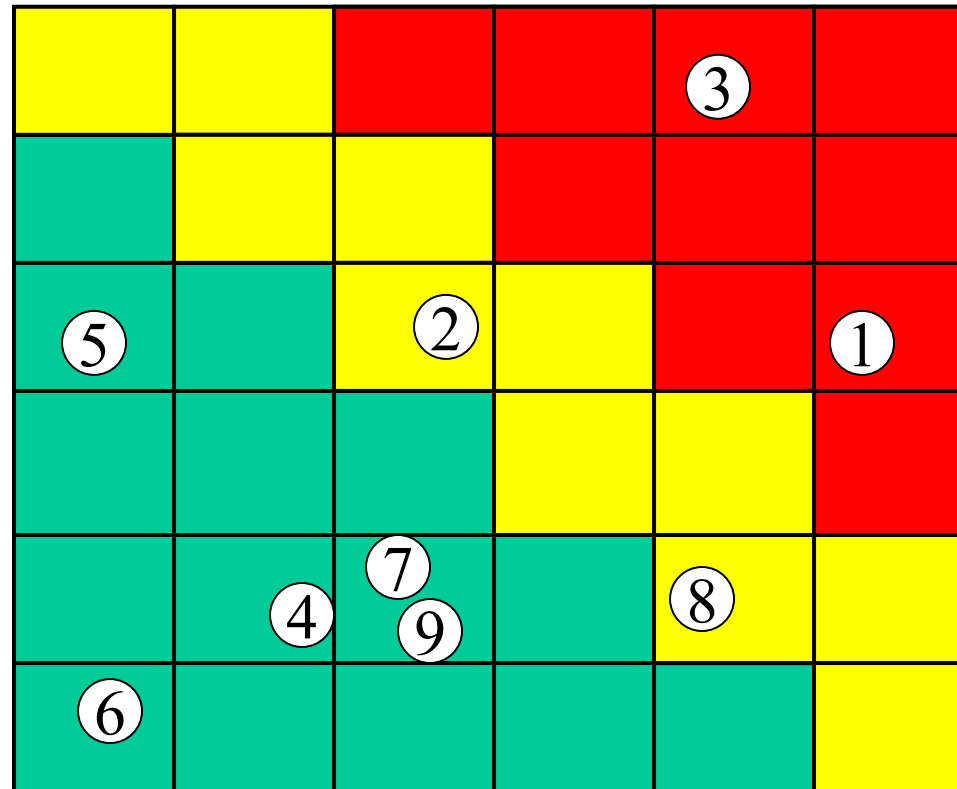
3) To evaluate gravity and frequency for all plausible scenarios

4) To locate scenarios into risk matrix

GOALS SET-UP



PROBABILITY



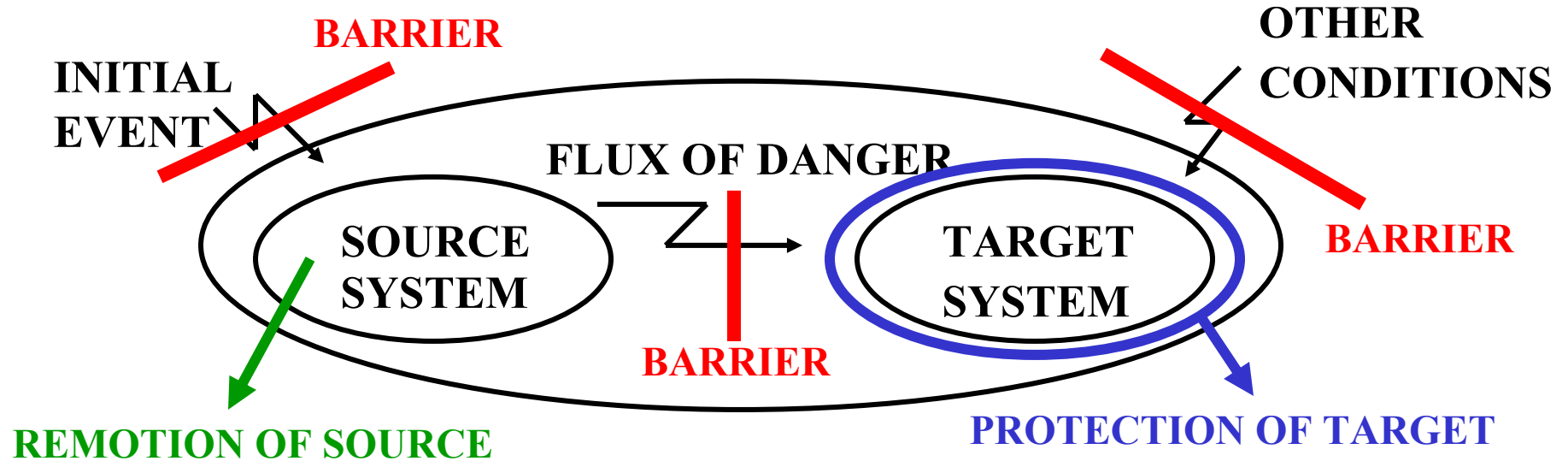
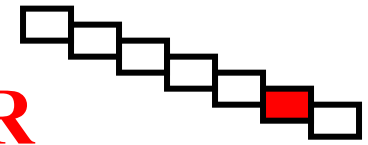
RISK MATRIX

GRAVITY

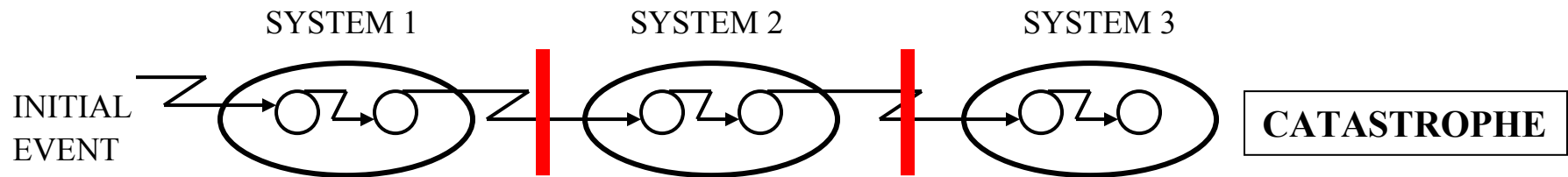


We select such scenarios in risk matrix, whose risks we want to reduce and we determine target value of risk.

PREVENTION OF FLUX OF DANGER

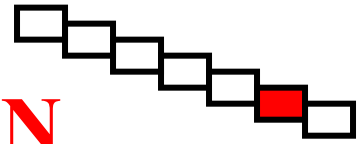


DOMINO EFFECT:

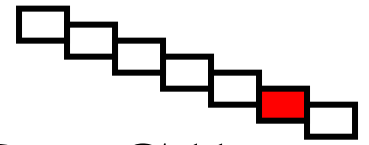


BARRIERS OF FLUX OF DOMINO EFFECT

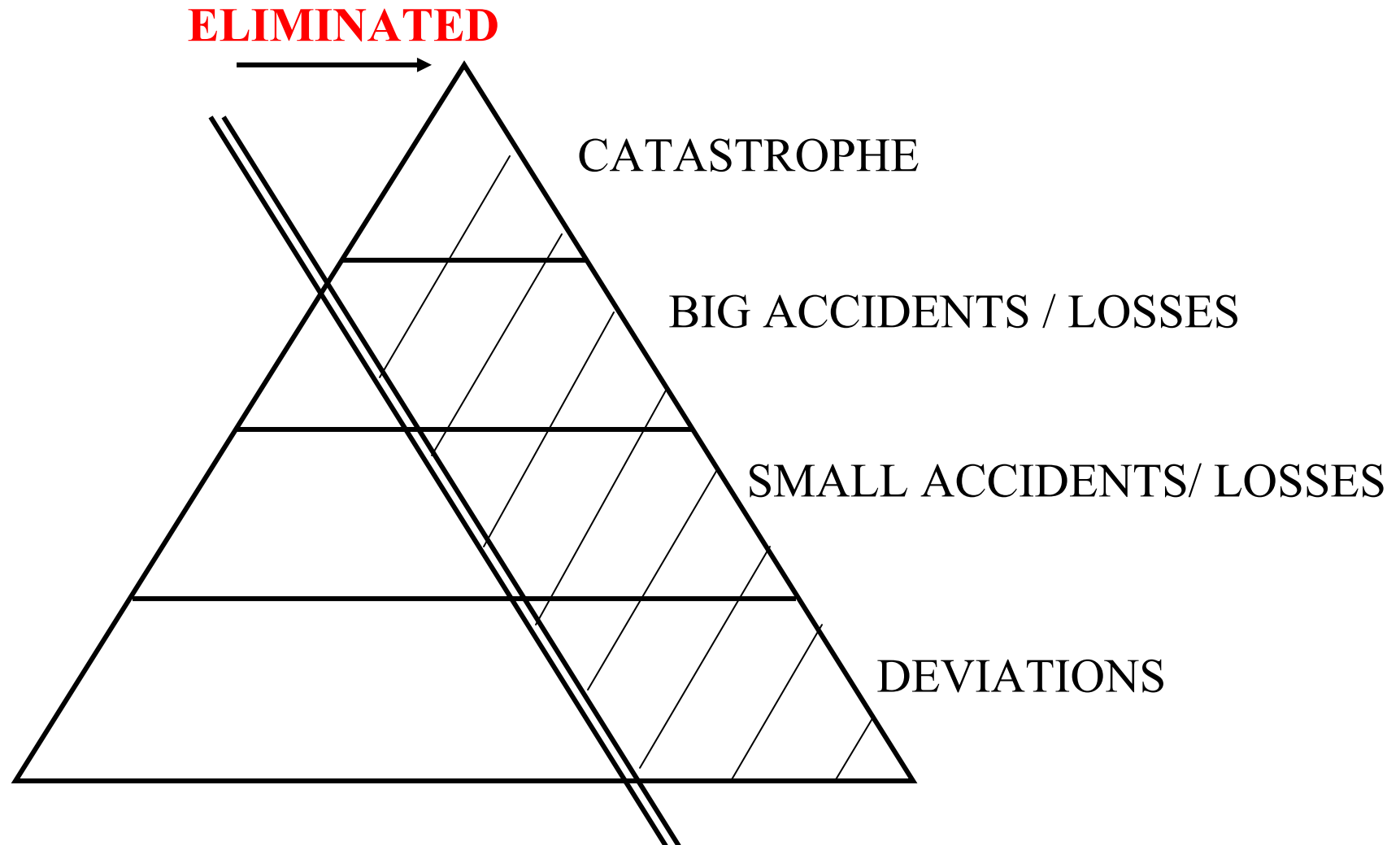
PREVENTION AND PROTECTION MEANS



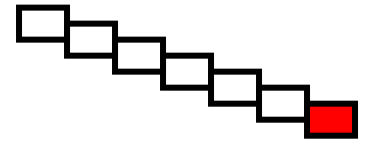
- **TECHNICAL PRECAUTION** - they are such precautions in construction of appliance, which lead to increase of safety in operation (examples: safety valve, sprinklers, automatic regulation, safety reservoir, double containment...)
- **ORGANIZATIONAL PRECAUTION** - they are precautions in work organisation, regulations, technological productions and procedures (including applicable technical equipment), which lead to increase of safety in operation.



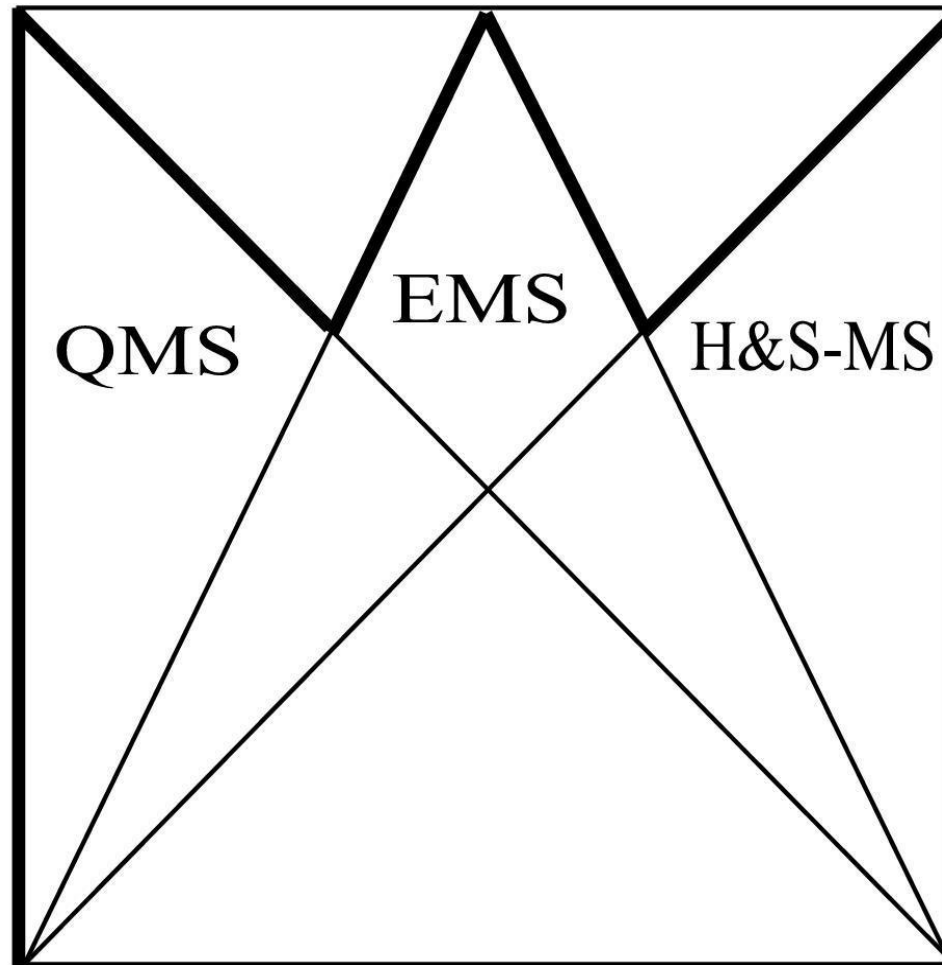
„HUNTING FOR DEVIATIONS“



RISK MANAGEMENT



- **Risk analysis**
- **Prevention**
 - technical and organisational precautions
 - education, courses and training
 - control and service
- **Regulation of crisis**
 - internal emergency plan
 - connection on emergency plan of district
 - readiness of action means
 - well-trained workers and emergency squad



Integrated Management