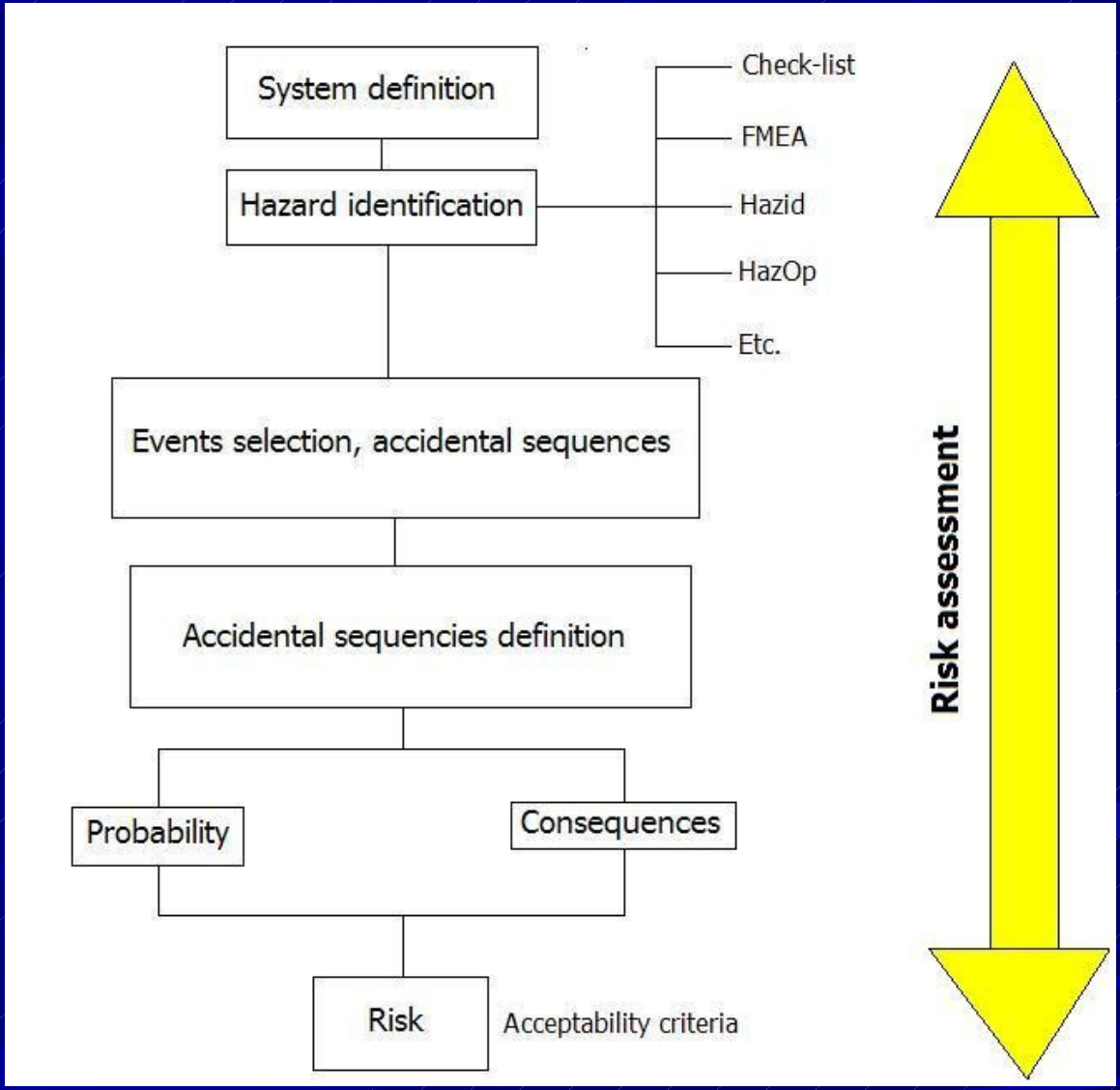
Risk assessment structure



Deterministic approach

- In the deterministic approach, the evaluation of the risk introduced by an activity / process is made only on the basis of the entity of the consequences, without taking into account the probability of the related events. So, even an event presenting a very low probability of occurrence is evaluated in terms of consequences on the plant, people and/or environment. In other words, a logic of threshold is applied to each event.
- In this approach, the entity of the consequences are compared to fixed values listed in national regulations or proposed in several standards – acceptance criteria.

Examples of reference damage limit values

REFERENCE DAMAGE LIMIT VALUES		Seveso Directive as it is in force in Italy through the Ministerial Decree of 9th May 2001 *Mandatory*	IGC Doc 75/01/E/rev *Not mandatory*
Fires (stationary thermal load)	Damage to equipment / domino effect	12.5 kW/m^2	37.5 kW/m^2
	High lethality	12.5 kW/m^2	
	Starting value for lethal effect	7 kW/m^2	9.5 kW/m^2 (pain threshold reached after 8s; second decree burns after 20s)
	High harm to people	5 kW/m^2	
	Minor harm to people	3 kW/m^2	
	No harm		1.6 kW/m^2
Bleve / fireball (variable thermal load)	Damage to equipment / domino effect	200-800 m (*)	
	High lethality	fireball radius	
	Starting value for lethal effect	359 kJ/m^2	
	High harm to people	200 kJ/m^2	
	Minor harm to people	125 kJ/m^2	
Flash-fire (instantaneous thermal load)	High lethality	LFL	
	Starting value for lethal effect	½ LFL	LFL
	No harm		½ LFL
Explosions (peak overpressure)	Damage to equipment / domino effect	0.3 bar	0.2 bar
	High lethality	0.3 bar	
	Starting value for lethal effect	0.14 bar	
	High harm to people	0.07 bar	0.07 bar
	Minor harm to people	0.03 bar	
	No harm		0.02 bar

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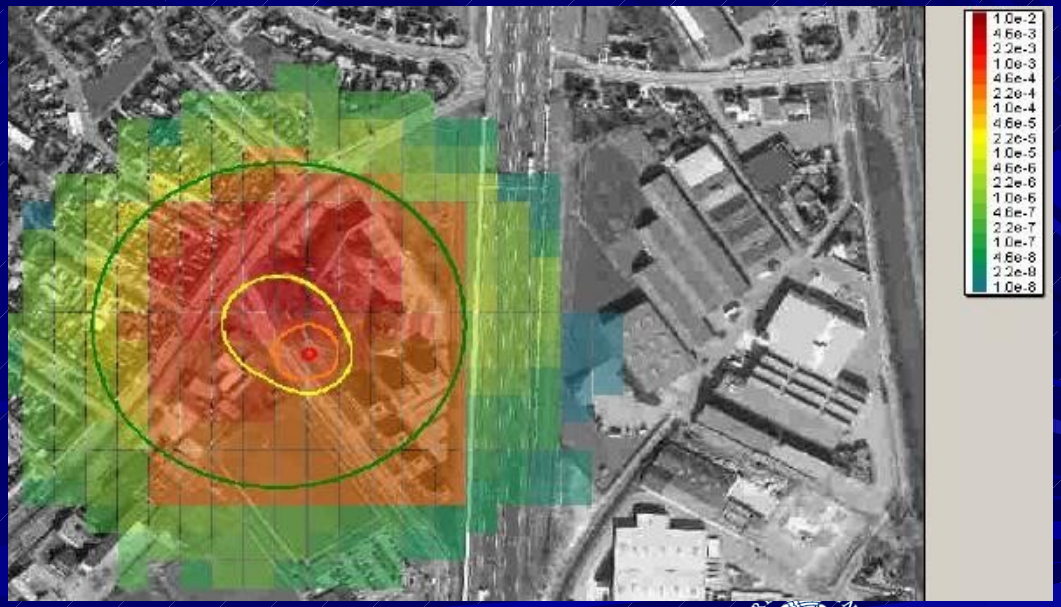
Probabilistic approach

- The Probabilistic Risk Assessment (PRA) approach is an organised process which answers the following three questions:
  1. What can go wrong?
  2. How likely is it to happen?
  3. What are the consequences?
- In this approach, not only are the consequences of an incidental/accidental sequence evaluated, but also the frequency of occurrence of such an event.
- In the probabilistic approach, the risk (probabilities as well as consequences) is evaluated by taking into account some acceptance criteria. These criteria can be related with Individual and Social Risk or with Matrix Acceptability.

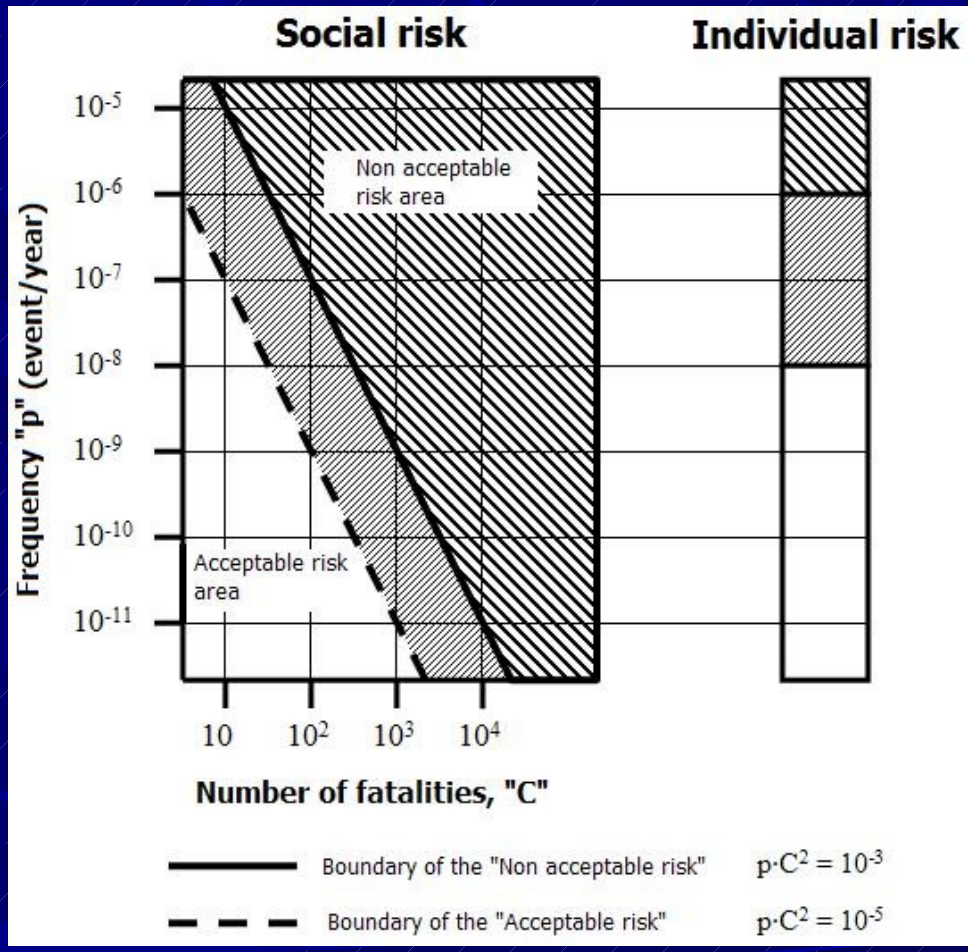
Individual risk criterion

- Individual risk of fatality is the chance that (in any year) a person who is close to a hazardous facility may die, due to potential accidents in the facility
- The variation of individual risk around a facility is usually presented on a map in terms of constant risk lines or contours



Social risk criterion

- Social (event) risk is the probability that a group of (at least) N persons is killed per year, due to exposure to the effects of an incident with hazardous substances. Societal risk is the total expected number of fatalities in a year due to a hazardous facilities, and is estimated from all possible events that may take place at the facilities.
- The acceptance criteria are shown in the graphs called “FN Curves”, where N is the number of fatalities and F is the cumulative frequency of events with N or more fatalities



Matrix approach criterion

CATEGORY	DESCRIPTION
1	< 0.02/year (Not expected to occur during the facility lifetime)
2	0.02 - 0.05/year (Expected to occur no more than once during the facility lifetime)
3	0.05 - 1/year (Expected to occur several times during the facility lifetime)
4	> 1/year (Expected to occur more than once in a year)

Frequency Categories

CATEGORY	DESCRIPTION
1	< 0.001/year (Less frequent than 1 in 1,000 years)
2	0.001 - 0.01/year (Between 1 in 1,000 and 1 in 100 years)
3	0.01 - 0.1/year (Between 1 in 100 and 1 in 10 years)
4	> 0.1/year (More frequent than 1 in 10 years)

CATEGORY	DESCRIPTION
1	< 10-6/year (Less frequent than 1 in 1,000,000 years) (Remote)
2	10-6 - 10-4/year (Between 1 in 1,000,000 and 1 in 10,000 years) (Unlikely)
3	10-4 - 0.01/year (Between 1 in 10,000 and 1 in 100 years) (Moderately Likely)
4	> 0.01/year (More frequent than 1 in 100 years) (Likely)

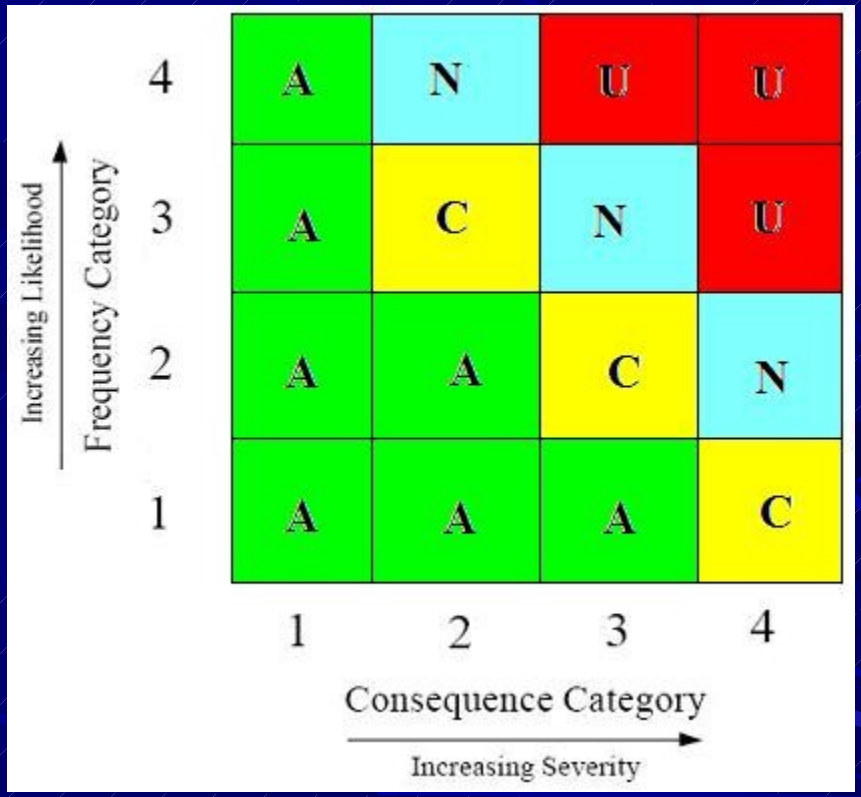
CATEGORY	PUBLIC CONSEQUENCES
1	No injury or health effects
2	Minor injury or health effects
3	Injury or moderate health effects
4	Death or severe health effects

Consequence Categories

Matrix approach criterion (cont)

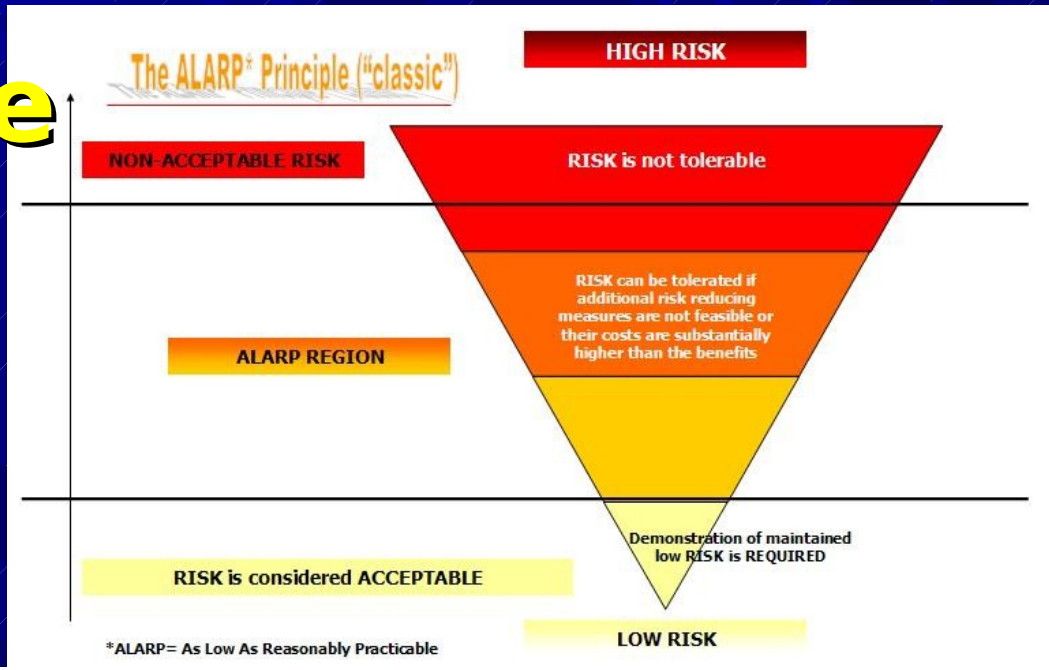
CODE	CATEGORY	DESCRIPTION
U	Unacceptable	Should be mitigated with engineering and/or administrative controls to a risk ranking of C or less within a specified period such as six months.
N	Not desirable	Should be mitigated with engineering and/or administrative controls to risk ranking of C or less within a specified time period such as 12 months.
C	Conditionally acceptable with controls	Should be verified that procedures or controls are in place.
A	Acceptable as it is	No mitigation required.

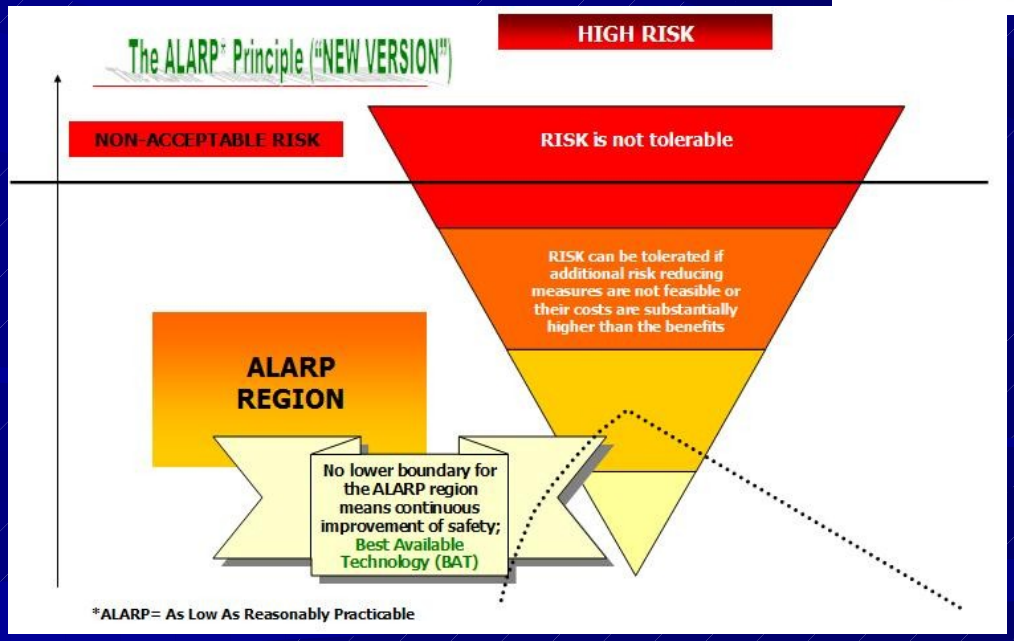
Example of risk matrix



ALARP principle

Classic ALARP approach





New ALARP approach