IMPACT ON RISK ASSESSMENTS WHEN EVALUATING PROBABILITY WITHOUT CONSIDERATION FOR HUMAN OR ORGANIZATIONAL FACTORS

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ABSTRACT

What is the impact on risk assessments when evaluating probability in scenarios without consideration for Human or Organizational Factors? Accidents and incidents cost lives, resources, grief and frequently years of an organization's reputation. The prevention of these undesirable outcomes is often controlled through risk management mitigation processes. Often, risk assessment results are purely based on assessor's personal values, experience, training and objectivity including assessment activity time constraints. Full understanding and appreciation for a complete context spectrum of the events therefore becomes a necessity in the decision making of probability versus possibilities.

This study uses a quantitative strategy to point out that qualitative research can help to illustrate the blind spots in established approaches to risk assessments. A survey was conducted to illustrate how the bridging of both quantitative and qualitative assessments can play an important role when probability decision-making is at hand. Results show that assessing probability in risk assessments without having considered all factors may jeopardize the quality level of the assessment and create uncertainty; contrarily, assessing probability in risk assessments with all human and organizational factors, can create a greater degree of certainty and understanding in the evaluation process and increase credibility in the future of risk assessments.

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Introduction

On September 9, 1980, during Typhoon Orchid south of Japan, the M. V. Derbyshire vessel carrying 44 passengers sank due to uncertainty about her precise state and speed during the typhoon, as well as wave conditions at the time. The sinking of vessel was most likely the cause of risk analysis (including probability) performed on a range of scenarios, in order to identify conditions at the time.

“Before there were sophisticated analytic tools such as probability theory, scientific risk assessments, and cost benefit calculus, humans used their senses, honed by experience, to determine whether the animal lurking in the bushes was safe to approach or the murky water in the pond was safe to drink.”(Slovic, 2006 p.10)

When, then was the theory of probability developed? According to Garibaldi (1997), “probability theory was first developed in the seventeenth century by Pascal and Fermat” (p.42) and has been applied ever since in many different processes, mostly in risk assessments in conjunction with severity and exposure to achieve quantification level of risk.

Halpern, (2006) adds:

> By acknowledging and modelling uncertainty in parameter estimates, we have provided an explicit tool for describing and explaining to stakeholder groups the realities of the state of scientific understanding and the consequences of the uncertainty inherent in that understanding. More importantly, the uncertainty modeling approaches have provide a mechanism for stakeholder groups to quantitatively evaluate acceptable levels of risk

> and then make informed decisions about reserve network designs based on those evaluation. (p.10)

How does one define the level of risk? Some will say that defining risk is an exercise of power and "if risk is defined one way, then one option will rise to the top as the most cost-effective or the safest or the best. If it is defined another way, perhaps incorporating qualitative characteristics and other contextual factors, one will likely get a different ordering of action solutions."(Slovic, 1999 p.689). Others, such as Jasanoff (1993) will say that "most risk analysts, regardless of their disciplines, would probably agree that risk assessment is not an objective, scientific process; that facts and values frequently merge when we deal with issues of high uncertainty; that cultural factors affect the way people assess risk; that experts perceive risk differently from other members of the public; and that risk communication is more effective when it is structured as a dialogue than as a one –way transfer of facts from experts to the public". (p.123)

It has been noted during the research for this thesis that "the problem of risk perception has been repeatedly the topic at professional meetings and that it would vanish if only probability was better understood" (Jasanoff, 1993, p.123). Is it that it is not well understood or is it that assessing is done purely on assigning numbers without sufficient contextual information? According to Nyce and Dekker (n.d.), such thinking invokes quite linear essentialist ideas about how the world works (and likely falsely so), as if it would be so that "if enough is known about the initial conditions and parameters of a system, when Newtonian laws are derived for this system, it will be possible to predict it's future". (p. 5)

If assessors have some understanding of probability concepts and how they are measured, why then would the process show signs of concerns or limitations?

If we take a closer look at the U.S. Government's nuclear reactor safety risk assessment that was condemned by Speed (1977) after it came out with estimates of: probability of one chance in 20, 000 per reactor per year a core meltdown at;

> One chance in a thousand million per reactor per year that containment would fail, releasing virtually all the volatile and gaseous products into the atmosphere; one chance in sixteen million per year of an individual in the US being killed by a reactor accident; and so on.

The calculations were based upon a fault tree analysis, which is a diagram linking all the things that might go wrong and cause disaster. Hundreds of probability statements were made about things like the following:

(i) The pump will work when required.

(ii) The operator will turn on the switch when required.

(iii) The safety system is undergoing maintenance when required.

Among more technical criticisms, Speed [1977] condemned the Reactor Safety Study on three elementary grounds:

a) Individual probabilities ascribed to events were based upon little or no data and were sometimes purely subjective.

b) There were unfounded assumptions of independence in chains of events, which could cause gross underestimates of the probability.

c) Fault tree analysis can only consider the chances of failure from an anticipated cause. It is possible that an unanticipated cause of failure may have a reasonably large probability of occurring. (Probability", n.d)

It becomes evident from the Nuclear Reactor Safety Study that one of the problematic areas in assessing probability is that there are clearly multiple conceptions of risks. Slovic (1999) states that "the traditional view of risk characterized by event probabilities and consequences treats the many subjective and contextual factors as secondary or accidental dimension of risk just as coloration might be thought of as a secondary or accidental dimensions of an eye".(p. 691)

Despite the many tools available in assessing probability, there are psychological factors that will come into play and impact decision-making. As written by Emerson, "people seem not to see that their opinion of the world is also a confession of character." (Ralph Waldo Emerson).

Let's not forget that there may be times when circumstances obtained are so unique or the outcomes so infrequent that it is meaningless to tabulate experience as a measure of their probability.

This thesis will explore a new science of probability in risk assessments that have occupied the high echelons of government and many intellectual circles, and that will continue to expand in decades to come. It will then look at the current processes in place when assessing probability, and why they are problematic or lacking information, followed by a discussion in what complexity systems reveal about risk in the areas of insensitivity to probability and managing the emotions. Finally, the results of a survey conducted will be laid out for the purpose to highlight “understanding that there are connections between technical knowledge and the context in which it is produced may make practitioners more reflectively conscious of biases built into their own methodological approaches, and hence more sensitive to possibilities they have not considered” (Jasanoff, 1993, p.128) and impacts on risk assessments results.

Jasanoff (1993) underlines the importance of “understanding that there are connections between technical knowledge and the context in which it is produced may make practitioners more reflectively conscious of biases built into their own methodological approaches, and hence more sensitive to possibilities they have not considered”(p.128) and that is at risk of wearing thin, as much work is needed bridging the two cultures of risk analysis (quantitative versus qualitative). What do these findings from incorporating qualitative research in risk analysis mean for future workers in the field of assessing risk? With that same train of thoughts, Leveson (2002) adds that “new models that are more effective for accidents in complex systems will need to account for social and organizational factors, system accidents and dysfunctional interactions, human error and flawed decision making, software errors, and adaptation.”(p. 25)

The following aims to highlight the fact that assessing probability in complex system requires more than simply assigning numerical figures, because, as stated by Stern, (1998) “any undesirable and uncertain outcome that cannot be estimated quantitatively by available techniques are ignored and then treated as though they had been analyzed and their risk values found equal to zero.” (p.1). Quantitative data is simply not substantial enough when assessing probability in complex systems; complete framework of risk assessments can only be achieved through the support of qualitative analysis.

2.0 METHOD

This work has been done in two steps: firstly a quantitative survey was conducted using a partial section of the Q850 Risk Assessment process that strictly focuses on the assessment of probability. A random selection of volunteers with various experience in risk assessments where contacted and an electronic copy of the survey was provide with instructions on how to proceed. The purpose of the quantitative survey was to gather data and experience with how assessors would grade probability without providing them with information regarding Human and Organizational Factors (HoF) versus grading probability with information regarding HoF. (Refer to Appendix A)

The results of the quantitative survey were analysed by comparing the probability values assigned in Section 3.0: Results Table-1, versus probability values in Section 3.0: Results Table-2. A second part of this survey was then conducted in the form of a questionnaire. The questions were developed to obtain data in regards to the use of different methodologies in the quantitative survey, their impact on risk assessment, whether assessors would consider accessing probability with HoF information in future assessments. (Refer to Appendix B)

The results of the survey in the questionnaire were analysed by looking for the difference in assessors’ process impact opinions and comments in Section 3.0: Results Table 3.

The qualitative results are discussed in Section 4.0

Both the quantitative and qualitative survey results are analysed and discussed in Section 5.0.

2.1 What is the current process with probability?

A quantitative approach is used to focus specifically in the area of the risk assessment process, where risk is assessed, and more specifically, where probability grading of series of sequences of events and consequences happening can possibly occur. Probability can best be described as the predictability of events occurring within a certain approximation. For Vicente (2003), predictability does not mean that we can predict when the event will take place, but only that it takes place fairly often. Probability comes with it's own vocabulary, such as foreseeability, likelihood, and interpretation. The prediction of events to occur is a process that decision makers are faced with during risk mitigation strategies, summarized under the term "Risk Assessments". Frequency, rather than probability, is also used in describing risk.

The current process for assessing probability is included in the risk estimation of the risk assessment process, as outlined in (FIGURE 1), and includes the following risk formula: Probability x Severity x Exposure. To aid the decision making with regards to acceptable or unacceptable risk levels, assessors product resulting from this formula. Shortreed (2000) adds that the "the quality of unknown risk is referred by the degree of knowledge of a hazard and the extent to and knowable by the individual or science, which it is observable." (p.A-20).

Probability is mathematically defined as the mathematical real number in the scale of 0 to 1 attached to random event. For example, in high degree of belief, the probability is near 1. Probability can be related to a long –run relative frequency of occurrence or to a degree of belief that an event will occur. Unfortunately, this mathematical definition does not take into consideration the valuable information surrounding the context of the events such as human and organizational factors, which could impact decision-making when evaluating probability.

3.0 QUANTITATIVE RESULTS

This thesis includes a two-part survey quantitative and qualitative to test the impact on risk assessments with and without consideration for Human and Organizational Factor information during the process of assessing probability. The results were gathered/summarized below in Table 1, Table 2, and Table 3 will be analysed further in the discussion section.

Table-1 Risk Assessment (RA-01) Probability Grading Survey Results

Risk Scenario Sequence of events	Consequences	Probability P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
a)	Above	0/1	2	2	2	1	2	2	1	2	1	1	2	3
b)	Above	1	2	1	2	1	2	2	1	2	1	1	2	3
c)	Above	1	3	1	2	1	2	2	2	2	1	1	2	3
d)	Above	2	3	2	3	2	2	3	2	3	3	1	3	3
e)	Above	2	3	3	3	2	2	3	2	3	3	1	3	3

P=Survey Participant

Probability (P) Grading 0 to 4

What is the probability of that sequence of event happening, including the consequence?

0 — Extremely Improbable
1 — Extremely Remote
2 — Remote
3 — Reasonably Probable
4 — Frequently

Table 2- Risk Assessment (RA-02) Probability Grading Results

Risk Scenario Sequence of events	Consequences	Probability P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
a)	Above	1/2	2	4	2	2	3	4	1	2	1	2	3	1
b)	Above	2	2	4	2	2	3	4	1	2	1	2	3	1
c)	Above	2	3	4	3	2	3	4	2	2	1	2	3	1
d)	Above	2	4	4	4	3	4	4	3	4	3	2	4	2
e)	Above	3	4	4	4	3	4	4	2	4	3	2	4	2

Table 3-QUESTIONNAIRE

Participant	**Question #1** Did human and organizational factor information provided in Scenario #2, helpful in grading "probability" versus Scenario 1 (Yes or No)? Why?	**Question # 2** Would you consider this methodology of accessing probability (consideration of human & organizational factors) in future risk assessments? (Yes or No)? Why?
P1	Yes. It adds context in order to evaluate the probability of the failure. This also increases the confidence level for assessing the risk based on qualitative and quantitative measures	Yes. The quality level of a risk assessment can be improved when using logical, accountable methodologies and more contextual/accurate performance measures. This improvement translates into a greater degree of certainty in the evaluation process, and thus will facilitate an improvement when making decisions.
P2	Yes. The human factor components are inseparable if indeed the they contribute to the over all hazard. They should not be omitted. By factoring in the human factors we gained a better appreciation for the overall condition. This realization helped to better assess the probability resulting in a raised figure in some instances.	Yes. It may be useful in order to better assess the actual human factor components by isolating the human components by within their own scenarios and then later factoring them in to the hazard condition. One of the consequences could be simply items missed or omitted during the inspection within the context of the hazardous condition (the environment and the human condition).
P3	Yes. We now have the full story.	Yes. In our case, as Regulators, having all the information is crucial to approving a revised Maintenance Schedule with assurance that flight safety is not compromised.
P4	Yes. Although the degree of relevancy of such available information can be highly subjective and non-empirical (i.e. non-quantitative and open to interpretation) it does, nevertheless, provide a relevant source of input for the assessor to draw educated conclusions from, based on his or her familiarity with and experience within the activity and type of enterprise under scrutiny (e.g. maintenance experience as an AME within an aviation organization). Simply put, there is no substitute for experience and the insight that it can provide.	Yes. There is a need to not only arrive at a set of conclusions but also to have the ability to illustrate an understanding of the pertinent indicators.
P5	Yes – very much so. It fleshes out the situation – in the first example, it was easy to downplay the likelihood of an occurrence, however once the real situation is better known, with the history, and situational issues revealed, it becomes easier to see how many factors inter-relate and could affect the outcome.	Yes. It gives a much more honest ability to make the assessment. Anything less is not giving due diligence or respect to the process.
P6	Nil	Nil
P7	Yes. It is always beneficial to have historical info plus Risk assessment data i.e., problem to help make decision.	Yes. It has to. You can't split them apart. People are part of the entire process therefore an integral part of the problem solving solution.
P8	Yes. In actuality I always assume a deficient organization or an organization that may not do things correct all the time (worst case scenario). The information provided gave me a bit more ammunition for rating the way I did.	Yes or No? Depends on the applicability.

P9	**Yes.** Identified those personnel not particularly happy with the lubricating process, conditions and environment. Not good.	**Yes.** Human and Organizational Factors is certainly a big consideration when identifying and mitigating risks.
P10	**No.** No difference	**Yes.** In some cases, there would be a difference.
P11	Yes. Detailed information added to thought process of probabilities	Yes. Factors seem relevant to exercise
P12	Absolutely. The more factual information that can be provided to support possible scenarios makes scoring a more educated decision by the risk assessment team.	Yes. Allows scoring decision to be based more on facts than on subjective opinions in the absence of facts.
P13	Yes. More details, more insight, higher comfort level-less risk.	Not sure…Scenario 2 pgs5-7 seem to be missing data; a), d) and e) are included but b) and c) are missing. Also now that I look at what's here-it's not clear if the company had problems or not

4.0 QUALITATIVE RESULTS

Sometimes it is difficult, if not impossible, for any assessors to judge the safety of their decisions when this is dependent on the decisions made by other people in other departments and organizations. People's views differ from one another. Slovic (1999) describes these different personal views in five categories: Fatalism, Hierarchy, Individualism, Egalitarianism, and Technological Enthusiasm.

> The Fatalists tend to think that what happens in life is preordained. The Hierarchists like a society organized such that commands flow down from authorities and obedience flows up the hierarchy. The Egalitarians prefer a world in which power and wealth are more evenly distributed and the Individualist like to do their own thing, unhindered by government or any other kind of constraints. (p. 694)

The importance of affect (Figure2), without it, information lacks meaning and cannot be used in judgment and decision-making. Slovic (2006) describes affect, as used here, as "a feeling (not necessarily conscious) that something is good or bad. Affective response occur rapidly and automatically –note how quickly you sense the feeling associated with the word" treasure" or the word "hate". A large research literature in psychology documents the importance of affect in conveying meaning upon information and motivating behaviors (p.8) Possible outcomes such as probability are anticipated by individual's known facts and how they feel about the future.

The human process of emotions for some assessors can play an important role in decision making of probability grading. According to Slovic (2004)"Now that we are beginning to understand the complex interplay between emotion, affect, and reason that is wired into the human brain and essential to rational behavior, the challenge before us is to think creatively about what this means for managing risk. On the one hand, how do we apply reason to temper the strong emotions engendered by some risk events? On the other hand, how do we infuse needed "doses of feeling" into circumstances where lack of experience may otherwise leave us too "coldly rational?" (p. 10). The topic of emotions highlight an area of concern in regards to managing risk and may need to be mitigated by careful selection of assessors.

Events associated with strong feelings that can overwhelm us even though their likelihood is remote Slovic (2004) states that:

> Because risk as feeling tends to overweight frightening consequences, we need to invoke risk as analysis to give us perspective on the likelihood of such consequences. For example, when our feelings of fear move us to consider purchasing a handgun to protect against terrorists, our analytic selves should also heed the evidence showing that a gun fired in the home is 22 times more likely to harm oneself or a friend or family member than to harm an unknown, hostile intruder. (p.10)

People's views, affect, emotions, feelings and scales are all psychological factors that must be kept in consideration and sometimes mitigated to achieve the best assessment results.

Providing assessors with research factual information prior to and during the assessment process may help individuals focus on the bigger picture of probability and set aside some of the psychological factors discussed.

Risk assessments have helped build consistency, credibility, crisis intervention and storable records for the decision making process, but are there parts of this, process such as when it comes to making probabilistic evaluations, that fall short of creditable assessments? Many assume that the projection of the future events does not necessarily require research, and that probability can be assigned scoring values without any context in which it arises. Often not enough energy is spent in context research and accumulating critical data prior to assessing probability for complex system analysis and is purely subjective. Jasanoff (1993) warns us that:

> In order to decide what is the risk of a given negative event, risk assessors have to make a host of simplifying assumptions about the context in which it arises. The kind of imagination they bring to this activity, moreover, depends on their objectives, values, training and experience. The risks they measure therefore exist not "in reality" but only in an artificial micro-world of the risk analyst's creation." (p.124). Dekker (2006) would also add that "Take any step along the way out of the sequence, and failure will no longer occur. In complex, dynamic systems, however this is hardly the case. The pathway towards failure is seldom linear or narrow or simple. Mishaps have dense patterns of cause, with contributions from all corners and parts of the system, and typically depend on many subtle concurrences. Leveson, (2002) cautions that: Experts do their best to meet local conditions and in the busy daily flow of activities are unaware of the potentially dangerous side effects. Each individual decision may

> appear safe and rational within the context of the individual work environments and local pressures, but may be unsafe when considered as a whole. (p.34)

The elementary ground of unfounded assumptions in the Nuclear Reactor Safety Study may have been the result of assessor's perception of the situation at the time and biases from different ethnic and socioeconomics groups. Perrow (1999) stresses that "people's perceptions when making the evaluation of risk is somewhat biased and their limits to consistently and easily making full rational decisions in probabilistic and statistical assessments is partly due to "neurological limitations, to limits on memory and attention, to lack of education, and to lack of training". (p.316)

Finally, the lack of data, assumptions and the choice of particular analysis, will cause gross underestimates of the probability consequently creating lack of public trust in the entire risk management process.

Members of the public and experts can disagree about risk because they define risk differently; have different worldviews, different affective experiences and reactions, or different social status. Social relationships of all types, including risk management, rely heavily on trust, and can be built and destroyed very easily.

Slovic (1999) states the following:

> One of the most fundamental qualities of trust has been known for ages. Trust is fragile. It is typically created rather slowly, but can be destroyed in an instant-by a single mishap or mistake. Thus once trust is lost, it may take a long time to rebuild it to its former state. In some instances, lost trust may never be regained. Abraham Lincoln understood this quality. In a letter to Alexander McClure, he observed: If you

> once forfeit the confidence of your fellow citizens, you can never regain their respect and esteem. (p.697)

The U.S. Nuclear Reactor is one of many assessment examples where probability was questioned after the fact and concerns were raised in regards to the process that is problematic and limited in certain areas. The use of a mathematical formula for assessing probability may be effective on small scale, although “the gap between prediction and experience warns us that modeling provides at best an imperfect bridge reality”. (Jasanoff, 1993 p.125).

4.1 Assumptions baked into the process today?

Time has evolved since the development of the probability theory, and the process has not been removed from the creation of assumptions. Often times, when a specific process is only partially understood, people in general will create assumptions in light of making the process workable. According to Slovic (1999), “probabilities and consequences of adverse events are assumed produced by physical and natural processes in ways that can be objectively quantified by risk assessments. Much social science analysis rejects this notion arguing instead that risk is inherently subjective.” (p. 690)

In the world of risk assessments there are assumptions that experts are seen as service providers, characterized as objective, analytical, wise, and rational-based on the real risks and the public is seen to rely on perceptions of risk that area subjective, often hypothetical, emotional foolish and irrational, even though there are studies that show that “experts tend to see riskiness as synonyms with probability of harm, or expected mortality, consistent with the ways that risks tend to be characterized in risk assessments”. (Slovic, 1999 p. 691)

There are assumptions that the present process of assessing risk with only the use of quantitative analysis is effective, and the numerical outcomes represent the best results.

We know now that the difference among individuals are both deeper and more subtle although we still assume that “how people interpret a given set of facts about risk may depend on a host of variables, such as their institutional affiliations, their trust in the information provider, their prior experience with similar risk situations, and their power to influence the source of the risk. Far from being irrational, these private calculations generally represent sophisticated attempts to translate risk information down to meaningfully intimate scales of personal experience. Physical observations are more highly valued than theoretical projections and what people claim to know about risk is in fact constructed in different ways in different political and cultural settings, which underscore the fact that knowledge, in turn, shapes and direct constraints across political and cultural boundaries. The resulting knowledge in turn, shapes and directs our capacity to conceptualize risks” (Jasanoff, 1993, p.12, 126,127)

These assumptions in regards to assessing risk and probability are baked into the young science of risk assessment process, but are they valid?

4.2 Are they valid assumptions?

When we assume things, it is because we are uncertain due to lack of knowledge or information, time constraints or negligence. The assumptions surrounding the topic that experts are seen as service providers, characterized as objective, analytical, wise, and rational and that the public is seen to rely on perceptions of risk that area subjective, often hypothetical, emotional foolish and irrational can perhaps best be explained by Slovic (2006) “probability can be assigned scoring values without any context in which it arises, and without experience and expert judgement risk assessments cannot prevail, does hold some truth although is short of completeness. “Most people are caring and will exert great effort to rescue “the one” whose needy plight comes to their attention. These same people, however, often become numbly indifferent to the plight of “the one” who is “one of many” in a much greater problem.” (p. 3.)

How people interpret a given set of facts about risk may depend on a host of variables, such as their institutional affiliation, could be explained by Slovic (1999) theory that “research has shown that the public has a broad conception of risk, qualitative and complex, that incorporates consideration such as uncertainty, dread, catastrophic, into the risk equation (p.691) and that “ there is a principle to the valuing of human life that suggests that a form of psychological numbing may result from our inability to appreciate losses of life as they become larger”(p.12). In the 19th century, E.H. Weber and Gustav Fechner discovered a fundamental psychological principle that: “describes how we perceive changes in our environment. They found that people’s ability to detect changes in a physical stimulus rapidly decreases as the magnitude of the stimulus increase. (Weber, 1834;Fechner, 1860)” Slovic , 2006, (page 11).

These assumption are valid from a science research point of view and opinions although should not restrict or interfere with future initiatives to process improvement.

4.3 Techno Optimism

Techno Optimism or perhaps Technological Enthusiasm is described by Slovic (1999) where a high-technology society is important for improving our health, and social being. (p.694) and is often the cure for gaining over our futures.

Dekker (2005) raises the question: “How can an increasingly illuminated society simultaneously retard into superstitious and scapegoating. One answer may lie in the uncertainties and anxieties brought on by the technological advances and depersonalizations that inevitably seem to come with such progress. New large, complex, and widely extended technological systems (e.g. global aviation that took just a few decades to expand into what it is today) create displacement, diffusion, and causal uncertainty.”(p.203)

How could Techno Optimism affect assessing risk and probability? Leveson (2002) reminds us that: “unfortunately risk assessments have so far been focused on probabilistic analysis and have not expanded to include the ground gained in the area of including software and other new technology, to management, and to cognitively complex human control activities”. (p.128)

The survey results in this thesis did not specifically highlight areas of concern specific to ground gained in the area of technology to human control but on the other hand did indicate lots of areas where information in regards to human limitations and situational issue such as: working in confined areas, night shift and lack of lighting, added more insight into the real context and thought process of the assessment.

Research in Kim Vicente, (2003) book “The Human Factor” illustrates many examples of how technology is wreaking havoc in systems and addresses needs for better understanding in the relationship between human limitations and technology. This information, in return, could provide assessors with crucial data when assessing probability.

4.4 System Thinking

Are experience and past successes the only answers when predicting future outcomes in assessing probability in complex systems? What about how peoples thought processes in decision making? Perrow (1999) describes that trying to find out how people think:

> The limits on our ability to consistently and easily make rational decisions might be due to neurological limitation, to limits on memory, and attention, to lack of education, and to lack of training in probabilities and statistics. But it also seems to be due to some very practical problems and concrete experiences in daily life. Hunches and rule of thumbs and rough estimates and guesses appear to be patterned and widespread. Cognitive psychologists call these "heuristics", from the word for discovery, and are now identifying several specific ones. For examples, the "availability heuristic" suggests that rather than examining all existing cases of some phenomenon, `and then basing their judgement on all the experience, people tend to judge a situation in terms of the most readily available case, the one most easily remembered. If there has recently been an airline crash, we focus on that event and ignore all the successful flights when we think about the probability of a crash while deciding whether to take flight or not (p.316).

As life became more complex and humans gained more control over their environment, research indicates that system thinking processes divided into two modes of thinking: Experiential and Analytic

Experiential System	Analytic Systems
Holistic	**Analytic**
Affective: pleasure-pain oriented	***Logical: reason oriented (what is sensible)***
Associationistic connections	***Logical connection***
Behavior mediated by "vibes" from past experiences	***Behavior mediated by conscious appraisal of events***

5. Encodes reality in concrete images, metaphors, and narrative	***Encodes reality in abstract symbols, words,***
More rapid processing: oriented toward immediate action	***Slower processing: oriented toward delayed***
Self-evidently valid: "experiencing is believing	***Requires justification via logic and evidence***

Slovic ((2004, p.3)

Slovic elaborates that "we now recognize that the experiential mode of thinking and the analytic mode of thinking are continually active, interacting and that while we may be able to "do the right thing" without analysis (e.g., dodge a falling object), it is unlikely that we can employ analytic thinking rationally without guidance from affect somewhere along the line. Affect is essential to rational action". (p. 4)

Furthermore, recent work in the field of science and technology studies suggests that there are recurrent ways in which scientific construction of risk scenarios falls short of completeness, and that "the culture of qualitative risk analysis offers at least a partial antidote to such surprises (disclosure of biases and basic omissions in risk assessment models), because it provides a relatively systematic approach to thinking about the constraining assumptions that are built into procedures for assessing risk". (Jasanoff, 1993 p.125)

The assessment of probability in the field of risk assessments can be very complex and somewhat limited, due to many factors as highlighted above. Rational decisions could be improved with the implementation of qualitative and quantitative analysis in the risk assessment process. Human and Organizational Factors is encouraged, and would equip the assessors with contextual information that could help them make accurate decisions versus blindly assigning quantitative numbers.

5.0 DISCUSSION

The survey results in this thesis confirm that assessing probability without consideration for Human and Organizational Factors will impact risk assessments. Findings suggest that both quantitative and qualitative analyses are required to produce the best results.

The quantitative results obtained from the small survey in Table 1 & 2 show a shift in grading the assessment of probability when additional information was provided to the assessors, such as Human and Organizational Factors. Throughout the results, there is a visible shift in the sequence of events happening and consequences more probable of happening in the Accident/Incident and Passenger/Crew Injuries consequences category but the greatest shifts are most evident in the Severe Damage to the Aircraft, Aircraft Unserviceable, and Disruption in Flight Schedules consequences category. This shift is important, as it illustrates Jasanoff's theory of "contingency or context –dependency which explains what we claim to know about risk, how we acquire more information, and how we interpret the facts in our possession are all contingent on contextual factors, ranging from individual or organizational experience to national political culture." (Jasanoff, 1993 p. 126)

Does this shift in probability have an impact on the risk assessment as a whole? There will be a numerical final outcome change of the risk formula (Probability X Severity X Exposure) as it is a numerical multiplication, but the greatest impact of the additional information provided may influence the assessors Decision Making throughout the entire process. We are reminded by Slovic (1999) "that studies show that experts tend to see riskiness as synonyms with probability of harm, or expected mortality, consistent with the ways that risk tend to be characterized in risk assessments" (p.691& 548). He also ponders whether if we do not understand what happened, how will we ever ensure it does not happen again.

The qualitative results from the questionnaire are more descriptive and bring out real assessors comments and opinions that help confirm the answer of this thesis.
All but one participant answered “Yes” to Question #1, that HoF information provided in the second Scenario was helpful in grading probability versus the limited information provided in the first scenario.
All but two participants answered “Yes” to Question #2, that they would consider this methodology of accessing probability (with the inclusion of HoF) in future risk assessments.

The answers and comments provided by the assessors in each question are important as they support Jasanoff’s (1993) theory of bridging quantitative and qualitative analysis and are expressed in this survey as the preferred prescription for achieving the best quality of assessing probability in risk assessments.
(Knoke, D. and Trocmé, N, 2005) have noted that, while assessing risk in child and neglect, “the lack of clearly defined goals and objectives, and poor implementation of risk assessment instruments in practice have complicated criterion probability.”(p.316)

In the quantitative assessment, one assessor graded probability with the same values in both scenarios (RA-01 & RA-02). In the questionnaire, the same assessor answered NO to question #1. This assessor, with an intensive engineering background, was familiar with the case study and had already included most of the additional information provided in RA-02, which then became irrelevant.

The selection of the assessment case in this study may have resulted in some uncertainty from a number of chosen volunteers, as they may not have been familiar with some of the technical information presented. Leveson (2002) adds, “when numerical risk assessment techniques are used, operational experience can provide insight into the accuracy of the models and probabilities used" (p. 251). The purpose for random selection of volunteers was to remove bias and run the process of risk assessment as naturally as possible.

One subject that remains to be explored when assessing probability with inclusion of Human and Organizational Factors information is how much qualitative research will be required to improve the quality level of the risk assessment.

In summary, the results of both surveys highlight the contribution of Human and Organizational Factor information while assessing probability in risk assessments.

6.0 CONCLUSION

This thesis has presented the facts surrounding the assessment of probability, and concludes that, because the latter is an integral part of the risk formula relating to risk assessment processes, assessing probability without all information could hamper the quality level of the entire process.

This thesis has addressed the current processes, problematic areas, assumptions, the affect of technology and system thinking in regards to the assessment of probability. It included a survey that supported the question of this thesis.

Ideally, a contribution that would incorporate qualitative studies into the risk assessment process, in particular, when grading probability, would make us rethink the value of this information, the opportunities that would be available for process improvement and accuracy, and the impact on assessments as a whole.

DISCLAIMER

The views and ideas in this project work only reflect the author and shall not be considered as official view of any organization to which the author belongs.

APPENDIX A

Quantitative Survey- Risk Assessment

ALASKA AIRLINES ACCIDENT REPORT

On January31, 2000, about 1621 Pacific standard time, Alaska Airlines, Inc., flight 261, a McDonnell MD-83, N963AS, Crashed into the Pacific Ocean about 2.7 miles north of Anacapa Island, California. The National Transportation Safety Board (NTSB) determined that the probable cause of the accident was a loss of airplane pitch control resulting from the in-flight failure of the horizontal stabilizer trim system jackscrew assembly's acme nut threads. The thread failure was caused by excessive wear resulting from Alaska Airlines insufficient lubrication of the jackscrew assembly.

The NTSB Report state:

> The FAA's certification scheme is intended to protect against catastrophic single-point failure conditions. Specifically, 14 CFR 25.1309 requires that airplane systems and associated components be designed so that "the occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane is extremely improbable." Further AC 25.1309-1A, "System Design and Analysis" defines "extremely improbable" failure conditions as "those so unlikely that they are not anticipated to occur during the entire operational life of all airplanes of one type" and "having probability on the order of 1X10-9 or less each flight hour based on a flight of mean duration for the airplane type." AC 25.1309-1A specifies that in demonstrating compliance with the CFR25.1309, "failure flight of any single element, component, or connection during any one flight…should be assumed, regardless of its probability," and "such single failures not prevent continued safe flight and landing, or significantly

reduce the capability of the airplane or the ability of the crew to cope with the resulting failure condition. (Pg. 163)

The survey in this thesis used the Alaska Airlines Flight 261 NTSB report information as a base to create the outline basic situation/activity, which is de-identified to create the most realistic sequence of events. All factual human and organizational factors used in scenario #2 were extracted from the TSB Final Report NTB/AAR-02/01.

Outline basic situation/activity:

XYZ Airline is a Commercial Operator and Approved Maintenance Operation (AM0) with a fleet of 26 MD-80 series aircraft.

XYZ Airline's maintenance program take guidance from the Maintenance Steering Group (MSG) developed in 1968.

Guidance is solely based on recommendation material and not mandatory

A recently inspection schedule change has been recommended by the Maintenance Steering Group in regards to a major flight control unit. XYZ will conduct a risk assessment prior to making any decisions.

Risk Assessment Survey Instructions # 1

Step 1(refer RA-01)

You have been selected as a team member to conduct a Risk Assessment for your company Airline (XYZ).

1. The assessment process is well under way with the identified Basic Situation / Activity and Hazard Statement.

2. You have reached Step 2.3 and have already developed your first risk scenario, sequence of events and consequences.

3. Your next step is to grade probability.

4. Please enter your grading scores (0-4), based on what is the probability of that sequence of events happening including each consequences, as you have executed numerous times in past assessments.

5. Once all probability-grading scores have been entered, please save changes to this document**.**

Step 1 is now complete and you may proceed to Step 2

The first part of the survey has confirmed that when Human and Organizational Factors are included in the assessments of risk, specifically in probability, assessors have a tendency to grade differently then when these factors are not included

Risk Assessment RA-01

Sequence of Events	Cause (N, E, T, H)	Consequences	Probability
Risk Scenario			
a) Implementation of MSG maintenance inspection schedule change b) Inspection cycle increase from 3700 flight hours/15 months to 7000 flight hours/30 months. c) Lubrication Failure. d) Flight component excessive wear. e) Flight component failure.		Accident /Incident	
		Passengers/ Crews injured	
		Severe damage to the aircraft	
		Aircraft unserviceable	
		Disruption in flight schedule.	

Risk Assessment Survey Instructions #2

Step 2 (refer RA-01)

Forget Step 1. Do not refer to it again or make any changes.

Again you have been selected as a team member to conduct a Risk Assessment for your company Airline XYZ.

The assessment process is well under way with the identified Basic Situation / Activity and Hazard Statement.

You have reached S2.3 and have already developed your first risk scenario sequence of events and consequences.

Your next step is to grade probability.

Please enter your grading scores (0-4), based on what is the probability of that sequence of events happening including <u>each consequences,</u> as you have executed numerous times in past assessments.

Once all probability-grading scores have been entered, please save changes to this document.

Step 2 is now complete and you may proceed to the questionnaire.

Risk Assessment RA-02

<table>
<tr><th>Sequence of Events</th><th>Cause
(N, E, T, H)</th><th>Consequences</th><th>Probability</th></tr>
<tr><td colspan="4">Risk Scenario</td></tr>
<tr><td rowspan="6">a) Implementation of MSG maintenance inspection schedule change
b) Inspection cycle increase from 3700 flight hours/15 months to 7000 flight hours/30 months.
c) Lubrication Failure.
d) Flight component excessive wear.
e) Flight component failure.</td><td rowspan="6"></td><td>Accident /Incident</td><td></td></tr>
<tr><td>Passengers/ Crews injured</td><td></td></tr>
<tr><td>Severe damage to the aircraft</td><td></td></tr>
<tr><td>Aircraft unserviceable</td><td></td></tr>
<tr><td>Disruption in flight schedule.</td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

3.1 Reported data:

Mode l	Lube Interval	MTBR	MTBU R-	Wear Rate
DC – 9	1,329 hrs	34,054 hrs	34,395 hrs	0.0011 inch per 1000 hrs.
MD-80	804 hrs	24,397 hrs	28,397 hrs	0.0013 inch per 1000 hrs.

Note: Manufacturer rate wear was .001 inch per 1000 hrs.

MTBR: Mean time between removal
MTBUR: Mean time between unscheduled removals

3.2 **MSG recommendations are minimum scheduled maintenance & inspection requirements.**

3.3 Older MD-80 fleet at XYZ.
XYZ previous inspections show trend of wear limits results that are close to the limits.

3.4 Maintenance personnel reported Inspection and End Play check located in confined and not easily accessible area.
Lubrication task reported by maintenance crews to consume several hours of work.

3.5 Task normally carried-out outside and during night shift (various weather conditions) with the use of battery headlamp for lighting.

3.6 History of controversy over grease type be used which has still not been settled.

3.7 Lubrication scheduled intervals has been increased from 6 months or 900 flight hours (fhrs) to 8 months or 2,2550 fhrs.
History of other operators reporting same flight component excessive wear.

APPENDIX B

Qualitative Survey- Questionnaire

The following questionnaire was part of the survey to see how the participants felt in regards to the Human and Organizational Factor information provided in Scenario #2 versus the limited information in Scenario #1and would they consider this methodology of accessing probability (consideration of human & organizational factors) in future risk assessments?

Question #1

Did human and organizational factor information provided in Scenario #2, helpful in grading "probability" versus Scenario #1?

(Yes or No)

Why?

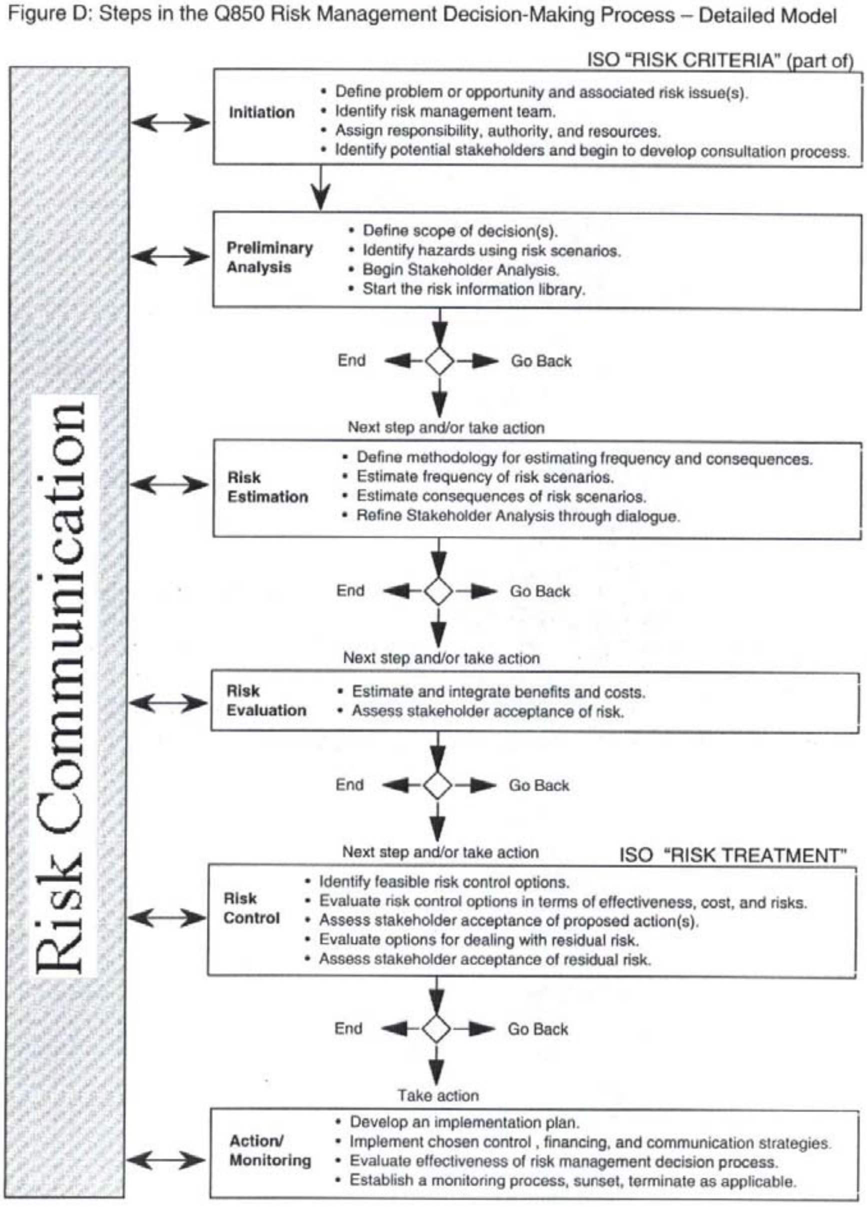
Question #2

Would you consider this methodology of accessing probability (consideration of human & organizational factors) in future risk assessments?

(Yes or No)

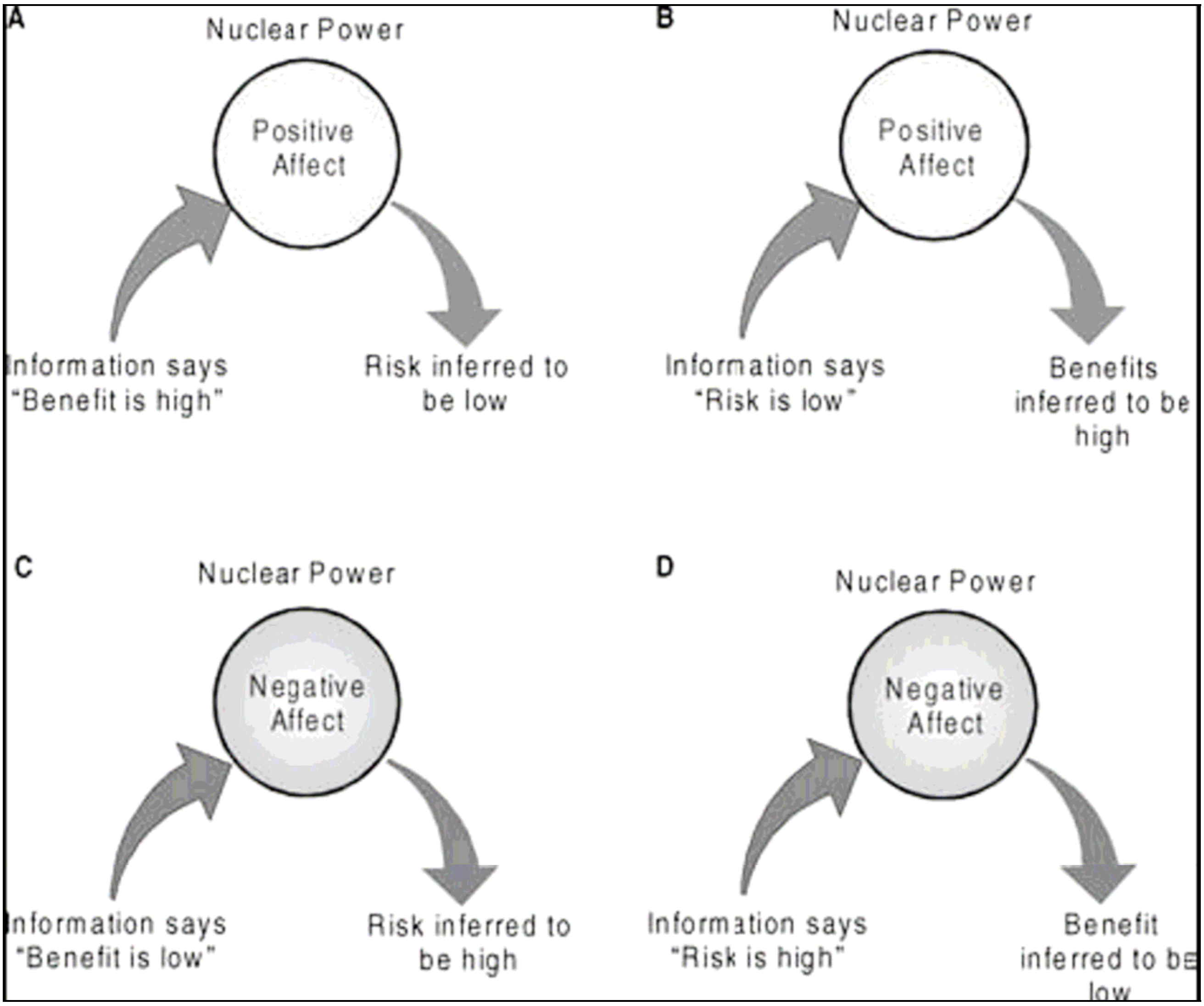
Why?

Figure 1- Q850 Risk Management Process



Source: CSA, July 1997. Risk Management: Guideline for Decision-Makers (CAN/CSA-Q850-97) Canadian Standards Association.

Figure 2-Model of the affect heuristics



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