Operational Risk Management for a NPP

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Abstract

Organizational failures are a hazard to the successful operation of a nuclear power plant. Risk reduction strategies have been developed around two themes: using an understanding of the nature and mechanism of human failures to eliminate them by modifying work processes; or, modifying human behaviour by creating a strong safety culture that overrides the tendency to fail. This paper examines the problem from the perspective of operational risk management. It includes the internal management of operations and the influence of the external environment on the organization. A model is proposed that encompasses all the operational risk factors in the organization's decision making process. To prevent failure the organization must have the capability to adapt and the capacity to evolve. The hazards that would lead to an organizational failure are developed from this evolutionary model. The operational risk management program would include these hazards as well as the conventional nuclear safety hazards.

1. Introduction

Organizational failures are a hazard to the successful commercial operation of nuclear power plants and other industrial facilities. Their contribution to the severity and frequency of accidents has been well documented [1,2]. However, they are not included in the design basis for plants. The design organization assumes the plant will be operated and maintained as it is intended to meet the safety, production and cost goals specified in the design basis. Continuous validation of this assumption and improvement upon the goals becomes the objective of the operating organization throughout the life of the plant. Failure to meet this objective is a failure to organize the resources needed to operate the plant successfully.

There have been two general responses to the recognition of the risk to public safety posed by organizational failures and lack of mitigating measures. Human failure analysts, e.g. Reason [2] and Whittingham [3], emphasize the psychology of human failures. From their perspective, knowing the cause of a human failure enables the operating organization to implement provisions to prevent the failure. On the practical side, plant managers identify the human failures that threaten the organization as behavioural problems that become manifest as a poor safety culture in the organization. The means of preventing organizational failures is then to modify the behaviour of individuals by promoting the behaviours attributed to a strong safety

culture. The desired attributes have to be defined within the context of a model of the safety culture such as that of IAEA [4] for nuclear facilities.

Behaviour modification can only lead to success if it is based on a correct model for the organization's culture. That is, the model must encompass all hazards that threaten the success of the organization. Cooper [5] has emphasized that safety culture is integral with the corporate culture. He identified three components to a strong safety culture: individual psychology, individual behaviour and the work environment or workplace conditions affecting behaviour. He proposed measuring these components as a quantitative measure of the quality of the 'safety culture'.

The work referenced above has increased our understanding of what it means to operate a facility safely. However, they are descriptions of the safety problems rather than solutions that address the root cause(s) of organizational failures. Moreover, safety is only one of the goals of the operating organization. It is far more common to see utilities failing to achieve the goals for production and unit electric cost. The concept of organizational failures is discussed in Section 2. In this paper I make the case that the analysis of organizational failures has to include commercial failures as well as safety.

The premise of this paper is that the root causes of organizational failures have to be understood in the context of the overall corporate culture, not its 'safety culture'. To develop this premise de Geus' paradigm for a successful company [6] is adopted and applied in Section 3. From de Geus we have the concept of a successful organization as an entity that can evolve. It has the capacity to adapt to changing circumstances and avoid failure. Success is achieved by proactive management of the operational risk which is discussed in Section 4.

In the evolutionary model the organization's success depends upon continuously balancing the self-interests of the stakeholders and fairly apportioning their operational risk. Section 5 presents a hazard analysis using the model to identify some of the potential failures of the organization. The success of the organization then depends on building defences by eliminating the hazard, preventing the failures occurring, or, mitigating their consequence if they occur. The paper concludes by discussing "organization accidents" in the context of the evolutionary model.

2. The Concept of Organizational Failures

Mosey [1] reviewed nuclear accidents and highlighted four types of management errors that were contributing factors. He concluded:

"*Institutional failures are failures of managed systems rather than mechanical failures, human errors or catastrophic natural events. They are the result of the absence or malfunction of some corporate activity necessary for safety, as the result of human failure in activities which may not be acknowledged as important to safety and which occur far from the man machine interface*".

The contribution of organizational failures to accidents cuts across all industrial sectors. Reason [2] has studied a diverse set of accidents and describes 'organizational accidents' as events that are not design basis failures and several human failures are contributing factors:

'Organizational accidents' are comparatively rare, but often catastrophic, events that occur within complex modern technologies such as nuclear power plants. These accidents have multiple causes involving many people operating at different levels of their respective companies.

Can organizational failures be understood by focusing only on the safety consequences of catastrophic accidents? Although serious accidents are infrequent, it does not follow that organizational failures are infrequent. There are many accidents with no harm to plant staff or the public yet they cause unanticipated financial losses which may or may not be catastrophic. For example, failure to apply foreign material exclusion procedures can lead to equipment damage and an extended shutdown for repairs. Moreover, accidents in the plant are not the only events for which organizational failures are contributing factors. A commercial failure, such as bankruptcy, is a result of failures in the organization.

If a nuclear power plant does not fulfill its mission is to produce power safely, reliably and at a competitive price, it has failed. With this broader concept of failure, it is clear that organizational failures are common place. Their contribution to radiological accidents is one of many possible outcomes. The following discussion considers nuclear safety within the broader context of organizational failures.

2.1 Lines of Defence

A nuclear power plant can experience a catastrophic accident that is not due to an organizational failure. It would be a beyond design basis accident which is a very unlikely event. An example is the beyond design basis tsunami at the Fukushima Daiichi nuclear power plant although post-accident analysis will determine if it was a very unlikely event. The investigations of catastrophic accidents [1,2] have found that most accidents did not occur or evolve as anticipated in the design basis for the facility. More specifically, the equipment or facility was not being operated as intended by the designer. The fault lies with the operating organization.

The selection of the design basis events and the effectiveness of safety provisions are verified by performing a design basis (probabilistic) risk assessment. Current risk assessments assume plant performance meets the operational objective. Research is being done to incorporate organizational failures into the design basis risk assessment [7]. However it will be some time before practical tools are developed.

Reason's [2] paradigm of organizational accidents as overlapping latent failures in defences has wide currency. His swiss cheese model assumes an accumulation of latent failures that make the defences inadequate when an active failure occurs. The on-going degradation of defences is an important characteristic of a failed organization. Nevertheless, the cheese model does not

capture the structure of the defences and the link to organizational failures as the cause of failure of the defences.

Figure 1 illustrates a model of the failure of defences as a hierarchy of failures within an organization. In this model the latent failures of equipment and the human error in use of procedures are the result of the organization failing to manage the operational risk. Many latent failures can be the result of one failure in the management of the organization. That is, an organizational failure is a common cause hazard.

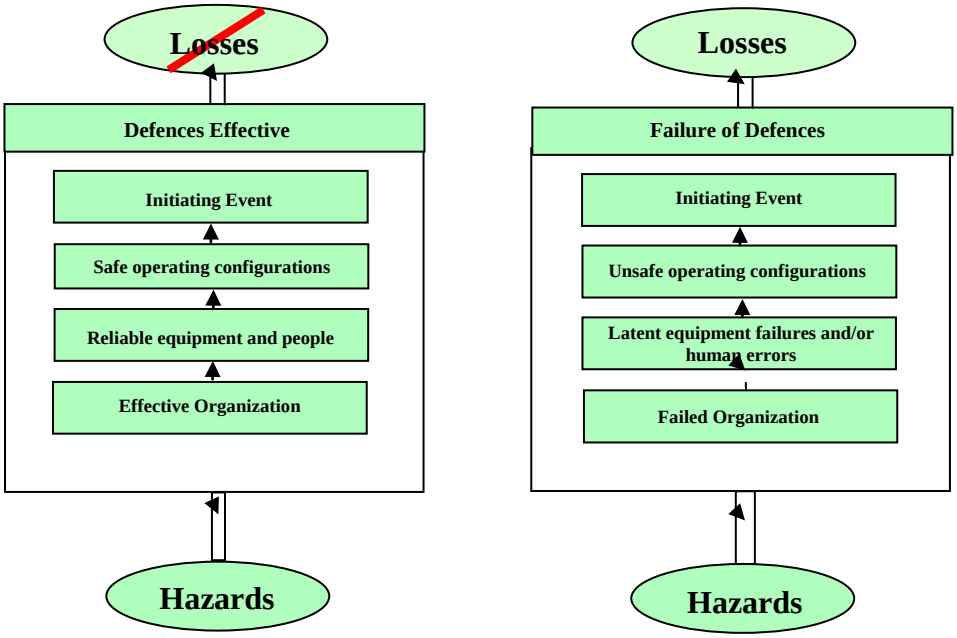

Figure 1. – A model of the failure of defences as a hierarchy of failures within an organization

2.2 Financial Losses vs Physical Harm

Table 1 summarizes some recent Canadian experience with catastrophic organizational failures. None of these events was anticipated by the responsible organization. Although the data in Table 1 is very limited, the frequency of events supports the observation that catastrophic organizational failures are common place. Also, it shows that Government agencies are prone to organizational failures.

Table 1 – Examples of recent Canadian experience with organizational failures

Event	Date	Losses			
		Exposure to Hazard	Serious Injury	Loss of Life	Financial(1)
Collapse of de la Concorde overpass, Laval, Quebec [8]	2006	0	0	5	$5B(2)
E-coli contamination of water supply, Walkerton, ON [9]	2000	2,300	NA(3)	7	>$65M
BSE infection of beef cattle, Alberta and Canada [10]	2003-05	N/A	0	0	$7B
Sinking of the Queen of the North ferry, BC [11]	2006	55	0	2	$100M
SARS outbreak, Toronto and Canada [12]	2003	330	NA(3)	44	~ $1B
Contaminated blood supply, Canada [13]	1978-85	>12,000	NA(3)	>627	$1.4B(4)
Subprime mortgage losses by Canadian Banks [14]	2007-2008	N/A	0	0	$6.5B
Listeriosis contamination of food [15]	2008	NA	57	22	$65M

(1) Estimates based on media and company reports.
(2) Rehabilitation cost for all bridges in the province.
(3) NA – Not Available: Long term effects of exposure to harm unknown or number of owners or investors exposed to financial losses is unknown.
(4) Compensation costs only.

The losses from exposure to an industrial hazard are of three types: financial loss of the owner, damage to the environment, which is a community asset, and physical harm to plant staff and the public. The nuclear power industry focuses on managing the risk of harm to people without much regard to the owner's total financial risk.

For process chemical industries the financial risk from property damage and business interruption is much greater than the third party liability for personal injury [16,17]. This means that making risk reduction decisions based only on public safety exposes the company to uncontrolled financial risk. A rough model of tolerable financial risk for a nuclear power plant [18] leads to the same conclusion. The data in Table 1 from a diverse set of industries illustrates the point.

The importance of financial risk management and its impact on safety means that organizational failures need to be understood in a wider context than just their contribution to catastrophic accidents. For example, precursors to accidents can lead to significant financial losses without harm to people. Managing precursors is an important element of a strategy for preventing accidents [19]. The failure to manage the financial risk from accident precursors increases the safety risk.

2.3 Life Expectancy of a Company

De Geus [6] considers the most serious commercial failure of an organization – its death. The end of life for a company is the point at which it ceases to be a self-sustaining organization. This terminal point includes merger, bankruptcy, a change in ownership to avoid bankruptcy, break up, etc. In Reference 6 he describes his research and that of his colleagues investigating why companies fail. He adopted the metaphor of a company as a living organism and develops the needs for survival. It incorporates the three cultural elements of psychology, behaviour and corporate environment. His work lead to the concept of a 'learning organization' which has wide currency in performance improvement programs.

De Geus [6] defined a successful company as being large and having been in existence for more than 100 years. Large companies have an average life span of 40-50 years which means very few are successful. The Directors cannot predict the evolution of a company because the future is unknown. They rely on managing the risk through the capacity to adapt and remain in harmony with the ever changing socio-economic conditions. In exceptional circumstances this includes revision of the success criteria and a transformation of the company.

The anticipated life span for new and refurbished nuclear power plants is in the range of 50-100 years. Thus, there is a reasonable expectation that the operating company will cease to exist during the life-time of the station. The safety management systems that have been adopted in the nuclear industry do not address the corporate stresses that threaten its life. What is the impact on safety from the conditions, e.g. financial pressures that could lead to a company's demise?

The link between life expectancy and safety is captured by operational risk management (Section 4). All internal and external threats to the company are included. Understanding how the company is organized to perceive and to respond to the threats gives insight into the contribution of organizational failures to accidents.

3. Model of a Successful Company

A company is an organization of capital and resources for the purpose of financial benefit to the owners for meeting its customers' needs. A successful company provides economic benefits and increases the wealth of the state. The owners, employees, customers, vendors and the community will suffer losses if the company fails. The risk of a failure of the company is allocated among the stakeholders by the laws and regulations governing the operation of the company. That is, the allocation of risk derives from the political process. Given their vulnerability each stakeholder has to manage their own risk.
In a capitalist society a limited liability company is the norm and the liability of the owners is limited to their investments in the company. In the event of a failure, bankruptcy laws provide rules for settlement of the conflicting claims of creditors. Also, employees are insured against job loss by the state's social welfare programs.

The provisions for allocating risk vary from state to state. In Canada, for example, many electrical utilities are owned by provinces. The tax payers are the owners of the company and they have unlimited liability for the obligations of the company. The perceived benefit from the tax payer assuming unlimited liability is the lower cost of financing capital projects. It is only a successful business strategy if the company does not fail.

An operating nuclear power company has four distinct groups of stakeholders. Figure 2 illustrates the groups and their roles in the organization of the company. The company exists at the pleasure of the stakeholders. It will continue to exist as long as there are sufficient benefits with an equitable distribution.

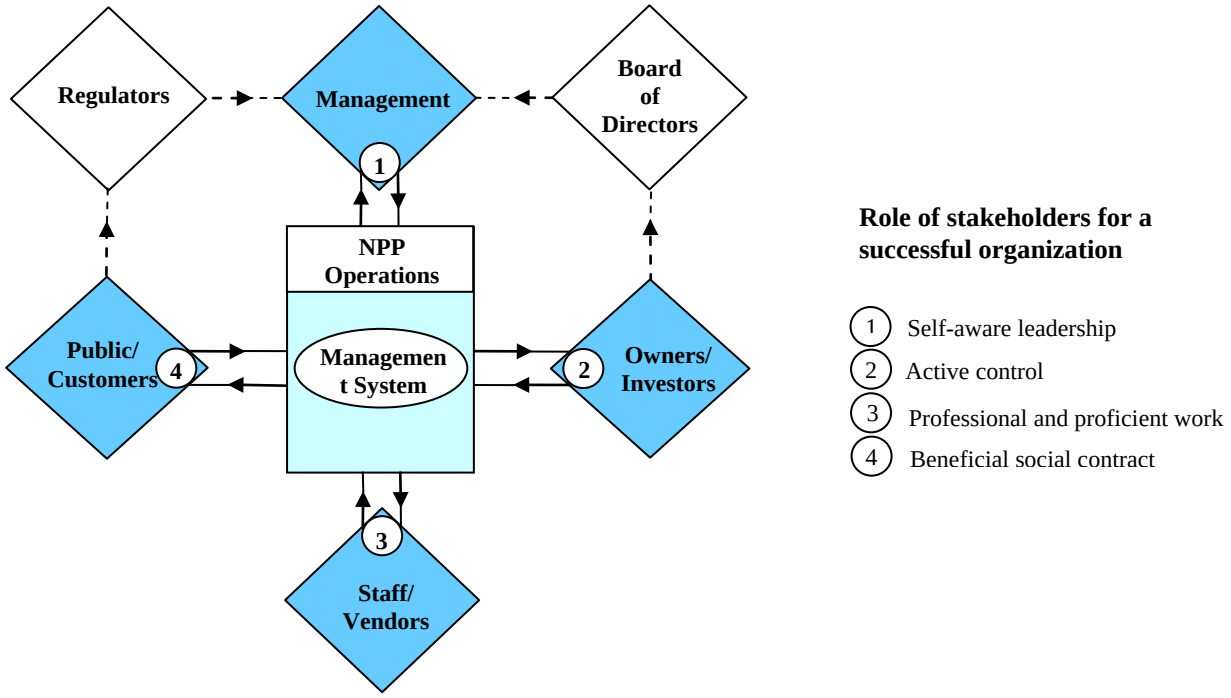

Figure 2 – The *Organization* for operating an NPP and the Roles of the Stakeholders

The owner/investor and public/customer groups are often large with limited capacity to affect the direction of the company and manage their risk. As a consequence, they have the Board of Directors and Regulators to act as their proxies. The roles of the stakeholders are discussed in the following subsections.

De Geus describes the operation of privately owned companies. Does the same living organization model apply regardless of the type of ownership? Meier and Bohte [20] address this question to some extent within the context of the Texas Education Excellence Project. They observe that public corporations do not die as a private one would. Instead, they are placed on indefinite life support sponsored by the state and continue to operate as dysfunctional organizations. The owners (public) and the customers of a public organization have unlimited

liability if it is dysfunctional. The public organization would have the same fate as a private one if the life support was removed.

3.1 *Management:* Self-aware Leadership

An 'organization' is an abstraction of a company's staff who individually perform tasks to achieve its goals. The individuals who comprise the management team, have the task of directing the evolution of the organization. As individuals they must be able to

a) assess the current performance of the company in achieving its goals;
b) perform self-assessments of their own performance in managing the company;
c) understand and assess the changing socio-economic environment and balance the stakeholder interests;
d) assess the organization's ability to adapt to changing conditions; and,
e) develop a plan for adapting to the changing environment.

The capabilities required of the management team can be summarized under the attribute of "self aware leadership". People who have a low level of self-awareness are not able to judge their performance, or that of other staff, against objective standards. In performing their work they are vulnerable to the Kruger-Denning effect [21] which is an overestimation of their own capability. Generally, this is not a trait that contributes to the evolutionary success of a living being. The management team manifests leadership by seeing the right things are done to ensure the organization's on-going success.

The Management Team has direct responsibility for the operation of the company. In their decision making they are vulnerable to selecting options that are in their self-interest and to the detriment of other stakeholders. For example, a performance bonus promotes this behaviour to detriment of the company.

3.2 *Owners/Investors*: Active control

The owners/investors of a company want a return on their investment that is commensurate with their risk of losing it. In principle, the Board of Directors protect the owners/investors interests by providing oversight of the Executive Management Group.

Board of Directors

The Board of Directors oversee the operation of the company on behalf of the shareholders. Monitoring of the operational risk is one of their fiduciary duties and critical for protecting the owner's investments. The concept of operational risk is discussed more fully in Section 3.0. It is in the owner's interest to have the risk shared fairly by the stakeholders. It is incumbent upon the Board of Directors to ensure that all stakeholders benefit.

The Executive Management group is responsible for implementing the operational risk management program. The Board of Directors should have an active independent committee for monitoring the operational risk and verifying that corrective actions are taken if it becomes greater than the risk basis for the owner's investments.

3.3 *Staff & Vendors:* Professionalism and Proficiency

The staff and vendors interests have to be aligned and balanced with those of the other stakeholders. In particular, the public has to have confidence the facility meets community needs without undue risk. Also, the power plant must produce electricity at a cost that is competitive with other generating stations locally and in other regions.

The performance of an organization is entirely dependent on the knowledge, skills and behaviour of its staff and the staff of its vendors. The single most important attribute of personal conduct is professionalism. A professional [22]:

- is committed to the highest standards of personal integrity and professional competence;
- aligns their career development and the organization's interests;
- treats all co-workers and clients fairly, honestly and with respect;
- places the interests of society ahead of their own self-interest; and,
- seeks to improve the conduct of their profession and its benefits to society.

The staff are the cells that made up the organs (departments) giving the organization its life. Although specialized in the work of their department, a person needs to understand the role of their department in giving life in concert with all the other organs. That is, each employee needs an understanding the organization and of the functions of the departments. Being specialized as a reactor physicist does not exempt the employee from knowledge of the design basis for both safety and commercial operation. More importantly, all employees need to understand how the cost of the electricity produced affects their customers personally and in business. Unprofessional conduct exposes the owners and public to unnecessary costs and safety risk.

3.4 *Public /Customers:* Beneficial Social Contract

The owner/operator needs the approval of the public and its customers to build, operate and modify a facility within a community. For a regulated industry, the Regulatory agency establishes criteria for the tolerable risk given the benefits to the community. An effective regulatory regime is a necessary but not a sufficient interface between the company and the community. The company needs to be engaged in a mutually beneficial and active social contract.

Social Contract

From the beginning an implied contract exists between the company and the community. The company will provide benefits in the form of jobs, taxes and products with acceptable risk to the workers, customers and the public. In return the community will accept the company as a beneficial member. The public and customers have to be confident that the public risk and the cost of electricity is as low as reasonably achievable. Consequently, the company is vulnerable to failure if it causes a breakdown of the social contract due to a lack of understanding or neglect due to the pursuit of self-interest.

The regulator, acting on the community's behalf, establishes the public risk criteria and monitors the operation of the facility for compliance. If the community loses confidence in the regulatory regime, it jeopardizes the social contract with the company.

3.5 The Operating Organization

To complete the model of an evolutionary organization we have to model the operation of the company. In the case of a nuclear power plant the business goal is maintain a high level of production while operating safely and controlling costs.

To achieve the business goal the station's Management System incorporates the basic principles of performance management:

- organize the human, material and financial resources for efficiency and effectiveness;
- control the work through defined processes derived from the business goal;
- perform the work to high standards for quality and efficiency; and
- continuously assess the effectiveness of the Management System in achieving the business goal and implement improvements.

The model for the operating organization is shown in Figure 3 with the performance management principles represented by the four pillars.

The operation of the business has a hierarchy of requirements at the strategic, tactical and operational levels. In Figure 3, these levels are shown as the implementation of business plans, work processes and human performance programs. They form a matrix of requirements with the pillars of performance.

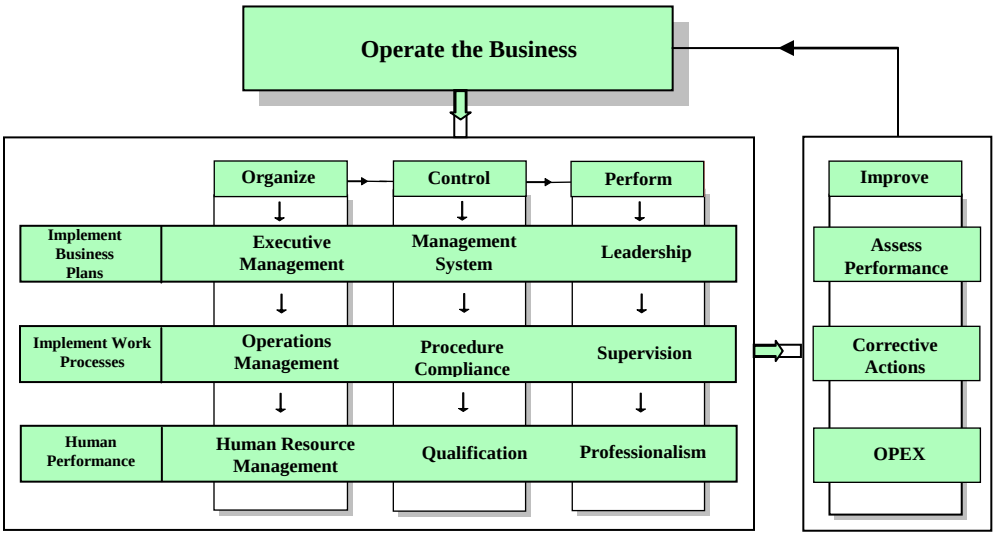

Figure 3. – The hierarchy of management for a high performance organization.

4. Operational Risk

Apart from acts of negligence or sabotage, no one deliberately takes an action that will harm themselves or their employer. Accepting this premise, it follows that organizations fail because decisions expose the stakeholders to a dangerous level of unknown risk. Bad decisions are made at all levels in an organization. At the corporate level decisions on exposure to financial losses may lead to bankruptcy. At lower levels poor quality may lead to lost production or compromise safety.

Uncertainty about the future makes decision making a risk based activity. The concept of risk is challenging in both its perception and its application. The organizational model proposed in this paper uses Holt's [23] definition of risk. Three aspects of risk merit emphasis when discussing the vulnerability of an organization.

Risk is the exposure to harm due to uncertainty in the outcome of a course of action. The decision making process identifies possible courses of action to achieve a desired future condition. The best course of action exposures the stakeholders to the least acceptable risk. The 'decision' is the selection of the best course of action. The correct decision is based on a correct assessment of risk [2] and conversely for incorrect decisions.

People, not organizations, are exposed to risk. People make decisions and the decision maker must be careful to define which stakeholders are placed at risk as a result of the decision. Moreover, it would be immoral to place someone at risk without gaining their acceptance. The public is a stakeholder in the operation of a nuclear power plant and the regulatory agencies monitor their risk on their behalf.

The recent collapse of company such as the Lehman Brothers bank [24] offers an example of a failure to manage the risk to all stakeholders in an enterprise. Investors in the bank are at risk if the market value of their shares decline. Senior managers of the bank receive bonus payments as an incentive to grow the share value. By making high risk investments they expose the shareholders to losses while increasing their potential bonuses. In short, they gamble with shareholders' money and take a share of the winnings and leave them with all the losses.

Perception of risk is used in decision making. The decision maker has three types of uncertainties that have to be evaluated for their potential of harm [25]: (i) the known; (ii) the known unknowns; and, (iii) the unknown unknowns. Uncertainty and harm can be assessed for (i); estimated for (ii); and managed by defence in depth and time-at-risk for (iii). The completeness of the information available to a decision maker directly affects their perception of risk. Also, the decision maker's perception of risk is affected by its context within the corporate culture [26].

The Basel Committee [27] defines operational risk as, "*The risk of direct or indirect loss resulting from failed internal processes, people and systems or from external events"*. This definition encompasses the exposure of the stakeholders (losses) to design basis failures and organizational failures. Operational risk changes as equipment condition, business processes, human performance and the environment change. Consequently, it must be managed by a self-aware organization that will maintain an acceptable level of risk.

A corporate culture is inherently a culture of production (business success). It provides the life force from the time the business is created. If it is not present, the business cannot survive. However, it biases the risk assessments. If decision makers do not recognize the bias, they will perceive the operational risk as acceptable when in reality it is unacceptable. Because of the bias on operational risk assessments due to a culture of production, organizations have an inherent tendency to fail.

5. Hazards & Defences

This section illustrates a hazard analysis using the model described in Section 3. The analysis would be the basis for an operational risk management program.

5.1 Failure of Management

Two significant hazards in the management group are

- the perception that safe operation conflicts with successful commercial operation [16,17]; and,
- the perception of risk that excludes the uncertainty of unknowns [23].

Both of these hazards are significant contributors to the operational risk.

Production Culture vs Safety Culture. Since events that lead to commercial losses or harm to people are infrequent as opposed to the normal routine of daily operations, they are considered 'abnormal'. This distinction and the inherent production bias of a company promotes the perception of a separation between safety and production. Moreover, it leads to a belief that safety can be compromised with no impact on production and success of the company.

Twenty-five years ago there was the same perception of the separation between quality and production. The transition to integrating quality into production processes has been completed by the implementation of Total Quality Management programs. The nuclear power industry can make the same transition if business leaders insist that safety and production are inseparable [17].

Risk as certainty vs uncertainty. Risk is the uncertainty of exposure to harm [23, 28]. In risk assessments analysts equate uncertainty to the probability of exposure to harm. In doing so, they address known unknowns and ignore unknown unknowns. In nuclear engineering we implement safety design provisions to make the probability of harm to the public very small. Ignoring the low probability events, risk assessment becomes an exercise in demonstrating certainty of no harm to the public. This feeds the perception that there is neglible risk to the public from the operation of the nuclear facility.

The probabilistic risk assessments performed to demonstrate low risk are incomplete. They do not include all known hazards and cannot address unknown hazards. The defence in depth principle recognizes the existence of unknown hazards including the known hazards of human failures. To maintain a focus on risk as uncertainty of harm, the defence in depth principle must be at the forefront of safety design and operation.

A proactive program of monitoring for accident precursors of all types is the best way to minimize the exposure to unknown events. An aggressive focus on the near future reduces the likelihood of unknown events occurring. The approach limits the time at risk from unknowns.

5.2 Failure of Active Control

Failure of the Board of Directors to protect the interest of the owners is a hazard to the success of a company. There are many examples of neglect by the Board of Directors that has led to failure

of companies and substantial losses for the owners. Following the collapse of Enron, the Sarbanes – Oxley Act [29] was passed to require greater independence and transparency when reporting financial results. Now, the international financial community seeks stricter regulation of banks to prevent the failures that occurred in the wake of the subprime mortgage crisis.

The Board of Directors sets the criteria for success of the organization and establishes policies to guide its evolution. The Senior Management group has responsibility for implementing the policies and meeting the success criteria. Although the Board's Mandate is to monitor the performance of the management team, it is vulnerable to being co-opted by the executives. The vulnerability is reduced by the owner/investors taking active control of their risk via the Board.

In the absence of active control by owners, the Board can adopt an effective Operational Risk Management program to monitor the Company's vulnerability to internal and external hazards. Corrective actions would include improvements in the management system and/or modifications to the business model. For example, changes to the business model that alter the nature of the investment and the risk to owners/investors would require their approval.

5.3 Lack of Professionalism

The failure of an organization to implement high standards of professionalism places it at risk. Among other things, it can lead to weak supervision, assignment of unqualified staff to perform tasks; and, decision making based on self interest rather than the interest of all stakeholders. This single failure of the organization leads to multiple failures in the organization at the working level. That is, it is a common cause failure and defence in depth does not protect against it [30].

The Columbia shuttle accident provides an example of compromised standards due to the use of PowerPoint slides to communicate complex technical information [31,32]. Edward Tufte also makes the case that only an engineering report can communicate complex technical information [33]. Without the formal technical report decision making is impaired.

There are two collective hazards that compromise the effectiveness of nuclear professionals - the normalization of deviance; and, the moral hazard.

Normalization of deviance. Diane Vaughan elucidated the role of deviance in the Challenger accident [34]. The normalization of deviance is an insidious hazard because it occurs in compliance with safety management processes. When deviations from the design basis occur, they become normalized through a rationalization that there is no incremental risk. This appears to be linked to the bias of perceiving the risk as a low probability and therefore certainty that no corrective action is required.

Moral hazard. Employees are given job security with the intention of receiving a higher standard of performance because of less stress. In practice, it makes it difficult to demand

accountability for personal performance [35]. Beyond that, the organization of professional staff as labour unions is incompatible with the code of conduct for professionals (Section 3.3).

5.4 Failure of the Social Contract

The primary factors in the social contract are safety and economics. The Fukushima accident has challenged the social contracts of utilities in many countries. Also, in North America the abundance of shale gas and renewables is challenging social contracts. The following are potential contributing factors to an organizational failure due to a breakdown of the social contract.

Involuntary Regulatory Compliance – safety. Regulatory bodies represent the public's interest in being protected from undue risk from the operation of the business. The adoption of an adversarial position to compliance with regulations is a failure to respect the social contract. Moreover, it reflects a lack of understanding of two important requirements for success.

i. Regulatory requirements for safety are not independent of the production objectives of the company.
ii. The company's performance standards must be higher than those of regulatory bodies. Regulatory standards are, by definition, the minimum acceptable standards.

Managers who believe that safety (or other) requirements interfere with their production objectives will naturally adopt an adversarial role with the regulatory body. This human tendency appears to be independent of the specific industry.

Lack of cost control. Most large scale nuclear projects exceed their planned cost and schedules. This in itself is a failure of the social contract because stakeholders accepted the projects based on the planned costs and schedules. If it is not addressed, this failure will be catastrophic for the industry. The industry should be proactive in addressing the problem.

Although nuclear electric costs can be competitive with renewables despite the high project costs, cost control cannot be ignored. It is a moral obligation to society to produce power at rates that ensure a strong economy. The industry workers need to respect the public and customers as stakeholders.

6. Conclusions

This paper proposed understanding organizational accidents in the broader context of all hazard that threaten a company's existence. The unforeseen events that threaten the organization are addressed by using an evolutionary model to capture the dynamic socio-economic environment. The owner's risk of a failed organization is managed by an operational risk program. An important part of the considering the organization within its socio-economic environment is capturing the management of risk from unknowns.

Table 2 lists key hazards that have to be addressed in an Operational Risk Management program along with the means of protection. It illustrates hazards not included in a traditional Probabilistic Safety Assessment.

Table 2 – Key Hazards for Operational Risk Management

Hazard	Means of Protection	Objective for Success
Only internal safety hazards	Self-aware leadership	Manage operational risk from all hazards
Unknown Unknowns	Learning organization	Minimize time at risk
Stakeholder imbalance	Active control by owner	Satisfy all stakeholders
Normalization of deviance	Plant status and configuration control	Protect the design basis
Lack of Leadership and Moral hazard	Professional standards and accountability	Excellent performance of people and equipment
Lack of cost control	Exercise responsibility to customers and community	Beneficial social contract

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