



## ***L10.- Description of the severity of the potential consequences (II)***

***International Atomic Energy Agency***



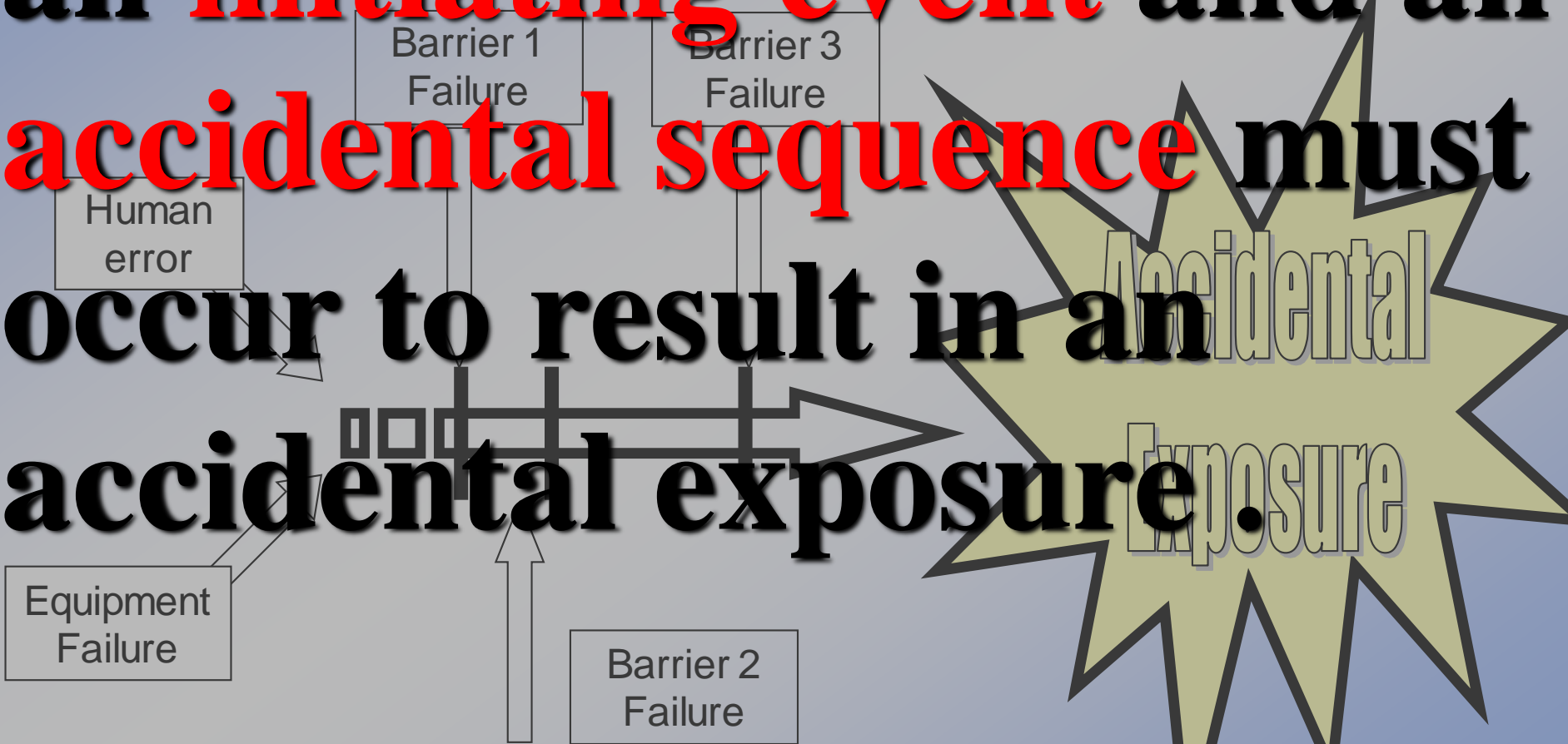
# OBJECTIVE

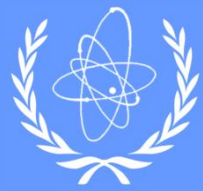
**Identify the elements of the safety assessment that includes a probabilistic approach based on the risk appraisal:**

- Magnitude of the consequences.
- Analysis of safety barriers.
- Risk estimation methods
- Risk management – decision making

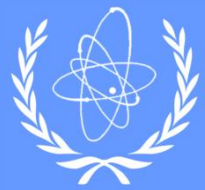
**Lesson learnt from accidents:** *few times accidents happen due to a single event*

**an initiating event and an accidental sequence must occur to result in an accidental exposure.**





# Risk estimation methods



# Risk estimation methods

All risk estimation methods are based on the general equation of the risk

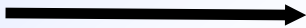
$$R = f \times p \times C$$

Human error  
or Equipment  
failure (f)

Safety  
Barriers (p)

Accidental  
exposure

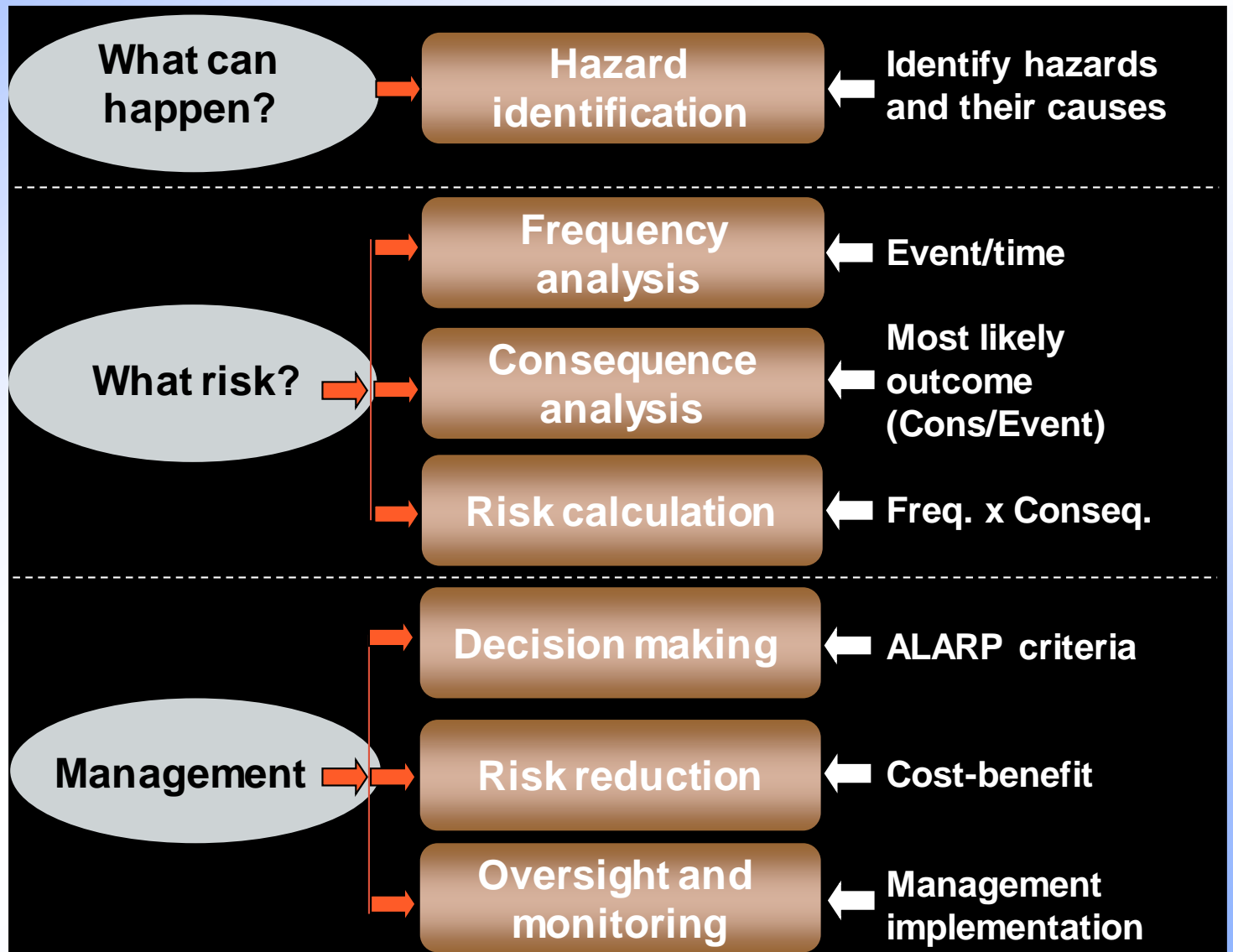
Consequences  
(C)

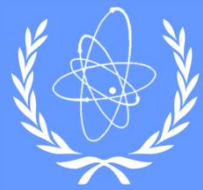




# Risk estimation methods

## Risk estimation methods

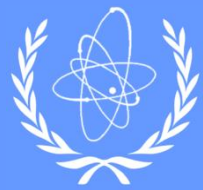




**Risk assessment can be performed using three approaches:**

- **Qualitative**
- **Semi-quantitative, or**
- **Quantitative**

All the approaches involve similar steps and any of the different techniques that have been developed to implement each of these approaches can be used

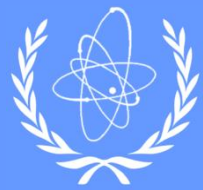


## Quantitative methods

Use numerical values obtained from different sources (e.g. data from historical or experimental analysis, data provided by manufacturers; data obtained from generic data banks) or calculate them using mathematical models

Quantification by event trees or fault trees and the Probabilistic Safety Analysis (PSA) stand out among quantitative methods





## Qualitative and semi-quantitative methods

Use indexes or descriptions of the probability and severity of consequences, combining information from various sources, some of which may be quantitative

The Risk matrix method can be used as a qualitative method

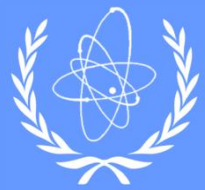
The Risk priority number method (RPN) can be used as a semi-quantitative method



# Risk estimation methods

## Example: The Event tree method

| POTENTIAL FAILURE | Soft interlock | Hard Interlock | Hard Interlock 2 | Dosimetric Tests QA |         |        | Patient Medical Follow-up | # S e c | Frequency (patients /year). | Consequence |
|-------------------|----------------|----------------|------------------|---------------------|---------|--------|---------------------------|---------|-----------------------------|-------------|
|                   |                |                |                  | DAILY               | MONTHLY | ANNUAL |                           |         |                             |             |
|                   |                |                |                  |                     |         |        | 1                         |         | SC                          |             |
|                   |                |                |                  |                     |         |        | 2                         |         | SC                          |             |
|                   |                |                |                  |                     |         |        | 3                         |         | SC                          |             |
|                   |                |                |                  |                     |         |        | 4                         |         | SC                          |             |
|                   |                |                |                  |                     |         |        | 5                         |         | Z31D<br>Z32D<br>Z35D        |             |
|                   |                |                |                  |                     |         |        | 6                         |         | Z31C<br>Z32C<br>Z35C        |             |
|                   |                |                |                  |                     |         |        | 7                         |         | Z31C<br>Z32C<br>Z35C        |             |
|                   |                |                |                  |                     |         |        | 8                         |         | Z31C<br>Z32C<br>Z35C        |             |



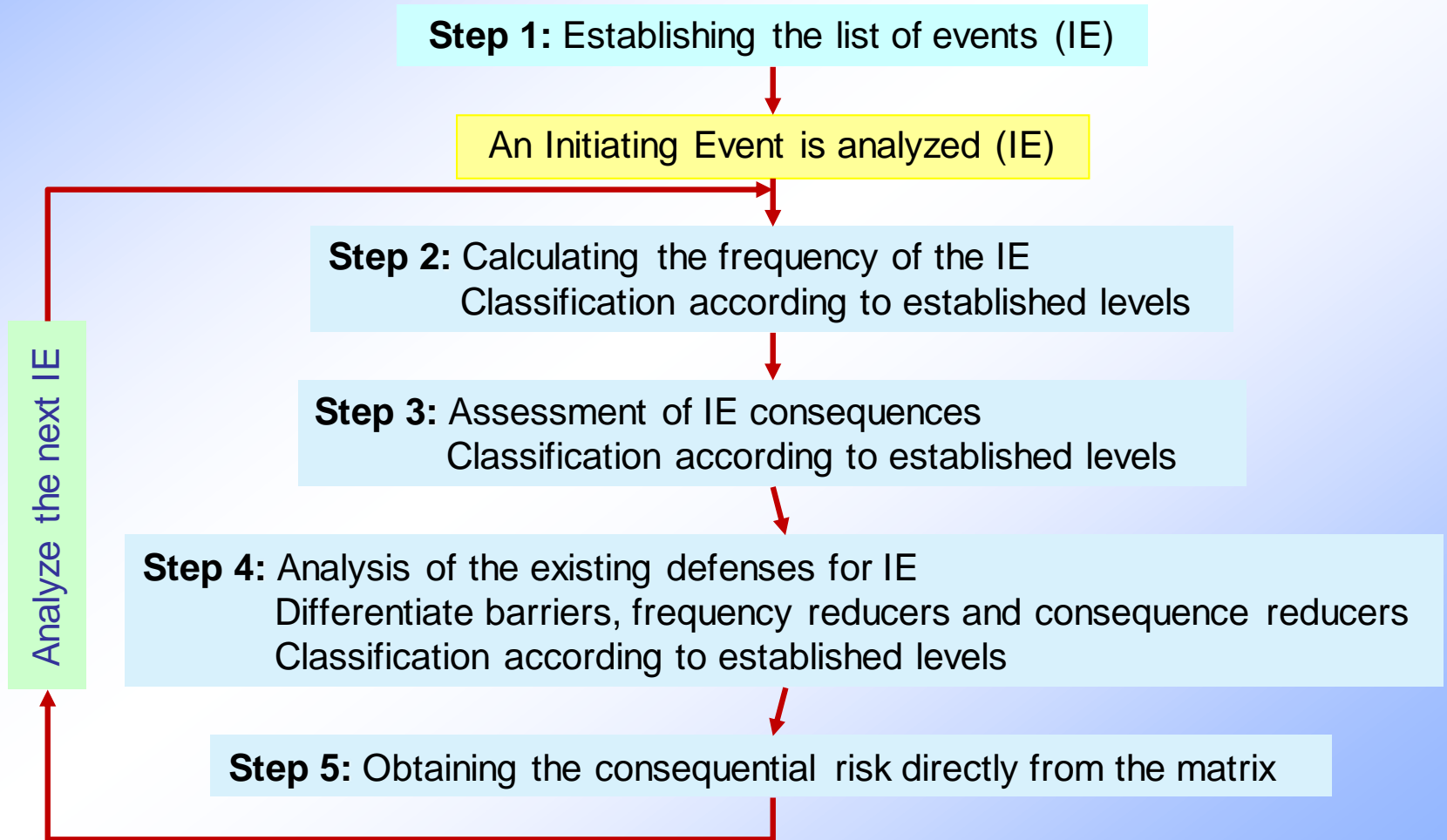
# Risk estimation methods

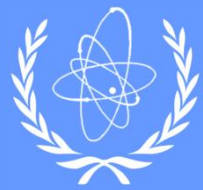
## Example: The Risk matrix method

|          |          |          |          |          |          |       |          |          |          |       |       |          |          |       |       |
|----------|----------|----------|----------|----------|----------|-------|----------|----------|----------|-------|-------|----------|----------|-------|-------|
| $f_H$    | $P_H$    | $C_{VH}$ | $R_{VH}$ | $f_H$    | $P_H$    | $C_H$ | $R_{VH}$ | $f_H$    | $P_H$    | $C_M$ | $R_H$ | $f_H$    | $P_H$    | $C_L$ | $R_M$ |
| $f_M$    | $P_H$    | $C_{VH}$ | $R_{VH}$ | $f_M$    | $P_H$    | $C_H$ | $R_H$    | $f_M$    | $P_H$    | $C_M$ | $R_H$ | $f_M$    | $P_H$    | $C_L$ | $R_M$ |
| $f_L$    | $P_H$    | $C_{VH}$ | $R_H$    | $f_L$    | $P_H$    | $C_H$ | $R_H$    | $f_L$    | $P_H$    | $C_M$ | $R_M$ | $f_L$    | $P_H$    | $C_L$ | $R_M$ |
| $f_{VL}$ | $P_H$    | $C_{VH}$ | $R_H$    | $f_{VL}$ | $P_H$    | $C_H$ | $R_H$    | $f_{VL}$ | $P_H$    | $C_M$ | $R_M$ | $f_{VL}$ | $P_H$    | $C_L$ | $R_M$ |
| $f_H$    | $P_M$    | $C_{VH}$ | $R_{VH}$ | $f_H$    | $P_M$    | $C_H$ | $R_H$    | $f_H$    | $P_M$    | $C_M$ | $R_H$ | $f_H$    | $P_M$    | $C_L$ | $R_M$ |
| $f_M$    | $P_M$    | $C_{VH}$ | $R_H$    | $f_M$    | $P_M$    | $C_H$ | $R_H$    | $f_M$    | $P_M$    | $C_M$ | $R_M$ | $f_M$    | $P_M$    | $C_L$ | $R_M$ |
| $f_L$    | $P_M$    | $C_{VH}$ | $R_H$    | $f_L$    | $P_M$    | $C_H$ | $R_H$    | $f_L$    | $P_M$    | $C_M$ | $R_M$ | $f_L$    | $P_M$    | $C_L$ | $R_L$ |
| $f_{VL}$ | $P_M$    | $C_{VH}$ | $R_H$    | $f_{VL}$ | $P_M$    | $C_H$ | $R_M$    | $f_{VL}$ | $P_M$    | $C_M$ | $R_M$ | $f_{VL}$ | $P_M$    | $C_L$ | $R_L$ |
| $f_H$    | $P_L$    | $C_{VH}$ | $R_H$    | $f_H$    | $P_L$    | $C_H$ | $R_H$    | $f_H$    | $P_L$    | $C_M$ | $R_M$ | $f_H$    | $P_L$    | $C_L$ | $R_L$ |
| $f_M$    | $P_L$    | $C_{VH}$ | $R_H$    | $f_M$    | $P_L$    | $C_H$ | $R_H$    | $f_M$    | $P_L$    | $C_M$ | $R_M$ | $f_M$    | $P_L$    | $C_L$ | $R_L$ |
| $f_L$    | $P_L$    | $C_{VH}$ | $R_M$    | $f_L$    | $P_L$    | $C_H$ | $R_M$    | $f_L$    | $P_L$    | $C_M$ | $R_M$ | $f_L$    | $P_L$    | $C_L$ | $R_L$ |
| $f_{VL}$ | $P_L$    | $C_{VH}$ | $R_M$    | $f_{VL}$ | $P_L$    | $C_H$ | $R_M$    | $f_{VL}$ | $P_L$    | $C_M$ | $R_M$ | $f_{VL}$ | $P_L$    | $C_L$ | $R_L$ |
| $f_H$    | $P_{VL}$ | $C_{VH}$ | $R_H$    | $f_H$    | $P_{VL}$ | $C_H$ | $R_M$    | $f_H$    | $P_{VL}$ | $C_M$ | $R_M$ | $f_H$    | $P_{VL}$ | $C_L$ | $R_L$ |
| $f_M$    | $P_{VL}$ | $C_{VH}$ | $R_M$    | $f_M$    | $P_{VL}$ | $C_H$ | $R_M$    | $f_M$    | $P_{VL}$ | $C_M$ | $R_M$ | $f_M$    | $P_{VL}$ | $C_L$ | $R_L$ |
| $f_L$    | $P_{VL}$ | $C_{VH}$ | $R_M$    | $f_L$    | $P_{VL}$ | $C_H$ | $R_L$    | $f_L$    | $P_{VL}$ | $C_M$ | $R_L$ | $f_L$    | $P_{VL}$ | $C_L$ | $R_L$ |
| $f_{VL}$ | $P_{VL}$ | $C_{VH}$ | $R_M$    | $f_{VL}$ | $P_{VL}$ | $C_H$ | $R_L$    | $f_{VL}$ | $P_{VL}$ | $C_M$ | $R_L$ | $f_{VL}$ | $P_{VL}$ | $C_L$ | $R_L$ |



## Example: The Risk matrix method



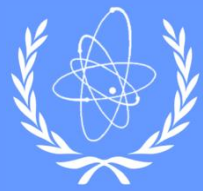


## Example: The RPN method

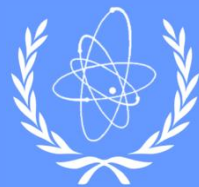
$$\text{RPN} = \text{S} \times \text{O} \times \text{D}$$

The RPN method classifies each mode of failure or deviation according to the following variables:

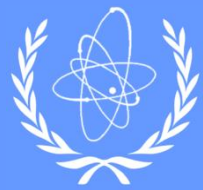
- **Severity (S)**, in which each effect or consequence is assigned a number of severity from 1 to 10, assigning 1 to 3 when there is no danger or it is minor, 4 to 6 when the danger is moderate, 7 to 8 when the danger is high or significant and 9 to 10 when the danger is very high or hazardous.
- **Occurrence or Likelihood (O)**, where the frequency of the cause of the failure or deviation is established, according to a scale of 1 to 10, assigning a number less than 4 when frequency is low, between 5 and 8 when the rate is moderate, and 9 to 10 when the frequency is high.
- **Detection (D)**, represents the probability that the problem can be detected before it leads to consequences, according to a scale 1-10, where 1 means that it is very unlikely and 10 when there are insufficient means to detect and prevent the consequence.



# Risk management – decision making



Risk Management involves, in addition to identifying and assessing risks, also **decision making about how we should act against assessed risks**

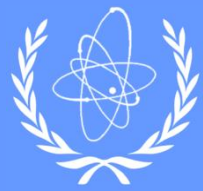


# Risk Management criteria

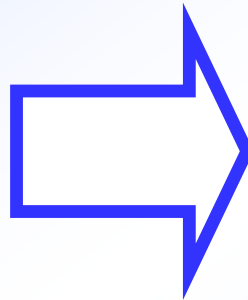
## Risk Matrix vs. Quantitative Analysis method

|   | Risk groups       | Workers (1/year)    | Public (1/year)     | Patients (1/patient)                   |
|---|-------------------|---------------------|---------------------|--|
| <p><b>Unacceptable Region</b></p>       | $R_{VH}$<br>$R_H$ | $>10^{-4}$          | $>10^{-5}$          | $>10^{-6}$ Type A<br>$>10^{-4}$ Type B |
| <p><b>Tolerable Region</b></p>          | $R_L$             | $10^{-4} - 10^{-6}$ | $10^{-5} - 10^{-7}$ | N/A                                    |
| <p><b>Broadly Acceptable Region</b></p> | $R_{VL}$          | $<10^{-6}$          | $<10^{-7}$          | N/A                                    |





**Accept  
risk**

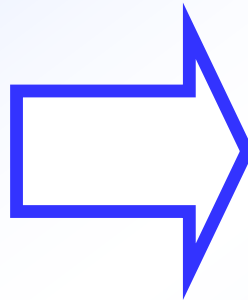


***“no action is  
taken to control  
the assessed  
risk”***

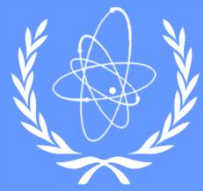
**When are risks  
assumed?**



**Accept  
risk**



***When the  
magnitude of the  
risk is not  
significant***



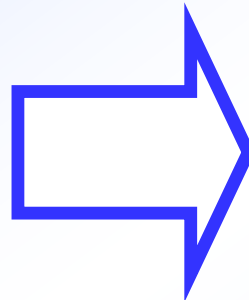
**Accept  
risk**

***When there are  
not resources***

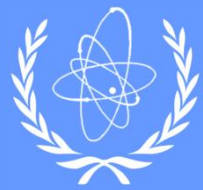
***When there are no  
technological  
alternatives to  
proceed***



**Accept  
risk**



***Involves the  
provision of the  
facility to accept  
in advance the  
consequences***

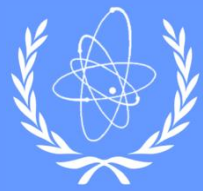


**Finance  
risk**

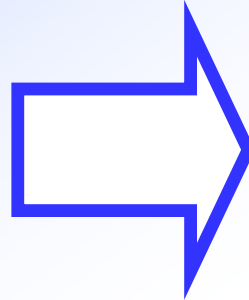


***Establishing the  
mechanisms for  
the total or partial  
financing of  
losses***

**How?**



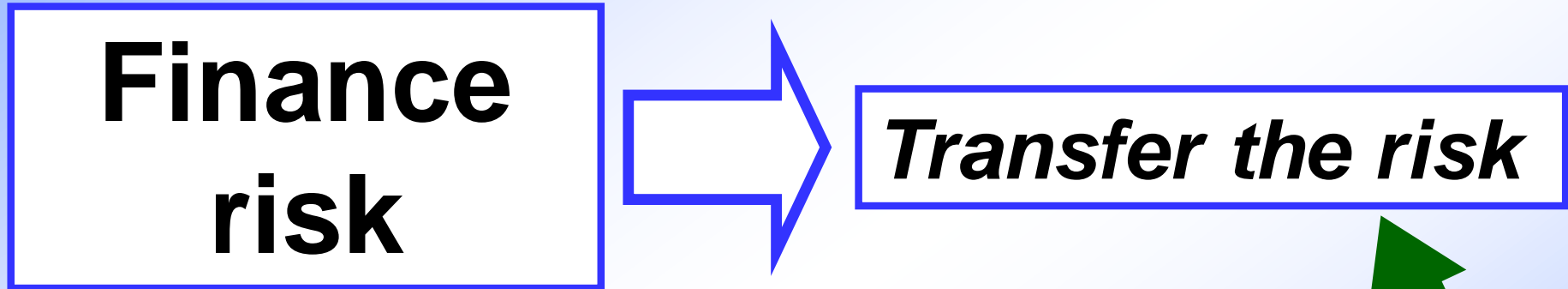
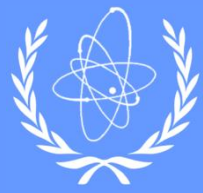
**Finance  
risk**



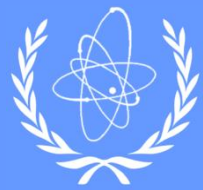
***Retain the risk***



**Establishing a real provision of funds  
adequate and sufficient to meet expected  
losses**



**Contractual agreements with a third party whom will assume possible loses in case the planned event occurs (assurance)**



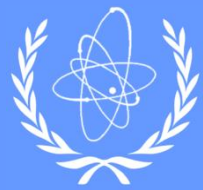
**Protect  
risk**



***To limit  
unwanted  
consequences***

**Example: Emergency plans**



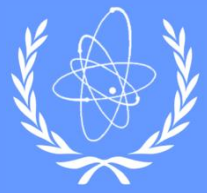


**Prevent  
risk**



***Acting on the  
causes that  
generate the risk***

**Remember: Prevent acts on Threats, and  
Protect acts on the Consequences**



***Thank you!***