3- Tasks on PRELIMINARY STUDY stage

or choosing the best option using engineering common sense

Using matrix multicriteria decision

	A1	A2	A3	A4
Reliability				
Environmental impact				
Economic Feasibility				

Main objectives

- Increasing knowledge about the project
- Studying the viability or feasibility (technical, economical…) of those solutions
- Obtaining possible alternative solutions and choose best (and sub-best ?)

3-1 Tasks at this stage
3-2 Reliability concepts
3-3 Environmental impact concepts
3-4 Economical feasibility definitions

3-1 Tasks on Preliminary study

Study the purpose
Needs to be satisfied
Description
Knowledge of the problem study

Processes

Manufacturing processes
Size and location markets
Plant distribution layouts
Possible geographical area location
Pre-quotations asks

Products

Manufacturing Product
Market descriptions
Product volume estimation
Industry propierty exam
Basic prototype

Technological viability and decisions

Organizational structure
Economic and financial viability
Tasks Programming
Environmental Impact Study
Conclusions

Revision points

Annexes

3-2 Reliability concepts

3-2.1 Technical Reliability
3-2.2 Human Reliability
3-2.3 Accident definition
3-2.4 Legal Framework

3-2.1 Technical Reliability

Technological and human reliability and related concepts

One of the three points of view in order to consider diferent alternatives to fix our problem or project (Reliability, Economics and Environmental)

Reliability definition

- It is the probability that a device, or person, performs a certain function under fixed conditions during a certain period of time (between 0 and t)

Reliability numerical evaluation

- For components

Starting at $N(0)$ working parts at moment 0, Ns working parts at moment t and Nf without working in t moment

- Reliability: $R(t)=Ns(t)/N(0)=1-[Nf(t)/N(0)]$
- No reliability: $Q(t)=1-R(t)$ $f(t)=dQ/dt=-dR(t)/dt$ then,
  $dR(t)/dt=-[1/N(0)][dNf(t)/dt]$ then,
- $dNf(t)/dt = -N(0)\, dR(t)/dt$ then,
  $[1/Ns(t)][dNf(t)/dt]= -[N(0)/Ns(t)][dR(t)/dt]= \lambda(t)$
  - $\lambda(t)dt= -dR(t)/R(t)$
  - $\lambda(t)$ Instant Failure Rate

- For systems
  - More than one component

For continuous functions:

$$R(t) = e^{\int_0^t \lambda(t)dt}$$

- If λ (t)= constant and the distribution is exponential (most used)
- $R(t)= e^{-\lambda t}$ and 1/λ is **MTBF**

– Other used distributions: Weibull, normal, lognormal…

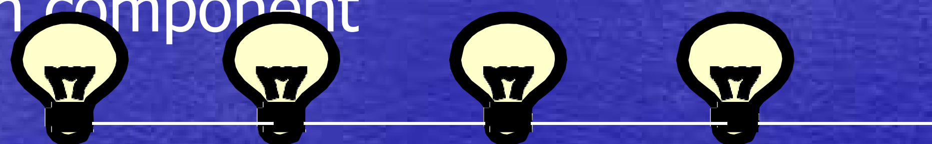
See reliability tables A1 to A3 for λ typical values

For systems

Serial systems

Their reliability is the result of multiplying the reliabilities of each component

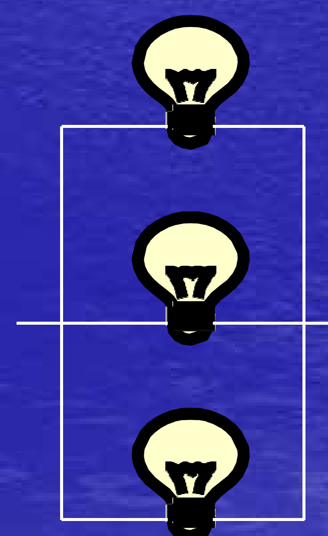
R=R1*R2*R3…



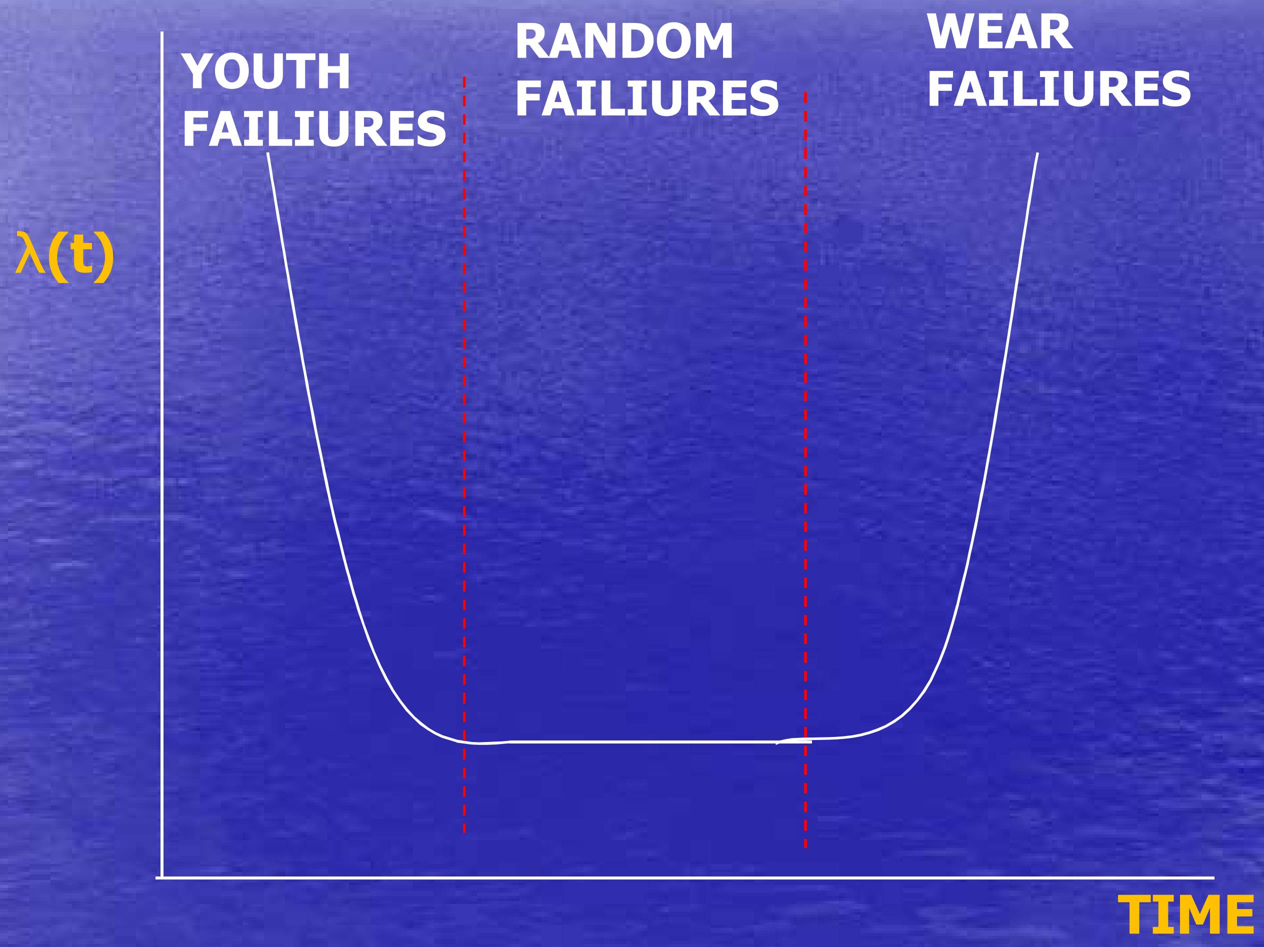
Parallel systems

Their no-reliability is the result of multiplying the no-reliabilities of their components

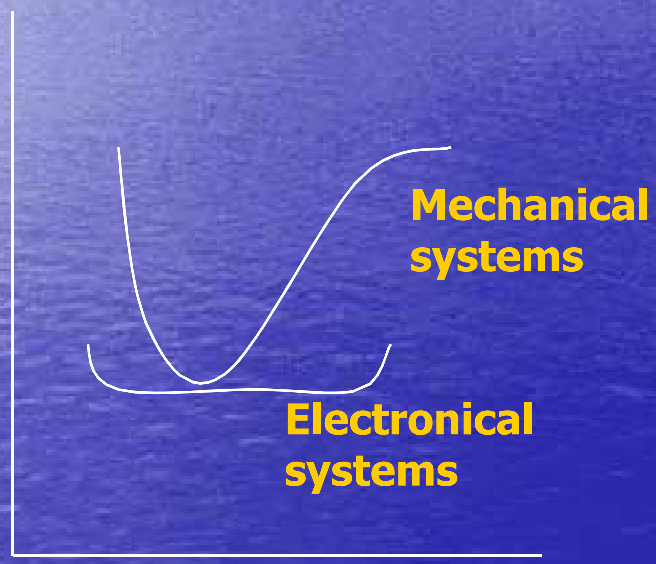
R=1-Q1*Q2*Q3…

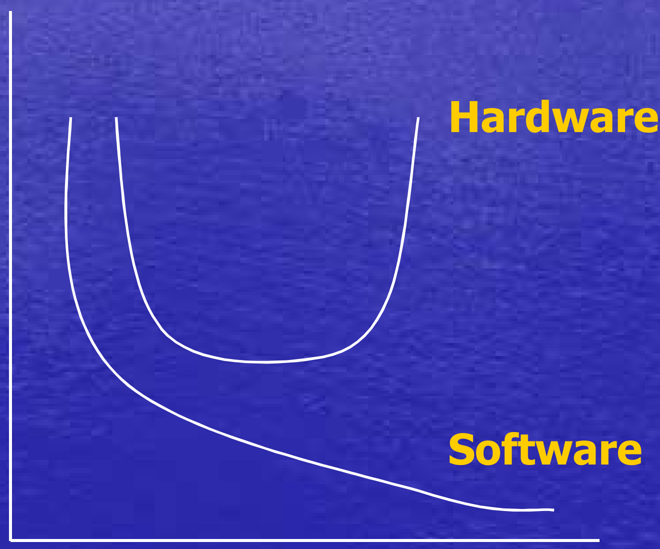


Bath failure rate curve



Some special cases of Bath failure rate curves:





Failure tolerating systems

Reducing system and user damage as much as possible

- Hospitals
- Aeroplanes
- Data Process Centers
- ...

Other cases:

Reservation systems

(an operational equipment (1) and the other one as a reserve (2))

$$R(t)=R_1(t)+Q_1(t_1)*R_2(t-t_1)$$

Repairing systems

(In paralel, one of them working)

$$R(t)=\frac{1}{r1-r2}((3\lambda+\mu+r1)\,e^{r1t}-(3\lambda+\mu+r2)\,e^{r2t})$$

$$r1,r2=\frac{-(3\lambda+\mu)\ +/-\ ((3\lambda+\mu)^2-8\lambda^2)^{½}}{2}$$

Other techniques for more complex models

Markov's models

It gives the probabilities of different system states (s) as a time function (t). Markov (s, t) in a system with 2 equipments has 3 states:

No errors in system
1 equipment fails
2 equipments fail

Petri networks, PN

As a graphic tool they model the component interactions between components and the flow activities in more complex systems

Based on:

- P np nodes
- T nt transitions
- I inputs signals
- O outputs signals
- M Identification

Monte Carlo's simulation

Computer Simulation is a numerical method that allows the solution of mathematical or physical processes using a model that represents the random variables linked to the system

Maintenance

It is the probability of restoring the system to its normal service in a t time

μ = number of maintenance repairs per moment

$$M(t) = 1 - e^{-\mu t}$$

Availability

It is the probability that a system is available and can be used in good conditions at a t time

$$D_{\infty} = \frac{\text{Ttotal service}}{\text{Ttotal service} + \text{Tstopped}}$$

If λ and μ are exponential $D_{\infty} = \frac{1}{1 + \lambda/\mu}$

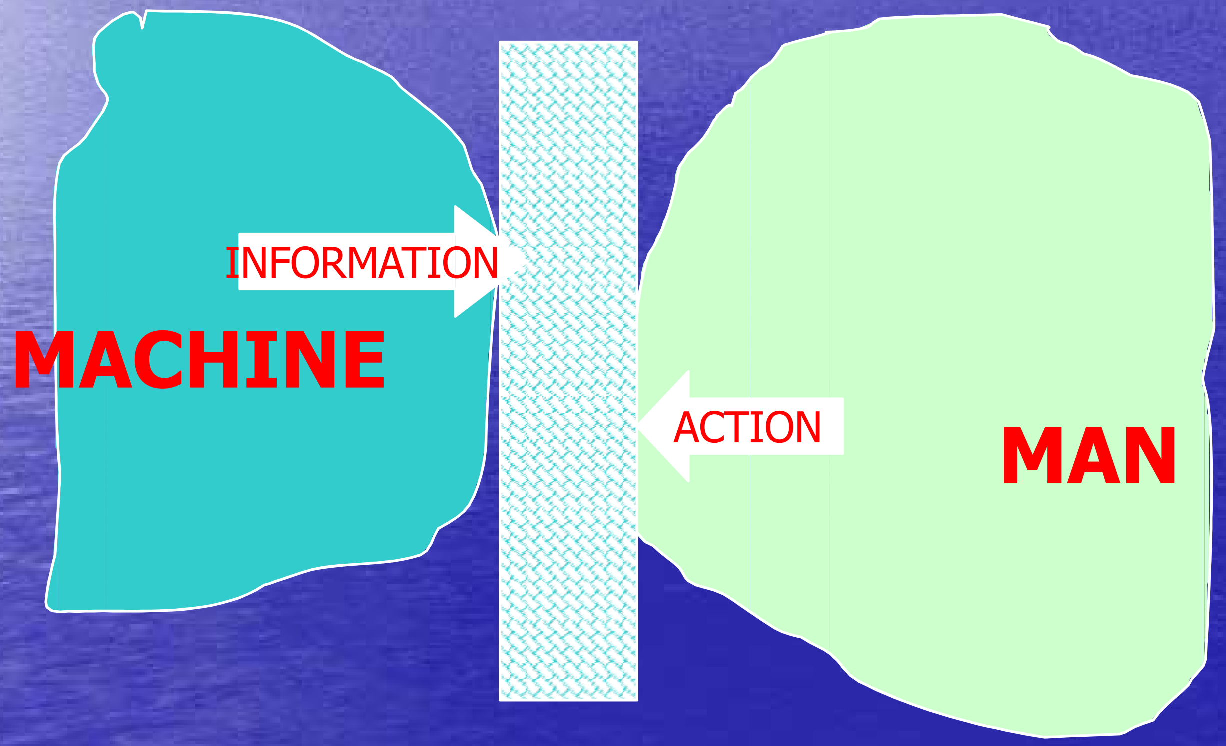
Maintaining

Preventive: MTBF function device periodic inspection

Corrective: It is repaired only when a component fails.

Predictive : Using sensors to know life limit for each component

3-2.2 Human Reliability



Human action

Machines or workers?

Human efficiency/Machine efficiency >1

- Sensing low level stimulus
- Detecting sound stimulus with background noise
- Sensing not usual events in the environment
- Deciding alternatives in case of failures
- Estimating and subjectively evaluating
- When necessary concentrating on important activities
- Using experience to make decisions
- Thinking inductively generalising observations
- Recognising complex sequences

Human efficiency/Machine efficiency <1

- Counting and measuring physical amounts
- Executing at the same time different activities
- Performing in hostile environments
- Working without any distractions
- Keeping activity level throughout time
- Answering quickly and consistently to inputs
- In order to sense stimulus that are out of human range nature
- Storing big amounts of data and providing data
- Processing data with a specific programming

Human error is inevitable

Now or some time ago someone made an error

The consequences of an error depend on

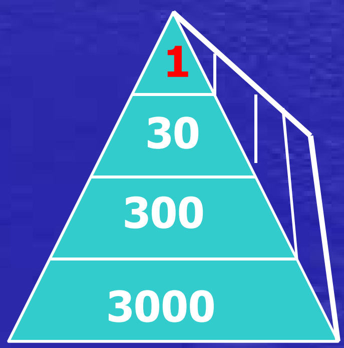
luck accident-incident pyramid

1 Critical injuried

30 accidents with Minor injuried

300 incidents with low injuries

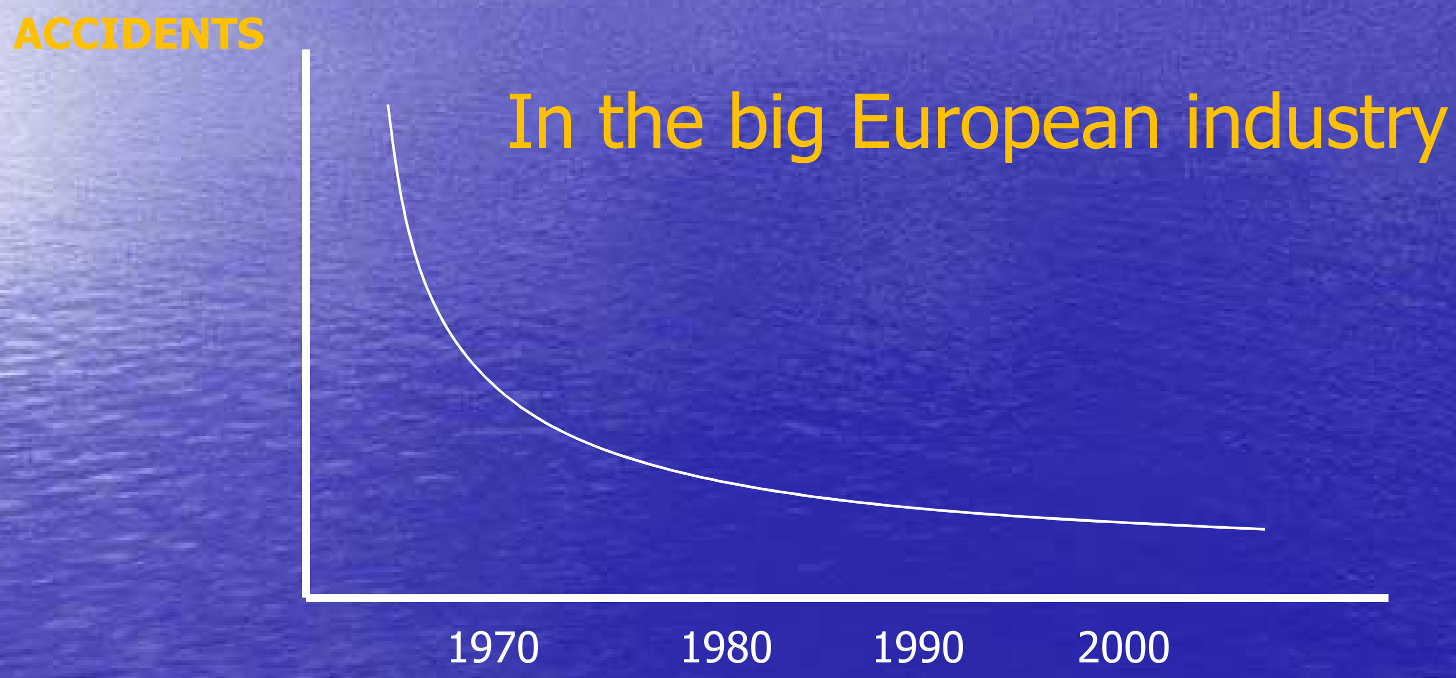
3000 critical situations



Critical work environment situation

- Clean and hygienic
- Environmental noise
- Excessive temperature
- Brightness
- Excessive working time
- Excessive responsibility
- ….

Number of accidents evolution



Design security: dummy-proof design !!!

Incorrect use problems

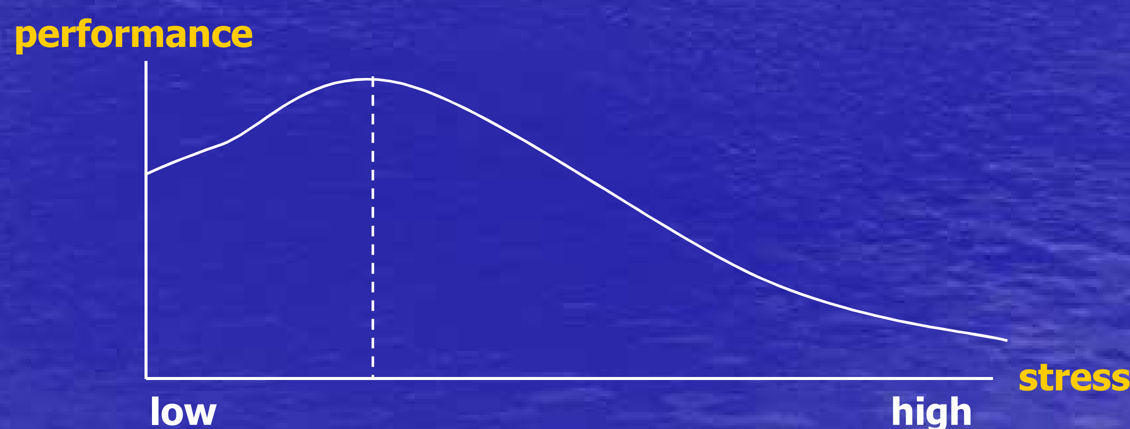
Correct functionality is not applied

Reliability problems

Artefact and artificial systems reliability

Human reliability

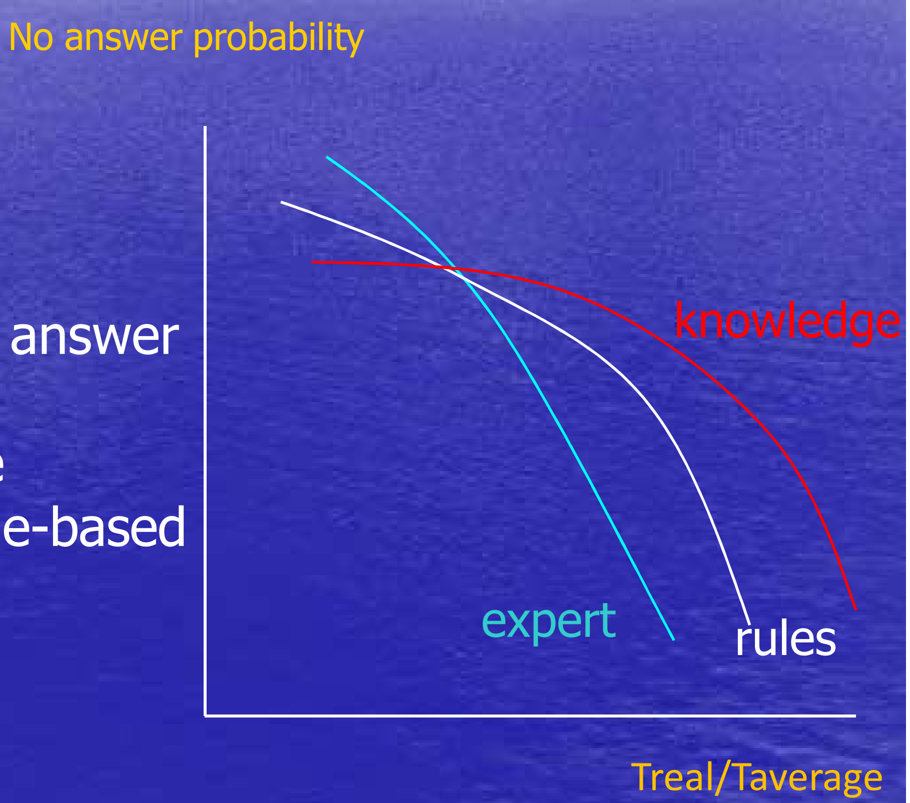
R+D experiments



Human behaviour model

Weibull's human behaviour model

Graphic representation of the no answer probability as a normalized time function (Treal/Taverage) for the experience norms and knowledge-based behaviour.

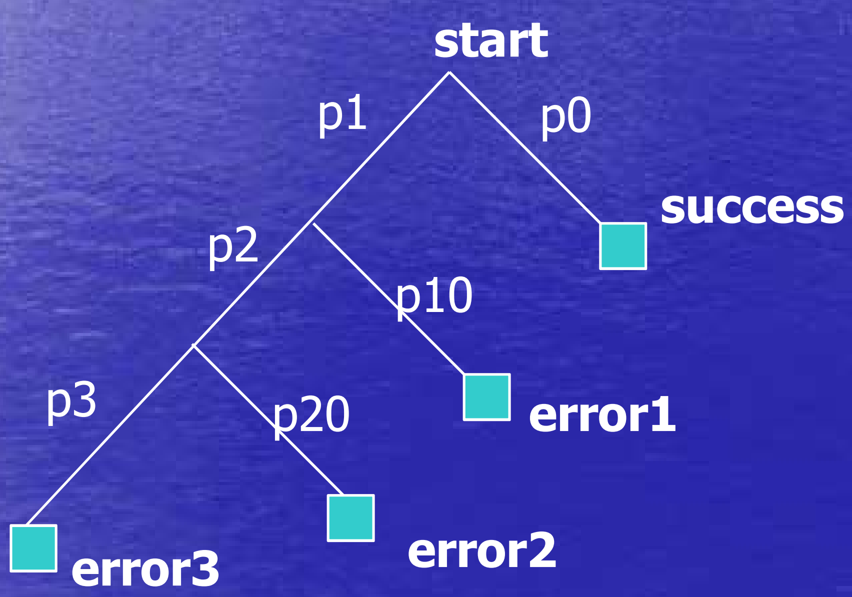


Human error quantifying

THERP methdology (Technique for Human-Error Rate Prediction

It divides human tasks into a sequence of unitary activities that are visualised in an event tree, together with its possible omission error form or commission error form deviations.

To calculate the basic event or the basic knot, it is sufficient to multiply the probabilities that are found along the path that leads us to executing the basic event



See reliability tables A4 to A8 for HEP typical values

3-2.3 Accident definition

Accident risk

An accident represents an intolerable deviation of a system working conditions related to those pre-established in the project

More common types of industrial risks

Fire

Explosion

Pollution

Fire Risk

Fires provoke thermal radiations that depend on:

The radiating object orientation towards the radiated object

The radiating energy (scattering) dispersion

Fire classification

Flash fire

$$(I - I_{cr})t^{2/3} = k1$$

Liquid fire

$$(I - I_{cr})t^{2/3} = k2$$

Radiation intensity I in W/m^2

I_{cr} critical intensity

t time

k1, k2 constants

Radiating energy intensity that some materials can withstand I_{cr}

material	kW/ m2
Cement	40-60
Reinforced concrete	200
Steal	40
Wood	10
Glass	30-300
Brick	400
People	4-5

Explosion risk

	Over pressure [bar]
Total demolition	0.80
Severe but repairable damage	0.15
90% of broken windows	0.04
50% of broken windows	0.01
Total destruction of houses	0.48
50% of houses destroyed	0.17
Brick wall broken	0.07 to 0.15

Fire and explosion Dow index

It is based on a Material Factor (flammability and reactivity), in the General Process Hazard and in the Special Process Hazard

$$IIE = MF \times GPH \times SPH$$

See reliability tables A9 for IIE calculations

Historical accident information

International data base:

Holland's FACTS

- Failure and Accidents Technical Information System
- factsonline.nl

Italy's SONATA

- Summary of Notable Accidents in Technical Activities

Norway's WOAD

- The world offshore accidental database (WOAD)

England's HARIS

- Hazards And Reliability Information System

Germany's CHEMSAFE

Hazards on chemical processes

- www.cas.org/ONLINE/DBSS/chemsafes.html

People vulnerability

Man's resistance can be modelled by means of a vulnerability model, such as the probability unit or Probit.

$Pr = a+b \ln x$

a,b correlation constants

x average physical impact variable which causes the damage (dose)

Pr percentage of damaged population

For thermal radiations

Time (s)	Intensity	Doses	% casualties (Pr)
1.43	146	1099	1
45.2	10	1000	1
45.2	18	2210	50
10.1	128	6546	99

For explosions

DAMAGE	P (N/m2*1000)	% affected people (Pr)
Broken timpani	19.3	10%
Broken timpani	84.3	90%
Lung bleeding	120	10%
Lung bleeding	200	90%
Spine fracture	7 m/sec	5 kg surely damaged
	3 m/sec	limit threshold

For toxic substances

Probit's equation:

$Pr = a + b \ln \int C(t)^n \, dt$

a,b and n depend on the substance

t explosion time

C(t) concentration variation depending on time

Risk analysis techniques

Qualitative analysis HAZOP

FMEA method

Markov's analysis

Failure tree analysis

Expert systems

Qualitative analysis: HAZOP (HAZard and OPerability)

It examines every possible process behaviour functioning deviation. Its objective is to foresee the deviation consequences in the usual process operation.

Risk= $\log[(10^{cause1}+10^{cause2}2)(10^{consecuences})(10^{protection})]$

See reliability tables A10 for risk calculations

FMEA method (Failure Mode and Effect Analysis)

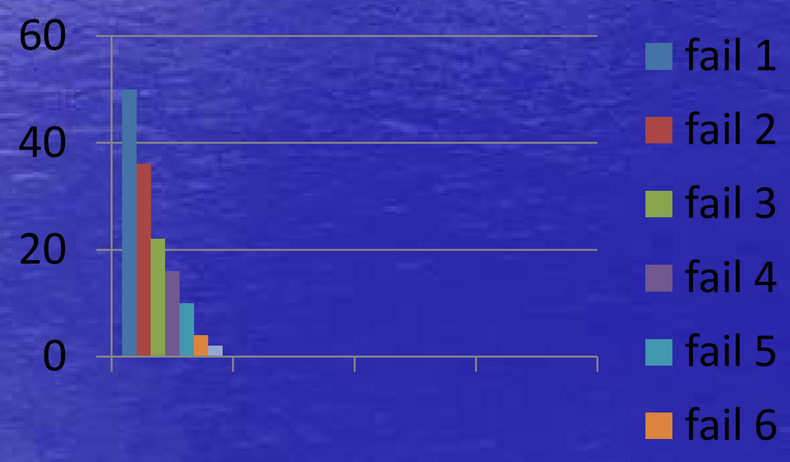
It analyses the consequences in the system of all the possible failures that may affect a system component, it identifies what kind of failures have important consequences and determines ways of detecting every failure

Sheets type are used

item	Type of fail	Cause	Effects	Actions to take

Pareto analysis

Determining a small number of causes that give rise to a big number of failures

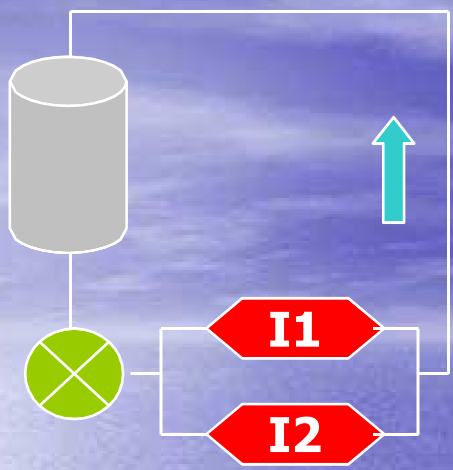


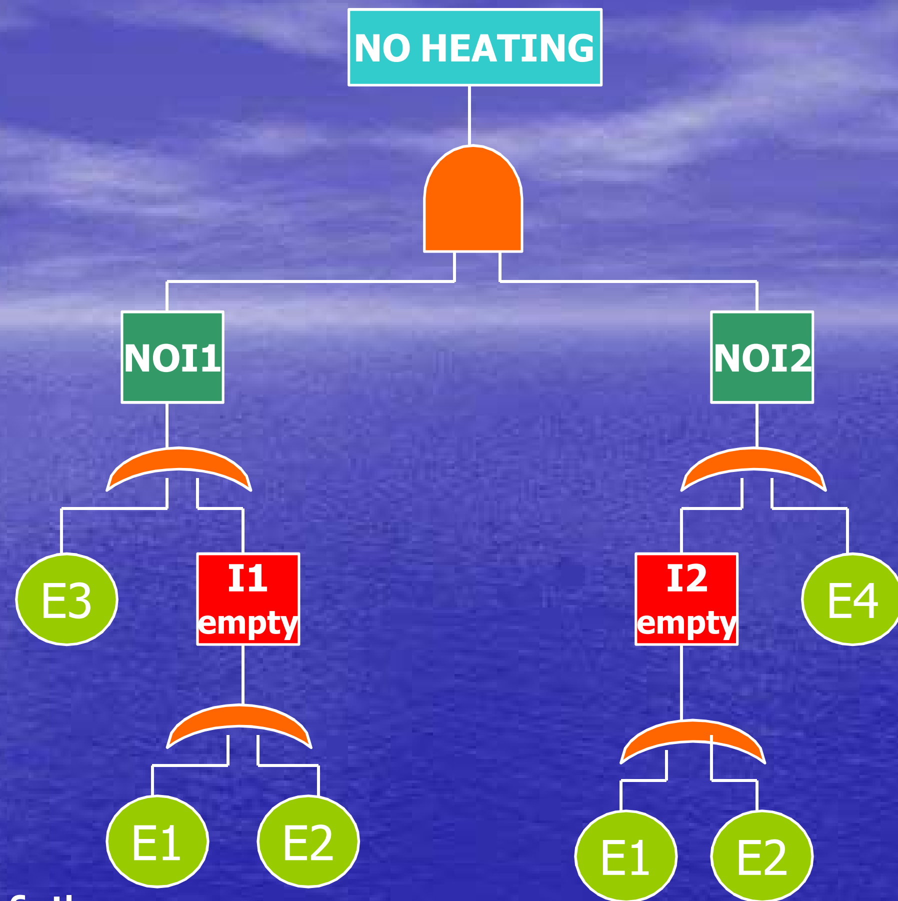
Markov's analysis

It consists in determining the probability that a system or random process is in one of the two possible states, while the change probabilities remain constant and future states are independent in relation to past states.

Failure tree analysis

It is the representation or deductive graphic development from the main or final event undesired or dangerous, named TOP EVENT, through all of its event combination, or intermediate events, to the determination of its causes, or basic events.





- E1: empty tank
- E2: Bomb failure
- E3: Interchanger # 1 failure
- E4: Interchanger # 2 failure
- TOP EVENT= $I1 \cdot I2 = (E3+(E1+E2)) \cdot (E4+(E1+E2))$ =……MINIMUM EXPRESSION FOR NOT FAVOURABLE SITUATIONS

Expert Systems

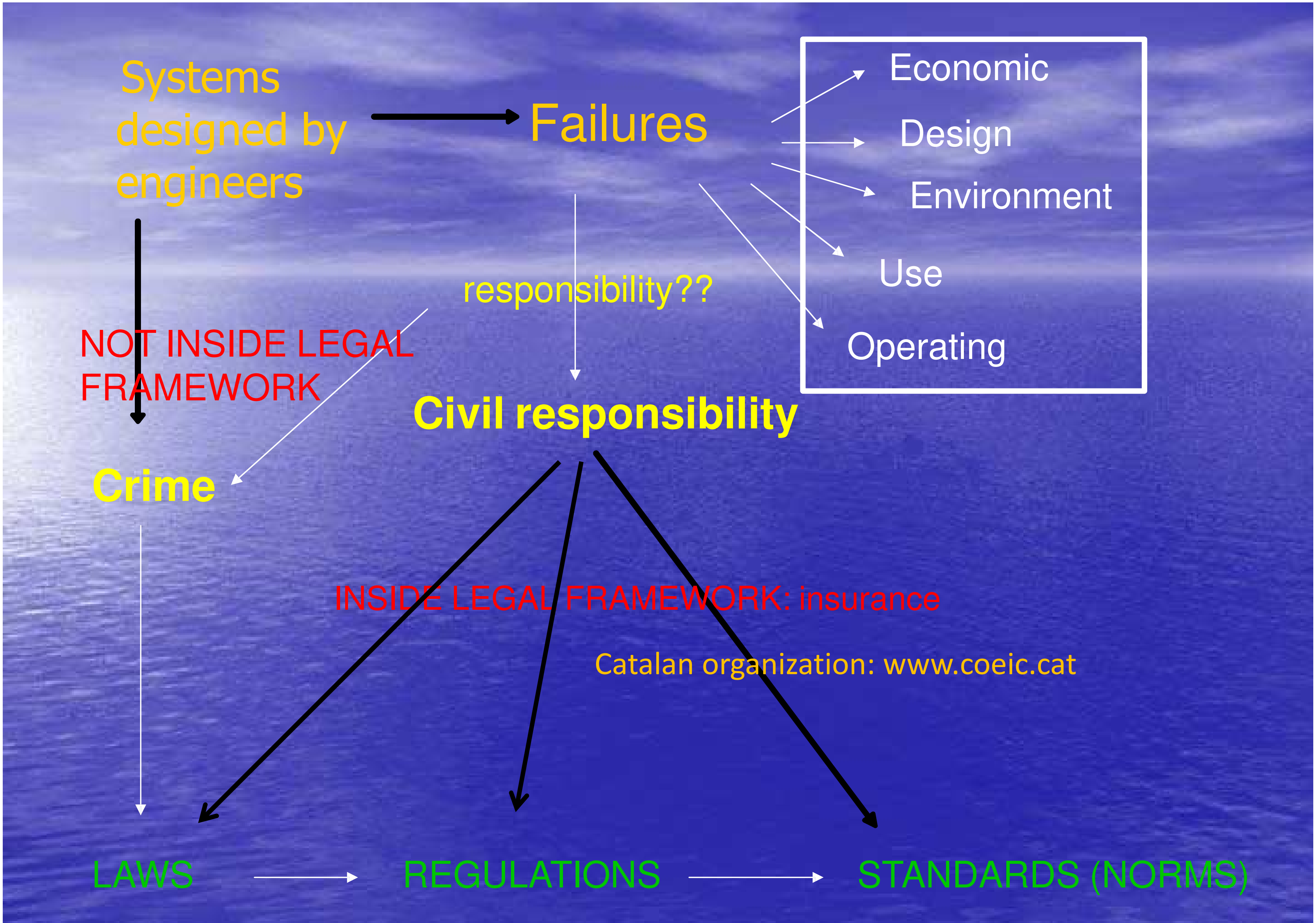
These are software programs that use knowledge acquired by means of introduced information in order to execute complex tasks.

3-2.4 Legal Framework

Industrial security and legislation

Its objective is people's, goods and environment security.

Technical specification concepts, norms, norm project and technical regulations are considered in the 98/48/CE directive.


Systems designed by engineers
Failures
Economic
Design
Environment
Use
Operating
responsibility??
NOT INSIDE LEGAL FRAMEWORK
Civil responsibility
Crime
INSIDE LEGAL FRAMEWORK: insurance
Catalan organization: www.coeic.cat
LAWS
REGULATIONS
STANDARDS (NORMS)

Legislative overview

Directives, Regulations and International Agreements influence on Spanish Legislation

Once they are published in the BOE, (www.boe.es state official bulletin) they must be compulsory observed.

Laws: principle declarations that refer to regulations

Regulations: Royal decrees and complementary Technical Instructions (CTI). Its content:

- Object
- Application field
- Competence
- Compulsory documentation
- Authorisations
- Periodical Inspections
- Application standards
- Infractions, sanctions, resources

Norms that are mentioned in regulation documents if they must be compulsory observed

- Spanish Industry law:
  - Pressure device regulation
  - Low tension electro technical regulation
  - Chemical product storage regulations
  - Ground setting CTI
  - Fuel distribution CTI
  - Sites with damp risk CTI
  - ……

Definitions

Technical specifications

It is a document in which a product technical characteristics are defined, such as quality levels, specific use, security or dimensions, symbols, tests, labelling and consent evaluation documents.

Technical regulation

Technical specifications or other required aspects or services related regulations (including administrative norms which are applicable) that must be followed for commerce, service assistance, product use, manufacturing, assembling

Norm (standard) Project

It is the document which includes technical specifications about a certain topic that one intends to “normalize”.

Norm (standard)

A technical specification approved by a recognzied organism of normalising activities for repetitive and continuous application, whose compliance is not compulsory (international, European, national).

Spanish organization: www.aenor.es

Types of Standards

USA	ASTM (American Society Testing Materials) ASME (American Soc. Mechanical Engineers) API (American Petroleum Institute) ASA (American Standards association) NFPA (National Fire Protection Association) NEMA (National Electric Manufactures Association) ANSI (American National Standards Institute)
Europe	UNE (Spain) BS (United Kingdom) AFNOR (France) DIN (Germany) UNI (Italy) SIS (Sweden)
International	ISO (International Standards Organisation)

Certification

Action that is carried out by an independent organism. Through this action it is proven that a certainproduct, process or service satisfies the specified regulation document.

Patent

Recognises the right to exclusively exploit the patented invention, stopping others from manufacturing it, selling it or using it without the “inventor's” previous permission.
It can refer to a procedure, a device or new product, or improvement on an existing product.
It lasts 20 years.
There are minor figures such as Utility Model and Industrial Picture.

Spanish organization: www.oepm.es

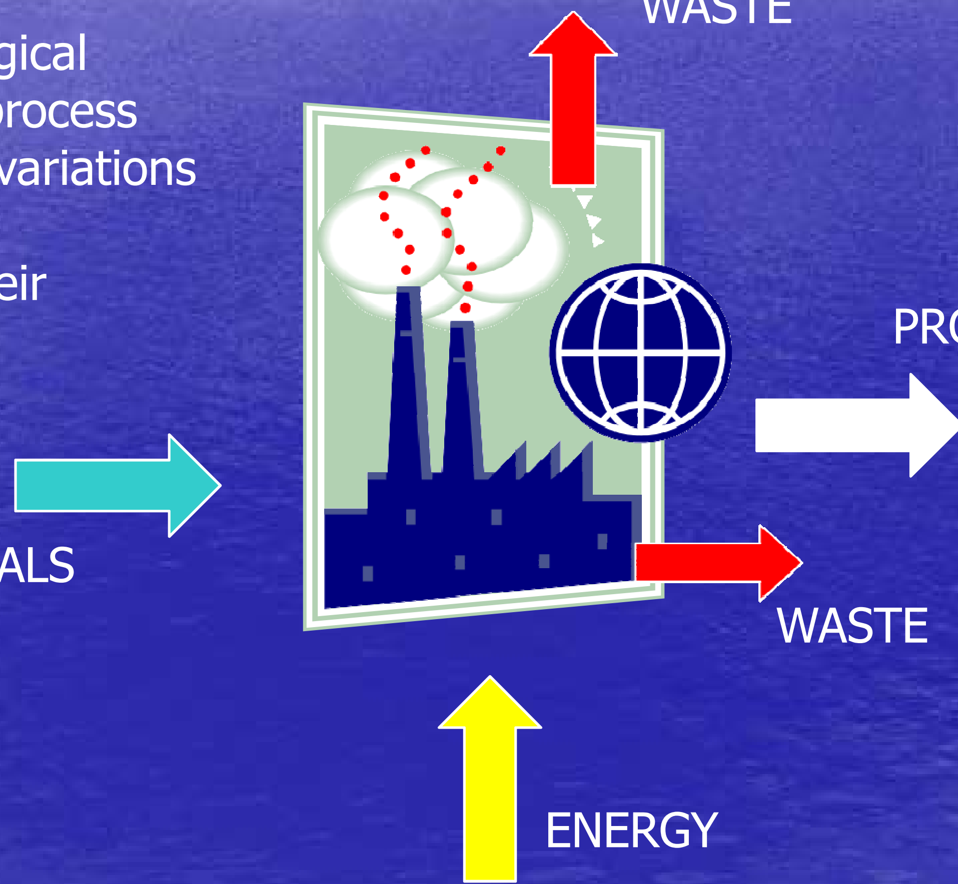
3-3 Environmental impact concepts

Environmental risk definition
Associated concepts: impact, capacity and fragility of the territory, sustainable development
Stages of an environmental impact study
Evaluation and declaration of the environmental impact

When we talk about environment impact….

Environmental risk

It is a physical, chemical or biological characteristic of a material or a process that has that potential to cause variations in the composition of air, water, fauna, flora and/or their interrelationships.



Types of impacts

Impact due to soil use changes
Pollution impact
Impacts on natural resources
Other (demography, traffic…)

Environmental Risk Analysis

UNE 150008 Aenor norm so that organizations can identify, analyse and evaluate the risk of their activities.

Environmental impact concepts

Environmental impact

– Every positive or negative effect that different procedures produce on diverse environmental factors (physical, chemical, biological or social).

Territory capacity

– It is the ability of the environment to satisfy the needs of a certain action or project.

Environmental fragility

– It is the environment's susceptibility to being affected by a certain action.

Environmental impact and its receptive media

Geographical situation
Demography
Orography
Geology
Climatology
Hydrology
Flora
Fauna
Singular natural areas

Landscape value
Cultural heritage
Soil use
Stockbreeding
Mining industry
Industry
Tourism
Water and atmosphere quality
Infrastructures
Other

Environmental policy will be based on:

Environmental aspects

Activity elements, products or services of an organisation likely to interact with the environment.

Environmental effects

Any environmental modification harmful or beneficial, total or partial, as an activity result, products or services of an organization.

Environmental behavior

Environmental manage system measurable results related to environmental activity aspects as control, products and services of an organization

Pollution prevention

Procedures usage, practices, materials or products that contribute to reducing or controlling pollution generation.

Environmental Impact Study stages (EIS)

Identifying the characteristics of a project

Receptive media analysis

Selecting evaluation criteria

Identifying and evaluating impacts

Producing alternatives

Formulating corrective measures

Result communication

Monitoring the installation, environmental surveillance

Content in an EIS

- Project description
- Non-technical summary
- Description of the environmental elements that are likely to be affected by the project
- Description of the effects that a project might produce on a territory
- Description of the measures planned to reduce or delete environmental risks.
- If necessary, an outline of the main substitution solutions that have been examined.
- An exam of the eventual difficulties due to a lack of technical knowledge.

From a legal point of view (Annex 1 RD 1131/1988)

Environmental Impact Study: It is a study that must identify, describe and value (in an appropriate way and considering every case) the notable foreseeable effects that the project execution will produce on different environmental aspects.

Evaluation of the Environmental Impact: It is the administrative procedure with which the environmental study impact is analysed and the correspondent impact declaration is executed, according to the legislation.

Impact declaration: The administrative decision of the environmental competent authority in which the convenience of executing the projected activity (with respect to the expected environmental effects) is determined. In case the activity is executed, the decision also describes the conditions that must be given in order to protect the environment and natural resources.

Environmental Manage Systems (EMS) and the product life cycle analysis (LCA)

They are the result of the different environmental disasters analysis and scientific assessment of environmental damage.

The most commonly used methodology to pass environmental audits is using Environmental Manage Systems (EMS).

What is an Environmental Manage System (EMS)

An EMS constitutes a part of a company's global management system including the organising structure, responsibilities, best practices and procedures to produce, implement, revise and maintain the company's environmental policy in order to manage the *Environmental Risk* associated to the activity carried out by the company.

What is a product life cycle analysis (LCA)

The LCA is an objective process than:

Evaluates environmental burden associated to a product, process or activity:

- Evaluates the use of matter and energy
- Evaluates product and sub-product generation
- Evaluates the waste spilled around, residues, wastewater and atmospheric emissions.

Analyses opportunities to execute environmental improvements.

Includes the complete cycle of the product, process or activity: Raw materials extraction, Production, Transport, Distribution, Use, Reuse and Final disposal

LCA objectives

- Supplying as complete as possible chart of the interactions between activity- environment.
- Contributing to understanding all the interdependent environmental consequences of human action
- Facilitating decision-making in environmental improvement opportunities
- Facilitating a constructive dialogue between sectors

ISO-14001 Norm

- Identifying potential environmental aspects
- Evaluating its significance
- Establishing procedures to respond to possible accidents and to allow prevention reducing impacts associated to them.
- Executing simulations
- Acting immediately over non-assumable risks
- Potential environmental aspects must be submitted to prevention and improvement

EMAS Norm

- Eco-Management and Audit Scheme
- Voluntary environmental management system
- Created and recognised by EU member in 1993

Difficulties related with EMS

Identifying and evaluating environmental aspects

Accessing to legislative and technological BBDD

Financing the EMS

Defining and monitoring indicators

Accessing quality education

Covering internal audit requirements

EMS associated costs

- Lab costs for sampling and analysis
- Purification systems maintenance costs
- Hiring services to treat waste disposal
- Environmental taxes
- Administrative paperwork, licenses and permissions
- Environmental insurances and guarantees
- Updating systems to new legislation costs

Industrial security and patrimonial risk prevention

The Penal Code (L.O. 10/95 of the 23rd of November) carefully regulates penal responsibility derived from a wide range of environmental or ecological crimes, with articles 325, 326 and 328.

Environmental civil responsibility dates back to 1902.

Activities with special environmental incidence

- Production, manipulation, storage, usage or disposal of dangerous materials.
- Confined usage, voluntary liberations and genetically modified organisms marketing
- Production and management of toxic and dangerous waste
- Valuing and disposing of all kind of waste
- Industrial activities listed in the A section of article 2 in R.D. 886/1988

3-4 Economical feasibility definitions

Economic Evaluation In Magnitud Order stage

Not easy, experienced engineers:

- Possibility to use elemental statistics
- Techniques applied in particular sectors
  - Industrial plant example, considering A old and B new plant

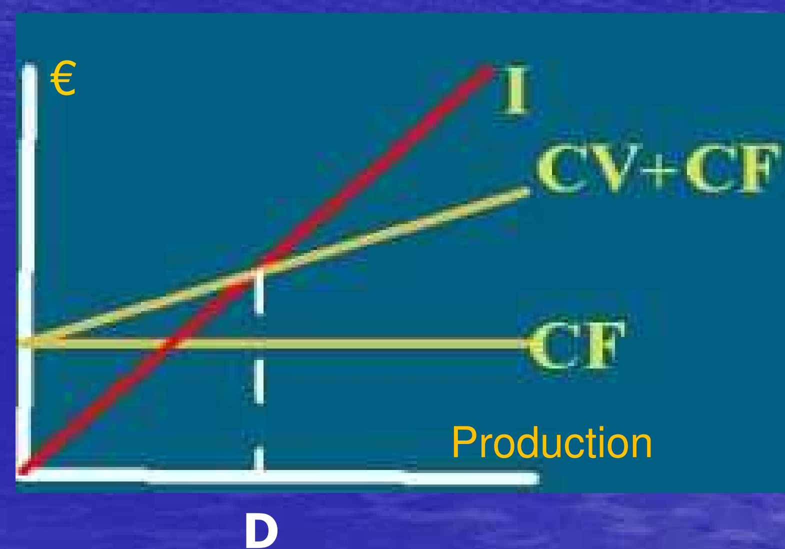
A Plant cost = Cta
B Plant cost = Ctb
A Plant capacity = CA
B Plant capacity = CB
Cta/Ctb = (CA/CB)**n

Industry	n	Cap. Unit
Cement	0.86	Tn/day
Industrial buildings	0.67	M2
Electric energy prod.	0.79	Mw
Refrigerating syst.	0.63	Tn
Residual water T.	0.68	Liters/day
Aluminum plant	0.70	Tn/year
Storage plant	0.63	Liters

Economical Evaluation during Preliminary Study stage

- Major precision in the initial costs
- First evaluation of the calculation of the deadlock or balance point **D**

  - I: Total Income
  - CV: Variable Costs
  - CF: Fixed Costs



Variable Costs

- Direct work cost
- Raw materials
- Spare parts
- Fuels
- Packing
- Commissions
- …

Fixed Costs

- Indirect work cost
- Amortizations
- General expenses
- Rents
- Financial interests
- Advertising
- …

Major precision in the project costs

- It must be a clear objective definition
- Easy evaluation of component costs
- Cost of the hours in the project realization:
  - In some cases, easy calculations
  - In others not so easy
  - Importance of past experience in similar projects
- Meeting with customer costs (*)
  - In some projects the customer is insatiable, with no limits
- Unforeseen events can apear

Typical economical ratios used at this level of knowledge:

Pay Back:
PB = Total Project Investment/Average Annual Benefit

Return Over Inversion:
ROI = Total Project Benefits/Total Project Investment

Not so used at this level of knowledge:

Countable Performance Rate:
r = Annual net benefit/ Average investment
Average investment= (Initial investment + residual value)/2 with fix annual amortization

Ratio Benefit – Cost:
RBC= Annual rent in n years/Initial Cost

Economical Evaluation during Pre-project/Draft stage

Net Present Value, NPV (VAN):

It is the updated value of all the foreseen Cash Flows Ci

NPV = -Co + C1/(1+K1)**1 +C2/(1+K2)**2+...Cn/(1+Kn)**n

K = discount types (money value)

- The greater NPV, the better.
- It is compared with an investment at a K interest

Internal Rate of Return IRR (TIR):

Doing NPV = 0 and value of **r** is worked out

r has to be greater than K

CASH-FLOW (Ci) in each period:

Income –Costs = Margin

Margin – Amortization = EBIT (BAII)

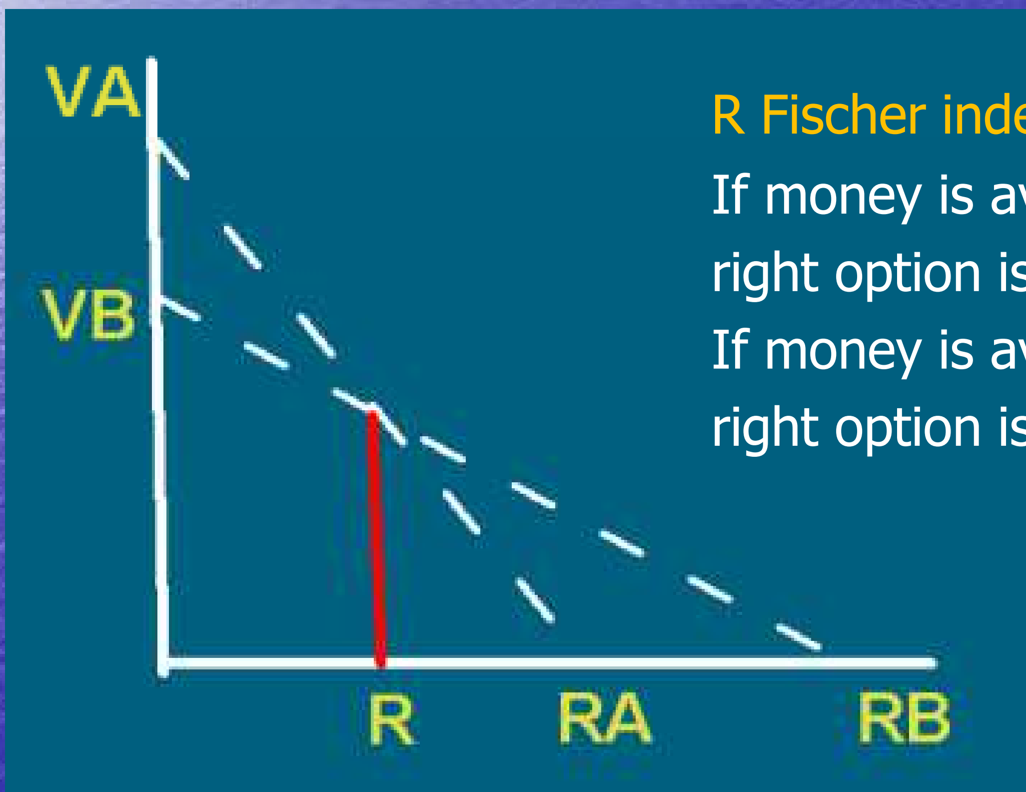
EBIT – Interests = EBT

EBT- Taxes = Net Benefit

Net Benefit +Amortization = Ci

EBITDA = EBIT + Depreciation + Amortization

Special situation IRR-NVP values:



R Fischer index

If money is available with Ri<R the right option is A

If money is available with Ri>R the right option is B

Other concepts to consider

Total Cost of Ownership (TCO)

TCO=sum(Direct costs+ indirects costs)

Due Dilligence

Due Diligence is a term used for a number of concepts involving either the performance of an investigation of a business or person, or the performance of an act with a certain standard of care. It can be a legal obligation, but the term will more commonly apply to voluntary investigations. A common example of *due diligence in various industries* is the process through which a potential acquirer evaluates a target company or its assets

Business Plan

Document investors oriented with an Executive summary, Innovation Team, Marketing plan, Production plan, Operational plan, Financial and Economical plan, Risks Analisys