PREVENTING CATASTROPHE

Research Report

FALL LINE SYSTEMS INC.

OVERVIEW

Catastrophe is exceedingly rare, even in industries working with a number of extreme risks. Organizations have sophisticated risk management systems, and their boards, senior management and regulators are more attuned to catastrophic risk than they ever have been.

But rare does not mean extinct. Industrial catastrophes continue to occur, with troubling recent examples like the 2010 Gulf of Mexico blowout at the BP Macondo well; the 2011 Fukushima Daiichi nuclear plant meltdown; and the 2013 train derailment and fire at Lac-Mégantic, PQ.

In 2011, in response to the Gulf of Mexico blowout, Fall Line Systems Inc. initiated a research project to uncover the keys to preventing catastrophe in organizations. This report summarizes the findings of that research, identifying systems and actions that must be in place so that leaders can protect their organizations from truly horrific events.

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For background on the research and report copies see www.fall-line.ca/preventing-catastrophe

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EXECUTIVE SUMMARY

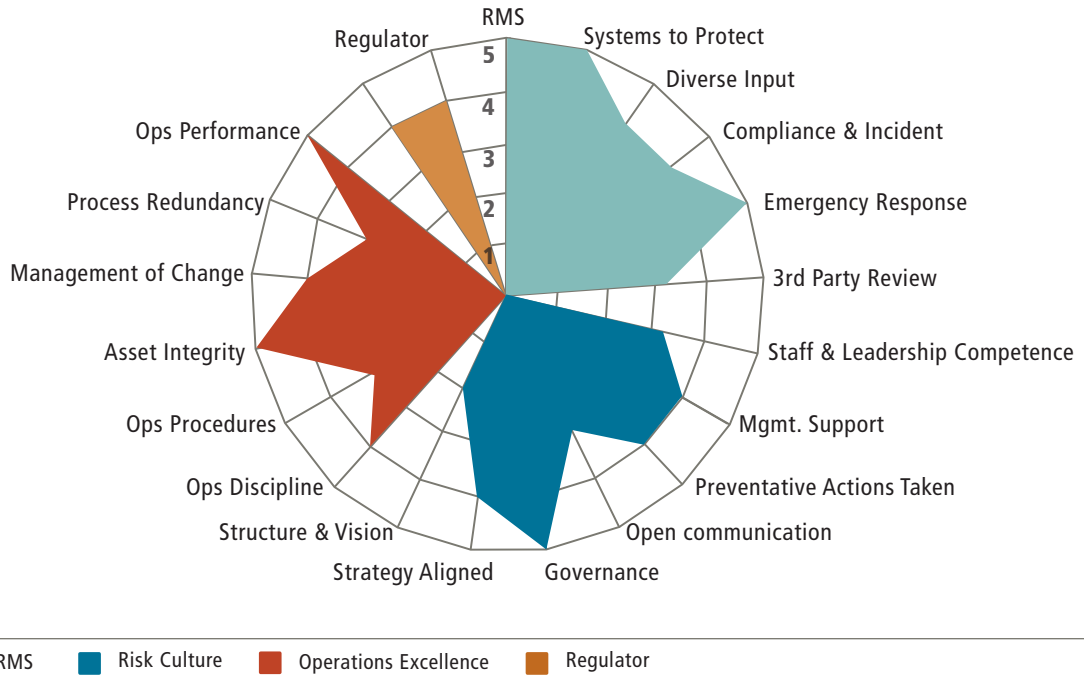
Prevention of catastrophe needs to involve every nook and cranny of the organization. This is work that cannot be outsourced to a Risk or Safety Department. It is work that must be carried on by people at all organizational levels and throughout the breadth of the organization, supported by Risk and Safety experts. The work of preventing catastrophe cannot be eliminated by any one-time fix such as the implementation of a Risk Management System or specialized task force.

Key Capabilities for Prevention

Twenty organizational capabilities are required to ensure catastrophe is kept at bay. Six of these capabilities are components of the Risk Management System (RMS) but the RMS is not even remotely adequate on its own. The RMS must be surrounded by a healthy risk culture, operational excellence and a skilled and knowledgeable regulator. The necessary capabilities identified in our research are outlined in the following sample Risk Scorecard.

If any one of these capabilities is weak, the pathway to catastrophe could open. One of our participants said, "Nature is very good at discovering the one fatal flaw in the organization."[1] It takes commitment throughout the organization to achieve a high level of performance on this set of elements. This effort is repaid through reduced catastrophe potential and increased organizational performance.

Risk Scorecard Sample Results



Catastrophe Fundamentals

A **catastrophe** is a great and usually sudden disaster. Our research focused on preventing man-made catastrophes of two types: major industrial incidents causing great harm to workers, the environment and the general public; and information technology disasters causing serious strategic damage. Catastrophes are distinguished from other incidents by their scale and the difficulty of containing the consequences on the host corporation and the public. We excluded financial catastrophes from our project.

It is difficult to grasp the potential for catastrophe partly because so few of us have direct experience with it. These are low frequency events so it is hard to test theories about catastrophe through experience. And the long period between events causes some people, and some teams, to feel invincible. This can feed their risk appetite and set the stage for huge problems.

Three concepts are fundamental to understanding catastrophe and how to prevent it:

- Performance on personal safety is a poor predictor of catastrophe potential.
- Prevention of major accidents depends on defence-in-depth: a series of barriers to keep hazards under control. Catastrophe happens when all these barriers fail simultaneously, or in rapid succession.
- In retrospect, after catastrophe hits, it is always evident that warning signs were not treated seriously, and that preventive action could have arrested the problem with very little cost.

Barriers to Preventive Action

Preventive action is routinely acknowledged to be cheaper and easier to implement than action after a problem occurs. This is true in widely varying fields such as product quality, surgery, highway safety and financial control. When considering catastrophic problems, the gap between the cost and benefit of prevention is astronomical – it is always massively better to prevent a catastrophe than it is to deal with and control its consequences.

In spite of the advantages of preventive actions they are sometimes blocked. The three most important barriers to preventive action are:

- Failure to perceive risk
- Leadership failure
- Production pressure

The **failure to perceive risk** is the most important of these barriers. In the apparent absence of risk, preventive action makes no sense. The pathway to catastrophe will be gapingly wide if key risks are not acknowledged and acted upon.

Leadership failure, particularly from senior leaders, is another critical barrier. The *tone from the top* is set by the actions and decisions of senior leaders. This tone builds the foundation of the risk culture.

Production pressure is the third most powerful barrier to preventive action. The pressure for cost reduction, profit, speed, quality and other aspects of production can be very positive, but only when balanced with pressures for protection against risk.

[1] All unattributed quotes in this report are direct quotations from the Expert Group participants.

Healthy Risk Culture or Culture of Risk?

A healthy risk culture supports people who manage risks well and strive for excellence, innovation and high levels of performance. In a culture of risk people are encouraged to take chances.

Developing a healthy risk culture is a challenging business. It requires leaders at all levels in the organization acting in an aligned way, each doing their part building and maintaining the health of the risk culture. The risk culture is built over time with an accumulation of what leaders do during their *moments of truth*.

The risk culture is important because the trigger event leading to a catastrophe can be any one of thousands of decisions taken every day close to or very far away from head office. The risk culture sets the template for these decisions, establishing the tolerance for risk and the requirements for protection. No one can possibly supervise or monitor the choices taken on any day in a complex organization but the culture guides these choices, for better or for worse. The right culture will keep the organization out of massive trouble.

Building a healthy risk culture is simple conceptually but challenging in practice. It is simple to say that the key requirement is having senior leaders walking the talk consistently. But this takes discipline and strength of character when the leaders are placed, as they always are, in a world of competing priorities, demands for improved performance and vast quantities of uncertain information.

Assessing the Health of the Risk Culture

We identified six foundational components of an organization's risk culture. Leadership behaviour in each of these areas determines the risk culture that is acted out in the organization.

Each of these elements is difficult to define and measure but you can be sure they are assessed every day by people in field offices, control rooms, maintenance shops and engineering shops. It is their assessment of the risk culture that establishes the templates for local decisions. These decisions establish whether the pathway to catastrophe is open or closed.

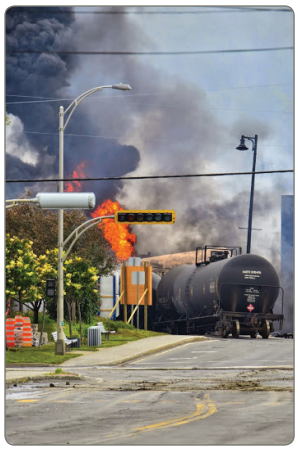
The foundational components of the risk culture are:

- Sincere management support
- Preventive actions taken when appropriate
- Open communication about risk
- Governance
- Organizational strategy and systems aligned with risk management
- Organization structure and vision

Performance in each of these areas has to be strong and consistent so that its effect is felt in all areas of the organization. Building a healthy risk culture is similar to building trust – both take a long time to establish and just one serious mistake to damage beyond repair.

Beware Subcultures

Even the healthiest risk culture can contain pockets of danger. These can be departments, district offices, business lines or other special divisions that are somehow immune from central influence. The technology, environmental conditions, market conditions or other factors may well demand a different approach to risk from the rest of the organization. But be careful that this does not mask a weakened risk culture.



Lac-Mégantic PQ 2013

The danger lurking within a strong subculture can be especially difficult to grasp when the subculture produces great financial results. This may cause a very strong organizational reluctance to disturb the goose laying all those golden eggs. The assessment will be further hampered if senior management does not have a gut-level understanding of the business model or technology used by the subculture, as they won't understand the risks either.

Subcultures may be a sign of a healthy risk culture if they are formed for the right reasons and their unique rules truly contain their unique risks. Subcultures do have the potential for hiding nasty surprises so they need to be monitored with care.

The Objectives of a Healthy Risk Culture

When a risk culture is healthy it produces three important results for the organization:

- Minimized risk blindness
- Reduced deafness to signals of danger
- Proper balance between production pressure and protection

As mentioned, the failure to perceive risk is the most powerful barrier to preventive action. As a consequence, reducing risk blindness is a primary objective of any healthy risk culture. In a healthy environment the RMS is used actively at all levels of the organization as a tool to help discover, discuss and manage risks rather than as a bureaucratic process. Risk awareness is also encouraged through storytelling, aligning management systems to support risk management, and training staff in operations and risk analysis.

Perceiving the risk is not enough. A healthy risk culture contains open, two-way communication about risk. This is supported by following up on danger signals – otherwise the organization appears deaf and the intensity of the signals diminish. It is not always popular to raise inconvenient concerns but a healthy risk culture makes sure it is safe for people to speak up.

A healthy risk culture balances two forces: pressure for production and protection against risk. Over-emphasis on either can freeze the organization. But when pressures for production and protection are in balance these forces are not in conflict. Preventive action reduces error, rework, disruption, injury and other factors that mess up schedules and budgets. And the safe way is often more certain, simple and easy to implement than the high risk road.

The Performance Bar is High

The best competitive advantage comes out of building a strong culture. Build it the wrong way and the culture can produce hubris (excessive pride, arrogance) and an enormous appetite for risk. Build it the right way and you will have solid results and good reason to sleep comfortably at night.

A healthy risk culture is demanding. As one of our Expert Group said, it needs "Board and senior Executive team 'walking the talk' about RMS all the time even if it costs more, reduces earnings, disappoints shareholders or analysts or results in dismissal of a senior executive. RMS can't be seen as being implemented only when it doesn't hurt." Once you get to this lofty peak, you then have to sustain the risk culture's health in an atmosphere of competitive pressure, investor impatience and technological change.

Role of the Regulator

Our Expert Group had a cautious appreciation of the regulator's role in prevention of catastrophe. They are very clear that a knowledgeable and skillful regulator can be a great help but they are cautious that the regulator can overplay its hand and in doing so could increase the risk.

There was very solid agreement on the general role of the regulator in prevention. By far the most important aspect of this work is in setting standards of performance together with industry stakeholders. This is followed at some distance by compliance action, work to raise the bar of industry standards, and investigation of serious incidents.

The prime responsibility for preventing catastrophe lies within the operating organization. The caution about the regulator's role comes in considering how prescriptive and interventionist the regulator should be. A skillful regulator will adjust its level of intervention to the maturity of the industry and the health of any individual company's risk culture. Erring in either direction could increase risk.

Keys to Preventing Catastrophe

Prevention of catastrophe is a test of an organization's character. Every organization says roughly the same things about the importance of safe operations. The test lies in what people do when production pressure, financial challenges, resource constraints and other issues push their hardest. Leaders have to demonstrate that they mean what they say about the priority of protective measures.

And leaders have to be relentless so their message is heard from a great distance. The real character of the organization is revealed by how risks are managed far from head office by front-line supervisors, district engineers, procurement specialists and others.

It is not about avoiding risk or compromising organizational performance. Preventing catastrophe requires staff and leadership competence, open communication, aligned strategy and operational discipline – these and the other key capabilities build broad organizational strengths. Healthy risk cultures can be enormously productive and highly innovative.

RESEARCH OUTLINE

This research explores the ideas and experience of a remarkable group of operations and executive leaders who have succeeded in preventing catastrophe during their careers. The members of this Expert Group work in industry segments that have the potential of catastrophic incidents: offshore drilling, high-speed rail, oil and gas production, engineering, procurement and construction management (EPCM), nuclear plant operation, pipelines, refining, industrial construction, electrical distribution, and information technology (IT). We also included the perspectives of regulators of these industries and process safety professionals.

The Expert Group represents a diversity of organizational levels and backgrounds. Every member has been (and may still be) a technical expert in their field; some are now in management, senior executive or board roles. A few are in academic or consultancy positions. None are currently in front-line operations jobs. Expert Group members reside in Canada, U.S., U.K. and Europe, with the bulk of participants from Western Canada.

Our purpose was to assemble the practical wisdom of the Expert Group members on this complex subject. We used a research tool called the Delphi Method, built on three rounds of iterative questionnaires. At the end of each round we produced an interim report and a more refined set of questions for the subsequent round. We all learned from the shared perspectives at each stage.

In April 2014 we published the final report of our research on preventing catastrophe in organizations. Fall Line Systems deeply appreciates the time and commitment of the Expert Group members. We had a 97 percent completion rate in our questionnaires and a great deal of challenging discussion in response to each interim report. The good ideas here come from people who have done the work to prevent catastrophe in their organizations. We thank them for this as well.

ORGANIZATIONAL READINESS TO PREVENT CATASTROPHE

Every leader believes they have adequate protective measures in place against catastrophe otherwise they would act to shore up any weakness. Our research indicates these leaders may be looking too narrowly to truly assess their organization's readiness.

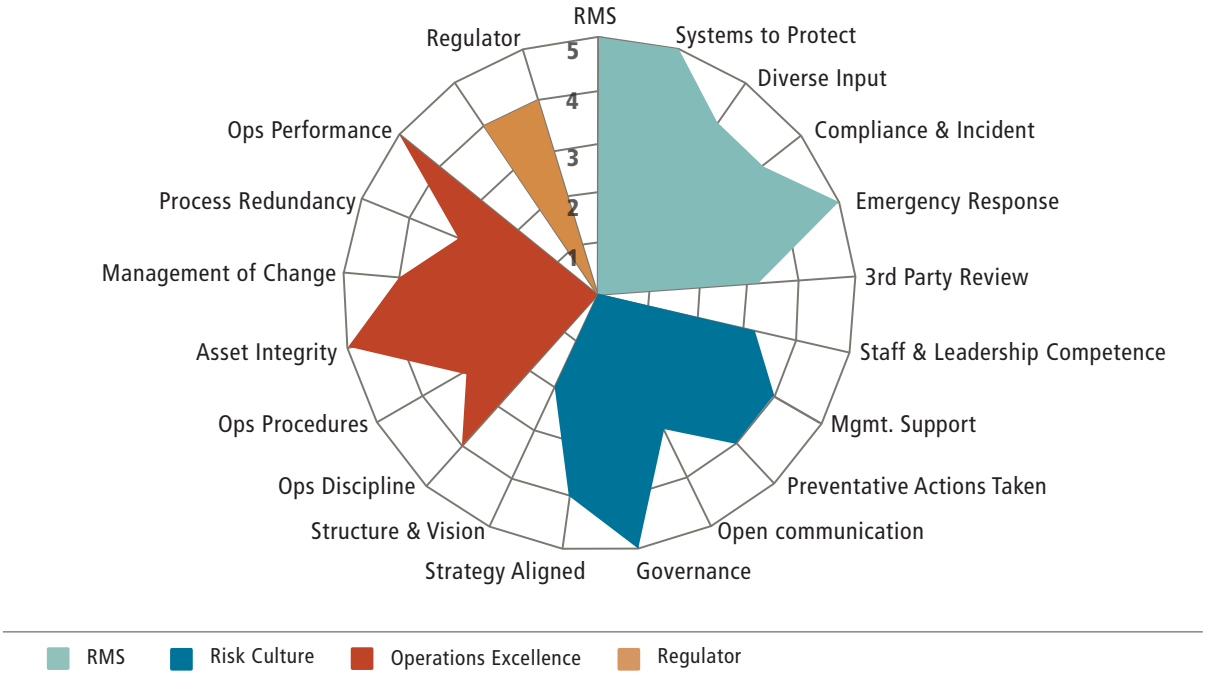
We identified 20 organizational capabilities that are critical for preventing catastrophe. If any one of these capabilities is weakened, the risk of catastrophe increases significantly.

The key capabilities fall into four categories: the risk management system, the risk culture, operational excellence and the regulator.

Risk Scorecard Sample

The following chart is a sample scorecard for the 20 key capabilities. Ideally, every capability would be rated 5 out of 5. Any other rating indicates danger – these weak areas could open the pathway to catastrophe.

Risk Scorecard Sample Results



Risk Scorecard Capabilities

The components of the Risk Scorecard are listed below[2].

Risk Management System

- Comprehensive Risk Management System (RMS)
- Systems in place to protect workers and data suppliers
- Detailed and diverse input to risk analysis
- Compliance and incident performance
- Emergency management / business continuity systems
- Third-party review

Risk Culture

- Sincere management support
- Preventive actions taken when appropriate
- Open communication about risk
- Governance
- Organizational strategy and systems aligned with risk management
- Organization structure and vision

Operational Excellence

- Staff and leadership competence
- Operational discipline
- Procedures
- Equipment / asset integrity performance
- Management of change
- Process redundancy
- Operational performance measures

Regulator

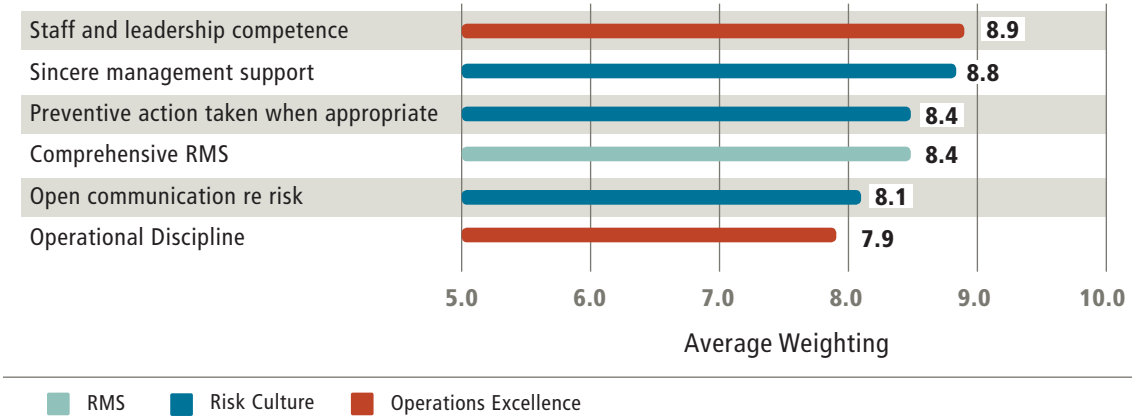
- Knowledgeable and skillful regulator in place

The Top-Rated Capabilities for Preventing Catastrophe

The six most highly rated capabilities on the Risk Scorecard demonstrate principles for preventing catastrophe that permeate all aspects of the research project.

This sample of the Risk Scorecard elements includes components of the risk management system, risk culture and operations excellence.[3]

Top Capabilities for Preventing Catastrophe



[2] For definitions of the Risk Scorecard elements, see Appendix 2 (pages 37-38).

[3] For the complete weighted listing of the Risk Scorecard elements, see Appendix 3 (page 39).

The Top Capabilities Defined

Every one of these capabilities eludes easy definition and concise measurement. It is a challenge to measure competence, sincere management support, when appropriate, comprehensive, open communication and discipline, yet each of these capabilities must be robust in order to reduce the risk of catastrophe.

- **Staff and leadership competence.** The technical competence of the staff and leadership is the most highly weighted capability for preventing catastrophe. This competence needs to be both broad and deep. It is a foundation element for operational excellence. On top of this, leaders have to be able to comprehend the risks embedded far from their area of specialization and direct authority. One of our Expert Group members recalled, "Some of our biggest incidents happened when senior management placed unqualified people into positions of authority."
- **Sincere management support.** It is not nearly enough to offer passive support for preventive action. The most strident Expert Group definition of sincere support was, "Board and senior Executive team 'walking the talk' about RMS all the time even if it costs more, reduces earnings, disappoints shareholders or analysts or results in dismissal of a senior executive. RMS can't be seen as being implemented only 'when it doesn't hurt.'"
- **Preventive action taken when appropriate.** People pay very close attention to see if the organization and its leaders mean it when they say they want preventive action. Everyone is aware that "being the bearer of bad news is not popular" and they watch to see what happens when others act to identify and prevent problems.
- **Comprehensive Risk Management System.** Every organization engaged in operations with risk of catastrophe must have a comprehensive risk management system in place. This system will ensure key leaders and staff weigh risks, and explore action to prevent and mitigate risk so that catastrophe does not occur.
- **Open communication re risk.** In the absence of open two-way communication about risk, the organization becomes deaf to risk signals. The organization and its leaders must make it "safe for people to offer opposing views openly", where everyone is accountable "for awareness and attention to risk warning signs WITHOUT fear of reprisal."
- **Operational discipline.** A well-run organization contains less risk than a sloppy organization. Clear accountabilities, solid procedures, high performance expectations, direct feedback and other components of operational discipline are critical for reducing the risk of catastrophe.

Principles for Preventing Catastrophe

Achieving and maintaining a high level of performance on each of these capabilities will significantly reduce an organization's exposure to catastrophe. The effort involved is not trivial, and it is just a starting point. The positive side effects of high technical competence, management support, appropriate preventive action, open communication and operational discipline are not trivial either. Done right, work to prevent catastrophe will strengthen the organization in many other ways.

The top-rated capabilities demonstrate important principles for preventing catastrophe. These principles can be seen in a quick look at the chart of the top six capabilities (page 11) and are supported throughout the research project:

- RMS is a vital component, but it is not even remotely adequate on its own.
- RMS must be surrounded by operational excellence and a healthy risk culture. (A skilled regulator is vital as well, but it does not show in the top six.)
- Prevention of catastrophe needs to involve every nook and cranny of the organization. Efforts to prevent catastrophe cannot be isolated in a Risk or Safety department or Operations. The whole of the organization, including supply chain, finance, audit, IT and other areas, must be engaged.
- You cannot outsource the responsibility for preventing catastrophe. Senior leaders have a vital role in setting and maintaining the tone from the top and this responsibility continues no matter what you delegate.
- It is difficult to measure organizational readiness. None of the 20 capabilities on the Risk Scorecard lend themselves to easy measurement. Our research did not focus on building a measurement process for these elements but this is clearly needed.

All 20 Capabilities are Important

You need strength in every one of the 20 capabilities presented in the Risk Scorecard to declare your organization is fit and ready to prevent catastrophe. Weakness in any one of the capabilities can indicate danger. As one of our Expert Group members said, "Nature is very good at discovering the one fatal flaw in the organization."

ASSESSING YOUR ORGANIZATION'S READINESS

Precise performance measures for the Risk Scorecard capabilities will have to be custom built for each company's industry and risk exposure. These performance measures must be built with an understanding of the following sections of this research report:

- Catastrophe Fundamentals
- Barriers to Preventive Action
- Healthy Risk Culture or Culture of Risk?
- The Role of the Regulator

The nature of catastrophe is often misunderstood. This can lead to a combination of ineffective preventive actions and a false sense of security which is a very dangerous brew. Effective protection must be based on the real properties of catastrophic incidents. Four of the most important properties are:

- Catastrophe is a very low frequency occurrence. Rarity makes implementation of the right preventive actions difficult and it may tempt some people to high-risk behaviour.
- Performance on personal safety is a poor predictor of catastrophe potential. This fact is hard for many of us to swallow as it is opposite to some safety training and counter to personal instinct.
- Prevention of major accidents depends on defence-in-depth: a series of barriers to keep hazards under control. Catastrophe happens when all these barriers fail simultaneously, or in rapid succession.
- In retrospect, after catastrophe hits, it is always evident that warning signs were not treated seriously, and that preventive action could have arrested the problem with very little cost.

Catastrophe is a Low Frequency Occurrence

Catastrophic incidents are rare. This is a very good thing, and it would be better if they were more uncommon. The low frequency produces two problems for prevention: it gives license to people to let down their guard; it makes it very difficult to learn from experience.

The Problem of Hubris

Most people, even those working in extremely hazardous industries, will never have direct experience of catastrophe. This is an accomplishment deserving pride. However, that pride can become excessive, leading to hubris and the belief that catastrophe could never happen to them or to their organization.

Hubris may grow even stronger when people hear of catastrophe that hasn't touched them, but could have. Andrew Ross Sorkin points out a common reaction to the financial crisis of 2008, "While the financial crisis destroyed careers and reputations, and left many more bruised and battered, it also left the survivors with a genuine sense of invulnerability at having made it back from the brink. Still missing in the current environment is a genuine sense of humility."[4]

The excessive pride of hubris may lead directly to high-risk behaviour. If this doesn't cause immediate problems the risks may be rewarded by the host organization, encouraging more risk. In this atmosphere preventive action is seen as a hindrance to progress or profit and, for a while, confidence is justified by results. The cause of many major incidents can be directly tracked to the belief that the organization or team is *special* and doesn't need to follow the restrictions needed for others.

[4] Sorkin, Andrew Ross. *Too Big to Fail*. Penguin Group (USA) Inc., New York, NY. 2010.

Learning Disabilities Caused by Low Frequency

People lose the connection between cause and effect when they cannot track the consequences of their actions. Catastrophe is so rare that it is very difficult to see how any particular action contributes to the accumulating risk, until it is too late. This void of feedback produces significant learning disabilities which can be seen in two areas: tearing down important protective measures, and measuring the wrong things.

Protective measures appear to lie dormant until the problem they were designed for occurs. But if these problems occur infrequently it is very difficult to judge whether or not the protective measure is useful or just a remnant of the old ways of doing things. So these protective measures can be tweaked in the search for work simplification, lowered cost, increased production and other useful objectives. The innovators may not learn the importance of the protective measures they have weakened until the low frequency, high consequence event occurs. By then it is too late.

The smart innovators will develop interim measures to give signals of growing risk so they can act before catastrophe hits. This is the right thing to do but choosing the wrong interim measure can fool you into complacency. For example, in the early 1990s the Canadian government scientists tested the health of the cod stock on the Grand Banks by measuring *fishing efficiency*, i.e., the time and effort it took to catch a ton of cod. This was a very poor indicator at a time when more powerful boats were using highly advanced fish location technology. The technology enabled the fleets to find and take almost all the fish, leaving a rare few for reproduction. The fish stock was so depleted that the fishery was shut down in 1992 and still has not rebounded substantially.

Learning is not impossible, unless hubris becomes overwhelming. You have to be open to learning from others' experience and you have to seek out relevant examples in your industry and related sectors. Or you can wait, and see if you are as right as you think you are.

Performance on Personal Safety is a Poor Predictor of Catastrophe Risk

Personal safety in the workplace is exceedingly important. However, even the best performance in personal safety does not provide much protection against catastrophe. Host companies of several recent catastrophes were trapped into complacency by relying on lost-time accident statistics as a measure of their protection from a major accident.

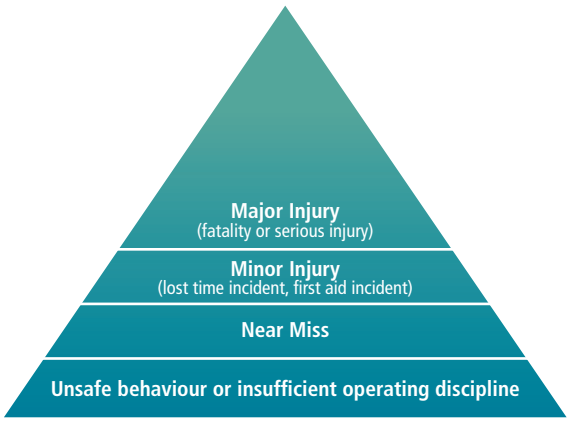
The Accident Triangle is the Wrong Model for Catastrophe

H.W. Heinrich established the foundation of much of today's thinking about industrial safety with his pioneering work in the 1930s[5]. In this very influential text, Heinrich described the Accident Triangle which is still a major component of much training in accident causation.

The Accident Triangle is based on *Heinrich's Law*: for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injury. Because many accidents share common root causes, addressing near misses can prevent time-loss accidents. People question Heinrich's statistics, but the Accident Triangle endures because the framework is very useful in preventing personal injury accidents.

The Accident Triangle can be a dangerous trap for efforts to prevent catastrophic incidents. The trap is built from what seems like a natural extension of Heinrich's Law: if we prevent personal injury accidents we are almost certain to prevent catastrophe. However, major accidents travel on different pathways than personal injury accidents so the Accident Triangle will only give the illusion of protection from catastrophe.

Accident Triangle



Two examples illustrate the trap of relying on injury statistics as a measure of catastrophe risk:

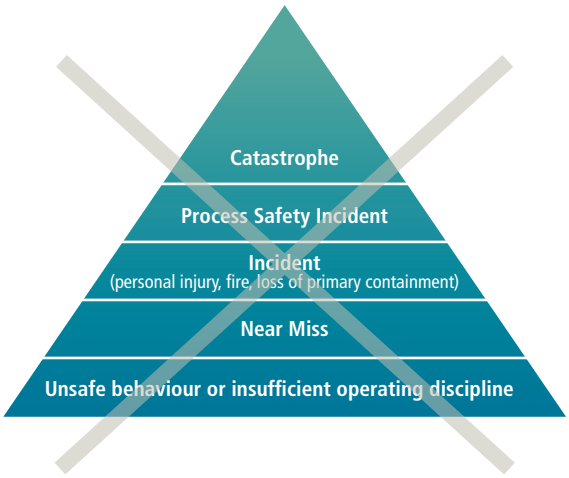
- On the morning of April 20, 2010 two executives each from BP and Transocean flew out to Deepwater Horizon to give recognition to the crew. Deepwater Horizon had just completed seven years of work with no lost time accident. At 9:45 p.m. when a massive blowout hit Deepwater Horizon, the executives were still on board. All four were rescued, but 11 crew members were killed and at least 11 million barrels of oil spilled into the Gulf of Mexico before the well was capped.
- On April 9, 1992 Westray Coal Inc. won the Canadian Institute of Mining, Metallurgy and Petroleum's John T. Ryan Trophy for the coal mine with the fewest accidents in the previous year. At 5:20 a.m. on May 9, 1992 a massive gas explosion ripped through the mine, killing all 26 miners underground at the time. The mine never reopened.

Exceptional performance on personal safety lulled the leaders and regulators of these organizations into lowering their guard. They were tracking the wrong measures.

[5] Heinrich, H.W. *Industrial accident prevention: a scientific approach.* McGraw-Hill, 1931.

Preventive action works against the cause of a potential problem. Catastrophe is caused by a system failure, where many things go wrong simultaneously. Prevention of catastrophe requires multiple barriers (defence-in-depth) defending against many different failures. The 2005 explosion at BP's Texas City refinery made it starkly clear that reliance on tracking single factors such as personal safety performance can mask dangerous conditions.

Accident Triangle Taken Too Far



Texas City Refinery Explosion: Process Safety is Different than Personal Safety

On March 23, 2005 the second largest refinery in Texas, BP's Texas City refinery, experienced a massive explosion and fire resulting in 15 people killed and nearly 200 injured. This tragedy led to a deepened understanding of the important difference between workplace safety practices and process safety which has improved refinery operations throughout the world.

The Texas City refinery was acquired by BP through its merger with AMOCO in 1998. BP worked very hard to improve workplace safety in its newly acquired refineries and by 2005 the safety performance at the Texas City refinery was greatly improved. Its occupational safety and health administration (OSHA) recordable injury rate was at an all-time low, one-third of the industry average. BP's senior management and board tracked these numbers and used them as a major component of the bonus structure for operations leaders and senior management.

Senior management and the board did not track what we now know as process safety incidents. Loss of containment incidents increased 52 percent from 2002 to 2004 and these were not reported to the board (in a refinery, loss of containment of highly combustible fluids and gases is very bad news). Numerous fires at the refinery were not treated as a safety issue and thus not reported to senior management and the board.

The subsequent inquiry, the Baker Panel,[6] commended BP for its performance on workplace safety and lambasted the company for its terrible record on process safety. The Baker Report went to considerable effort to define the difference between the two types of safety:

- **Personal or occupational safety hazards** give rise to incidents – such as slips, falls, and vehicle accidents – that primarily affect one individual worker for each occurrence.
- **Process safety hazards** give rise to major accidents involving the release of potentially dangerous materials, the release of energy (such as fires and explosions), or both.
- **Process safety incidents** can have catastrophic effects and can result in multiple injuries and fatalities, as well as substantial economic, property, and environmental damage.

This distinction has made considerable difference in refining and chemical plants but had not been fully integrated into BP's offshore drilling practices by 2010. BP and Transocean had exceptional personal safety results in their offshore drilling operations supported in part by detailed procedures to minimize personal safety risks, e.g., carrying a cup of coffee on the rig (use a lid) and walking on the metal stairs (use a handrail). BP did not have similarly detailed procedures for testing the cement plug or monitoring the well after cementing. Failures in these areas led to the explosion, fire and sinking of the Deepwater Horizon rig.

A great deal of work is being done to build tools for process safety in the upstream oil and gas industry. One of the best overviews of this work is the 2011 report, Process Safety – Recommended Practice on Key Performance Indicators from the International Association of Oil and Gas Producers (OGP).[7]

Prevention of Catastrophe Relies on Defence-in-Depth

One of the reasons that industrial catastrophes happen infrequently is that a catastrophe is an avalanche of problems happening simultaneously. A series of protective barriers has to fail all at once for this avalanche to occur. The probability of multiple failures at one time is low and so catastrophes don't occur all that often.

Protection from catastrophe requires defence-in-depth, i.e., a series of barriers designed to keep the various hazards under control. If the barriers are truly independent, the failure of one will not influence the strength of the others. A good system of defence-in-depth will ensure that even a very serious problem will not unleash a catastrophic failure.

Defence-in-depth is a dangerous illusion when one or more protective system depends on the others to function or if people start to think they are so safe they don't need all the components. Catastrophe always involves a failure of defence-in-depth.

[6] The Report of the BP U.S. Refineries Independent Safety Review Panel. (Baker Report). January 2007.

[7] Process Safety – *Recommended Practice on Key Performance Indicators.* Report No. 456. November 2011. http://www.ogp.org.uk/pubs/456.pdf

Failure of Defence-in-Depth: BP Macondo, 2010

The blowout at the BP Macondo well in the Gulf of Mexico on April 20, 2010 is a classic case of defence-in-depth failure.

The Deepwater Horizon rig, floating on 5,000 ft. of water, had just completed drilling to a total depth (TD) 13,000 ft. below the sea bed. Steel casing had been run and a cement plug installed at the bottom to seal off the well so the drilling rig could leave the location. It is a routine procedure for drilling rigs to *abandon* wells once they are safely sealed with cement so that a specialized production rig can get on the location and produce oil and gas from the well. It had been a very difficult job to drill this well, but the work was nearly complete.

But a series of failures happened, unnoticed by the crew until a massive explosion doomed the rig, killing 11 people and setting off the largest oil spill in U.S. waters.

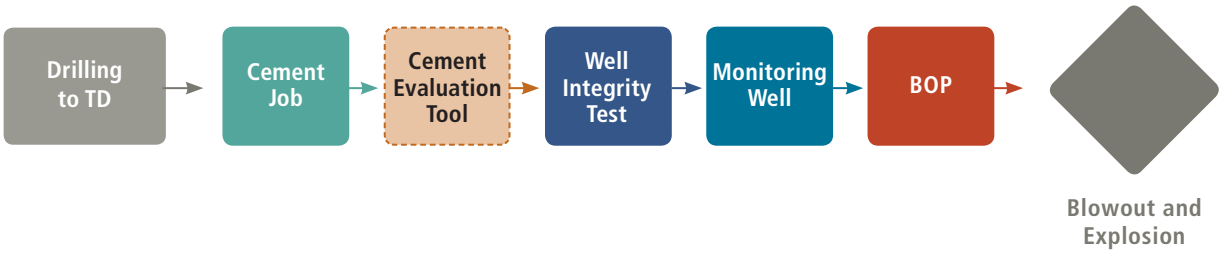
The **cement job** failed to seal the well. The precise reason for this failure is still not agreed on, but this is not a surprising failure. At this depth 5% to 10% of cement jobs fail, and there had already been two cementing problems higher up in the well that had to be corrected. It was serious that the cement job failed, but it was disastrous that no one detected the problem until it was too late.

Deepwater Horizon 2010. Source U.S. Coast Guard

Once the cement job was complete, a **cement evaluation tool** called a cement bond log was scheduled. This is an electronic test that checks if the cement job has completely sealed around the casing at the bottom of the well, thus successfully plugging the well at the bottom. The logging crew was on board the rig but the rig management determined that this test was unnecessary and the crew was flown off the rig without doing their work.

A **well integrity test**, called a negative pressure test, was conducted. If the cement seal is successful oil and gas will not flow into the well and the two pressure gauges on the surface will record zero pressure. If it is not successful, oil and gas flow will produce recordable pressure on these gauges. In this case, one gauge indicated significant pressure and one gauge recorded zero pressure. Basic well control theory would say this situation needed further investigation but the senior technical leaders explained the different pressure readings by saying it was caused by the *bladder effect*. They told the crew the cement plug was secure and they could prepare to abandon the well.

Defence-in-Depth, BP Macondo 2010



Because flow of oil and gas into the well is critically dangerous, two independent systems were in place to **monitor the well**. Once the well was declared secure neither system was used. Detecting gas in the wellbore is extremely important as gas is highly compressed at these depths by the pressure of gravity. As it rises up the well the pressure is reduced and gas expands massively with the most expansion (explosive expansion) as it nears sea level. If gas is detected before it gets past the **blowout preventer** (BOP), the crew can use the BOP to seal the well at the top and the gas can then be bled off under controlled circumstances.

The bladder effect does not exist. The cement job had failed. Oil and gas flowed into the well and began to rise to the top.

The problem was not detected until gas was outside the BOP, which sat on the seabed under 5,000 feet of ocean directly below the rig. In that last mile of water the gas expanded violently and hit the rig like a bomb. The crew tried to close the BOP. The shear rams failed and the well stayed open.

The Deepwater Horizon rig caught fire and burned until it sank two days later. Eleven crew members died. The blowout continued until a relief well was drilled in August and four million barrels of oil were spilled into the Gulf of Mexico. Costs to BP are still being assessed but are estimated between US$60 to 90 billion.

Warning Signs and Preventive Actions are Always Available Beforehand

In retrospect, after catastrophe hits, it is *always* evident that critical warning signs were not treated seriously and that preventive action could have arrested the problem with very little cost. And the rationale for failing to prevent the problem invariably sounds weak once the crisis has hit.

This certainty about what should have happened stems to a large degree from knowing what did happen. Warning signals ring like clarion bells if you know what problem you are going to face and where and when the problem will occur. If we are going to prevent catastrophe we must get good at recognizing and acting on these signals, before the event.

It is very difficult to understand why the following signals were not acted upon to arrest certain tragedy:

- In late 1991, Carl Guptil, one of the most experienced miners at the Westray Mine in Nova Scotia, met privately with the mine inspector to outline safety problems at the mine. Guptil reported that methane meters were routinely shut off because high readings caused the equipment to shut down. He also reported that highly volatile coal dust was not neutralized and was inches deep on all floors; mining equipment was refueled while it was running and kicking off sparks at the mine wall, and butane torches and farm tractors with no spark suppressors were used, all against regulation. The mine inspector did not take any direct action but did tell the mine management about the conversation with Guptil. As a consequence Guptil was fired, operating practices did not change and no other miners met with the mine inspector. The mine exploded on May 9, 1992 killing 26 miners.
- In 2005, Alberto and Rosa Ramirez, strawberry pickers in California, obtained a loan to buy a $750,000 house. The couple made less than $15,000 a year, and they were not required to put any money down. Thousands and thousands of similar loans were made, and these were bundled into mortgage-backed securities. These bundles of subprime mortgages were rated AAA, the highest rating available for investment products, and were sold to customers around the world. On September 15, 2008 the financial crisis driven by subprime mortgages came to a head with the bankruptcy of Lehman Brothers bank. The worldwide financial system teetered on the edge of collapse, housing markets around the world tanked and governments poured money into firms to stave off a complete collapse.

Catastrophe happens due to a surprising convergence of events. Warning signals and preventive actions are available but they must be heeded and acted upon for them to do any good.

BARRIERS TO PREVENTIVE ACTION

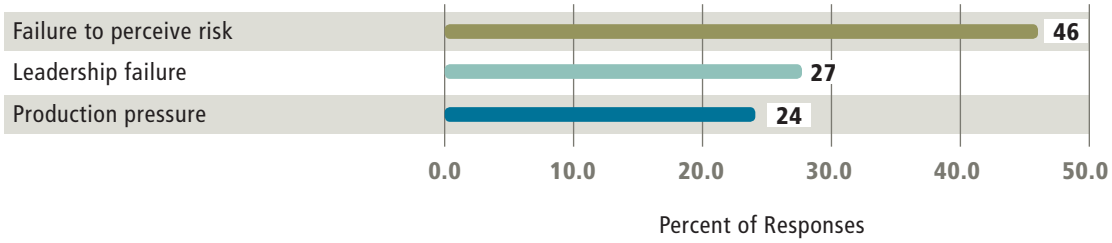
Prevention is clearly superior to dealing with the consequences of a catastrophic accident. But catastrophes do happen. It rarely takes long to uncover the two or three preventive actions that would have closed the path of catastrophe and kept people safe.

In retrospect, the rationale for not taking critical preventive action always looks weak. For example, Tokyo Electric Power (Tepco), the host of the 2011 Fukushima Daiichi nuclear plant meltdown in Japan said in the subsequent inquiry, ''There was a worry that if the company were to implement a severe-accident response plan, it would … lend momentum to the anti-nuclear movement."[8]

Certainly there would have been cost to acting before the tsunami hit and the three nuclear reactors melted down but this, as always, pales in comparison to the post-catastrophe cost. As of late 2013 Tepco is bankrupt, the Japanese nuclear power industry nearly shut down, and 26,000 people are nuclear refugees.

Tepco's story is not unique by any means. The right preventive actions were contemplated, affordable, implementable but not undertaken in virtually all catastrophes in the last decade. We identified the three most important barriers to taking proper preventive action in organizations: the failure to perceive risk, leadership failure and production pressure.

Key Barriers to Preventative Action



[8] McCurry, Justin. *Company admits Fukushima was avoidable.* Sydney Morning Herald, October 17, 2012. http://www.smh.com.au/world/company-admits-fukushima-was-avoidable-20121016-27p1p.html

Failure to Perceive Risk

Preventive action requires pessimistic imagination – you must be able to identify potential risks before you can do anything to prevent their occurrence. Risk identification is not nearly strong enough in most organizations. Almost 50 percent of responses cited the failure to perceive risk as a key barrier to preventive action.

The five biggest impediments to perceiving risk in organizations are:

- **Inadequate Risk Assessment Systems and Processes.** Poorly conceived or implemented risk management systems can keep people blind to the magnitude of risk. This may be due to a lack of resources, separating risk assessment from operations personnel, or having people so overwhelmed by the bureaucracy of the RMS that they are distracted from managing risk.
- **Short Term Focus.** People who are focused on the short term can be blind to most catastrophic risks and to the benefits of preventive action. There may be a "management view that the problem will not occur on my shift" or perhaps "everybody is looking for quick wins but not correcting systemic issues."
- **Normalization of Deviance.** Defined as "accepting the unusual as normal" this happens partly because "things have been like that for so long that people don't see them." If it worked fine last time, this becomes the standard and "experienced personnel pass these habits on to younger personnel as 'on the job training.'" Normalization of alarms is a subset of this problem – in poorly designed control rooms there can be so many alarms going off that operators have to ignore them to do their job.
- **Complacency.** Complacency was defined as "the belief that real catastrophes occur elsewhere, rarely occur in our business and are just plain bad luck." A few people said that complacency came from the lack of personal or institutional experience with catastrophe; others pointed out that the low frequency of catastrophic events led to low attention to the issue.
- **Silos.** "Teams tend to focus on what their specific scope is." The narrow focus keeps teams blind to the "ripple effect of decisions" and keeps responsibility diffuse for any issue that crosses team / organizational borders. In this situation we think that "someone has done the obvious" and dismiss the potential risk.

Leadership Failure

Senior leaders set the tone for preventive action. This tone is not always favourable. Leadership failure was identified as a key blockage to preventing catastrophe in 27 percent of our responses. A lack of "sincere support" from leaders makes it very difficult for people to take action to manage risk. Specific leadership blockages include:

- **Senior Leaders.** "Lack of buy-in, particularly from senior management" can create a substantial block to preventive action in the organization. This may stem from "weak management who cannot comprehend the risks," "lack of operational experience," or "lack of technical skills or background." The wrong "tone from the top" may produce "unclear expectations and lack of accountability," and/or the "lack of an open political environment for people to raise issues or offer opposing views."
- **Flawed Management Systems.** Preventive action can be blocked by "lack of a cohesive set of standards and procedures," and a "lack of clear accountability, discipline and strategy" as well as other poorly implemented management systems. In addition, "if individual behaviours are not aligned, then preventive action by individuals is compromised." Problems can occur when you have "multiple companies within the project without clear definition of contractual links and responsibilities."

Production Pressure

Preventive action is perceived to both delay implementation of projects and increase costs. Excessive production pressure was identified as a key barrier to preventing catastrophe in 24 percent of our responses. Many people believe "you can't do preventive action and meet targets." The pressure to produce short-term results will overwhelm preventive action if this pressure is too strong. Two important areas of concern were emphasized by the expert group.

- **Delay to Schedule.** "It takes time to plan," and "it takes time to look at root causes" and many people think this delays implementation rather than improves reliability. One person pointed out that real preventive action may require "a radical modification in the way a corporation functions" and this may get in the way of getting work done over the short term.
- **Cost of Preventive Action.** "Preventive actions are seen as a cost rather than a cost savings." It is difficult to measure the benefit of preventive action as "it is only when these measures fail that tracking is possible."

Summary

It is preferable to prevent problems than to experience them. But our actions betray our intentions. Almost all (95 percent) of health care expenditures are directed to fixing illness, rather than to promoting health.[9] Only 4 percent to 9 percent of U.S. fire department budgets are directed to fire prevention.[10] The barriers to taking preventive actions are very real in society. We must overcome these barriers in our organizations if we are to prevent catastrophe.

[9] Ornish, Dean. *Yes, Prevention is Cheaper than Treatment.* Newsweek, April 23, 2008. http://www.thedailybeast.com/newsweek/2008/04/23/yes-prevention-is-cheaper-than-treatment.html

[10] Mirkhah, Azarang. *Fire Prevention in America at the Dawn of the New Millenium.* Las Vegas Fire & Rescue. July 1999. http://www.usfa.fema.gov/pdf/efop/efo30302.pdf

The risk culture matters. It sets the template for decisions throughout the organization, determining risk tolerance, exposure levels and the amount of focus placed on prevention of problems. A healthy risk culture supports people who manage risks well *and* strive for excellence, innovation and high levels of productivity. In a culture of risk people are encouraged to take chances.

The risk culture is built over time with an accumulation of what leaders do during their *moments of truth*. Actions speak way louder than words. Asserting the importance of preventing catastrophe is useful but it pales in comparison to what you demonstrate.

In a culture of risk profit, shortcuts and efficiency are valued so much that compromises to the protective systems are accepted as a trade-off for short-term gains. In this culture, people see the risk management system as a bureaucratic hindrance to be worked around because it has little relevance to their real day-to-day priorities. People take chances, exposing themselves and the organization to the potential of very serious harm.

In a healthy risk culture risks are openly acknowledged and considerable effort and resources directed to preventing major problems. People take on significant challenges, push for innovation, strive for high performance *and* they manage risk as part of doing their job.

Assessing the Health of the Risk Culture

The health of a risk culture is determined by what is done, not by what is said. People use the very same words to describe vastly different risk cultures. But culture is determined by what senior leaders do when under pressure and faced with a choice between the expedient and the safe action. Six components of our Risk Scorecard measure the health of the Risk Culture.

- **Sincere Management Support.** It is the demonstration of support for risk management by senior leaders, not the declaration, that establishes if the support is sincere or not. Leaders have to walk the talk especially during decisions about capital allocation, hiring, and corporate priorities.
- **Preventive actions taken when appropriate.** Preventive actions do cost money and time in the short term. On the other hand, failure to take appropriate preventive action sends out signals that rot the foundation of the risk culture.
- **Open communication about risk.** In a healthy risk culture the bearers of bad news, and those concerned about potential risks, get listened to. Diverse viewpoints are sought out and considered, producing a good dialogue about key risks and how to manage them.
- **Governance.** A healthy governance system ensures the right people (those with the most knowledge and skill in the area) are making key decisions. It also ensures risks are identified and managed in the decision process.
- **Organizational strategy and systems aligned with risk management.** All strategic choices require acceptance of assumptions and considerable uncertainty about the future. Strategy has to acknowledge risk. Corporate systems, such as objectives and bonus structure, must encourage people to focus on prevention of problems as they implement strategy and run the business.
- **Organization structure and vision.** The seeds of catastrophic problems are often planted when the effects of decisions in one department are experienced as problems in another. The structure and vision of the organization has to help people focus and keep the broader picture in mind at the same time.

Beware of Subcultures

Even the healthiest risk cultures can contain pockets of grave danger. Subcultures can develop in special divisions, district offices or business lines where people feel a different approach to risk is justified. The differences can fine-tune risk management to make things safer but they can also mask a weakened risk culture.

The danger lurking within a strong subculture can be especially difficult to challenge when the subculture produces great financial or operational results. This may cause a very strong organizational reluctance to disturb the goose laying all those golden eggs. One of the strongest American banks learned about subcultures the hard way.

JPMorgan Chase & Co. has long been considered one of the very best-run investment banks in the world. They had a very healthy risk culture and managed their way through the financial crisis of 2008 with very little damage.

CEO Jamie Dimon exempted one section of the bank, the Chief Investment Office (CIO), from many of the bank's risk controls[11] and a subculture developed in the CIO. The London-based CIO was successful as its assets ballooned from $75 billion to $375 billion between 2008 and 2012. It appears that the successes were built on an imbalance between production pressure and protection, or as some have described it, on greed.

One of the star brokers working in the CIO was Bruno Iksil, who made bets so large that he was nicknamed *The London Whale*. Mr. Iksil made a whale of a profit for the CIO from 2008 to 2011 but in 2012 trades in a product called CDX IG Series 9 led to losses of about $3 billion. The losses led to the firing of *The London Whale* and his boss, Ina Drew.

After the crisis hit, Mr. Dimon took the position that risk management within the CIO was poor. He said their portfolio was "poorly conceived and vetted. The strategy was not carefully analyzed or subjected to rigorous stress testing within the CIO and was not reviewed outside"[12] the division. The CIO reported directly to Mr. Dimon. A more attentive boss might have sensed that having a trader called The London Whale indicated a slippage in the risk culture. This would have allowed him to make sure the CIO's subculture aligned with the corporate risk culture prior to the massive loss rather than after.

[11] Schatzker, Erik, Dawn Kopecki and Bradley Keoun. *How Jamie Dimon let JPMorgan rack up US$2 billion in losses.* Financial Post, June 12, 2012. http://business.financialpost.com/2012/06/12/how-jamie-dimon-let-jpmorgan-rack-up-us2-billion-in-losses/

[12] Kopecki, Dawn and Phil Mattingly. *JPMorgan traders behind US$2B loss didn't understand risks, CEO Dimon says.* Financial Post, June 12, 2012. http://business.financialpost.com/2012/06/12/jpmorgan-traders-behind-us2b-loss-didnt-understand-risks-ceo-dimon-says/

Minimize Risk Blindness

The strongest barrier to preventive action in organizations is the failure to perceive risk. A healthy risk culture recognizes, discusses and manages risks in the business without freezing up innovation or reducing the drive for excellent performance. This process starts by ensuring that people throughout the organization know what the risks are, so that preventive action makes sense.

The four most important methods for reducing risk blindness are:

- Use the risk management system effectively at all levels of the business
- Use stories of catastrophe, incidents and near misses
- Align management processes
- Provide effective training

Use the Risk Management System Effectively – in All Levels of the Organization

You have to look for risk or you will be shrouded in risk blindness. This is a comforting state, for a while. Projects, planning, budgets and key strategic initiatives are much easier to get moving when you are blind to potential problems but in this state risks accumulate. It is much better to search for and deal with potential problems during planning than experience them during implementation or operations.

The risk management system can help reduce risk blindness, but it has to be used by people at all levels of the organization and in all departments as a tool in the active search for risk. Samples of appropriate risk-seeking action for three organizational levels are included in the following table.

Senior Management & Board	Operations Leaders	Operations Staff
Establish a healthy risk culture throughout the organization	Update risk profiles, reporting to appointed board member	Discuss risks in a two-way conversation at pre-job, tailgate and other meetings
Make risk management part of governance	Ensure reasonable projected costs and schedules are presented	Build culture by talking about risk at the start of every meeting
Include risk assessment in capital and project approvals	Conduct job hazard assessments	Review identified risks
Monitor against the formation of dangerous risk subcultures	Push to assess risks broadly, e.g., public safety, financial, project management	Build culture of risk-based decision-making in day-to-day operations

Use Stories of Catastrophe, Incidents and Near Misses

Risk blindness occurs, in part, because catastrophic events and near catastrophe happen so rarely. Stories of incidents and near misses are powerful tools for opening people's eyes to risk and to fight the tendency to think, "It can't happen here." These stories are most effective if they encompass personal experience or similar work but stories of more distant incidents can be powerful as well.

Our Expert Group points out that Board members "have or do hold senior executive positions in other companies, so there is a bank of experience that should be utilized" for examples of incidents and ideas for managing risk. Balanced with this is the reality that many Board members are "bankers, lawyers and chartered accountants. My experience is that line people need to identify and explain the risks to them."

Annual safety meetings, project kick-off meetings, toolbox talks and many other opportunities to share stories of incidents are identified in the survey. Our Expert Group stresses the need to use these opportunities, with one person saying "Risk identification needs to be institutionalized – at the outset of EVERY briefing, risk profiles and safety considerations must be addressed."

Align Management Processes

Management processes are implemented to focus people on organizational priorities. All these management processes have to be aligned with each other and with the demands of managing in a hazardous environment. Items to check include:

- Clear accountabilities for leadership
- Safety / risk performance targets
- Operating budget targets aligned with process safety requirements
- Strong oversight programs

Provide Effective Training

Two types of training are seen as important: broadening individuals' competency to understand the operations, particularly the implications of actions on other parts of the business; and analysing risk.

Reduce Deafness to Catastrophe Signals

Major accidents are always preceded by warning signs that, for one reason or another, are not recognized as such.[13] Isolating and acting on these signals are essential to preventing catastrophe.

Build an Open Culture so that People Speak Up

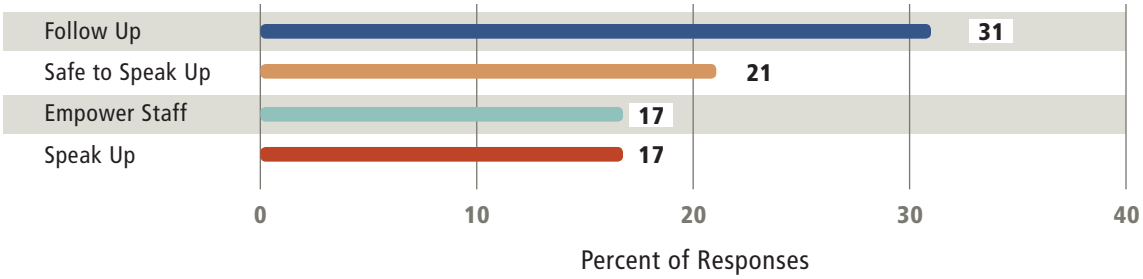
Deafness to warning signals is dangerous. It discourages people from speaking up loudly against conventional *wisdom*, even when that wisdom appears to be leading to catastrophe. In a culture of risk, the signals still exist but they are weak and often ignored.

In a healthy risk culture warning signals are heard loud and clear. Leaders show their openness to these signals by following up on them, making sure it is safe to speak up, empowering staff to act to keep operations safe and providing training where needed.

Our group emphasized the need to build an open culture where people "feel safe to offer opposing views openly" and "we don't only value the 'yes' men."

[13] Turner, B. *Man-Made Disaster*. Wykeham Publications, London. 1978.

To Build an Open Culture



Keys to building an open culture include:

- **Follow up.** Thank people for their input personally and act on the input when appropriate. When you don't act on the input, let people know why.
- **Make it safe to speak up.** Encourage signals through good leadership practices. For example, "never shoot the messenger," even if you don't like the message. On top of this, establish channels separate from the normal supervision chain that are clearly safe – hotlines, independent safety reps, whistle-blower channels.
- **Empower staff.** Involve staff in early stages of planning and make sure they have the power to stop work when facing unsafe conditions.
- **Provide training.** Train management on how to engage in two-way communication, staff in how to speak up effectively, and everyone in risk assessment.

Investigate Signals with Diligence

The downside of building an open culture is that there will be a lot of warning signals and some of these will certainly be false alarms. Our Expert Group emphasized the need to treat all signals with respect and caution, even though there will be some noise to sort out from the key signals. Diligent investigation of the signals demonstrates listening and this builds the culture of openness that is at the heart of a healthy risk culture. Two methods for managing warning signals were suggested in our research, depending on the quantity of signals that are received:

- **Act on all signals.** Don't "prejudge it was noise – a little digging normally identifies if it is just noise. I have often failed to do this the first time due to pressures of the job and it has cost." The fire department responds to all alarms even though they know that many are false alarms.
- **Filter the signals.** Score and sort out the risks from low to high. In order to do this well you need common definitions and an agreed method to score the risks. The ranking also has to be updated as information, the situation and the risks change.

Balance Production Pressure and Protection

The job of a healthy risk culture is to establish the right balance between production pressure and protection in every corner of the organization. The appropriate balance of these forces has to be imbedded in every key decision even when the decision-makers are many miles and many organizational levels distant from senior executives.

Organizations must continue to push for increased efficiency, productivity and profitability – the danger is that people interpret this push as a request to take shortcuts and unnecessary risks. In a healthy risk culture people know when and how to let up on the throttle and bring the forces of protection into balance with production pressure.

Establish Constant Vigilance

Constant vigilance is an essential component of a healthy risk culture. But people tire of vigilance as they do a low-level headache. This is especially true when people have had success in the face of risk – they can develop hubris, believing bad things won't happen to them. Or they can develop complacency when risks previously considered dangerous don't cause big problems.

Without vigilance people let down their guard, production pressure gets out of balance with protection and risks grow unimpeded. Vigilance becomes part of the culture when it is consistently applied over a long period in all corners of the organization. Our Expert Group identified three important tools for keeping vigilance alive in the organization.

- **Discuss project / operations risk.** This can be done in informal brainstorming of the downside risks, ensuring deliverables are reviewed for quality, and engaging third-party cold-eye reviews. The objective is to make the discussion, of risk and the management of risk, commonplace.
- **Use risk assessments.** Formal risk assessment becomes part of everyday culture when consistently applied in appropriate situations. It is important that people treat risk assessment as a tool for increasing vigilance and not a bureaucratic obligation.
- **Stop work to review risks.** Several Expert Group members cited instances when they stopped all production pressure and held offsite meetings or lengthy start-up meetings to review and discuss risk. This increases costs in the short term. It appears to have significantly reduced injuries, breakdowns, spills and other problems so much that the payback period is very short.

Demonstrate Commitment to Safe Production

The importance of leaders walking the talk was emphasized over and over again in our research. We asked our Expert Group what they had done to maintain a proper balance between production pressure and protection. Examples of actions that demonstrated commitment follow:

- "We have publicly declared to all our employees and contractors that safety is not a priority, it is a value. Priorities change from time to time, but safety is a consistent effort that will not be compromised by any business priority."
- "Ensure the understanding that the longevity of the operation and production is equal to, or even more important than, the short-term production to the shareholder's value."
- "Hire and retain great people – people who care AT LEAST if not MORE about their people than they do about the Excel spreadsheet. And then trust them."
- "The operational commander in the field should never be trumped by someone in head office who is headed to his yacht or not standing on the platform."
- "Support schedule delays and productivity interruptions in the name of safety regardless of production implications. We have a rankless protocol that enables any employee to intervene."
- "Bosses that make production the first and last thing that are talked about make the inadvertent message that production is most important. Start meetings with Safety Moments or a discussion about safe work practices. End with a discussion about the safety."

Production Pressure and Protection Can Coexist

Preventive action is too often seen as a cost that reduces profit and/or produces delays. But when pressures for production and protection are in balance these forces are not in conflict. Preventive action reduces error, rework, disruption, injury and other factors that mess up schedules and budgets. And the safe way is often more certain, simple and easy to implement than the high-risk road.

One member of our Expert Group said, "My objectives are top quartile operational performance / productivity and similar top quartile safety performance. The balance is achieved through personal accountability of everyone on the team to keep the appropriate balance."

Summary

The risk culture of an organization determines a large part of that organization's exposure to catastrophe. The culture signals what risk tolerance is expected in decisions, how much effort to expend in managing risk, and the appropriate balance between production pressure and protection.

The health of the risk culture cannot be determined by what people say they value. Everyone will say they want people to take proper precautions. The proof of the culture is in what people do when under pressure to perform. This is especially true of senior leaders – their actions far outweigh their statements.

ROLE OF THE REGULATOR

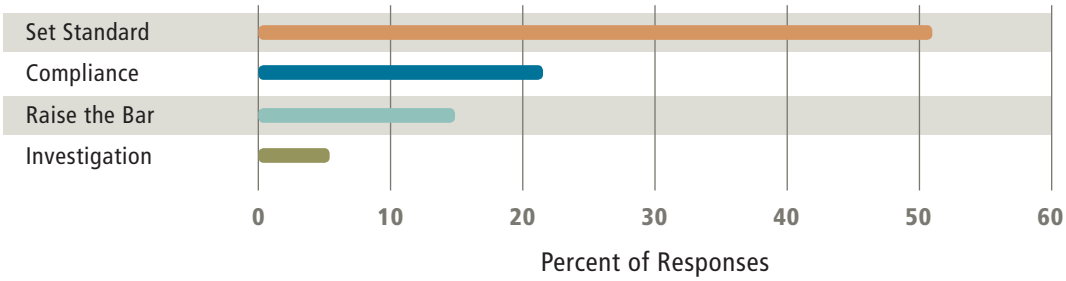
There is considerable difference of opinion on the role of the regulator in preventing catastrophe. The Expert Group members stress the importance of the regulator and agree on the regulator's role when it is stated in general terms. They also stressed that the regulator needs to be both knowledgeable and skillful.

There was much less agreement on the details of this role and on how the regulator should carry it out. In particular our group did not have a common view of how prescriptive the regulator ought to be, nor did it concur on how active the regulator should be in enforcement.

Regulator's Role in General Terms

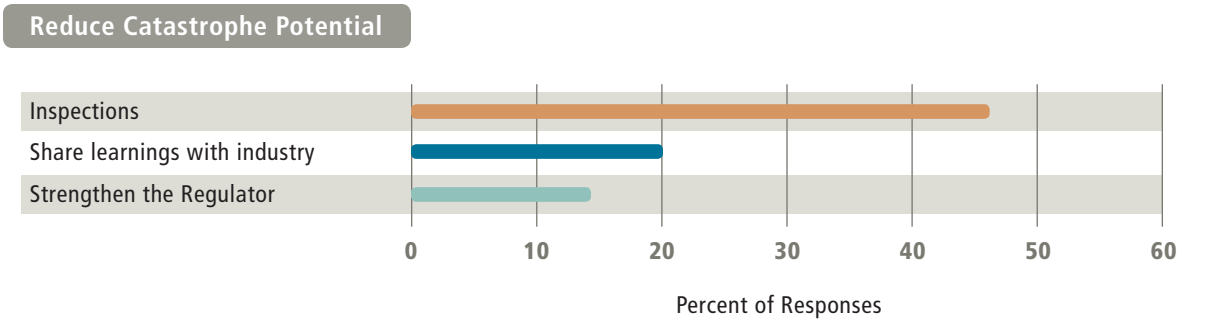
There is very strong agreement on the general view of the regulator's role. The setting of standards for industry practice is seen to be by far the most important aspect of the regulator's work. This is followed at a considerable distance by compliance activities, work to raise the bar of industry practice and investigation.

Appropriate Role for Regulators



The components of the role include:

- **Set Standards.** The most important aspect of the regulator's work is its role in defining and setting standards of industry practice. This work must be done in consultation with the industry and other key stakeholders. The standards may include technical and environmental performance, mandatory qualifications for professionals and technical staff and risk management practices.
- **Compliance.** The regulator's work in monitoring, inspection, and enforcement is seen as important.
- **Raise the Bar.** The regulator has a significant role in helping industry players raise the bar of performance beyond minimum standards. This role is carried out in a less formal manner than the others described here. The regulator is uniquely placed to capture and share learnings from good and bad industry experience and it can raise executive attention to areas that may not have been receiving adequate attention.
- **Investigation.** Thorough investigation of serious incidents is very important from the perspective of capturing and communicating learnings that can lead to the prevention of much more serious or catastrophic problems.



How the Regulator Can Reduce Catastrophe Potential

The Expert Group focused on inspection when asked specifically what the regulator could do to reduce the potential for catastrophe. In general, the Expert Group was not in favour of a highly interventionist regulator. When asked about the overall role of the regulator (see previous graph) compliance activities were a distant second to setting standards.

Other key regulator actions for reducing catastrophe potential were the sharing of learnings with industry, and strengthening the knowledge and skill of the regulator.

The most important actions the regulator can take to reduce catastrophe potential are:

- **Inspections.** Inspections are seen as a key tool for the regulator to reduce catastrophe potential. It is important that the inspections are visible, that the regulator be firm in dealing with violations of compliance and that the regulator be seen as fair in its findings and any penalties.
- **Share Learnings with Industry.** The regulator is seen as an important source of industry learning. Many people thought the regulator had a key role in the development of tools for effective risk management that can be shared with industry. It can also disseminate case studies from real incidents and communicate best practices.
- **Strengthen the Regulator.** The knowledge and skill of the regulator is vital to its ability to help industry reduce the potential for catastrophe. The regulator must build a reputation of expertise, integrity and impartiality.

Cautions about the Regulator's Role

A skillful regulator can be a tremendous asset in an industry's or organization's quest to prevent catastrophe. However, a poor regulator can be an impediment to this same objective. Many cautions about the regulator's role were expressed, including:

- **Different situations require different approaches.** What is perfectly effective for one organization may be totally ineffective or hopelessly burdensome to another. Procedures in one location may not fit a different situation.

- **Self-assessment is more powerful than imposed inspection.** The regulator can help individual organizations build their capacity for self-assessment, building a prevention plan and evaluate the plan. Internally developed assessment and planning produces a much higher level of commitment to action than external inspection.
- **Level of intervention needs to vary.** Oversight should be proportionate to an organization's track record, the regulator's assessment of their safety practices and the completeness of their operational plans.
- **It is not only about finding fault.** Regulators and auditors often have to find things wrong. This can lead to getting bogged down in inconsequential matters. If the focus is truly on prevention of catastrophe, the regulator would work constructively and in partnership, focusing on major issues and significant trends.
- **The regulatory environment is becoming complex and confrontational.** It is now more difficult, because of legal caution, for senior executives to communicate with senior regulators. Perhaps more liberal rules and adopting a more risk-based approach would allow better focus on the right safety / catastrophe issues.

Summary

The regulator has a very important and very difficult role to play in helping to prevent catastrophe in its industry. Industry leaders prefer a light-handed regulator, one that adjusts its level and style of intervention to the skill and performance level of different organizations and different situations. The regulator is seen to be most effective when acting in partnership with industry stakeholders and supporting organizations' ability to self-assess and self-regulate; however, the regulator must intervene firmly when appropriate.

THE OBJECTIVE OF OUR RESEARCH

Preventing catastrophe in organizations depends on a lot of components. We identified twenty organizational capabilities that have to be robust, many actions required of leaders, understanding the nature of catastrophe, tools to strengthen the risk management system and many other factors. It is possible to get lost in this task in a modern complex organization.

It is important to remember that all these components are in the service of one objective: that people throughout the organization use good judgement in assessing major risks and implementing preventive actions. Our research was done to help you support solid risk management and keep us from the terrible costs of catastrophe.

OVERVIEW OF THE RESEARCH PROJECT

The objective of the research project is to *identify barriers to and best practices for Preventing Catastrophe in Organizations*. We used a three part Delphi Study in which 22 participants (the Expert Group) responded to a series of three questionnaires. **Round One** was completed in March 2011, **Round Two** in May 2011 and **Round Three** in September 2011. The questionnaires had a 97 percent completion rate.

A literature review and case study reviews were conducted in 2012-13, the Final Report completed in 2014.

Expert Group

The 22 participants in the Expert Group were selected because they had each built a reputation for working successfully in industry sectors where the risk of catastrophe is fairly significant. These are people who are known for their ability to manage complex, high-risk projects and operations without producing dramatic problems.

Titles

Members of the Expert Group have a long history in their industry – their current titles are listed below:

- Business Leader, Operations;
- CEO
- Chief Reservoir Engineer
- Corporate Director
- Director of Engineering, Major Projects
- Drilling Manager, Gulf of Mexico
- Emergency Management Advisor
- General Manager SAGD Major Projects
- General Manager Refining
- Manager Emergency Preparedness
- Manager Process Safety
- Partner
- President
- Principal Structural Engineer
- Project Manager
- Visiting Professor
- VP Midstream
- VP Operations and Engineering
- VP QHSET
- VP SAGD
- Well Engineering Manager

Organizations

Members of the Expert Group work for a variety of organizations, listed below:

- ALE Energy
- Bantrel
- Canadian Petroleum Engineering
- Chui Consulting
- CNRL
- EM&I Alliance
- Energy Resources Conservation Board
- Husky Energy
- Imperial College
- Irving Oil
- National Energy Board
- Nexen
- Provident Energy
- Statoil
- Suncor
- TransCanada
- Tricon Solutions
- United Illuminating Company

APPENDIX 1

Industry Sectors and Locations Represented

Members of the Expert Group are located in Western Canada (primarily), New Brunswick, Connecticut, and the UK. They have experience in a broad range of industry sectors, including:

- Electrical distribution
- EPCM engineering
- High speed rail
- Industrial construction
- Information technology
- Offshore and onshore drilling
- Oil and gas production
- Oilsands SAGD
- Oilsands upgrading
- Pipelines
- Refining
- Regulators

Research Team

The research project was led by **George Campbell** of Fall Line Systems Inc.

To comment on the research or for further information contact George at george.campbell@fall-line.ca; (403) 228-6623.

Research Advisors

Claire Munroe	Lloyd's Register: Human Engineering Services, Calgary
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Ken Burrill	Chalynder Inc., Calgary
Robin Stuart-Kotze	Behavioral Science Systems, County Cork, Ireland
Bill Ratcliffe	Collected Conscience, Toronto

RISK SCORECARD CAPABILITIES DEFINED

Twenty organizational capabilities required for preventing catastrophe.

Risk Management System

- **Comprehensive Risk Management System (RMS).** A solid, operational RMS utilized broadly in the organization.
- **Systems in place to protect workers and data suppliers.** Front-line workers empowered to stop work in unsafe conditions; whistle-blower protection in place.
- **Detailed and diverse input to risk analysis.** Knowledgeable people from a multitude of disciplines and operations provide input to risk assessments.
- **Compliance and incident performance.** Number and trends of incidents compared to industry norms.
- **Third-party review.** Independent audits or inspections used to assess key risks. Peer reviews of project design and risk assessments.
- **Emergency management / business continuity systems.** Detailed, comprehensive emergency response capability regularly tested.

Risk Culture

- **Sincere Management Support.** Board and senior executive team walking the talk about RMS.
- **Preventive actions taken when appropriate.** Evidence that the organization has taken appropriate preventive action to control known risks.
- **Open communication about risk.** People discuss concerns about risk in an open manner, without fear of reprisal.
- **Governance.** Active governance of risk in place and widely understood, board committees in place, sound decision-making processes at executive and board levels.
- **Organizational strategy and systems aligned with risk management.** Risks identified and managed through normal organizational systems and processes such as capital allocation, budgeting, bonus structure, and objective setting.
- **Organization structure and vision.** There is some proof that statements of vision and values are in practice and aligned with the requirements of risk management. Organization structure supports longer-term needs of preventive action.

APPENDIX 2

Operational Excellence

- **Staff and leadership competence.** Technical competence of staff and leaders at all levels is appropriate to the tasks they manage.
- **Operational discipline.** Clear accountabilities, solid procedures, high quality performance, high expectations exhibited throughout the organization.
- **Procedures.** Procedures and systems are established and regularly tested. Results of these tests are made widely available and discussed openly.
- **Equipment / asset integrity performance.** Performance and trends on equipment integrity and preventive maintenance, including completion rates and maintenance backlogs.
- **Management of change.** Management of change processes are implemented, well understood and used with diligence.
- **Process redundancy.** Critical processes are identified and redundancy established where appropriate.
- **Operational performance measures.** Measures are specific to the industry. Examples: plant reliability, operational costs, project delivery, and production volume.

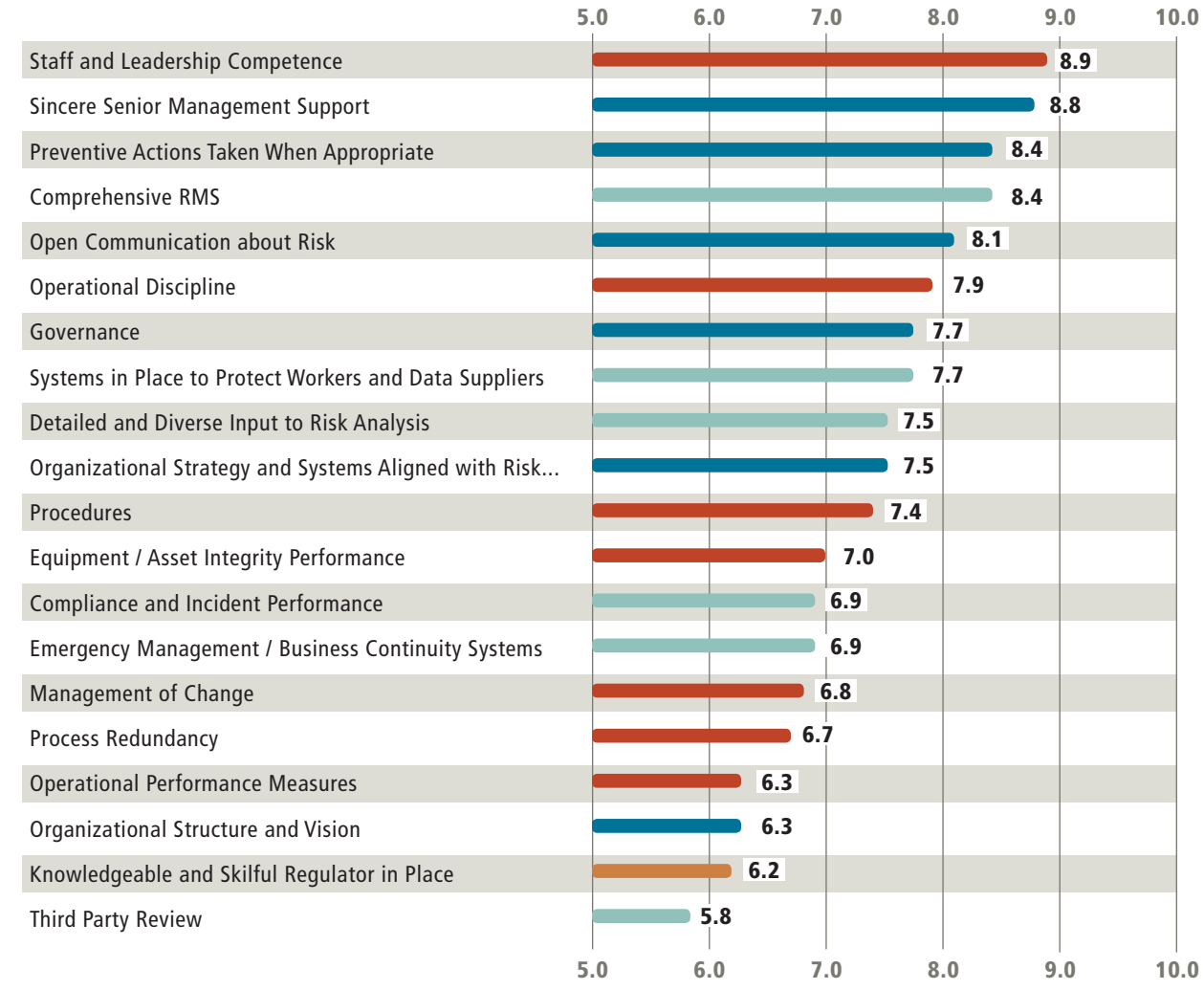
Regulator

- **Knowledgeable and skillful regulator in place.** Regulator has high standards and enforces these standards. Regulations are developed in consultation with industry. Regulator's staff has comprehensive knowledge of the industry.

RISK SCORECARD CAPABILITIES PRIORITIZED

Our Expert Group rated the importance of the 20 key capabilities for preventing catastrophe so that we might have an indication of where to begin. There is considerable range in weighting; however, we must emphasize that weakness in any one of the key capabilities increases the potential for catastrophe.

Top Capabilities for Preventing Catastrophe



Annotations are the publisher's descriptions, taken from Amazon.ca.

Center for Chemical Process Safety (CCPS). ***Guidelines for Risk Based Process Safety*****. Wiley, 2007.**

Guidelines for Risk Based Process Safety provides guidelines for industries that manufacture, consume, or handle chemicals, by focusing on new ways to design, correct, or improve process safety management practices. This new framework for thinking about process safety builds upon the original process safety management ideas published in the early 1990s, integrates industry lessons learned over the intervening years, utilizes applicable total quality principles (i.e., plan, do, check, act), and organizes it in a way that will be useful to all organizations – even those with relatively lower hazard activities – throughout the life-cycle of a company.

Gleick, James. ***Chaos: Making a New Science*****. Penguin Paperbacks, 2008.**

This edition of James Gleick's ground-breaking bestseller introduces to a whole new readership the story of one of the most significant waves of scientific knowledge in our time. By focusing on the key figures whose genius converged to chart an innovative direction for science, Gleick makes the story of chaos theory not only fascinating but also accessible, and opens our eyes to a surprising new view of the universe. The twentieth-anniversary edition of the million-copy plus bestseller.

Harford, Tim. ***Adapt: Why Success Always Starts with Failure*****. Bond Street Books, 2011.**

Tim Harford introduces a new way of thinking about how to solve the world's most urgent problems, from climate change to terrorism, African poverty to global finance – even the problems we encounter in our own daily lives. When faced with such challenges, we instinctively look to leaders, experts, and gurus to provide us with pre-chewed solutions. Harford argues that the world has become too unpredictable and complex for that. Instead, we must adapt – improvise rather than plan, work from the bottom up, take baby steps. *Adapt* draws on exciting new work by passionate young economists and on innovative ideas from across the sciences. It looks at how and why innovation really comes about, extolling the value of trial and error and arguing that we should learn to embrace failure.

Heffernan, Margaret. ***Willful Blindness: Why We Ignore the Obvious at our Peril*****. Doubleday Canada, 2011.**

In the case of the U.S. Government versus Enron, the presiding judge chose to employ the legal concept of willful blindness: you are responsible if you could have known, and should have known, something which instead you strove not to see. The guilty verdict sent shivers down the spine of the corporate world. In this book, Margaret Heffernan draws on psychological studies, social statistics, interviews with relevant protagonists, and her own experience to throw light on willful blindness and why whistle-blowers and Cassandras are so rare. Ranging freely through history and from business to science, government to the family, this engaging and anecdotal book will explain why willful blindness is so dangerous in a globalized, interconnected world, before suggesting ways in which institutions and individuals can start to combat it. Margaret Heffernan's thought-provoking book will force us to open our eyes.

Hopkins, Andrew. ***Disastrous Decisions: the Human and Organizational Causes of the Gulf of Mexico Blowout.*** **CCH Australia, 2012.**

This book takes the reader into the realm of human and organisational factors that contributed to the Deepwater Horizon disaster in 2010. It is important to know what people did, but even more important to know why they did it, so this book attempts to get inside the heads of decision-makers and understand how they themselves understood the situations they were in. It also seeks to discover what it was in their organisational environment that encouraged them to think and act as they did. Professor Andrew Hopkins is an internationally renowned presenter, author and consultant in the field of industrial safety and accident analysis.

Hopkins, Andrew. ***Failure to Learn: the BP Texas City Refinery Disaster*****. CCH Australia, 2008.**

In *Failure to Learn: The BP Texas City Refinery Disaster*, respected OHS expert Professor Andrew Hopkins discusses the causes of a major explosion at the Texas City Oil Refinery on March 23, 2005, that killed 15 workers and injured more than 170 others. *Failure to Learn* also analyses the similarities between this event and the Longford Gas Plant explosion in Victoria in 1998, featured in his earlier book, *Lessons from Longford*. Professor Hopkins poses questions such as: Why was the number of victims so large? Who was blamed for

the explosion? What were the real causes? Had lessons been learnt from the earlier incident at Longford? Has anything changed as a result of the Texas City accident? The foreword for the book was written by Carolyn Merritt, chair of the CSB at the time of the accident and subsequent inquiry.

Hsu, Chia-Chien and Brian Sandford. *The Delphi Technique: Making Sense of Consensus*. Practical Assessment, Research & Evaluation; Volume 12, Number 10, 2007. http://pareonline.net/pdf/v12n10.pdf

The Delphi technique is a widely used and accepted method for gathering data from respondents within their domain of expertise. The technique is designed as a group communication process which aims to achieve a convergence of opinion on a specific real-world issue.

Monks, Robert and Nell Minow. *Corporate Governance*. Wiley-Blackwell, 2008.

The new edition of this successful text offers an indispensable guide to the key concepts of corporate governance every student and business professional should know. It includes more exercises and student questions, penetrating analysis of the latest examples of corporate failure and controversy, and the lively cases in point which have characterized previous editions.

Reason, James. *Managing the Risks of Organizational Accidents*. Ashgate Publishing, 1997; illustrated edition.

This is a practical book aimed at those whose daily task it is to think about and manage or regulate the risks of hazardous technologies. The book is not targeted at any one domain, but attempts to identify general tools and principles that are applicable to all organizations facing dangers of one sort or another. This could include banks and building societies just as much as nuclear power plants, oil exploration and production, chemical process plants, and air, sea and rail transport. The emphasis is placed upon the principles and practicalities of defences against accidents, and how to meet the challenges and minimize risk.

Sorkin, Andrew. *Too Big to Fail*. Viking USA, 2009.

Andrew Ross Sorkin delivers the first true behind-the-scenes, moment-by-moment account of how the greatest financial crisis since the Great Depression developed into a global tsunami. From inside the corner office at Lehman Brothers to secret meetings in South Korea, and the corridors of Washington, *Too Big to Fail* is the definitive story of the most powerful men and women in finance and politics grappling with success and failure, ego and greed, and, ultimately, the fate of the world's economy.

This true story is not just a look at banks that were too big to fail, it is a real-life thriller with a cast of bold-faced names who themselves thought they were too big to fail.

Vinnem, Jan Erik. *Offshore Risk Assessment: Principles, Modelling and Applications of QRA Studies*. Springer, 2007.

Offshore Risk Assessment was the first book to deal with quantified risk assessment (QRA) as applied specifically to offshore installations and operations. This book is a major revision of the first edition. It has been informed by a major R&D programme on offshore risk assessment in Norway (2002-2006). Not only does this book describe the state-of-the-art of QRA, it also identifies weaknesses and areas that need development.

Weick, Karl E. and Kathleen M. Sutcliffe. *Managing the Unexpected: Assuring High Performance in an Age of Uncertainty*. Jossey-Bass, 1997.

Since the first edition of *Managing the Unexpected* was published in 2001, the unexpected has become a growing part of our everyday lives. The unexpected is often dramatic, as with hurricanes or terrorist attacks. But the unexpected can also come in more subtle forms, such as a small organizational lapse that leads to a major blunder, or an unexamined assumption that costs lives in a crisis. Why are some organizations better able than others to maintain function and structure in the face of unanticipated change?

Authors Karl Weick and Kathleen Sutcliffe answer this question by pointing to high reliability organizations (HROs), such as emergency rooms in hospitals, flight operations of aircraft carriers, and firefighting units, as models to follow. These organizations have developed ways of acting and styles of learning that enable them to manage the unexpected better than other organizations.