ASSESSMENT OF CATASTROPHE RISK IN INDUSTRY

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Abstract

This paper describes the potential contribution of near-miss management systems to improving company profitability and reducing the frequency and severity of major industrial accidents. The near-miss concept has long been understood in both manufacturing and finance, as several examples in this paper illustrate. However, what has been largely missing is the integration of near-miss management into the culture and day to day operations in a manner that underlines the critical connections between near misses and behavior. Too often, near-miss management has been relegated to special staff or company-wide risk management committees, with the result that near-miss management has tended to play an ex post forensic role in risk management rather than the alerting role as a means of summarizing leading indicators and precursors of hazardous conditions. This paper describes several strands of recent research that aim to correct this and to make near-miss management an organic element of Enterprise Risk Management.

Key words

Near Miss, Enterprise Risk Management, Safety Pyramid, Leading Risk Indicators

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Introduction

Catastrophic events in (process) industries are categorized as "Low Probability High Consequence Occurrences". Although in industry the word "catastrophe" is mainly associated with loss of lives, equipment and/or major environmental damage (definition of classic "industrial catastrophe"), in this paper, we use the terminology "catastrophic event" to encompass any unplanned event or accident that results in significant "business losses", including major business disruptions that can stem from natural hazards, major accidents, supply-chain disruptions, and product recalls. These events may result from natural sources or management system failures, and may be connected to broader external drivers of risk such as climate change or sudden shifts in technology and regulation.

Catastrophic events have been increasing in both frequency and severity in recent years. These have been especially visible in process industries (Kleindorfer et al, 2007) and in financial services (Muermann and Oktem, 2002; Oktem et al. 2010), but there is a growing recognition of the importance of Enterprise Risk Management to prevent catastrophic events in other industries as well. The reasons for this heightened sensitivity to events causing major business losses arises from several factors: a) increasing global population and, therefore, proximity of housing to industrial facilities (ref: An EPA Analysis of Urbanization), b) increasing size and complexity of industrial facilities, and c) global interdependencies of both large and small industries to each other (Kunreuther and Michel-Kerjan, 2007). Thus, understanding the risks involved in industrial operations and reducing both the likelihood of occurrence of major accidents and their impact are of great interest to corporate risk managers. In this paper we will focus on "near-miss management" as an assessment approach for reducing the frequency and severity of industrial accidents.

The essence of near-miss management stems from the fact that accidents typically have a history of warning signals that are leading indicators or precursors of major events causing business disruptions. Thus, assessment of company and site vulnerabilities should not just be focused on external data or on ex post major accident reviews, but rather on the effective definition, measurement and auditing of performance against leading

indicators of vulnerability and resiliency. That is, near-miss management should not be an isolated activity relegated to special staff or company-wide risk management committees. It should be organically integrated into the operations and employee/management responsibilities to help Enterprise Risk Management.

Near-Miss Concept

Near-Misses are probably the most important indicators of major accidents. The notion of a near-miss for industry is best explained by what is known as a "safety pyramid", which was discussed as early as 1931 by H. W. Heinrich and was further developed by Frank E. Bird based on his 1969 study of industrial accidents (Bird and Germain, 1996).[2]

The characteristics of an event that qualify it as a "near-miss" depend on the organization's definition. The Wharton study (Phimister et al., 2003) recommends using a broad definition to be able to catch a greater number of possible improvement opportunities. It defines near-miss as "*an opportunity to improve environmental, health and safety practice based on a condition, or an incident with potential for more serious consequences".* Later, Muermann and Oktem (2002) discussed the near-miss concept as part of the operational risk in financial institutions and used the following definition "*near-miss is an event, a sequence of events, or an observation of unusual occurrences that posses the potential for improving a system's operability by reducing the risk of upsets, some of which could eventually cause serious damage*". These definitions can be interpreted as "too broad" by some, such as the Department of Energy (DOE Manual 231.1-2) which considers a near-miss as a case where "*no barrier or only one barrier prevented an event from having a reportable consequence.*" Similarly, near-misses are also referred to as "close calls" or "near-hits". In the Encyclopedia of Quantitative Risk Assessment and Analysis (2008) Oktem and Meel presents a broad spectrum of "near-misses" from different industries. As mentioned above, in the earlier Wharton study (Phimister et al., 2003), the bottom region of the pyramid was expanded to include events with no adverse effects, such as observation of a condition that has the potential of causing an incident, and the lower portion of the pyramid was identified as the "near-miss" region. This concept has been expanded even further by Oktem et al. 2010 as shown in Fig 1 to include (a) another region: "Positive Illusions, Unsafe conditions and Unobserved Problems – Unawareness, Ignorance, Complacency" to the bottom of the pyramid; and (b) a new dimension called "risk perception" along the height of the pyramid, and called this new version the "Risk Pyramid". By making these modifications they included a broad spectrum of safety and operational risks organically present in different parts of the businesses that normally go unrecognized. Of course, it is worth noting that the categories in the risk pyramid represent a continuum, where there will be some overlap between the different areas as one moves up the progression. Examples that are given in the rest of this article will demonstrate the different near miss levels and even point out situations when corporations might get into trouble even though they think they are operating in a low/no risk region.

Defining and labeling of each level of risk (or safety) pyramid has been subject to long discussions with no agreed upon resolution. Industrial near-misses are defined as events with minimal consequences. In case of major accidents from natural causes, such as seismic events, hurricanes, floods, drought, heat waves, etc., near-misses are defined as events that nearly gave rise to a major catastrophe. For example, a category 4 hurricane that missed a highly populated region and damaged the environment in a neighboring unpopulated area can be considered as a near-miss from which regional governments can learn the damage potential and take necessary precautions to minimize consequences in the future. In finance there are several examples of near-misses, such as being blindsided by apparent lack of problems in A.I.G Financial Products before its dramatic losses (Oktem et al. 2010).

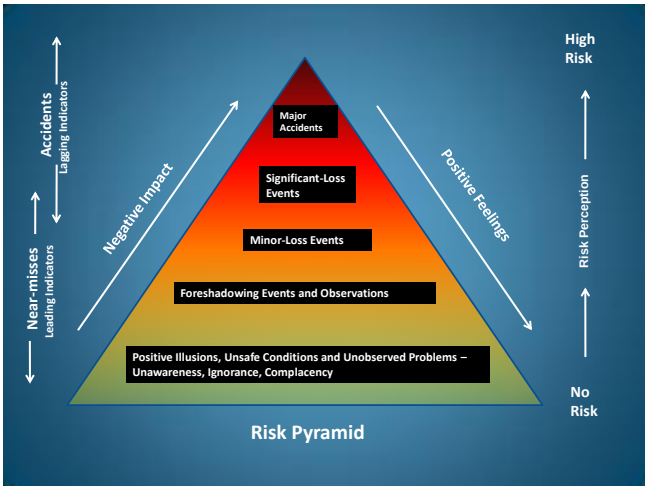

Figure 1. Risk Pyramid

[2] This is later discussed in several articles related to "industrial accidents". See e.g Phimister et al.(2003) and Kleindorfer et al. (2007)

During the post catastrophe investigation, of historical developments of events up to the catastrophic incident, usually multiple indicators of the approaching disaster are identified. Incidents at the tip of the pyramid are what we call in this article "catastrophes". They may result in injury and loss, major environmental impact, significant business disruption and/or reputation loss. These catastrophes are almost always obvious, are vehemently brought to the attention of management, and are assessed according to corporate protocols. "Near-misses" comprise the lower portion of the pyramid. These incidents, depending on the circumstances, either result in minor losses or have the potential for but do not result in a loss. Near-misses are often less obvious than accidents and are defined as having little, if any, immediate impact on business, process, or individuals. Near-miss concept covers a broad range of incidents. Although in most cases it is not difficult to differentiate between a near-miss and an accident, under some conditions, such as an adverse event with significant negative impact, the case can be classified either as an accident or as a near-miss. Accidents represent the region between catastrophes and near-misses, connected to both with fluid borders.

The very bottom level is the 'False Comfort Zone'. It describes the conditions when management, employees and/or customers are under the impression that they are not facing any risks, everything is happening as good as they planned, may be even better. Problems go unobserved, as do unsafe conditions, aided by general attitudes of ignorance or unawareness. For example, when the BP Texas refinery explosion was analyzed by the Corporate Safety Board, BP's unawareness of its process safety problems and its complacency due to its improved personal safety record became obvious (see example below).

In the chemical industry while personal/process accidents are observed every year catastrophic incidents are rare and usually result from process safety problems. Process near-misses, that are the warning signs for catastrophic events, do not contribute to the injury and illness statistics on an annual basis. Therefore learning from near-misses and improving process safety requires a different approach, such as using alarm data as near-miss indicators, rather than injury and illness statistics, to predict the emergence of unsafe conditions that may be precursors to catastrophes.

Near-Misses have three fundamental characteristics: (a) frequency, (b) actual damage, and (c) maximum potential damage of related worst case scenarios that could result from specific categories of near misses. All of these should be recorded, monitored and used to track progress in safety, operability, and reliability of any manufacturing or financial process. These three fundamental characteristics form the base of leading indicators. From a process control perspective, the use of the process performance indicators as a basis for prediction and control has been a central research area since the work of Pontryagin and Kalman in the 1950's and 1960's, leading to the revolution in real-time control.[3]

Near-miss management applies to almost all facets of an operation and it can play a critical role in the survival of a business. For example, before the 1984 Bhopal incident of Union Carbide, which caused the collapse of the company, they had numerous near-misses which were ignored by management. Similarly, in 1999, the Concept Sciences Inc. catastrophe killed five people, injured many more and destroyed several buildings, but it also brought the end of the company before it even started to grow its business. Here again, if near-misses observed during laboratory development had been taken seriously, the facility and the operating conditions would have been designed differently to prevent the formation of an explosive condition, a matter which had been well studied in the literature. With an explosion during its first production batch, Concept Sciences Inc. did not even get a chance to have a single large-scale operation, losing its survival opportunity.

Although most reported near misses are associated with safety and health issues in manufacturing, there are numerous other examples where near misses did signal the potential for a catastrophe. For example, in their book "Wharton on Making Decisions", Stephen J. Hoch, Howard C. Kunreuther, and Robert E. Gunther (2001) describe in detail how Nick Leeson's bad decisions, which led to the spectacular failure of Barings Bank, started with his attempt to cover the mistakes of a new employee (whom he had hired). The loss caused by the employee's error was on the order of £20,000, which can be considered as a near miss compared to the final outcome.

The decision to hide such a small failure, perhaps to avoid the risk of being perceived as someone who made a bad hiring decision, set off a chain of further, even bigger problems. Barings' managers, including the one auditor who noticed a £50M problem, overlooked any "questionable outcome - losses" associated with Leeson's operations due to their admiration of his fast conduct of business and apparent success in earnings. So, Leeson,

[3] For a concise summary of the history of optimal control theory and its applications to business problems, see Sethi and Thomson (2000).

who actually started to gain people's trust by fixing other people's problems (a highly admirable situation), enjoyed the popularity he gained by accomplishing results that were almost too good to be true. In this "Positive Illusions (ignorance, complacency)" region of the pyramid, the perspective of many individual managers seems to be biased towards seeing only *"positives"*, such as unprecedented success, and avoiding consideration of possible, "*negatives*", that is potential problems. The lesson of Barings Bank, and many similar events in the financial industry, is that effective near-miss management systems can both lead to reliable predictions of developing catastrophic problems as well as improving the monitoring and decision processes of the company.

Lessons can be learned from every near miss regardless of where and how it happened. The main cause of the 1999 Paddington train crash in the UK - where a passenger train crashed with a freight train killing 31 people and injuring over 500 - was one of the trains not stopping at the red stop sign. In fact in the previous six years, this (SPADs –Signal Passed At Danger – when it is red) had actually happened eight times without any accident. So there were eight near-misses as opportunities to take precaution to prevent such a catastrophe. This is a very good example of addressing the root cause of problems even if no adverse consequence has happened. In this case, every time a train operator crossed at a red light, the event was reported by the operator shortly after he crossed the red light informing his missing the signal. But, despite the fact that this was one of the most missed signals in the train system no effort was made in order to determine the root cause of this repeated event and prevent its recurrence. Reporting of such near misses, especially if this is done by the responsible operator, requires a change in the culture of the company, in which employees understand that they are the ultimate risk managers in the company. On the other hand, management has to have equal ownership in analyzing near-misses and preventing accidents since most of the time they have the resources to make necessary changes. Using near-miss management to effect the necessary cultural change is discussed further below.

The above discussion has focused on near-miss management for internal operations. An increasingly important application of near-miss management is its extension to external sources of disruption, such as disruptions in the company's supply chain (Kleindorfer and Saad, 2005). Given the globalization of economic activity in the last three decades, it is therefore not surprising that learning from near misses or even catastrophes of others and developing alternatives for more robust supply chains has become a central tenet of business sustainability.

Natural disasters have become an increasingly important source of supply chain disruptions. This is the result of the rapid increase in the global spread of customers and suppliers in the last decade. This may also be the result of demographic movements to coastal areas and climate change (Kunreuther and Michel-Kerjan, 2009). Natural disasters have proven to be especially critical sources of supply chain disruptions for supply chains originating in emerging economies. These economies provide benefits of low-cost labor and cheaper availability of certain critical inputs. However, they also suffer from poor infrastructure as well as emergency response and recovery systems, so it may take several months before disrupted supply lines return to normal. As a result, global companies have set up company-wide crisis management centers to manage major supply chain disruptions[4]. These centers also act as a central gathering point for near misses associated with the company's supply chains. Simulation and other modeling approaches are used to examine the consequences of potential disruptions and to rehearse crisis management response to such events. Companies learn not only through events that directly affect their own supply chain; they also learn from events that affect other companies. A major flood in India or an earthquake in Turkey may not affect a given company's operations but the observation of the resulting chaos and interruptions can be considered as a near miss, providing an opportunity for the focal company to improve its own risk mitigation and response strategies.

Examples of Various Near-Misses in Different Business Environments

A. BP Refinery Case:

The findings of BP Independent Safety Review Panel **(**2007**)** formed to study the March 2005 explosion of BP's Texas refinery which killed 15 people, indicates that "*BP has emphasized personal safety in recent years and has achieved significant improvement in personal safety performance, but BP did not emphasize process safety. BP mistakenly interpreted improving personal injury rates as an indication of acceptable process safety performance at its U.S. refineries. BP's reliance on this data, combined with an inadequate process safety understanding created a*

[4] See, for example, the excellent description of the crisis management operations at Cisco Systems in Harrington and O'Connor (2009).

false sense of confidence that BP was properly addressing process safety risks."

That is, there were series of near-misses leading up to this 2005 BP incident but the main reason for failure to learn from these near-misses was the way safety was managed in the Texas refinery. Safety efforts were driven by workforce injury statistics which is mainly dictated by workforce injuries that are the result of slips, trips, and falls.

B. Sony Battery Case:

A recent example that demonstrates how identification and management of near-miss could have saved significant business losses is the Sony battery recall case. Although Sony was made aware that there were some overheating issues in laptop computers as early as October 2005 and February 2006, they did not order a recall and continued using previously stocked batteries. This was clearly a near-miss, which was ignored by Sony. Later, Sony batteries were identified for potential incidents in Dell laptops, which then led to battery recalls, causing a 96% decrease in Sony's reported quarterly net profit. Even at this point, they could have treated the Dell incident as a near-miss (although clearly with more significant impact) and recalled the batteries from other companies like Fajitsu, Toshiba, Gateway, Dell, and Apple, all of whom were users of Sony batteries. However, the company continued to miss the signals from these early near-miss incidents, and, ultimately, the problems were revealed in other companies as well. Estimates indicate that this problem will cost Sony at least $429 million before it is resolved, and possibly twice as much when the results of legal actions are considered. Sony could have avoided much of this expense and business risk had they addressed the problem and recalled the batteries when they originally observed the overheating issues (near-misses).

According to CPSC, at least 124.7 million products were recalled in 2010 and overall, recalled products were associated with 26 deaths. (Ref: http://pressroom. consumerreports.org)

C. Environmental Sustainability:

Environmental sustainability is gaining increasing importance and the attendant risks associated with this field indicate a further important area of application for near-miss management. Rising awareness among consumers, growing pressure on regulators, and searching for new technologies can present unexpected challenges for many traditional lines of business. These challenges arise in part because they often come from non-market sources such as regulators and legislators. Near-miss management, therefore, is useful in drawing attention to these non-market drivers, which might otherwise be overlooked or neglected entirely as potential sources of significant gain and loss for a company. For example, regulatory and legislative incentives promoting the sudden increase in production of biodiesel from vegetable oil in 2007 and 2008 caused major increases in food prices, especially oils. (Mitchell, 2008) These changes caught some companies off guard and put significant strains on their businesses. Near-miss management, focused on regulatory drivers of market supply and demand, have since become important elements of companies like Kraft, Nestle and Unilever in predicting future prices of key inputs like vegetable oil based on broader monitoring of their environment. This practice enables these companies to understand their environment better through gathering and processing of near misses stemming from environmental sustainability and to modify their products and operations to minimize the impact of similar situations on their business.

D. Fannie Mae Case:

One can make the argument that 'failure to notice' the weak signals around subprime lending and to act is what happened in the recent case of Fannie Mae's 'accident', where they lost $59bil in 2008, leading to a $15bil cash injection from the government (ref: Washington Post, Feb 27, 2009, p.D1). Leading up to this 'accident' was a series of visible events, arguably going all the way back to the change in their subprime underwriting policy in 1999, that were not acted upon by firm management or public policymakers. Putting aside the longer history, just in the past few years, the near-miss signals were growing in volume and strength. Subprime loans were at historically high levels in the early 2000s but did not prove problematic because rising home prices meant that debts could be settled. However, this should have been a signal that if home prices were to fall, the risk models would prove inadequate. Another near-miss signal was the rise in loans without documentation (low- or no-doc loans), which in 2006 made up 50% of subprime and 81% of near-prime mortgages. (Federal Reserve Bank of Dallas, 2007) At the end of June 2007, "Fannie Mae held $47.2 billion of securities backed by subprime mortgages…[and] all but $300 million of Fannie Mae's subprime bonds as of June were rated AAA", even though 5% of subprime mortgages in bonds were at least 90 days late on payments and 7.4% were in foreclosure or seizure. (Bloomberg News, July 30, 2007) Given the deteriorating situation in the subprime market and the clear signals that risk models were being invalidated, nonetheless, the near-

misses accelerated up the risk pyramid until the well-publicized accidents of 2008.

Ultimately, the crisis at Fannie Mae has had much more widespread repercussions, as has been well documented.

Power of Near-Miss Management in Prevention of Catastrophes

Near-Misses - a way of eliminating catastrophes or mitigating damage when it happens.

Identification of early stress signals and taking the proper action to eliminate the stressor forms the core of "Near-Miss" concept. There are numerous examples of major accidents in both manufacturing and financial industries whose earlier signals were ignored. This oversight exists in other industries as well, such as airline industry. In this section we will present a methodology for integration of near-miss management into the culture and day to day operations in a manner that underlines the critical connections between near misses (both personal and process related) and behavior (both employees and management). This methodology, which resulted from observations of successful near-miss management in various industries and research on principles of risk management, is built on three fundamental pillars, all of which is equally essential for successful reduction in accidents and significant improvements in operational reliability:

a. Organic integration of near-miss management into the operational fabric

Effective utilization of near-misses requires its components to be organically integrated to the operational fabric. That is every employee and manager has an active role and participates fully in near-miss management process (such as the eight step process described in the next section).

b. Categorization of near-misses

To be able to track and monitor in a manner that helps with decision making the overall risk has to be divided into meaningful, track able categories. For example in chemical industry these categories would include, but not limited to, the following main and sub categories:

- Technology: 1. Process, 2. Procedures
- Facility: 1. Mechanical Integrity, 2. Quality Assurance, 3. Process Hazard Analysis
- Personnel: 1. Training, 2. Contractor Safety, 3. Management Leadership, 4, Operational Discipline, 5.Auditing, 4. Incident investigation, 5. Emergency Planning,

Similarly in financial industry following are examples of categories to be used:

- Retail Banks: 1. Check processing, 2. Branch network, 3. Credit servicing and processing, 4. Printing and statementing,
- Investment Banks: 1. Trade processing, 2. Report production, 3. Corporate action processing, 3. Trading P&L generation
- Insurance Companies: 1. Underwriting, 2. Claims processing, 3. Field and client servicing

c. Tracking and monitoring of near-misses in each category

As mentioned above the tracking of near-misses in each of the categories should be done based on its three characteristics:

a) *Frequency* refers to the number of events per unit period. Depending on the operation this can be monthly or quarterly.

b) *Actual damage* is the observed damage and applies only to those cases where an incident has actually happened. If a near-miss is only an observation of a potential problem this characteristic does not apply.

c) *Potential damage* is associated with each and every near-miss regardless of the presence of actual damage. Usually, in personal near-misses, the person who actually experienced the near-miss is the most informed individual about the experienced near-miss' potential.

For example, a type of incident that is happening occasionally with no significant actual damage should in fact be gaining importance if its frequency or the potential damage associated with such incidents is rising.

Finally, the above categorization combined with the track able characterization of near-misses would make a powerful tool to manage near-misses so as to reduce accidents.

To measure and monitor the overall performance one can assign different weights to various categories and calculate the weighted sum. The important point is that the underlying details of the summed value are transparent and directly addressable since it points to the key areas.

The most accurate near-miss information is available at the basic worker level. Employees who are responsible for day to day operations of a corporation - such as plant operators who are responsible for the production, purchasing personnel who are responsible for managing suppliers and providing the raw materials, sales and customer support who are responsible for timely delivery of quality material - usually know the business disturbances, causal factors of these disturbances, and the difficulties to overcome such disruptions best.

An eight step near-miss management process was developed as part of The Wharton Risk Center study (Phimister et al., 2003, Oktem, U. 2003, Muerman and Oktem, 2002), which included over 100 interviews in 20 industrial locations of Fortune 100 companies. The eight steps identified in this study to address near-misses in a facility to reduce accidents and catastrophes are briefly explained below:

1. Identification

Identification is the first step of the process where an individual recognizes an incident or a condition as a "near-miss". To execute this step successfully there must be a) a clear definition of a near-miss, and b) the means to ensure that every employee across a facility knows this definition at all times.

2. Disclosure (Reporting)

Once a near-miss is identified it must be disclosed, preferably in a written form. This can be done either by the person who identified the near-miss or by a supervisor to whom a near-miss is reported verbally. Having a clear, simple, and possibly multi-channel procedure for reporting would encourage this process and would increase the probability of reporting most near-miss observations.

3. Prioritization

Once an incident is reported it needs to be prioritized. This very critical step determines the path to be followed in the subsequent steps; the level of attention that will be given to the incident, the depth of analysis that will be performed in finding causes, the amount of resources that will be dedicated to finding and implementing solutions, and the extent to which the information about this incident will be disseminated. It is important for each corporation to set their own criteria for prioritization which includes the above mentioned three factors (a) frequency, (b) actual damage, and (c) maximum potential damage of related worst case scenarios

4. Distribution

Based on the priority and the nature of a near-miss, the information is distributed to the people who would be analyzing the cause of incidents. The distribution mechanism for various priority levels must be determined during system development by the management team.

5. Identification of Causes (Causal Analysis)

This step includes identification of both direct- and root- causes of a near-miss. During implementation this step can be as simple as the reporter inputting his/her ideas for what the causes are. On the other hand, for highest priority near-misses, a committee may form to do a full-blown root cause analysis. Again, the extent of this step is determined by the prioritization step.

6. Solution Identification

The most important feature of this step is looking for a solution for each identified cause. Sometimes, several causes can be corrected with a single solution. In other there may not be a feasible, effective solution, hence a less than ideal corrective action may need to be taken. All solution decisions, even "no solution for the time being", should be noted. In the end, each cause must have been addressed.

7. Dissemination

Once solutions are identified the information should be communicated to the people who will execute these decisions assuming they have not been part of the solution identification process. This step also includes an important intermediate function, which, if overlooked, can stall the system: Obtaining permission from the manager with resources to implement the solutions. Another function of the dissemination step is to inform all possible interested parties of the particular near-miss. This may extend well beyond the site or corporate functions and may include customers, contractors, suppliers, etc.

8. Resolution (Tracking)

Once solutions are identified and implementers are informed, it is important to track all suggested changes to ensure that they are properly executed. Also, when all the changes are completed, for future encouragement

purposes, the reporter of the near-miss should be informed of the results from his/hear identification of a given near-miss.

Two important factors should be noted about the above process:

1) To get the full benefit (lessons and corrective actions) from a near miss system, all of the above steps should be performed fully and completely. That is, not only all the steps should be executed but also each step must be carried out as completely as possible. (An example is finding all possible causes not just immediately apparent ones and possible solutions to each cause not just one or two.)

2) Although the above process is derived from a study focused on large chemical corporations, the logic flow represented by these steps would apply to any size or sector organization. Even a single person enterprise can easily follow the above steps to learn from a near-miss and to prevent future problems.

The resulting system from implementing this eight step process would address the causal factors of potential catastrophes, thus either eliminate them or reduce their impact if/when they happen.

The main thrust of the Wharton Risk Center study is on personal safety related near-misses which depend on people recognizing and reporting a near-miss. Therefore, in this case, building an institutional memory of near-misses would totally depend on workers' observations and their initiative to follow-up on a near-miss by reporting it.

In the last decade, Anjana Meel, Warren Seider, Ulku Oktem and Ankur Pariyani from University of Pennsylvania (Pariyani et.al. Part I (AIChE J. in press), Pariyani et.al. Part II (AIChE J. in press), Pariyani et.al. (2010), Pariyani et.al. (2010 - ESCAPE), Meel et. al. Part I (2008), Meel et. al. Part II (2008), Meel et. al (2007),Meel et. al. (2006)), expanded the near-miss concept to process safety. They demonstrated the utility of a) treating alarms as near-misses and b) exploiting the large collection of alarm data to indicate process risk levels in an operation. For example, when a "high" alarm associate with a process variable, such as temperature, gets activated it is recorded as a near-miss. The patterns, such as increase in the number of these alarm near-misses, indicate when the system may be heading towards a shut-down. This patent pending technology utilizes automatically registered "near-misses" from the alarm data which is provided in just-in-time manner by the alarm system.

Do We Learn From Past Catastrophic Events?

Examples abound of catastrophic events that could have been avoided or mitigated. To be able to manage extreme risks effectively, organizations need to learn from past disasters, whether they have natural or unnatural causes.

BP's Deepwater Horizon explosion might have been avoided, or at least there would have been fewer casualties, if numerous cost cutting measures that compromised safety were not made and vital warning systems were not disabled (so as to not wake up workers in the middle of the night).

If BP's Texas refinery had not placed contractor Senko's workers in a trailer parked close to the manufacturing facilities (which was against the regulations), 15 people would not have perished in the 2005 explosion.

If levees and evacuation plans were well managed, building codes were well enforced and insurance premiums reflected the actual risk from risk reduction measures, the damage from Katrina would have been much less.

In their book, "Learning from Catastrophes" (2009), Howard Kunreuther and Michael Useem present seven principles for characterizing and developing strategies and leadership for perceiving, assessing, and managing risks associated with extreme events. These are summarized below:

Principle 1: Appreciate the importance of estimating risks and characterizing uncertainties surrounding such estimates.

Principle 2: Recognize the interdependencies associated with risks and the dynamic uncertainties associated with the interdependencies.

Principle 3: Understand people's behavioral biases when developing risk management strategies.

Principle 4: Recognize the long-term impact of disasters on a region's or nation's politics, culture, and society.

Principle 5: Recognize transboundary risks by developing strategies that are global in nature.

Principle 6: Overcome inequalities with respect to the distribution and effects of catastrophe.

Principle 7: Build leadership for averting and responding to disasters before it is needed.

These risk-management strategies and guiding principles are designed to reduce and even prevent losses from low-probability, high-consequence events.

One of the methods to understand how people learn from catastrophes is to look into the mitigating measures they take after they have been exposed to or learned about a catastrophe. The recent Wharton study by Michel-Kerjan et. al. (2011) on the National Flood Insurance Program shows that in 2006, after the 2005 Katrina disaster 1,299,000 new flood insurances were issued (compared to the average of 850,000) under this national program. But in three years only 43% of the households still had insurance. In general, people as well as companies do not invest in protection against low probability high consequence events until after the disaster has occurred because they tend to ignore risks and are highly myopic. When investment for protection from catastrophe is considered, people tend to focus on short term benefits of these measures in relation to the upfront costs, hence the measure is often viewed as not feasible or economically attractive.

Near misses can help corporations refresh the institutional memory and provide repeated justification for taking corrective actions. Above we shared examples of how people/institutions have short-term memory and vision when it comes to low-probability, high-consequence events. "Low" probability does not mean "zero" probability. If near-miss mechanisms are strongly established in an organization, they can be used as reminders of potential low probability events. For example, at Bhopal there were safety issues that could have been used to create alertness within the organization and sensitivity to near-misses as signals for potential disasters. In the case of the World Trade Center, the 1993 terrorist attack could have been considered a near-miss and impelled companies to take measures to minimize the business damage in an extreme event.

A well-established eight step near-miss management program mentioned above can address the "five neglects": that are identified by Berger et al. (Kunreuther and Useem, 2009) as critical elements for rational decision making. These shortcomings of individuals in making risk-related decisions are the following:

1. Probability neglect – people sometimes do not take the probability of the occurrence of an outcome but focus on the consequences only.
2. Consequence neglect – just like probability sometimes individuals neglect the magnitude of outcomes.
3. Statistical neglect – instead of subjectively assessing small probabilities and continuously updating them, people choose to use rules of thumb (if any tool at all) which can introduce systematic biases in decisions.
4. Solution neglect – choosing an optimal solution is not possible if one fails to consider all solutions.
5. External risk neglect – in making decisions individuals or groups consider the cost/benefit of a decision only for themselves, without including any externality, sometimes leading to significant negative outcomes for others.

This paper has argued that near-miss management can help to correct such biases, essentially by improving institutional memory and by focusing attention on emerging hazardous conditions.

Conclusions and Implications for Management Action

Industrial catastrophes are primarily, but not exclusively, driven by safety issues. A comprehensive near-miss management system, designed and implemented as an organic part of a company's operational structure can reduce significantly the occurrence as well as impact of catastrophes. In this paper, we highlighted the important components of an effective near-miss management system which would apply to different business risks regardless of their source. For example, safety issues as well as product quality issues can be addressed using the same principle.

Near misses are "leading indicators" for catastrophic events. Therefore, establishing new metrics to account more accurately for different near misses is imperative to learning from high frequency low impact events to prevent low frequency high impact occurrences (catastrophes).

Since most industrial catastrophes are the result of process safety issues, companies need to recognize the significance of differences between metrics to be used to assess personal safety and process safety. Currently, personal safety metrics are better defined than the process safety metrics due to safety and health regulations (e.g in the US, as promulgated by OSHA). Hence, it is important for corporations to develop a comprehensive process near-miss metrics as leading indicators of potential problems in their processes.

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