

# Managing Scientific Projects

## Part 2 on Project Risk Management

### References

The following resources were used to prepare the two parts of this course:

**Bonnal, P.; Baudin, M.; Ruiz, J.-M.** (2013) "Systems Engineering and Safety Issues in Scientific Facilities Subject to Ionizing Radiations." *Int. J. Advanced Robotic Systems* 10 (8) Sep. 2013. 10 p.

**Hillson, D. A.** (2003) *Effective opportunity management for projects. Exploiting positive risk.* New-York: Marcel Dekker (Center for Business Practices Series / 6). 344 p. ISBN 0824748085

**Hillson, D.** (2002) "What is 'risk'?" *talk given at APM Risk SIG.* London, UK. 11 April 2002. 15 p.

**PMI Standard Committee** (2008) *A Guide to the Project Management Body of Knowledge.* 4th ed. Newton Square, PA: Project Management Institute. 459 p. ISBN 1933890517

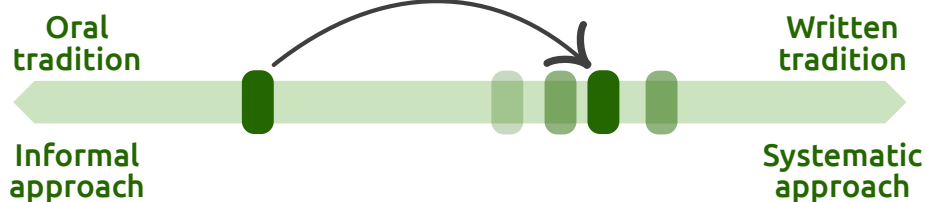
See also: [www.PMI.org](http://www.PMI.org).

**PMI Standard Committee** (2009) *Standard for Project Risk Management.* Newton Square, PA: Project Management Institute. 128 p. ISBN 193389038X

**Ward, S. C.; Chapman, C. B.** (2012) *How to manage project opportunity and risk. Why uncertainty management can be a much better approach than risk management.* 3rd ed. Chichester: John Wiley & Sons. 520 p. ISBN 0470686499

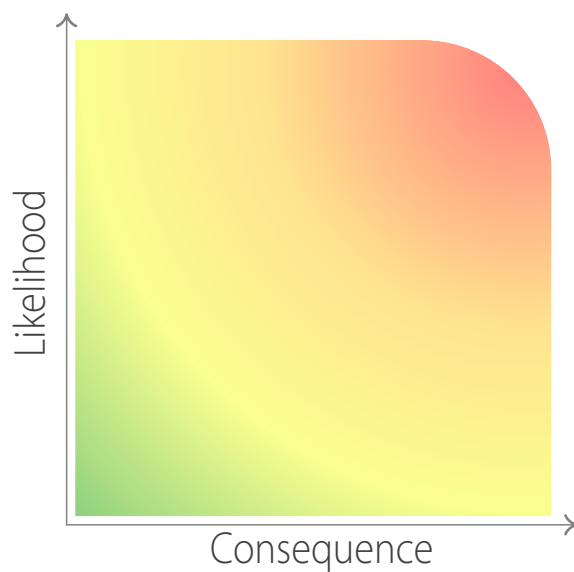
## 01 -- Introduction to the Concept of Risk

### Risk Management



## Etymology

- ➔ From ancient Latin : *risicare* = reef → *risk-careful*
- ➔ From ancient Greek :  $\rho\iota\zeta\alpha$  = root → *risk-careful*
- ➔ From Latin : *rixa* = quarrel, brawl → *risk-action*



## PRM → Six steps

- Step 1.** Strategy & risk planning
- Step 2.** Risk identification
- Step 3.** Risk evaluation
- Step 4.** Risk quantification
- Step 5.** Risk handling
- Step 6.** Risk follow-up

PMI Standard Committee (2000) *A guide to the project management body of knowledge*. (4th ed.) Newton Square PA: Project Management Institute. 216 p. ISBN 1880410230.

## Project Risk Management



## 02 -- Risk Planning

### Risk management strategy

Who decides?

- ➔ Unilateral decision
- ➔ Bilateral decision

### Risk management strategy | Process

#### INPUTS:

- ➔ Project Roadmap
- ➔ Organization policy → PRM
- ➔ Identification of the contributors (incl. their tolerance towards risks)
- ➔ Framework for editing a Project Management Plan
- ➔ Work Breakdown Structure (WBS) of the project

#### TOOLS & TECHNIQUES:

- ➔ Some meetings

#### OUTPUTS:

- ➔ Project Risk Management Plan  
or section related to Risks in the Project Management Plan

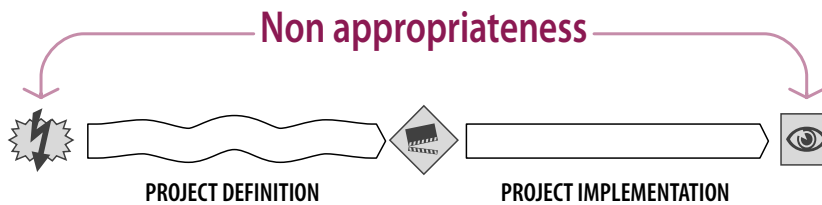
## Project Management Plan → Section Related to Risks

- § 1. Purpose and guiding principles
- § 2. PRM methodology
- § 3. Responsibilities
- § 4. Budget and resources for PRM
- § 5. Timescale
- § 6. Risk categories and thresholds
- § 7. Risk reporting
- § 8. Lessons learned

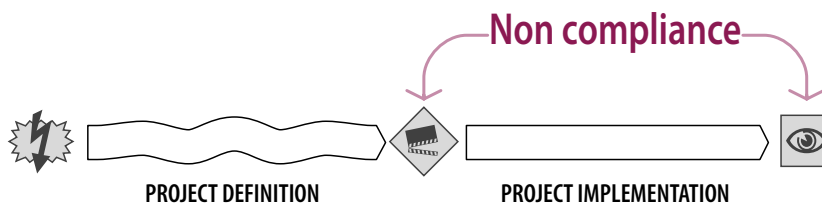
## Risk categories → first scheme

- **Technical** risks → related to the product being designed and developed
- **Programmatic** risks → related to the project itself: on schedule, on budget...
- **External** risks → for which the NPD project team has no control

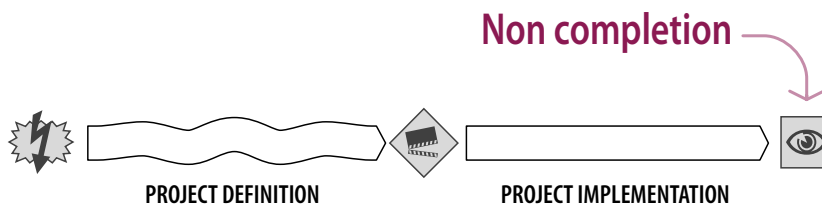
## Risk categories → second scheme



## Risk categories → second scheme



## Risk categories → second scheme



## 03 -- Risk Identification

### Risk identification | Process

#### INPUTS:

- ➔ Project Roadmap
- ➔ Project Management Plan
- ➔ Outputs of the project planning phase → PBS, WBS, Gantt Chart...
- ➔ Lessons learned in matter of PRM on former NPD projects
- ➔ Databases, check lists, *vade-mecum*...
- ➔ Organizational policy → PRM
- ➔ Names of NPD PRM experts → interviews

#### TOOLS & TECHNIQUES:

- ➔ Project document screening
- ➔ Brainstorming sessions, Six-hats, Delphi method...
- ➔ Interviews
- ➔ SWOT analysis, Ishikawa diagrams...

## Risk identification | Process

**OUTPUTS:**

- ➔ **Project Risk Register**
- ➔ List of feared events
- ➔ Recommendations

## Risk Register

Risk Scenario	Risk Category	Likelihood	Consequence				Risk Level	Current Response	Mngt Decision
			Cost	Schedule	Performance	Env't / Safety	Reputation		

↑      ↑    ↑                  {                  ↑         ↑                  ↑  
①       ②    ③                  ④                  ⑤        ⑥                  ⑦



## 04 -- Risk Evaluation

### Risk evaluation | Process

#### INPUTS:

- ➔ Project Roadmap
- ➔ Project Management Plan
- ➔ Project Risk Register

#### TOOLS & TECHNIQUES:

- ➔ Risk Level Matrix
- ➔ Failure Mode Analysis and Consequences (FMAC)

#### OUTPUTS:

- ➔ Project Risk Register
- ➔ Preliminary **Risk Assessment Forms**

### Risk Level Matrix

Probability	<b>P</b>
Very unlikely	.1
Rather unlikely	.3
Possible, plausible	.5
Rather likely	.7
Very likely, quite certain	.9

Consequences	<b>C</b>
Negligible	.05
Marginal	.1
Significant	.2
Major, critical	.4
Catastrophic, crisis	.8

## Risk Level Matrix

Consequences	C	on budget	on schedule
Negligible	.05	$\Delta C \approx 0$	$\Delta D \approx 0$
Marginal	.1	$1\% < \Delta C \leq 5\%$	$1\% < \Delta D \leq 5\%$
Significant	.2	$5\% < \Delta C \leq 10\%$	$5\% < \Delta D \leq 10\%$
Major, critical	.4	$10\% < \Delta C \leq 20\%$	$10\% < \Delta D \leq 20\%$
Catastrophic, crisis	.8	$\Delta C > 20\%$	$\Delta D > 20\%$

## Risk Level Matrix

Consequences	C	on the project performance
Negligible	.05	Minimal or no consequence
Marginal	.1	Small reduction of the performance
Significant	.2	Significant degradation of the performance
Major, critical	.4	Technical goals cannot be achieved
Catastrophic, crisis	.8	Project cannot be completed

## Risk Level Matrix

$$S = P \times C$$

$$S < 0.05$$



low risk

$$0.05 \leq S < 0.20$$



medium risk

$$S \geq 0.20$$



high risk

## Risk Level Matrix

$P \backslash C$	.05	.1	.2	.4	.8
.9	.05	.09	.18	.36	.72
.7	.04	.07	.14	.28	.56
.5	.03	.05	.10	.20	.40
.3	.02	.03	.06	.12	.24
.1	.01	.01	.02	.04	.08

## 05 -- Risk Quantification

### Risk quantification

Four approaches for dealing with probabilities:

- ➔ **Classical** approach
- ➔ **Mathematical** approach
- ➔ **Frequentist** approach
- ➔ **Bayesian** approach

### Risk quantification

Four approaches for dealing with probabilities:

- ➔ **Classical** approach:

The probability  $P(A)$  of an event  $A$  is the property that determines its frequency of occurrence.

E.g.:

$$P(\text{head}) = P(\text{tail}) = 1/2$$

$$P(\text{☐}) = P(\text{☒}) = 1/6$$

$$P(\text{☒ and ☒}) = 1/36$$

## Risk quantification

Four approaches for dealing with probabilities:

➔ **Mathematical** approach:

$P(A)$  is a number that obeys the many axioms of the theory built up by A. Kolmogorov in the '30s:

$$0 \leq P(A) \leq 1$$

$$P(A \vee B) = P(A) + P(B)$$

$$\sum P(A_i) = 1$$

...

## Risk quantification

Four approaches for dealing with probabilities:

➔ **Frequentist** approach:

$P(A)$  is a limit over a set, when the number of elements of this set tends to  $\infty$

## Risk quantification

Four approaches for dealing with probabilities:

➔ **Bayesian** approach:

$P(A)$  is the degree of belief in the occurrence of an event

## Risk quantification | Process

### INPUTS:

- ➔ Project Roadmap
- ➔ Project Management Plan
- ➔ Project Risk Register
- ➔ Risk Assessment Forms
- ➔ Outputs of the project planning phase → PBS, WBS, Gantt Chart...
- ➔ Lessons learned in matter of PRM on former NPD projects
- ➔ Names of NPD PRM experts → interviews

### TOOLS & TECHNIQUES:

- ➔ Math toolbox → probability, combinatory...
- ➔ Decision trees
- ➔ Monte-Carlo simulations

## Risk quantification | Process

**OUTPUTS:**

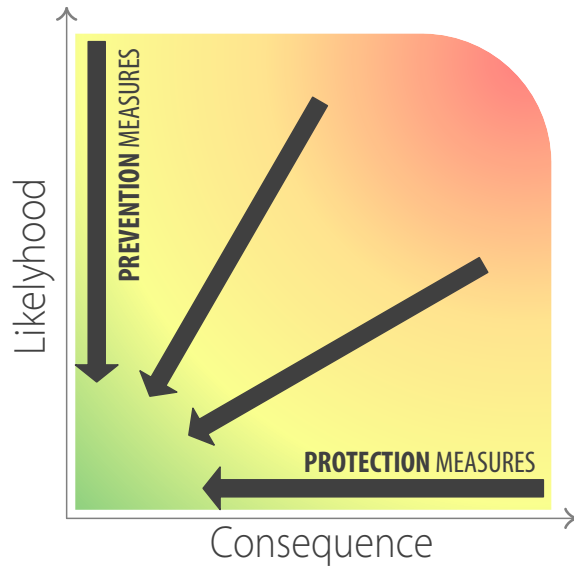
- ➡ Project Risk Register
- ➡ Risk Assessment Forms
- ➡ Quantitative risk analysis calculation notes...

## 06 -- Risk Handling

## Risk handling

Four strategies:

- ➔ **mitigate**
- ➔ **accept**
- ➔ **avoid**
- ➔ **transfer**



## Risk handling | Process

### INPUTS:

- ➔ Project Roadmap
- ➔ Project Management Plan
- ➔ Project Risk Register
- ➔ Risk Assessment Forms
- ➔ Lessons learned in matter of PRM on former NPD projects
- ➔ Names of NPD PRM experts → interviews

### TOOLS & TECHNIQUES:

- ➔ Brainstorming sessions, Six-hats, Delphi method...
- ➔ Interviews



## Risk handling | Process

### OUTPUTS:

- ➡ Project Risk Register
- ➡ Risk Assessment Forms
- ➡ **Response Plans**
- ➡ **Contingency Plans**

## 07 -- Risk Monitoring

## Risk follow-up

Consists of:

- ➡ Following up the risks identified of the Project Risk Register
- ➡ Detecting the emergence of residual risks, and engaging the appropriate Contingency Plans
- ➡ Following up the implementation of the Contingency Plans and appraising their efficiency
- ➡ Scrutinizing the emergence of **new risks** (i.e. risks that weren't identified during the Planning phase of the project) and applying to them all the methodology presented here before

## Risk follow-up | Process

### INPUTS:

- ➔ All PRM documents
- ➔ Project performance indices → EVM...
- ➔ Checklists

### TOOLS & TECHNIQUES:

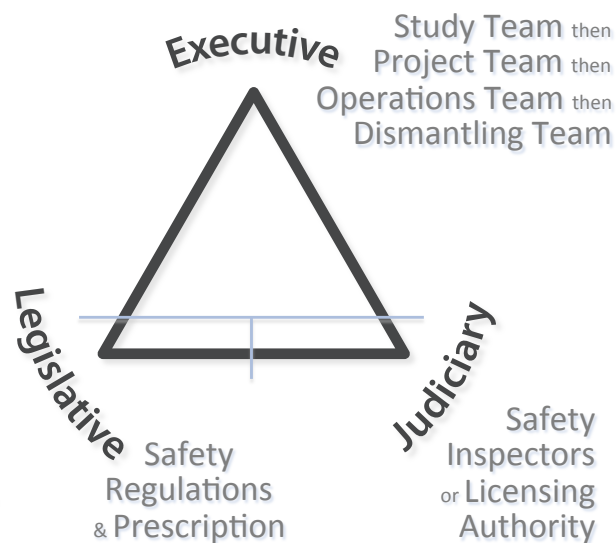
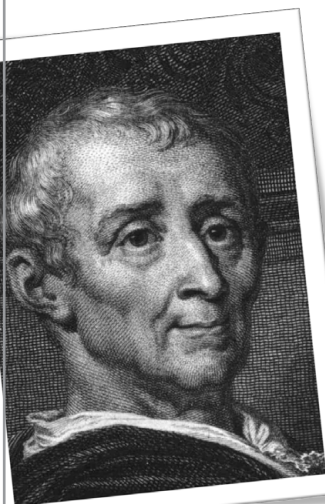
- ➔ Project audits and reviews focused on PRM

### OUTPUTS:

- ➔ Updated PRM documents

## 08 -- Safety Risk Management

Montesquieu *The spirit of the laws* 18<sup>th</sup> century



## Two perspectives

Workers should not fall victim of accident or occupational illness because of the facility or system

Occupational health and safety, *Sécurité*

The presence of the facility should not represent any hazard to the people or the environment to do so, it should operate **reliably**

Facility integrity, *Sûreté*

## Aim (Documenting Safety)

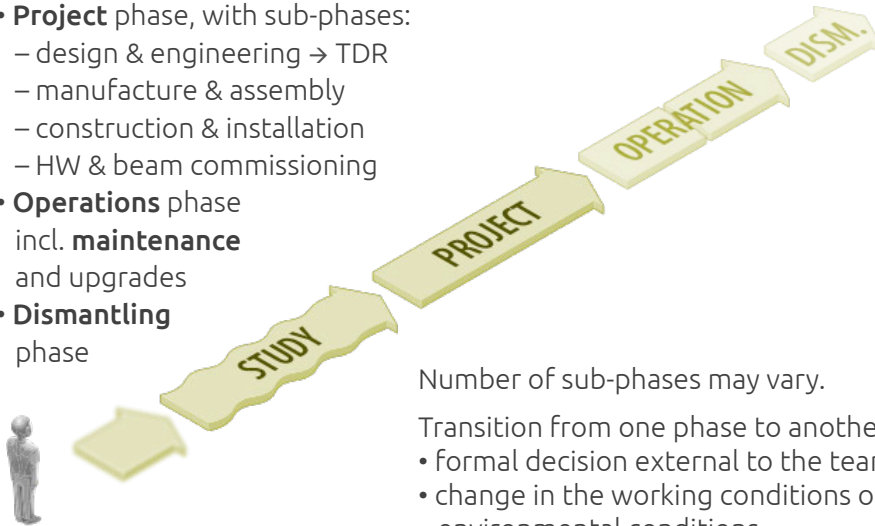
Demonstration by the study / project / operations / dismantling team that the **safety regulations and requirements are fulfilled** from the two perspectives of safety and integrity

Providing team members with procedures for **safe operation and maintenance** of the facility or the system

## Facility Lifecycle

4 major phases:

- **Study** phase → Study Report / CDR
- **Project** phase, with sub-phases:
  - design & engineering → TDR
  - manufacture & assembly
  - construction & installation
  - HW & beam commissioning
- **Operations** phase  
incl. **maintenance** and upgrades
- **Dismantling** phase



## Step 1 – Launch discussion

When:

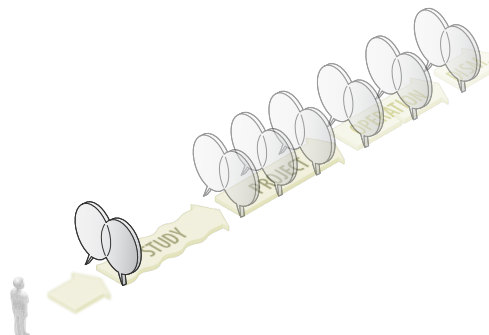
**Study phase**, then  
after each **transition**

Instigator:

- **Project Manager**

Participants:

- **Key team members**
- **Safety engineers / officers**
- **Safety authority**



## Step 1 – Launch discussion (cont'd)

Topics to be addressed:

- A **description** and a **common understanding** of the facility or system and of its processes in term of safety
- The review of the **hazards and safety risks** identified
- The review of the **technical and organizational risk control measures** identified
- The identification of the **safety requirements** that shall be considered in the specific framework of the study
- The strategy in matter of **safety documentation** (their contents, editorial schedule, reviewing processes...)
- The identification of **safety checks** (clearances)

## Step 2 – *Launch Agreement*

When: after the **launch discussion** is held

What: typically a memorandum, entitled:

### **Launch Agreement on Safety Aspects**

Author and releaser: **Safety authority**

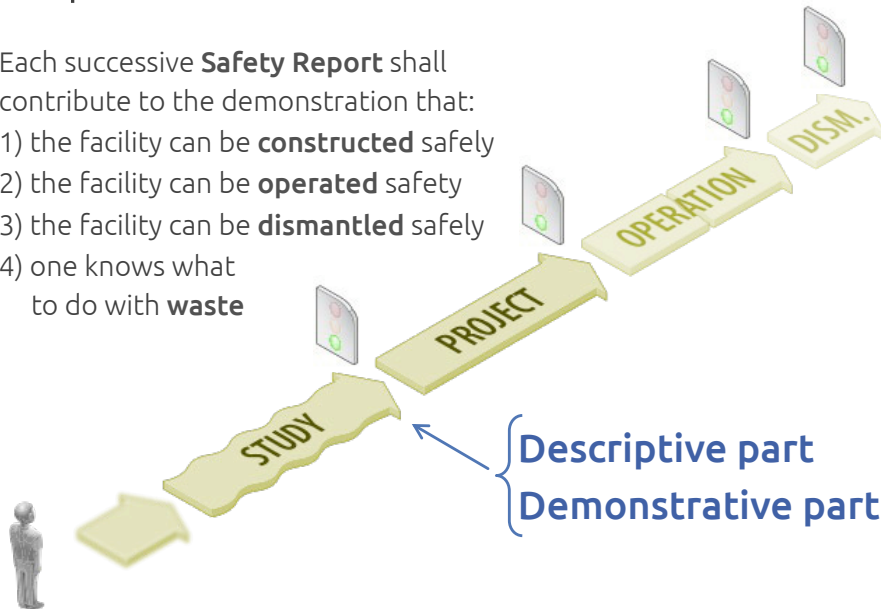
Dispatching:

- **Project manager**
- **Key team members**
- **Safety engineers / officers**
- **Management** (directors, heads of entities concerned)

## Step 3 – Editorial work

Each successive **Safety Report** shall contribute to the demonstration that:

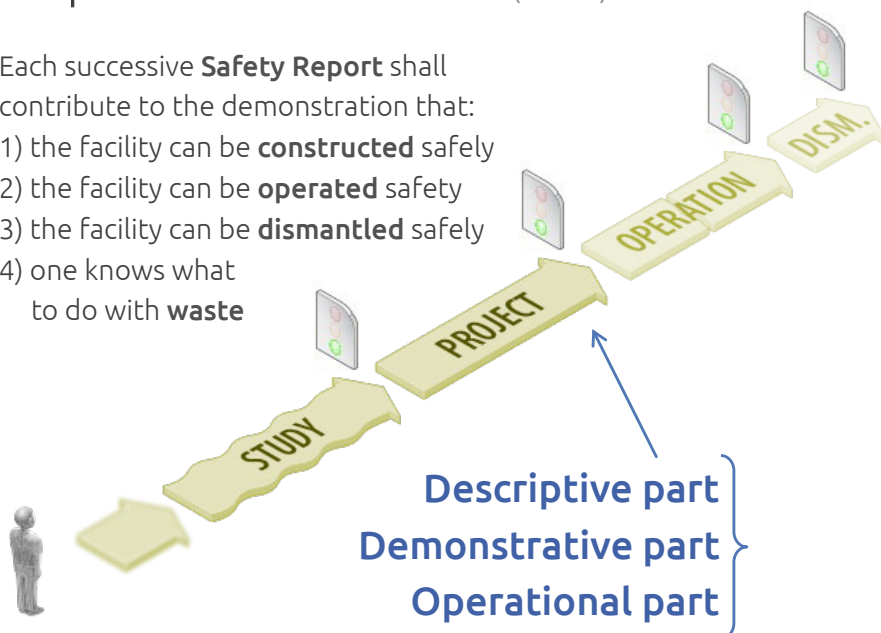
- 1) the facility can be **constructed** safely
- 2) the facility can be **operated** safely
- 3) the facility can be **dismantled** safely
- 4) one knows what to do with **waste**



## Step 3 – Editorial work (cont'd)

Each successive **Safety Report** shall contribute to the demonstration that:

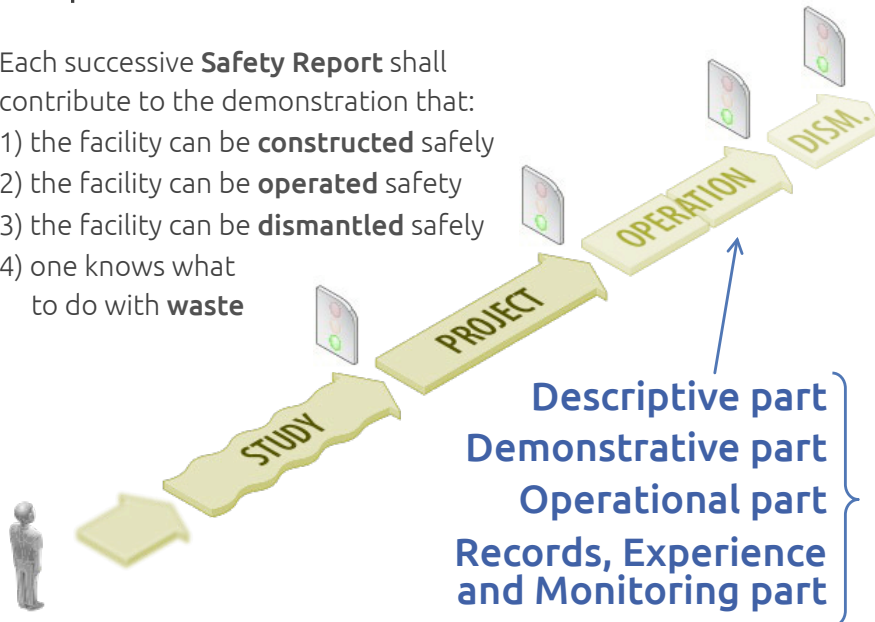
- 1) the facility can be **constructed** safely
- 2) the facility can be **operated** safely
- 3) the facility can be **dismantled** safely
- 4) one knows what to do with **waste**



## Step 3 – Editorial work (cont'd)

Each successive **Safety Report** shall contribute to the demonstration that:

- 1) the facility can be **constructed** safely
- 2) the facility can be **operated** safely
- 3) the facility can be **dismantled** safely
- 4) one knows what to do with **waste**



## Part 1 – Descriptive Part

Description of the facility or of the process

- Why is it useful
- Where is it located
- What is it made of
- How does it work
- When will it be constructed, operated, dismantled
- Who is responsible for its construction...
- How will it be constructed...
- Who will be responsible for its operation, dismantling...
- How will it be operated, dismantled...

« Quis, Quid, Ubi, Quibus auxiliis, Cur, Quomodo, Quando »



## Part 1 – Descriptive part (cont'd)

Description of the facility and of the process

« Quis, Quid, Ubi, Quibus auxiliis, Cur, Quomodo, Quando »

Which **hazards** are present in the facility or in the process?

- Energy and radiological source terms
- External (environmental) hazards
- Internal (processes/utilities) hazards

Identification:

- Vade mecum, knowledge sharing...
- Systematic approaches  
(process/utility diagrams, layouts)

**Safety philosophy** (incl. applicable regulations...)

## Demonstrative part (1/2)

- Risk **identification** (see hazard identification)
  - Sequence of events
  - Potential incidental/accidental situations
- Risk **evaluation**
  - Risk assessment matrix  
 $\text{risk level} = \text{likelihood} \times \text{consequence}$
  - Failure mode and effects analysis (FMEA)  
 $\text{severity} = \text{probability} \times \text{detectability} \times \text{gravity}$

- Risk **analyses**





## Demonstrative part (2/2)

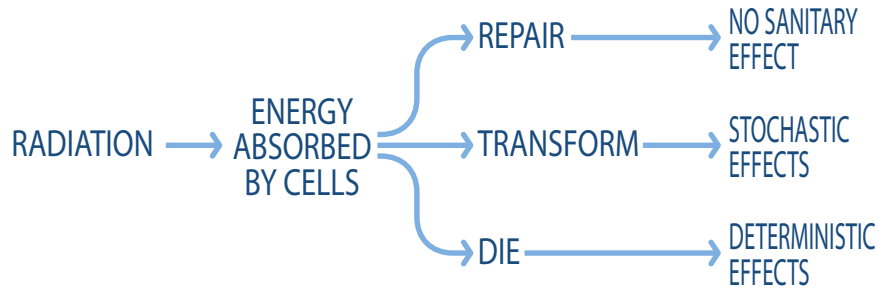
- Risk **responses/treatments**
  - **Technical (structural)** measures or provisions implemented to mitigate the risks  
Conception documents (notes, drawings...)  
Zoning principles  
Calculation notes...
  - **Organizational** measures or provisions planned to mitigate the risks  
Outline of the instructions and procedures
  - **Operations thresholds**



## Safety philosophy

All (most) nuclear safety regulations suggests that individual exposures and number of exposed persons is maintained to a level that is **as low as reasonably achievable**, taking into account economical and social factors

## Safety philosophy



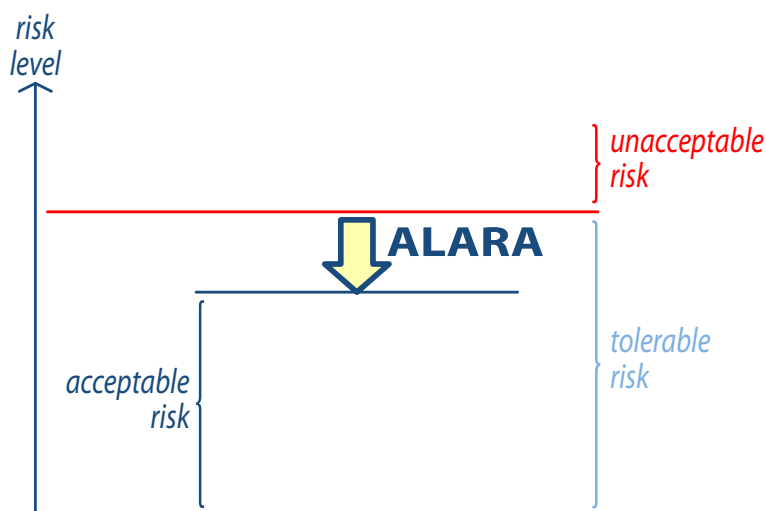
### DETERMINISTIC EFFECTS

- Effect =  $f(\text{dose})$
- Gravity =  $f(\text{dose})$
- Early effects
- $\exists$  thresholds
- Probability = 1

### STOCHASTIC EFFECTS

- Effect  $\neq f(\text{dose})$
- Gravity  $\neq f(\text{dose})$
- Late effects
- “**No threshold**”
- Probability =  $f(\text{dose})$

## Safety philosophy



## Safety philosophy

### Practically:

For a given hazardous situation,

- Evaluate **risk level** (radiation exposure...)
- Identify possible **protection** and **prevention**, structural and organizational treatments
- Estimate their **impact** on the performance (incl. construction/operation costs and schedule)
- Select the most appropriate one(s)

## Step 4 – Safety review / Clearance

When:

before the end of the **study phase**,  
then before each **transition**

Instigator:

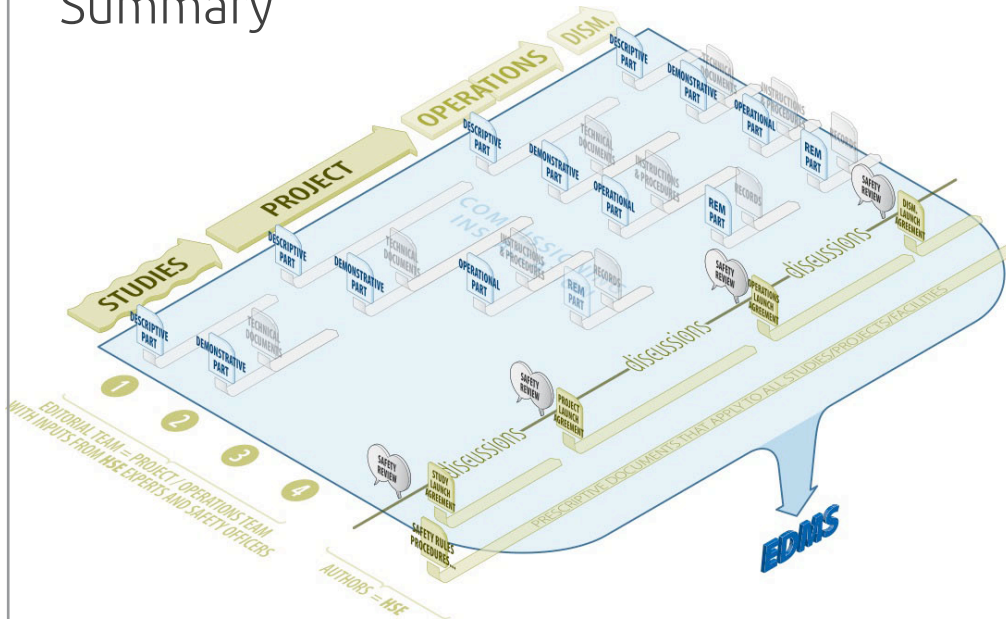
- **Project manager** and **Safety authority**

Participants:

- **Key project team members**
- **Safety engineers / officers**

Outcome: **Safety Clearance** (or **Safety Refusal!!**)

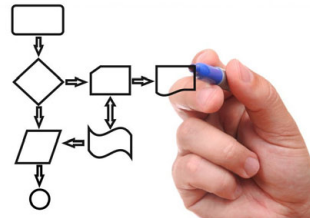
## Summary



## Part 3 – Operational Part

- Operations limits (thresholds) not to be exceeded
  - Operations instructions and procedures
    - for operating the facility
    - for maintaining and ensuring its integrity
    - quality management framework
  - Organizational structures
    - for handling the project, constructing the facility
    - for operating and maintaining the facility
    - for dismantling the facility and handling waste
- 
- ```

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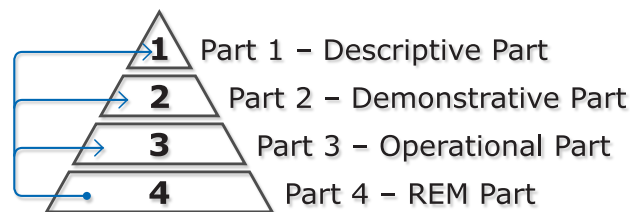


## Part 4 – REM Part (Records, Experience and Monitoring)

Elicitation of storage and retrieval facilities for:

- **Records** (safety and inspection reports...)
- **Lessons learned** from the development, operations, maintenance and dismantling so that all concerned can benefit from them

List of the actions run to continuously improve the level of safety of the facility or system



## Document Lifecycle

Safety document **prepared** by:

- Members of the project team
- Safety engineers / officers

Safety document **verified (checked)** by:

- Other safety engineers / experts
- Key equipment/technology experts
- Etc.

Safety document **validated (approved)** and released by:

- Project manager
- Directors and heads of entities involved