Engineering as experimentation

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TOPICS COVERED

- Engineering as experimentation
- Engineers as responsible experimenters
- Concept of Risk and Safety
- Responsibilities of Engineers
- Risk Benefit analysis

What is Engineering?

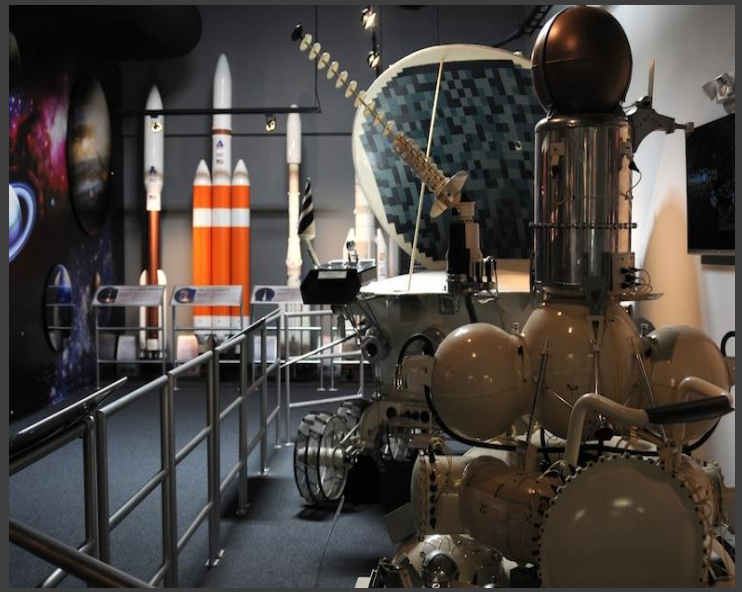
- **Engineering is the application of math concerned with the design, building,and use of engines, machines , and structures.**

- **Engineers figure out how things work and find practical uses for scientific discoveries.**

- **To solve real world problems that improve the world around us.**

Experimentation

A test under controlled conditions that is made to demonstrate a known truth , to examine the validity of a hypothesis or to determine the efficacy of something previously untried . The process of conducting such a test is called as a experimentation.



Engineering as Experimentation

Experimentation (Preliminary tests or Simulations) plays a vital role in the design of a product or process(Engineering).

The test for designing should be evolved till the final product produced. With the help of feedback of several tests, further modification can be made if necessary.

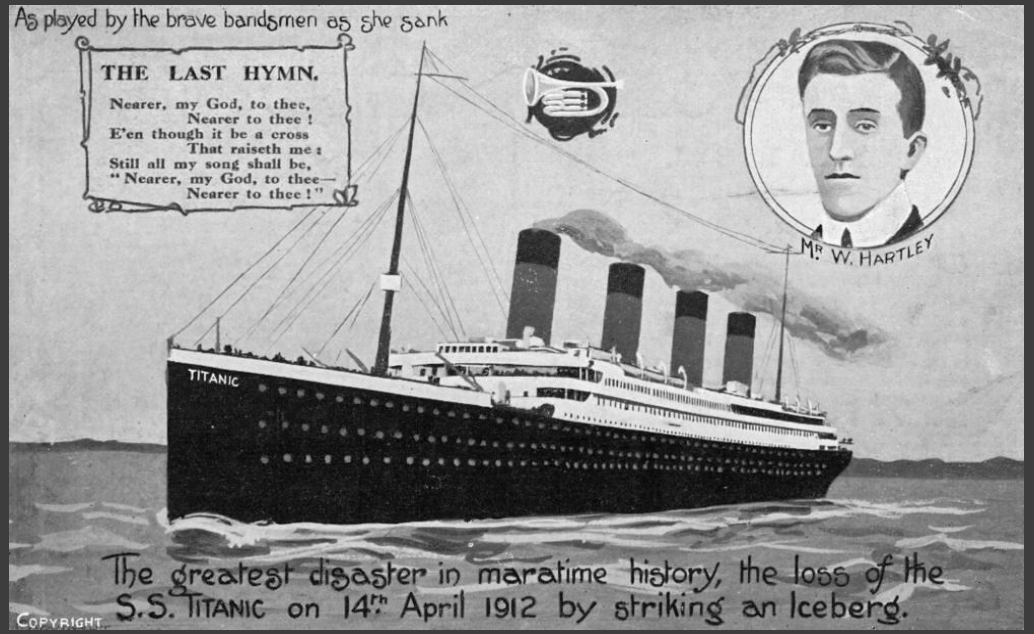
Beyond these tests and experiments, each engineering project has to be viewed as an experiment.

Engineering as experimentation

Experimentation process playing vital role because the engineering field itself is a risky one.

All product have potential dangers

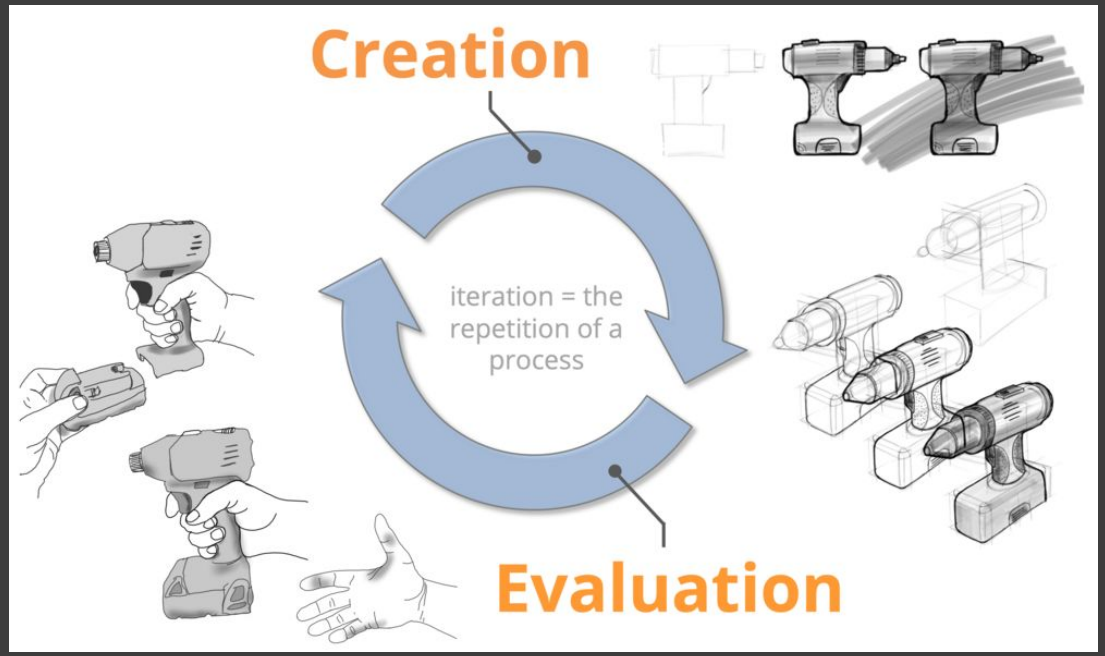
E.g Titanic ship



Before manufacturing a product or providing a project ,we make several assumptions and trials

We try different materials and experiments .

Thus , design as well as Engineerings
is iterative process as illustrated in
figure.

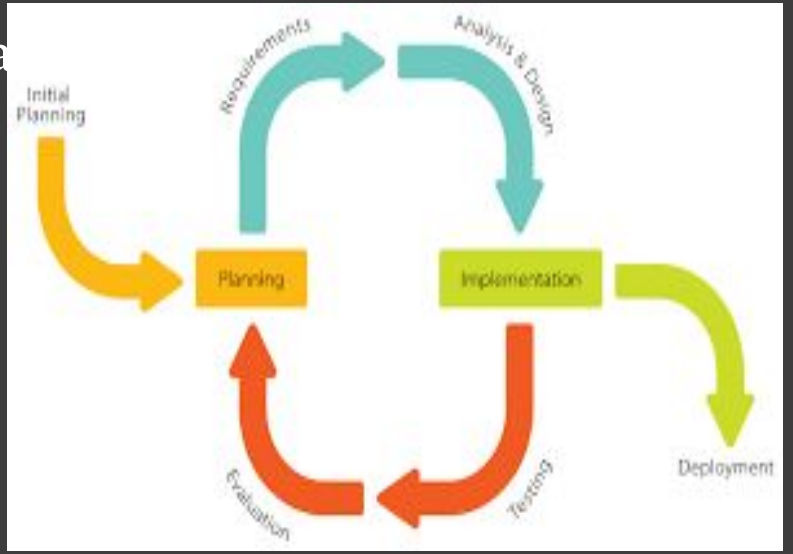


Design as an iterative process

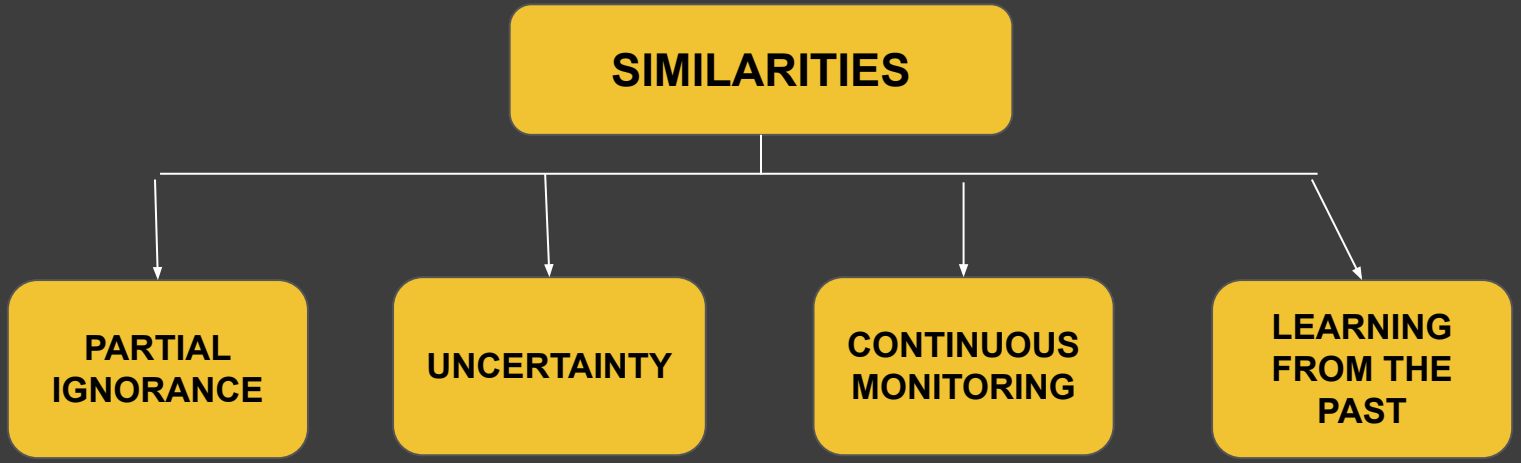
Several redesigns are made upon the feedba
information

Modification during execution

Hence ,the development of a product
or a project as a whole may
be considered as an experiment.



ENGINEERING PROJECTS VS STANDARD EXPERIMENTS



*project executed in Partial ignorance.
*uncertainty in the Model assumed.

*final outcomes of the projects are uncertain.
*unintended risks.

*needed before,during and after projects.

*learn from prior designs Infer from analysis of opera tion and reports of other engineers.

EXTRA! The Evening Star. EXTRA!

No. 18,628. WASHINGTON, D. C., MONDAY, APRIL 15, 1912 ONE CENT.

GIANT TITANIC GOES DOWN; HUNDREDS OF LIVES LOST.

PASSENGERS AND CREW

Women and Children Among Those to Perish When Steamer Sinks.

FIFTEEN HUNDRED MISSING AND BELIEVED DROWNED.

Six Hundred Passengers, Mostly Women and Children, Known to Be Safe—Olympic Finds Only Wreckage.

The White Star steamship Titanic sank at 2:20 o'clock this morning according to wireless dispatches received from various sources, and it is admitted that a large number of lives were lost. Just how many persons perished, it is impossible to tell. The White Star officials admit that there was a "horrible" loss of life. From Cape Race comes the statement that 675, mostly women and children, were rescued from the sinking ship. Passengers and

CLEAN-UP CRUSADE OPENS IN CAPITAL

Eyes of Nation Directed to City's War on Dirt.

CITIZENS TAKE PLACES ON THE FIRING LINE

Premises in All Sections of Washington Are Improved.

COMMITTEES ARE KEPT BUSY

Large Number of Children Report Activity About Own Homes During the Easter Holiday.

Campaign Suggestions.

1—Clean up your own premises first.

2—If in doubt as to any matter connected with the campaign, communicate by telephone with Dr. Murray, secretary, at the District health office, Main 800, Branch 38.

3—Obtain a copy of the clean-up instructions issued by the central committee at the committee headquarters in the District health office.

4—Report all nuisances that come to your attention to the central committee. This may be done by mail or telephone. It is not necessary that complainant's name be divulged.

5—Donations to defray the cost of conducting the campaign should be addressed to John Joy Edson, treasurer; Arthur C. Moses, chairman of the central committee, or Dr. William C. Woodward, chairman of the executive committee.

INTERVENTION HELD TO BE INEVITABLE

Believed U. S. Troops Will Be Necessary to Restore Order in Mexico.

INVASION IS FORECASTED IN PRESIDENT'S WARNING

Government Resents Mistreatment of American Citizens.

BOTH PARTIES ARE NOTIFIED

Ultimatum Presented to Federals and Rebels—Taft Authorizes Another Shipment of Arms.

Despite official disclaimers intervention by the United States for the restoration of peace and order in Mexico is now believed by even the most conservative observers to be practically inevitable, unless both parties to the conflict in that country heed the warning given by President Taft and reform their methods of warfare by paying more respect to the rights and interests of Americans and other foreigners in that country.

There is no other meaning to be given to the President's declaration that the United States will hold Mexico and the Mexican people, federals as well as rebels, "responsible for all wanton or illegal acts sacrificing or endangering American life or damaging American property or interests," and by the further declaration that "any maltreatment of American citizens will be deeply resented by the American government and people, and must be fully answered for by the Mexican people."

In issuing the above statements Wash-

Only 825 lifeboats!!!

2227 passengers

Full capacity: 3547

Similar incidents reported

!

Lesson not learned

CONTRASTS

EXPERIMENTAL CONTROL

* 2 groups - A & B are selected at random. A–special treatment B–controlled group in standard Experiment.
*does not happen in project.
.
.
.

HUMANE TOUCH

*Engineering experiments involve human souls, needs,views.

INFORMED CONSENT

*informed consent not practiced in engineering Like in medical experiments.

Koodangulam power
Sethusamudram
canal project

KNOWLEDGE GAINED

*not much new knowledge gained in engineering experiments.
* helps us to:
Verify adequacy, check stability and prepare unexpected outcomes of designs

ENGINEERS AS RESPONSIBLE EXPERIMENTERS

Although the engineers facilitate experiments, they are not alone in the field. Their responsibility is shared with the organizations, people, government, and others. No doubt the engineers share a greater responsibility while monitoring the projects, identifying the risks, and informing the clients and the public with facts. Based on this, they can take decisions to participate or protest or promote. The engineer, as and experimenter, owe several responsibilities to the society, namely,

1. A conscientious commitment to live by moral values.

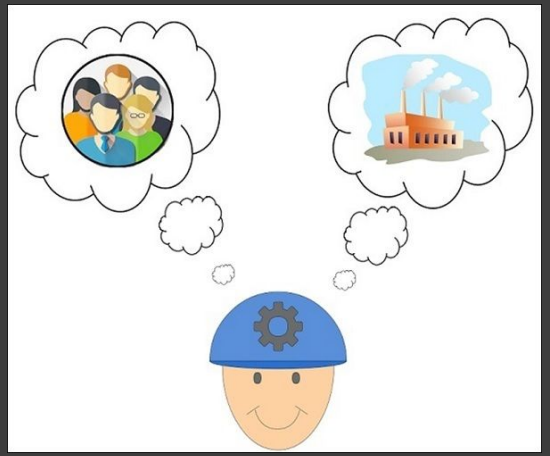
2. A comprehensive perspective on relevant information. It includes constant awareness of the progress of the experiment and readiness to monitor the side effects, if any.

3. Unrestricted free-personal involvement in all steps of the project/product development(autonomy).

4. Be accountable for the results of the project (accountability).

General features of moral responsible engineers:

1. Conscientiousness
2. Comprehensive Perspective
3. Moral Autonomy
4. Accountability



Conscientiousness

Conscientious moral commitment means: (a) Being sensitive to full range of moral values and responsibilities relevant to the prevailing situation and (b) the willingness to develop the skill and put efforts needed to reach the best balance possible among those considerations. In short, engineers must possess open eyes, open ears, and an open mind (i.e., moral vision, moral listening, and moral reasoning). This makes the engineers as social experimenters, respect foremost the safety and health of the affected, while they seek to enrich their knowledge, rush for the profit, follow the rules, or care for only the beneficiary. The human rights of the participant should be protected through voluntary and informed consent.

Comprehensive Perspective

The engineer should grasp the context of his work and ensure that the work involve results in only moral ends. One should not ignore his conscience, if the product or project that he is involved will result in damaging the nervous system of the people (or even the enemy, in case of weapon development). A product has a built-in obsolete or redundant component to boost sales with a false claim. In possessing of the perspective of factual information, the engineer should exhibit a moral concern and not agree for this design.

Moral Autonomy

Any person can be morally autonomous only when one is being genuine in one's commitment towards moral values. The moral autonomy is the ability to think critically and independently about moral issues and apply this moral thinking to situations that arise during the professional engineering practice.

When an engineer demonstrates moral autonomy, they are taking responsibility for their actions and the potential impact of their work on others. This can lead to better outcomes, as the engineer is more likely to consider the ethical implications of their work and make decisions that align with their values.

Accountability

Accountability includes being answerable for meeting specific obligations, i.e., liable to justify the decisions, actions or means, and outcomes, when required by the stakeholders or by law.

In the engineering practice, the problems are:

(*a*) The fragmentation of work in a project inevitably makes the final products lie away from the immediate work place, and lessens the personal responsibility of the employee.

(*b*) Further the responsibilities diffuse into various hierarchies and to various people. Nobody gets the real feel of personal responsibility.

(*c*) Often projects are executed one after another. An employee is more interested in adherence of tight schedules rather than giving personal care for the current project.

This makes them wary of showing moral concerns beyond what is prescribed by the institutions. In spite of all these shortcomings, engineers are expected to face the risk and show up personal responsibility as the profession demands.

Concept of Safety and Risk

RISK

- **Any work which might lead to harm us and is not considered safe, can be understood as a risk.**
- **“A risk is the potential that something unwanted and harmful may occur.”**
- **Risk involves the possibility of losing something of value, whether that be money, health, safety, or other resources.**

Risk is a broad concept covering many different types of unwanted occurrences. When it comes to technology, it can equally well include dangers of bodily harm, of economic loss or of environmental degradation. These in turn can be caused by delayed job completion, faulty products or systems or economically or environmentally injurious solutions to technological problems.

Safety

According to William W Lowrance,Safety was defined as “A thing is safe if its risks are judged to be acceptable.”

To be more clear on this, let us consider three cases.

1. **Let the first case be where we seriously underestimate the risks of something. Buying a non-brand electric dryer from a local market without any guarantee, may eventually send us to a hospital with a severe electric shock or burn. While buying this dryer, according to Lowrance definition, this is quite safe, as the risks are judged to be acceptable.**

2. Let the second case be where we grossly overestimate the risks of something. If we suddenly know that the consumption of carbonated beverages like cola are the cause of cancer for 5% of the world's cancer patients, then we start worrying considering Cola as a poisonous drink. So, in this case, the Cola becomes unsafe the moment we judged the risks of using it to be unacceptable for us.

Let the third case be a situation wherein, a group makes no judgment at all about whether the risks of a thing are acceptable or not. This is the position where the thing is neither safe nor unsafe with respect to that group. Just like using the products of certain brands are considered safe, while others are not where nothing seems to differ.

For e.g driving a car on a well- maintained road. Here we can solve this dilemma by saying driving is relatively safe.

Acceptability of Risk

"A risk is acceptable when those affected are generally no longer apprehensive about it".
Influential factors that lead to such apprehension are –

- **Whether the risk is accepted voluntarily.**
- **The effects of knowledge on how the probabilities of harm (or benefit) are known or perceived.**
- **If the risks are job-related or other pressures exist that cause people to be aware of or to overlook risks.**
- **Whether the effects of a risky activity or situation are immediately noticeable or are close at hand.**
- **Whether the potential victims are identifiable beforehand.**

Job Related Risks

In some jobs where the workers are exposed to chemicals, radiations and poisonous gases etc., they are not informed about the probable risks the workers would be facing, in doing their jobs. These are such dangers where the toxic environments cannot readily be seen, smelled, heard or sensed otherwise.

The workers at such places are simply bound to their work and what they are told to do. The health condition of a person who gets affected under such environments cannot be neglected because that will be the future condition of co-workers.
For e.g - Engineers faces design risk and environmental risk.

Job Related Risks -Engineering

- **Physical Hazards:** Engineers working in fields such as civil engineering, construction, or manufacturing may be exposed to physical hazards such as working at heights, exposure to hazardous chemicals, working with heavy machinery or equipment, and handling potentially dangerous materials. These hazards can pose risks of accidents, injuries, or occupational illnesses if proper safety precautions are not followed.

- **Ergonomic Hazards:** Engineers who spend long hours working at desks or using computers may face ergonomic hazards such as poor posture, repetitive motions, and inadequate workstation setup, which can result in musculoskeletal disorders and other health issues.

- **Environmental Factors/ Design Risk :** Environmental factors such as extreme weather events like earthquakes, hurricanes, or floods can impose significant loads on the structure and potentially result in structural failure if the building is not designed and constructed to withstand such forces.

Risk-Benefit Analysis

Risk-benefit analysis, also known as cost-benefit analysis, is a decision-making process that involves evaluating the potential risks and benefits associated with a particular action, activity, or decision. It is commonly used in various fields, including business, finance, economics, public policy, to assess the potential risks and benefits of different options and make informed decisions.

The major reasons for the analysis of the risk benefit are:

1. To know risks and benefits and weigh them each
2. To decide on designs, advisability of product/project
3. To suggest and modify the design so that the risks are eliminated or reduced

Risk-Benefit Analysis -Process

The process of risk-benefit analysis typically involves the following steps:

1. Identify the risks and benefits: Clearly define and identify the potential risks and benefits associated with the action or decision under consideration.
2. Compare the risks and benefits: Compare the quantified risks and benefits to determine the magnitude and significance of each, and assess their relative importance.
3. Weigh the risks and benefits: Consider the likelihood or probability of the risks and benefits occurring, as well as the potential consequences or impacts of each.
4. Make a decision: Based on the comparison and weighing of the risks and benefits, make an informed decision on whether the benefits outweigh the risks, or vice versa.
5. Monitor and review: Regularly review and monitor the risks and benefits associated with the decision or action, and update the analysis as new information becomes available.

Responsibilities of Engineers

COLLEGIALITY

It is the tendency to support and cooperate with colleagues. It is the virtue, essential for the team work to be effective. The main factors that help in maintain harmony among members at a workplace are –

- Respect to the ideas and work of others
- Commitment to the moral principles
- Connectedness

Loyalty

Loyalty is the faithful adherence to an organization and the employer. Loyalty to an employer can be either of the two types –

- **Agency-loyalty** – It is an obligation to fulfill his/her contractual duties to the employer.
- **Attitude-loyalty** – It is concerned with attitudes, emotions and a sense of personal identity as it does with actions. It includes willingness to meet moral duties with attachment, conviction and trust with employer.

Respect for authority

In order to meet the organizational goals, the professionals should possess respect for authority. The levels of authority maintained by the organization provides a means for identifying areas of personal responsibility and accountability. Following are the major types of authority –

- Institutional Authority – The corporate or institutional right given to a person to exercise power based on the resources of an organization.
- Expert Authority – This is the possession of special knowledge, skill or competence to perform a particular task or to give sound advice.

Collective bargaining

Collective bargaining is the process in which working people, through their unions, negotiate contracts with their employers to determine their terms of employment, including pay, benefits, hours, leave, job health and safety policies, ways to balance work and family, and more. There always exist conflicting views between the professionalism and unionism.

Types of Collective bargaining

- Distributive Bargaining – In this, one party's gain is another party's loss. Example – Wages
- Integrative bargaining – In this, both the parties may gain or none of the parties may face a loss. Example – Better training programs
- Attitudinal Structuring – When there is backlog of bitterness(ego) between both the parties then attitudinal structuring is required to make smooth industrial relations.
- Intra-organizational Bargaining – There can be conflicting groups in both management and unions also. So, there is need to achieve consensus in these groups.

Types of Risks

PERSONAL RISK - Loss of senses such as sight, hearing or loss of limbs.
Loss of earning capability especially due to physical disability.

PUBLIC RISK - Assessing the public risk is relatively easy, as in the societal value system the cost of disability can be averaged out. To assess the public risk, the loss on the assets and correction cost are estimated.

VOLUNTARY RISK - Involvement of people in risky actions, although they know that these actions are unsafe. The people take these actions for thrill, amusement or fun. They also believe that they have full control over their actions (including the outcomes!) and equipments or animals handled, e.g., people participate in car racing and risky stunts.

CONCLUSION

In the process of developing a product, an engineer generally learns through experimentation.
Even the outcomes of the experiments may not be as expected. An engineer should always be ready for the unexpected output. The improvement of current prototype will lead to some change which may or may not be fruitful.

THANK YOU!