FUTURE RISKS IN PROJECT ENGINEERING

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Abstract

The text is a proposal of Innovations in Risk Management for Engineering Projects. The subjective framework of risk makes that consideration is first given to the more frequent events; these events have generally lower impact.

Probability does not exist for Risks, like: voluntary anthropogenic events (terrorism and armed conflicts); some abnormal natural events (such as Climate Change); big crisis (that impact economy, environment and society). It is about situations of “low probability” and enormous potential of damage. They are often undervalued, avoiding anticipative solutions.

The text proposes a forecast of Risk for the next decades, understanding that risk perception and acceptance has, in its essence, a social dimension.

An increase of the contingency capacity betters the resilience to such events. This capacity includes the uses of early warning systems and anticipation; “talk” with the citizens as part of the solution.

As a conclusion, Engineering Projects must adopt methods to dialogue with the stakeholders, specially with citizens, as a way to respond to Risks of the Future.

Keywords*: Future Risks, Project Risk Management, Risk Prediction*

Resumen

El texto plantea innovaciones en Gestión de Riesgos en Ingeniería de Proyectos. Afrontar los riesgos tiene un marco subjetivo donde se consideran primero los eventos más frecuentes, y con impacto menor.

Por otro lado, la probabilidad no existe para los Riesgos, como: incidentes antropogénicos voluntarios (terrorismo o conflictos armados); los atípicos derivados de la acción de la naturaleza (Cambio Climático, etc.); y las grandes crisis (que afectan a economía, ecología y sociedad). Se trata de situaciones de “ baja probabilidad” y con daño potencial enorme; son a menudo infravalorados, evitando plantear soluciones anticipativas. El texto realiza una pronóstico de la evolución de los Riesgos de las próximas décadas, entendiendo que la percepción y aceptación del Riesgo tiene una dimensión social esencial.

Un incremento de la capacidad de contingencia permite poder afrontar los Riesgos citados en mejores condiciones. Esta capacidad incluye los sistemas de predicción y anticipación y la articulación de un diálogo con los ciudadanos.

Es pues prioritario que los Proyectos de Ingeniería aborden este diálogo de las personas involucradas, sobre todo los ciudadanos, para dar respuesta a los Riesgos del Futuro.

Palabras clave*: Riesgos del Futuro, Gestión de Riesgos, Predicción de Riesgos*

1. Introduction

World changes are enormous and we notice that impact every time quicker; among more uncertainty and under situations where unknown risk is present; rarely do we pay enough attention.

The aim of the research work is to adapt ourselves to deal with such new risk and uncertainty models. The text revises basic ideas as risk, hazard and uses Psycho cognitive theory and experience from a research on Crisis as Disasters and Catastrophes as well as on Big Changes or Radical Innovation.

Project Engineering should not explain any more serious incidents based on “fortuity” or “exceptional” and misuse on the legal protection against responsibility and liability of norms and rules build on past or historical data. Recent years’ news proves our inability to cope with “exceptional situations” that are becoming common.

Project Engineering must pay special attention to Global Risk scenarios, Global Catastrophic Risks and Existential Risks. We should cope with an uncertain future where more sophisticated visions and models of Risk are needed to reverse fallacies and cognitive biases, and as a consequence, enable a better Risk Assessment for Project Engineering.

2. Objective: Global Risk scenario

2.1 Dimensions of Disruptive Risks

The main objective of this section is understanding the Global Risk scenario. Low and Medium-impact risks are thoroughly studied in Project Engineering Risk Analysis. Exceptional Risks are often transferred to Insurance or covered by laws or norms created from history of the past. The political processes for updating such norms often mean inadequate responses to present and future Global Risk scenarios. (Smil, 2008)

The first step is describing the situation and the dynamics of important harmful events that are relevant to Project Engineering in the next five decades. The text approach is:

- Avoiding extreme positions towards the XXI Century Scenarios of Risk. Project Engineering must prepare responses to avoid or mitigate impacts of events like violence, natural disasters, technological accidents, pandemics; Project Engineers can drive response to face these challenges using science and technology.
- Adopting scope, intensity and probability as variables, settle a series of important risk severity categories. Global catastrophic and existential risks are part of a taxonomy that could dimension the risk scenario in specific Project Engineering cases.
- Understanding of 2008 dimensions of Catastrophic Risks, using Swiss Re latest study. 137 natural catastrophes and 174 man-made disasters make 2008 one of the worst years. Awareness of not-such-exceptional-situations must be included in normal Project Engineering practice.

2.2 XXI Century Scenarios for Risk and Project Engineering

XXI Century Project Engineering must respond to present and future Risks. “The unusual and the unknown make us either overconfident or overly fearful”. (Gaius Julius Caesar, Comentarii de Bello Civili, II.4) Inexorable progress or unavoidable collapses are two extreme positions. We must accept that no individual will be prescient enough to separate the matters that are truly consequential from those that appear important but will make no difference. (Smil,)

Project Engineering may increase our understanding of the importance of faint or weak signals. Low-probability events may change in an instant everything. Unfolding trends will come as unpredictable discontinuities. Poorly predictable events need a critical, interdisciplinary exam.

Economic collapse, social turmoil, widespread violence, a deteriorated global environment, viral pandemics, etc. must be understood for prevention, anticipation and improvement; Project Engineering can contribute to our effort to reverse trends.

Natural and anthropogenic catastrophes and disasters unfold trends that must be studied. Natural catastrophes (less frequent, geotectonic processes –killed 900,000 people between 1970-2005; more frequent and increasing, effects from extreme temperatures- 550,000 people, killed by floods and cyclones during the same period) (Swiss Re reports).

Violent conflicts or man-made death has been and is the single largest cause of non-natural mortality. Terrorists in the future will exploit the potential of the growing complexities of modern societies. Attacking nodes of electricity networks, energy supply systems –nuclear power systems included-, water systems, harvested-crops, chemical factories and communication links are easy and impossible to safeguard at the present moment. Design and Project Engineering will face this conflict, submit ideas and solve specific problems like those mentioned.

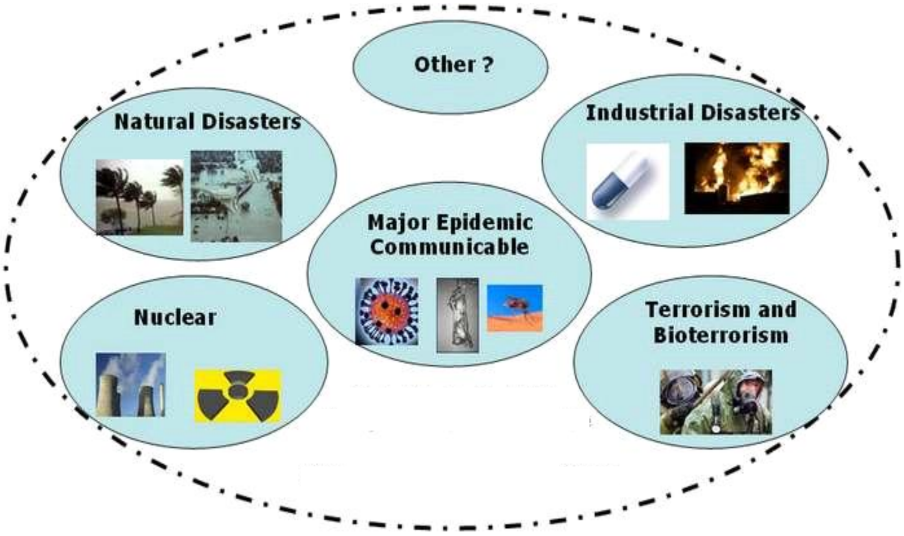

Figure 1. Natural and Anthropogenic causes of Health Crisis (source: www.gaptheproject.eu)

Science and Technology are source of both negative and positive outcomes. “One type of threat comes from humanity’s collective actions: we are eroding natural resources, changing the climate, ravaging the biosphere and driving many species to extinction”.

Climate Change is the number-one environmental challenge. The most vulnerable people (for instance, Africa and Bangladesh – see graphs and text in par. 2.4) are the less able to adapt. Because of the burning of fossil fuels, the CO_2 atmospheric concentration has reached levels that it has never been in the last half million years. The greater the concentration the warming and the possibility of triggering something irreversible (i.e.: the melting of Greenland’s icecap and rising sea level). It requires coordinated action and altruism towards our descendants. The “worst case” is a “runaway” process that would render much of the Earth inhabitable.

Our society confronts “threats without enemies”. Among it is the threat to biodiversity. Five extinctions occurred in the geological past and humans are now causing the sixth. “We are destroying the book of life before we have read it.”

Genetic manipulation is also an area of concern. We produce bacteria, yeast, etc. for industrial, pharmaceutical, etc. processes. The matter is not moving genes, is shaping life. Mutability of the multitude of viruses represents a frightening eventuality if we imagine a pathogen as virulent as HIV or more.

2.3 Global catastrophic and existential risks

Global catastrophic risks have the potential to inflict serious damage to the human in a global scale. A long list of candidates constitutes global catastrophes. 10,000 fatalities or 10 billion dollars would not qualify for a global catastrophe, but 10 million fatalities and 10 trillion dollars worth of economic loss would count as a global catastrophe. Disasters between these points can be characterized by the severity of risk by three variables:

- Its **scope**: how many people and other relevant beings would be affected. It can be personal (affecting one person), local, global (affecting a large part of the population), or trans-generational (affecting also the world population that would come to exist)
- Its **intensity**: how badly these would be affected. It could be classified as imperceptible (barely noticeable), endurable (causing significant harm, but not destroying quality of life completely), or terminal (causing death or permanently and radically reducing quality of life).
- Its **probability**: the probability dimension that is not displayed in the diagram, and is one of the essential matters of discussion in this text.

An important subset is existential risks. They threaten the extinction of Earth-originating intelligent life or reduce quality of life permanently and radically.

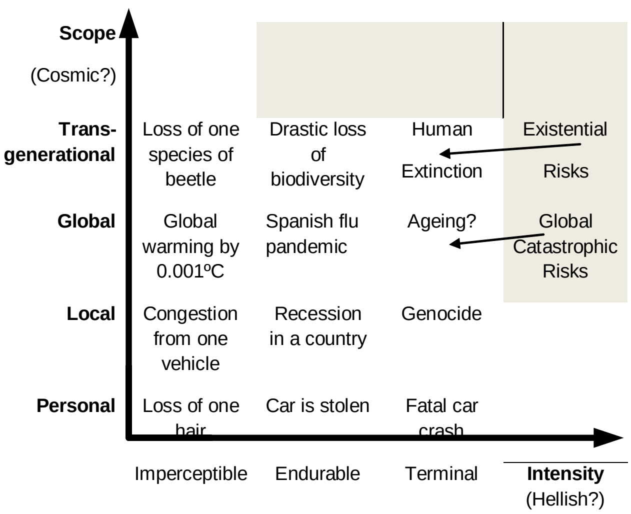

Figure 2. Taxonomy of risk categories. Global and Existential Risks. (Bostrom,)

We must generate a more systematic thinking on Risk and Project Management. For many risks there is abundance of data (from past impacts of meteorites we can determine a probability); for most of risks we lack of data. We must rely on plausibility arguments, analogies and subjective judgement.

2.4 The Global Scenario of Risk

Swiss Re's latest sigma study is relevant to avoid under or over estimating the importance of Disasters and Catastrophes: "2008 was one of the worst years for catastrophe losses; 2008 was exceptional in terms of fatalities and losses. More than 240 500 people lost their lives. Insurers across the sector paid out USD 52.5bn to compensate for property claims, and the total impact on the economy caused by natural and man-made catastrophes around the world added up to USD 269bn".

137 natural catastrophes and 174 man-made disasters occurred in 2008 (see fig. 4).

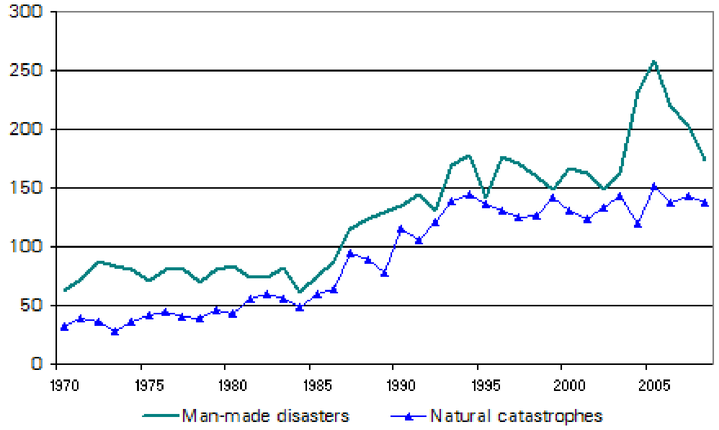

Figure 4. Number of Natural and Man-Made disasters and catastrophes (Swiss-Re)

Asia suffered the most in terms of the number of lives lost, while the US was worst hit in regard to insured property losses. Europe was less impacted with only minor losses compared to last year.

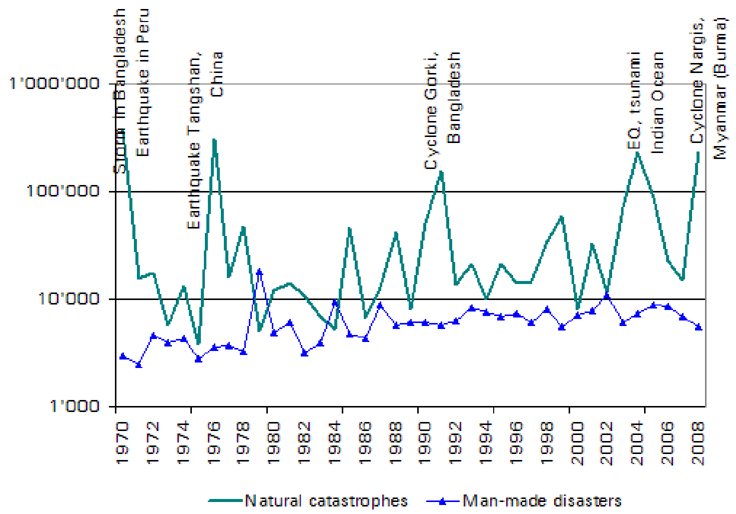

Figure 5. Lives lost in Natural and Man-Made disasters and catastrophes (Swiss-Re)

Natural catastrophes cost property insurers more than US 44.7billion. High catastrophe claims in the US were driven by Hurricanes Ike and Gustav as well as thunderstorms during the first half of 2008. Europe's losses, down from last year, represented slightly more than a tenth of the world total in 2008, largely due to lower storm and flood damages. In early 2008, China suffered losses amounting to more than USD 1.3bn, driven by an unusually cold winter with record amounts of ice and snow.

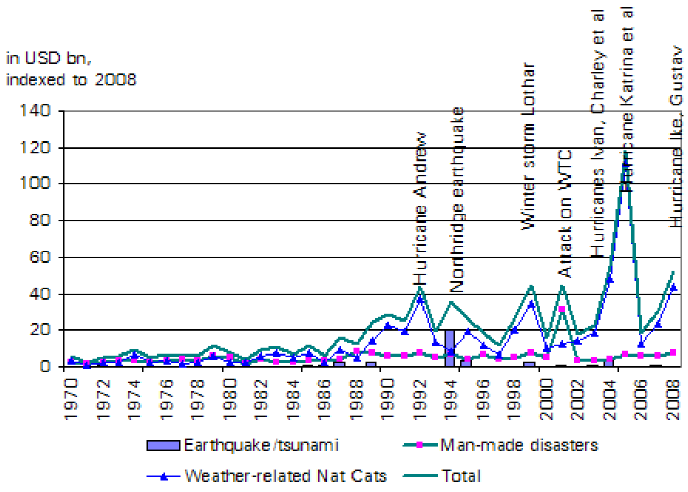

Figure 6. Insurance losses in Natural and Man-Made disasters and catastrophes (Swiss-Re)

Major man-made disasters caused losses of USD 7.8 billion in 2008, with large-scale industrial fires, explosions and losses in the energy sector at the top of the list. Man-made catastrophes resulted in 5,600 deaths in 2008; shipping and boating accidents as well as bombings and social unrest caused the most casualties.

In 2008, the total damages to the economy amounted to USD 269 billion worldwide. Almost half this amount can be attributed to the earthquake that struck China in May, which caused costs to the economy of USD 124 billion. This corresponds to approximately 3% of China's GDP.

3. Risk and Uncertainty: models, fallacies, and cognition

3.1 Uncertain future and Risk

Uncertainty is inherent to every facet of our lives. Project Engineering is a multi-disciplinary endeavor that faces complex problems in government and industry. It involves consideration of uncertain future events. Multiple stakeholders, power brokers, economic or environmental constrain, sociopolitical and geographical forces, etc. color or affect decision-making along the different Project phases.

Academia and practitioners devote a large portion of time and effort to deal with uncertainties in decision-making. The more we know, the more we find that much remains unknown.

The text approach is the diffusion of more useful definitions of risk, and the need to avoid to early risk models and the limits of the expected value approach. Finally cognitive biases and judgement of risk are explored: our brain cannot return good answers for global risks due to its dimension.

3.2 Risk useful definitions

Risk as a measure of probability and severity of adverse effects is a concept that many find difficult to apprehend. A more precise definition of Risk is: combination of probability (likelihood of the incident) and severity (the magnitude of the damage or loss of people, property and environment – or elements at risk damaged or lost).

There are confusions between Hazard and Risk. Hazard is the inherent potential of a material or activity to harm people, property, or the environment. Hazard does not have a probability ingredient (or chance) as the Risk.

For the vulnerability idea we can see (Alexander, 2002) the overlap between concepts of hazard, vulnerability and risk as in figure 4:

- **Hazard** is expresses danger: natural, technological and social.
- We associate **Risk** to the **likelihood of impacts**.
- **Vulnerability** is the susceptibility of people, things and environment to losses attributable to a given danger, a given probability that a hazard will manifest itself at a particular time, place, way, and magnitude.

A natural disaster is linked to the threat of a natural danger and the existence of vulnerable assets, or elements at risk: personal, social, property… Then, the hazards are a trigger to vulnerability.

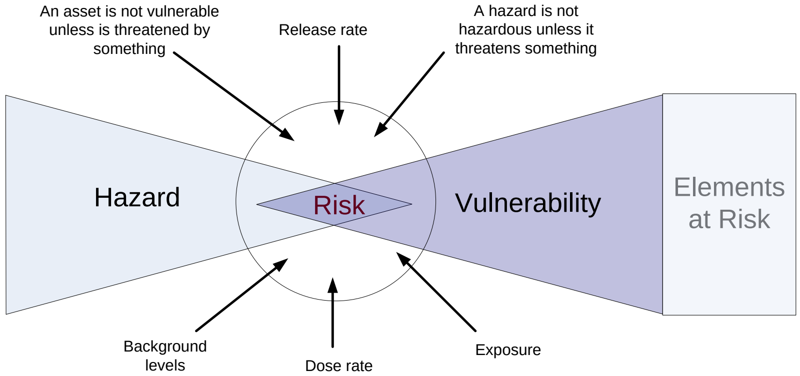

Figure 4 - Relationship between hazard, vulnerability, and risk associated concepts (Alexander, 2002)

(Haimes) A similar definition of risk is the product of impact, vulnerability and threat.

- **Vulnerability** is the manifestation of the inherent states of the system (physical, technical, organizational, cultural, etc) that can be exploited to adversely affect (cause harm or damage) that system.
- **Intent** is the desire or motivation to attack a target and cause adverse effects.
- **Threat** is the intent and capability to adversely affect (cause harm or damage to) the system by adversely changing the states.

Risk (when viewed from the perspective of terrorism) can be considered quantitatively as the result of a threat with adverse effects to a vulnerable system. Quantitatively, however, is a measure of the probability and severity of adverse effects.

Modeling risks as the probability and severity of adverse effects requires knowledge of the vulnerabilities, intents, capabilities, and threats to the system (infrastructure, plant, product, etc.) "In the example of a terrorist network as a threat to change some of the fundamental states of a country: from stable government to unstable government, from operable infrastructure to inoperable infrastructure, etc. These terrorist networks have the same goals as those commissioned to protect its safety, albeit in opposite directions – both want to control the systems in order to achieve their objectives"(Haimes).

Our first observation is that Risk (and Risk Management) depends strongly on Psycho Cognitive processes.

3.3. Too early Risk Models

Risk definitions shown in previous paragraph include terms as "likelihood of impacts", "probability". Aphorisms like (Morgan,2007):

- "Probability does not exist" Bruno de Finetti, preface *The Theory of Probability*
- "The theory of the probability is at the bottom nothing but common sense reduced to calculus" (Pierre de Laplace, *Théorie Analytique de Probabilités*) (1812-20).

Both raise important questions about the use of probability. We can use the objective or frequentist, or classical and the subjectivist or Bayesian views.

Frequentist or classical view defines probability as the frequency of an event for a long sequence of trials. There are events where probabilities are knowable, but in risk and uncertainty situations, in Project Engineering we often need probabilities that are "unknowable".

In the Bayesian or subjective view, likelihood or probability is a measure of "uncertain belief" the output of a "compatible sets of beliefs, values, models, and decisions". Information relevant to an event is used by a person that may acquire new information; it depends on the observer, this is why "probability does not exist". Once again, we see the importance of Psycho Cognitive processes.

A good way if we wish to represent uncertainty about an empirical quantity we may use a probability distribution and select parameters. Talented specialists can develop a mathematical model. We face the problem of inherent randomness, as in quantum mechanics theory we may view Heisenberg indeterminacy, or still Einstein's dictum: "God does not play with dice". We must acknowledge our limited understanding of our world. Some systems are unpredictable and in the case of non-linear systems they show a big sensitivity to initial conditions. As a conclusion, avoid too early Risk Models, good judgment, experts, etc. can improve our vision of Risk scenarios.

3.4. The fallacy of the expected value

We must accept the limitations of mathematical modeling as a way to represent reality. Risk analysis is cross-disciplinary; it involves engineers, scientists of social or behavioral sciences, lawyers, economists, etc. Project Engineering must build an extended professional community requiring effective and efficient decisions has been more critical on existing tools.

Tools must capture not only the average risk but also the extreme and catastrophic ones. The best decisions are not necessarily the optimal in sense of maximizing expected utilities, but rather to avoid the worst, the extreme.

Risk is quantified by an operation that multiplies discrete or continuous event by its probability of occurrence and sums this values over the entire universe of events. Low probability or less frequent exceedance highly adverse events are compared with high probability of exceedance and low consequences (probability of exceedance is one minus the cumulative distribution functions 1-cdf) (Haimes, 2008).

The expected value fallacy when it is used as the sole criterion for risk in decision making. The problem is averaging extreme and catastrophic events with more commonly occurring high frequency/low-consequence

3.4 Cognitive biases and judgement of risks

Humans use methods of thought "heuristics" which quickly return good answers in most of cases (Bostrom,2008). Systematic errors affect heuristics, named biases. A society well protected against minor hazards will take no action against major risks. It will guard against regular minor floods and not occasional major floods. Risks of human extinction might be underestimated. "Humanity has never yet encountered an extinction event". There are different studies on biases, but the more important is "not knowing what we do not know".

There has to be an organized body of thinking about global catastrophic and existential risks. The hazard of being a biological human running on an analogous brain; the brain can not multiply 6 billion and understand the stakes of the 6 billion human alive today. We cannot feel it. All we can do is to defend it. (Bostrom, 2008).

4. Concluding remarks

The concluding remarks and recommendations include main findings of our research that Project Engineering can integrate in dealing with "abnormal" Risks:

- Risk scenarios and cognitive biases and judgment: Focus is on information and on predictive and anticipative models, to produce generic predictive models for specific risks. Anticipation includes looking into research in risk prediction, assessment and management tools for preparation, surveillance, support and intervention in case of large-scale adverse events.
- Risk definition: an increase of the resilience or the contingency capacity to such events. It involves "talk" with the citizens.

Project Engineering can be extremely useful in reversing the impact of "low probability" voluntary anthropogenic events and natural events.

The proposal should include the development a holistic and full life cycle approach that may start in the early detection of weak and warning signals. It will include collection, distribution and analyses of information signals and signs. The objective is helping decision makers to raise the flag and alert national and multinational administrations and populations in an early and timely span. (Pons, 2008).

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