How has the implementation of Safety Management Systems (SMS) in the transportation industry impacted on risk management and decision-making?

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Abstract

The concept of Safety Management Systems (SMS) has evolved from the best principles of high reliability organizations, strong safety culture and organizational resilience. This paper will examine how the introduction of SMS is affecting the way safety risks are managed in the transportation industry. It will focus primarily on management decision-making, since managers create the operating environment by setting priorities and providing resources to produce goods and services (Dekker, 2006). It reviews TSB occurrence investigation reports involving operators with (or developing) a SMS, where shortcomings in organizational risk management contributed to an incident or accident. It will discuss the challenges and benefits of implementing SMS and demonstrate how an effective SMS can reduce safety risks by creating a ”mindful infrastructure” (Weick & Sutcliffe, 2007).

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1.0 Introduction

In any complex organization, managers are required to manage competing (often conflicting) goals and multiple priorities e.g. customer service, productivity, technological innovation, cost-effectiveness and return on shareholder investment, usually in the face of risk and uncertainty. In those organizations that produce safety critical products and services (e.g. nuclear power, medicine, transportation etc.), an additional imperative is the need to reduce or eliminate risks to safety. Many such organizations publically assert that “Safety is our first priority”. There is, however, convincing evidence that ‘Customer Service’ or ‘Return on Shareholder Investment’ is really their first priority, but that products and services must be ‘safe’ if the organization wishes to remain in business, maintain customer and public confidence, avoid accidents and consequent costly litigation, and reduce the potential for overly prescriptive regulations (Dekker, 2005; Perrow, 1999; Reason, 1997; TSB, 2004).

Risk management is inherent to any manager’s decision-making process, regardless of the source of risk (safety, economic, technological etc.). Arguably, some risks are easier to assess than others. When it comes to safety, experience has shown that it can often be very difficult to foresee the specific combination of circumstances that might result in an accident (Reason, 1997; Perrow, 1999). With the benefit of hindsight after the event, an accident investigation identifies findings as to causal and contributing factors (including organizational issues). This does not necessarily mean we can predict exactly how, when or why the next accident will occur. This is particularly challenging in a complex socio-technical organization with a very low accident rate (e.g. air traffic control, airline operations).

Rasmussen suggested that organizations systematically migrate to the limits of acceptable performance “under the influence of pressure toward cost-effectiveness in an aggressive, competitive environment” (1997:189; see Figure 1). Dekker added: “Pressures of scarcity and competition**,** the intransparency and size of complex systems, the patterns of information that surround decision makers, and the incrementalist nature of their decisions over time, can cause systems to drift into failure. Drift is generated by normal processes of reconciling differential pressures on an organization (efficiency, capacity utilization, safety) against a background of uncertain technology and imperfect knowledge.” (2005: 43)

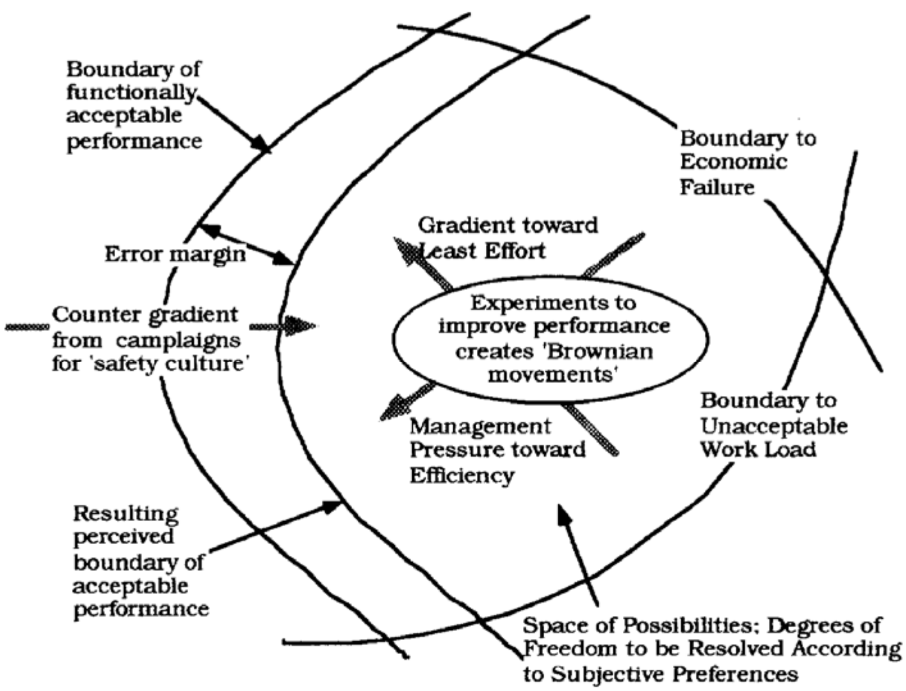

Fig. 1. Under the presence of strong gradients behaviour will very likely migrate toward the boundary of acceptable performance. (Rasmussen, 1997:190)

Drift may be visible to outsiders, especially following an adverse outcome. But drift is not necessarily obvious within the organization since incremental changes are always occurring (Dekker, 2005). Given the constant need to reconcile competing goals and the uncertainties involved in assessing safety risks, how can managers recognize if or when they are drifting outside the boundaries of safe operation while they focus on customer service, productivity and efficiency?

Many transport organizations are implementing safety management systems (SMS) either voluntarily as a pro-active strategy to help them manage safety risks or in response to new international and/or domestic regulations requiring SMS. Reason (2001:28) describes a successful SMS as a “systematic, explicit and comprehensive process for managing safety risks... It becomes part of that organization’s culture, and of the way people go about their work”. Yet what remains unclear is exactly how organizations internalize SMS so that it becomes part “of the way people go about their work” and how SMS “becomes part of that organization’s culture”. Can SMS help an organization identify and stay within the “boundaries of safe operation”, cope with the insidious pressures of “scarcity and competition” or recognize and prevent “drift”?

The purpose of this thesis is to shed some light on these issues by reviewing how SMS has impacted risk management and managerial decision-making processes in the transportation industry. It will focus on decision-making at the management or supervisory level, rather than the operator level. By their nature, management decisions tend to have a wider sphere of influence on how the organization operates and a longer term effect. Managers create the operating environment by establishing and communicating the goals and priorities and by providing the tools, training and resources to accomplish the tasks required to produce the goods and services (Dekker, 2006).

2.0 Background

2.1 Decision-Making Models

To place the research question in its proper context, it is first necessary to understand how managers make decisions in the face of risk and uncertainty. A review of the literature on decision-making models identified many descriptions and theories about how individual managers and groups of managers in organizations make decisions. Most of these models reflect the influence of situation recognition/ assessment, context, individual knowledge, experience and risk-taking propensity as well as organizational structures and culture (March, 1994; Orasanu & Connolly, 1993; Plous, 1993). Weick (2005:159-160) suggested that:

> *... to analyze decision-making is to take a closer look at what people are doing at the time they single out portions of streaming inputs for closer attention, how they size up and label what they think they face, and how continuing activity shapes and is shaped by this sensemaking...Decision-making is not so much a stand-alone one-off choice as it is an interpretation shaped by the abstractions and labels that are part of the ongoing negotiations about what a flow of events means.*

2.2 Risk Taking

March warned that "Persistent success leads to a tendency to underestimate the amount of risk involved because of oversampling cases in which luck was good….Successful organizations build a "can-do" attitude that leads people in them to underestimate risk." (March, 1994:46-47) He went on to say that decision makers will tend to underestimate the risk of an unlikely event if they have never experienced one. This is particularly relevant in so-called "high-reliability organizations" (HRO) which go to great lengths to avoid accidents. "In such high-reliability systems, most individual decision makers never experience a failure. They come to think the system is more reliable than it is. This exaggerated confidence in the reliability of the system is likely to lead to relaxation of attention to reliability and to a degradation of reliability over time." (March, 1994:48)

In contrast to March, Weick & Sutcliffe (2007) contend that one of the defining characteristics of HRO that helps them avoid negative outcomes, and manage the unexpected when it does happen, is their preoccupation with failure. For example, they observed that some HRO develop a list of expectations before an event (e.g. a reactor shutdown), compare these to what really happened (after the event) and analyze the differences for signs of trouble. "Candor about failed expectations encourages others to be similarly candid…" (2007:49). HRO also actively look for malfunctions and encourage "incident" reporting by creating a climate where people feel safe to report their "mistakes", without fear of reprisal, so that others can learn from these events. Reason expressed a similar notion in a different way. In describing why deteriorations in safety defences leading up to two accidents had not been detected and repaired, he suggested "the people involved had forgotten to be afraid...If eternal vigilance is the price of liberty, then chronic unease is the price of safety." (Reason, 1997:37)

Vaughan thoroughly examined the role that organizational culture plays in decision-making and risk taking in her extensive review of the management decision to launch the space shuttle Challenger over the objections of some engineers concerned about the risk of launching in such unprecedented cold temperatures (Vaughan, 1996). She explained how the work group culture at NASA and its various field units evolved over time from the original professional engineering imperative of technical excellence and a "can do" attitude embodied in the early, heady days of manned space flight; how it became modified by bureaucratic accountability as NASA was forced to adopt a more business like hierarchy and approach under the Reagan administration, and the eroding impact of political accountability as NASA fought for diminishing resources to assure its very survival. Over time, this culturally developed worldview affected the interpretation of information and shaped NASA decisions about risk in a prerational manner i.e. “influencing decision making ... without requiring any conscious calculus” (Vaughan, 1996:68). “Although the case concerns a technical artifact and statistical deviation, it suggests how conformity to rules and norms, incrementalism, precedent, patterns of information, organizational structure, and environmental conditions congeal in a process that can create a change-resistant worldview that neutralizes deviant events, making them acceptable and nondeviant.” (Vaughan, 1996:410)

Woods (2006:32) described the tension between acute production goals and chronic safety risks stating that: “...the decision to value production over safety is implicit and unrecognized” so that “individuals and organizations act much riskier than they would ever desire.” He described how difficult it can be to make “sacrificing” decisions (e.g. stop production in the face of ambiguous signals) particularly if, in the aftermath, there turns out not to have been a problem, or the outcome was successful. Perrow (2007:32) attributed this tendency to short-sightedness on the part of company executives. “If investing in safety would improve its quarterly or yearly rate of return, the company will do so; if the investment (say rebuilding pipelines that are becoming hazardous…) might pay off only if a storm hits that particular area in the next twenty years, it will be reluctant to do so, especially if the executive making the decision is to retire in five years.”

2.3 Evolving Concepts in Risk Management

Given the predisposition for managers and organizations to strive for efficiency (Hamel, 2007), the chaotic processes involved in decision-making (e.g. March’s “garbage can model” (1994:200)), the limitations of human cognition, the influence of organizational hierarchy and culture and the complexity of factors that affect safety, one might become very pessimistic about our ability to reduce the risk of accidents in complex, safety critical socio-technical enterprises.

A number of researchers have suggested approaches they believe would enhance an organization's ability to anticipate failure and rebound from unexpected events.
Gene Rochlin, Todd Laporte, Karlene Roberts and others from the University of California at Berkeley postulated that hazardous technologies could be safely controlled by complex organizations if wise design and management techniques are followed. The concept of high-reliability organizations is based on their studies of the U.S. ATC system, an electric power and gas company and peace-time flight operations of two U.S. Navy aircraft carriers. They found that in high-reliability organizations: leaders placed a high priority on safety and reliability, significant levels of redundancy existed, there was a strong organizational culture and continuous training and a high capacity for organizational learning through trial-and-error processes and simulation. (Rochlin et al., 1987)

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In a review paper prepared for the Canadian Civil Air Navigation Services provider, Westrum (1999) identified a number of organizational factors indicative of a strong safety culture, namely:

1. a strong organizational emphasis on safety;
2. high collective efficacy (i.e. a high degree of cooperation and cohesiveness);
3. congruence between tasks and resources;
4. a culture encouraging effective and free-flowing communications;
5. clear mapping of its safety state;
6. a learning orientation; and
7. clear lines of authority and accountability.

Weick & Sutcliffe (2007:32) suggested that decision-makers and organizations need to develop “mindfulness”, defined as “a rich awareness of discriminatory detail”. They explained that “expectations are built into organizational roles, routines, and strategies...(which) create the orderliness and predictability that we count on when we organize...(and) create blind spots” (P. 23); “expectations act like an invisible hand that guides you toward soothing perceptions that confirm your hunches and away from more troublesome ones that don’t. (P.32)” They proposed the creation of (P.2) “a mindful infrastructure that continually does all of the following:

- Tracks small failures
- Resists oversimplification
- Remains sensitive to operations
- Maintains capabilities for resilience
- Takes advantage of shifting locations of expertise.”

In particular, they emphasized the need to listen for and heed ‘weak signals’ and to respond vigorously. The goal is to promote both anticipation – “to foresee or imagine an eventual unchecked outcome, based on small disparities” (P. 45) – and containment, in order to bounce back after unexpected events have occurred.

Increasingly, resilience engineering strategies and practices are suggested as a way to “provide decision support for balancing production/safety tradeoffs, and create feedback loops that enhance the organization’s ability to monitor/revise risk models and to target safety investments” (Woods, 2005:302). “...(A) resilient system is defined by its ability effectively to adjust its functioning *prior to* or *following* changes and disturbances so that it can continue its functioning after a disruption or major mishap, and in the presence of continuous stresses” (Hollnagel et al., 2008:xii-xiii). Such a system must be able to:

1) Respond to various disturbances and to regular and irregular threats;
2) Flexibly monitor what is going on, including the system's own performance;
3) Anticipate disruptions, pressures and their consequences; and
4) Learn from experience.

Woods (2005:305) also proposed that organizations maintain a safety organization "...designed and empowered to be independent, involved, informed, and informative. The safety organization will use the tools of resilience engineering to monitor for "holes" in organizational decision-making and to detect when the organization is moving closer to failure boundaries than it is aware. Together these processes will *create foresight* about the changing patterns of risk before failure and harm occur."

2.4 Safety Management Systems (SMS)

Traditional approaches to safety management based primarily on compliance with regulations, reactive responses following accidents and incidents and a 'blame and punish' philosophy have been recognized as being insufficient to reduce accident rates (ICAO, 2008). SMS was designed around evolving concepts about safety which are believed to offer great potential for more effective risk management. SMS is generally defined as a formalized framework for integrating safety into the daily operations of an organization including the necessary organizational structures, accountabilities, policies and procedures. It originated in the chemical industry in the 1980s and has since evolved and been progressively adopted in other safety critical industries around the world.

In many cases, the motivation for adopting SMS was prompted by high profile, tragic accidents and the realization that organizations needed to find a better way to prevent such occurrences. For example, during the second half of the 1980s and early 1990s, a number of high profile shipping accidents occurred including the *Herald of Free Enterprise, Exxon Valdez*, *Scandinavian Star* and *Estonia* to name a few. A number of investigations and public inquiries were held which led to the generally accepted conclusion that more attention had to be paid to how shipping companies were run. In May 1994, IMO[1] formally incorporated resolution A.741 (18), the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code). The objectives of the Code are "to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment". It applied progressively over time to Ro-ro ferries operating between ports in the European union, passenger ships, oil tankers, chemical tankers, gas carriers, bulk carriers, cargo ships and mobile offshore drilling units of 500 gross tonnage and upwards.

In Canada, the safety regulator Transport Canada (TC) requires that federally regulated modes of transportation implement safety management systems (Transport Canada, 2007). Since 2001, pursuant to IMO requirements, the Canada Shipping Act has required SMS for all Canadian vessels engaged in international voyages. A number of Canadian domestic shipping companies have voluntarily adopted SMS, and TC is actively promoting its adoption.

The Canadian railway industry underwent significant changes in the late '80s and early-mid '90s including restructuring, privatization and deregulation. The Railway Safety Act, first adopted in 1989, has been reviewed and amended several times and since 2001, SMS has been required in the federally-regulated rail sector.

[1] The International Maritime Organization (IMO) is a specialized United Nations agency responsible for developing conventions and guidelines under which ships can be regulated in the areas of safety at sea, pollution prevention and training of seafarers. Each IMO member state is responsible for enforcing the international conventions it has ratified on the ships flying its flag. (Source: Anderson (2003))

Since 2005, SMS is progressively being implemented in the commercial aviation sector in advance of international requirements promulgated by the International Civil Aviation Organization (ICAO)[2].

While details may vary from one industry or regulatory regime to another, a SMS generally includes the following elements:

- an accountable executive or designated authority for safety;
- a safety policy on which the system is based (articulating senior management commitment);
- a process for setting safety goals and measuring their attainment;
- a process for identifying hazards, evaluating and managing the associated risks;
- a process for ensuring that personnel are trained and competent to perform their duties;
- a process for internal reporting and analyzing of hazards, incidents and accidents and for taking corrective actions;
- a process for documenting SMS and making staff aware of their responsibilities; and
- a process for conducting periodic reviews or audits of the SMS.

The following table shows the historical trajectory towards SMS as well as its intellectual pedigree. It loosely maps concepts of risk management (discussed in section 2.3) to the components of SMS: for example, HRO's concept of commitment, Westrum's notions of accountability and emphasis on safety and the SMS component of accountable authority.

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[2] The International Civil Aviation Organization (ICAO), a UN Specialized Agency, is the global forum for civil aviation. ICAO works to achieve its vision of safe, secure and sustainable development of civil aviation through cooperation amongst its member States. (Source: ICAO Website)

Table 1.0 **Summary Comparison of Concepts**

High-Reliability Organizations	Strong Safety Culture (Westrum)	Resilience (Weick)	SMS
• Commitment • Strong safety culture • Redundancy • Training • Continuous Learning	• Authority/ accountability • Emphasis on safety • Collective efficacy • Congruence between tasks and resources • Free-flowing communications • Mapping of safety state • Learning orientation	• Pre-occupation with failure • Track small failures • Resists oversimplification • Sensitive to operations • Capabilities to bounce back • Deference to expertise • Heeds weak signals	• Accountable authority • Safety policy • Set / measure safety goals • Hazard analysis • Trained competent personnel • Incident reporting • Documentation of SMS processes and accountabilities • Periodic reviews/ audits of SMS

Some people misconstrue SMS as a form of deregulation or industry self-regulation. However, just as organizations rely on internal financial and HR management systems to manage their financial assets and human resources, SMS is a framework designed to enable companies to better manage their safety risks. This does not obviate the need for effective regulatory oversight.

3.0 Methodology

Measuring the impact of SMS is challenging since it is impossible to measure the accidents that didn’t happen because of it. Establishing a ‘before’ and ‘after’ SMS comparison of accident rates is also problematic given the progressive deployment of SMS, the relatively short elapsed time period since implementation, and a low baseline accident rate where it is sometimes difficult to draw meaningful conclusions due to cyclical fluctuations. However it is possible to identify shortcomings in risk management practices that may have contributed to an incident or accident, as well as changes in how managers, in particular, position themselves relative to their decisions, risk and its management.

I undertook the following research steps:

- reviewed a selection of documents that discussed the impact of the introduction of SMS in the transportation industry;
- reviewed published occurrence investigation reports of the Transportation Safety Board of Canada (TSB)[3] where at least one of the companies involved had implemented or was implementing SMS and in which ineffective risk management practices were explicitly identified in the findings[4]; and
- conducted 10 focussed oral (6) and written (4) interviews with a number of senior managers and other industry experts across various organizational sizes and modes of transport (6 Air, 2 Marine and 2 Rail) who had extensive knowledge or experience with the implementation of SMS.

The purpose of reviewing occurrence reports was to identify real-life examples of ineffective risk management and decision-making processes in a SMS environment and, where possible, why they had occurred. Since SMS was first introduced by regulation in the Canadian transportation industry in 2001, a keyword search on the terms “safety management system”, “safety management”, “risk management” and/or “safety culture” was performed on published TSB reports for occurrences during the period January 1, 2001 to December 31, 2008.

[3] The Transportation Safety Board of Canada (TSB) is an independent government agency that investigates occurrences in federally regulated air, marine, rail and pipeline sectors for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability. (Source: www.TSB.gc.ca)

[4] A finding as to Causes and Contributing Factors identifies an element that has been shown, through the results of thorough analysis, to have operated in the occurrence or to almost certainly have operated in the occurrence. Findings as to Risk expose a risk that is materially in excess of the risks inherent in that mode of transport. (Source: TSB Manual of Investigations Volume 4)

Those occurrence reports where findings referred only to factors such as “operator error” or equipment malfunction (to name a few), but not explicitly to organizational risk management practices, were not included in this review. While these might imply underlying deficiencies in organizational risk management, the necessary data to substantiate that link was not accessible. Only information available in the final published report was utilized.

This narrowed the search from close to 600 published investigation reports down to 39. These reports were then reviewed in detail and analyzed for commonalities and trends. During this review, I developed a coded list of ineffective risk management practices e.g. not conducting a formal risk analysis, inadequate follow-up on known mechanical defects etc.

The interview questions were designed to ask informants about their experiences with the introduction of SMS and specifically how risk management and decision-making processes and practices had changed. Topics included: challenges of implementing SMS, internal processes for safety planning, hazard identification and risk assessment, incident reporting, resolving goal conflicts, heeding weak signals and the influence of leadership and culture. Interviews were conducted on a confidential basis. Using examples from the occurrence reports provided an opportunity to probe deeper into informants’ attitudes and practices if faced with similar situations. The objective was to identify how SMS had impacted on risk management and decision-making, test analytical assumptions (such as if the absence of regulations affects “mindfulness”) and identify some good practices which could be shared with other operators.

To preserve confidentiality, informants have been identified in this thesis as follows (e.g. A-2O):

A, M, R: refers to mode of transport - Air, Marine, Rail;

1, 2, 3 etc.: refers to interview order within the mode;

O: senior manager of a transport operator; **S**: industry expert (e.g. marine classification society, pilot association representative or other).

As a current TSB Board Member, protocol limited my access to primary sources of data. However, I was able to triangulate data by using multiple sources. And I have high confidence in the data that I could access, for example:

- final TSB report findings and safety deficiencies have been validated through a comprehensive and rigourous investigation process; and
- the depth of study processes used (including surveys, public consultations and independent research) in support of documents on the impact of the ISM Code on shipping practices (Anderson, 2003) and the report of the Advisory Panel tasked with reviewing the Canadian Railway Safety Act (Railway Safety Review Panel, 2007).

While I could not directly interview current officials in any organizations with occurrences actively under investigation by TSB, interviews with a range of transport companies and industry experts allowed me to gain valuable insight into what happens behind the scenes in organizations either developing or operating a SMS.

This thesis intentionally does not address the adequacy of either the regulatory framework for SMS or regulatory oversight processes during the transition to / or following the implementation of SMS. While these factors do play an important role in the successful implementation of SMS, I wanted to focus on what happens <u>inside</u> the transport organization.

4.0 Review of TSB Occurrence Reports

4.1 Scope of Review

During the period Jan. 1, 2001 to Dec. 31, 2008, TSB started investigations of 402 air, 100 marine, 9 pipeline and 113 rail occurrences. Of these, 39 published reports (7 air/18 marine/14 rail) met the search criteria and were analyzed in greater detail. The reduced availability of data in the air mode primarily reflects the later introduction of SMS compared to marine and rail modes.

Not surprisingly, there were usually a number of organizational factors that, in combination with “operator errors” and equipment malfunctions, contributed directly to the occurrence, and/or created a risk of such occurrences. There was also evidence of goal conflicts, previous warnings (‘weak signals’) and adaptations (symptomatic of normalization of deviance (Vaughan, 1996) or practical drift (Snook, 2000)) .

I made the following observations about organizational risk management practices:

- no formal risk analysis conducted;
- risk analysis conducted but hazard not identified;
- hazard identified but residual risk underestimated;
- risk control procedures not in place, or in place but not followed;
- issues related to equipment design and/or maintenance practices;
- inadequate tracking or follow-up of safety deficiencies;
- insufficient personnel for the task at hand, heavy workload, inadequate supervision;
- insufficient training or lack of qualifications for the task to be performed;
- conditions conducive to physical or mental fatigue;

- ineffective sharing of information before, during or after the event including verbal communications, record-keeping or other documentation; and/or
- gaps created by organizational transitions affecting roles, responsibilities, workload and procedures.

The complexity of the interaction of all the causal/ contributing and risk factors should not be underestimated or oversimplified. However, I cite examples below to illustrate certain specific observations, extracting extensively from the reports (*shown in italics*) to ensure I retain the original meaning.

4.2 Adaptations/ Drift

In a context of limited resources, time pressures and multiple goals, workers often create "locally efficient practices" to get the job done (Dekker, 2003; Snook, 2000; Reason, 1997). There were several examples of the impact of such local adaptations on incidents/ accidents. In one example *(***M03W0237***)*:

> *A container vessel ran aground while departing a river channel. The river pilot had handed over conduct of the vessel to the coast pilot and departed the vessel while still in an area for which the coast pilot was not licenced. The coast pilot in charge of the vessel was not aware of the restrictions in channel widths, nor the latest channel depth soundings.* ***It had become customary during times of heavy traffic and/or bad weather for the pilot handover to take place within the river, close to the mouth of the river entrance. However, this practice had apparently become the norm, and river pilots routinely handed over the conduct of the vessel to coast pilots prematurely, even when it was not warranted by the prevailing conditions****.*

In another example (**M05L0203)**:

> *A bulk carrier ran aground following a power blackout and resultant loss of steering control. Sometime later it was discovered that the cargo hold was taking in water...* ***This situation was exacerbated by the unwritten but common practice of sealing off the strainer plates in the hold using cardboard, plastic sheeting and duct tape to prevent the cargo (in this case, iron ore pellets) from entering the bilge wells.*** *The ship's inability to pump water from the cargo hold (until portable pumps were obtained later) could have impaired the vessel's stability to a point where it could contribute to a more serious occurrence.*

With the best of intentions, organizations may develop policies and procedures to mitigate known safety risks which then subsequently erode under production pressures. The following case **(A04H0004)** provides a concrete example of Vaughan's (1996) "normalization of deviance"**:**

> *A B-747-244SF on a non-scheduled international cargo flight crashed during take-off when the crew inadvertently used the aircraft weight from a previous leg to calculate take-off performance data. This resulted in incorrect V speeds and a thrust setting too low to enable the aircraft to take off safely given its actual weight. Crew fatigue likely increased the probability of error during calculation of the take-off performance data and, in combination with the dark take-off environment, degraded the flight crew's ability to detect this error.*
>
> *The company was experiencing significant growth and a shortage of flight crews. Some of its planned flight safety programs were not yet fully developed or implemented. During the previous four years, the company had gradually increased the maximum allowable duty period from 20 hours (with a maximum of 16 flight hours) to 24 hours (with a maximum of 18 flight hours). Originally, the crew complement consisted of two captains, two co-pilots and two flight engineers but was then revised to include three pilots and two flight engineers. At the time of the accident, the flight crew had been on duty for almost 19 hours and, due to earlier delays experienced, would likely have been on duty for approximately 30 hours at their final destination had the remaining flights continued uneventfully* ***. The Crewing Department routinely scheduled flights in excess of the 24 hour limit. This routine non-adherence to the Operations Manual contributed to an environment where some employees and company management felt that it was acceptable to deviate from company policy and/or procedures when it was considered necessary to complete a flight or a series of flights.***

In several other occurrences, crews did not follow formal documented safety procedures. "People do not always follow procedures." (Dekker, 2003:233) There is often a mismatch between how procedures specify work should be done and how it actually gets done. This could be a result of many factors.

> *Rules that are overdesigned… do not match actual work most of the time… (which) creates an inherently unstable situation that generates pressure for change… Emphasis on local efficiency or cost-effectiveness pushes operational people to achieve or prioritize one goal or a limited set of goals... (that are) easily measurable … whereas it is much more difficult to measure how much is borrowed from safety. Past success is taken as a guarantee of future safety. Each operational success achieved at incremental distances from the formal,*

> *original rules can establish a new norm….Departures from the routine become routine…violations become compliant behaviour. (*Dekker, 2003:236*)*

For example (**A04Q0188**):

> *A corporate Beech 300 landing on a snow-covered runway, subsequently departed the runway and came to rest in a ditch. The accident occurred after an unstabilized and unsafe approach followed by a landing on a contaminated runway**. The crew did not follow company SOPs. Specifically, flight planning was incomplete, the landing limits were not adhered to, the runway contamination limits were ignored, the approach briefings were not conducted in full, and crew coordination was deficient.** There was no indication that the company pressured pilots to descend below the minima. On the contrary, (the company) had put in place recognized means for improving flight safety, including an SMS and SOPs, as well as simulation training in CRM and CFIT. The pilots and ground personnel demonstrated inadequate knowledge of the SMS program by not recognizing the risk elements previously identified by the company. Neither pilot had received theoretical training in cockpit resource management (CRM), which could explain their non-compliance with procedures and regulations.*

In another example, the report did not explain the crew's rationale for not following documented procedures *(***M03N0047)**:

> *A Coast Guard ship returning late at night from engine trials collided with a small fishing vessel just outside the harbour entrance during a period of reduced visibility. Although the Coast Guard's SMS embraced the Bridge Resource Management (BRM) philosophy, it was not fully implemented and the risks associated with operating a vessel in reduced visibility while approaching a port were not fully addressed. **The vessel's speed was excessive for the conditions, the radar watch was ineffective, no security message was sent to alert other vessels, the Officer of the Watch lacked experience in these conditions and the helm orders issued to avoid the collision were ambiguous.***

Following an occurrence, investigations need to probe more deeply into why formally documented rules, procedures and 'safe practices' were not followed. In particular, was such behaviour unique to this operator or crew, or generalized to other operators and crews? Understanding the context-specific reasons for the gap between written procedures and real practices will help organizations better understand this natural phenomenon and, allow for more effective interventions beyond simply telling the workers to “Follow the rules!” or to “Be more careful!”.

4.3 Goal Conflicts

Building on the previous section, a number of other occurrences underscore Woods’ (2006:32) belief about the routine tension between acute production goals and chronic safety risks which may prompt deviations from sound risk management practices**.** In one case *(***M02L0061)**:

> *A crewmember fell overboard when the lifeboat he was securing suddenly released and the lifeboat struck him on its descent. The port lifeboat davit had been damaged while transiting a lock.* ***The ship’s managers ashore had instructed the Master to make repairs while the ship was underway using onboard resources available to avoid delaying the ship.*** *These repairs were subsequently inspected by TC and a classification surveyor who rejected them. An additional liferaft was secured to meet classification standards, prior to the home voyage through international waters.* ***Although the defective davit was not approved for safe use, the master wanted to assure himself that this equipment could be operable in the event of an emergency. Accordingly, he ordered the port lifeboat lowered and then raised to his own satisfaction.*** *The port lifeboat had not been secured prior to getting underway. A combination of design and maintenance flaws contributed to the unexpected release of the lifeboat while it was being secured.*

In another occurrence *(***M06N0014***)*:

> *A fire started in the cargo oil tank of a shuttle tanker during welding repairs in port resulting in serious injuries to the welder and the death of an assisting crew member Although a safety meeting was held to review and approve the planned hot work, conflicting work items and appropriate mitigation measures were not identified and established procedures for hot work and enclosed spaces were not followed. A crew member with a high workload of safety-sensitive duties worked while in a fatigued state leading to insufficient oversight of the welding activities. Protective gear supplied or available to crew members was not consistent with their risk exposure profile.* ***The report noted that approaching bad weather added an element of time pressure with the crew required to complete the work so the vessel could leave two days ahead of schedule.***

As March (1994), Vaughan (1996) and Woods (2006) suggested, routine pressures to get the job done or get underway can exert an insidious and prerational influence on decision makers that leads them to act in ways that are riskier than they realize. Following an occurrence, uncovering and explaining how and why certain decisions were made can promote organizational learning and result in more effective corrective actions.

4.4 Non-reporting of incidents

A cornerstone of SMS is free-flowing communication of safety data. Westrum (1993:402) describes a key criterion of successful information flow in organizations: "... the organization is able to make use of information, observations or ideas wherever they exist within the system, without regard for the location or status of the person or group having such information, observations or ideas."

One report identified the fear of discipline as a reason for the involved parties not reporting the occurrence *(***R06H0013**). This is also another good example of local adaptations (use of cell phones) to compensate for lack of appropriate equipment (radio towers).

> *A passenger train exceeded its limits of authority and stopped approximately one mile short of a head-on collision with a work train after inadvertently contacting the wrong work train to ask permission. Employees had developed an informal style of communication procedures while using cell phones for train communications in the absence of radio towers.* ***In this occurrence, because of the fear of discipline, the train crews did not report the near collision, compromising the opportunity for a timely investigation and for the identification of defences to prevent similar incidents from occurring.***

Dekker describes incidents as a 'free lesson' (i.e. no one died) and reminds us that: "The point of reporting is to contribute to organizational learning. It is to help prevent recurrence by making systemic changes that aim to redress some of the basic circumstances in which work went awry." (Dekker, 2007:39) But people won't report their mistakes if they are afraid of being punished, representing a lost opportunity for organizational learning and risk reduction (Dekker, 2007).

4.5 Identifying Hazards and Mitigating Risks

Pro-active **h**azard **i**dentification and **r**isk **a**ssessment (HIRA) is another cornerstone of SMS. Yet, the most frequent observation was that the organizations involved had either not conducted a formal risk assessment or had not identified the particular hazard that contributed to the accident.

When investigating an incident or accident, "hindsight changes how we look at past decision making. It turns real, convoluted complexity into a simple, linear story...". (Dekker, 2006:25) However, before an occurrence, it can be quite challenging intellectually to try to identify what might go wrong. Westrum calls this ability "requisite imagination". "The cultivation of imaginative inquiry into potential problems often avoids the occurrence of these problems in real life... Members of the organization are given a license to think, and use it to probe into things that might go wrong." (Westrum, 1993:414)

4.5.1 Lack of "Requisite Imagination" or "Mindfulness"

In some marine accidents, the lack of applicable international, flag state or classification[5] regulations or standards may have led operators to overlook potential hazards. For example (**M01W0006**):

> *While stowing an accommodation ladder soon after departure, a crew member on a container ship was struck and killed by a steel snatch block shackled to a pad eye that fractured in two from shear due to tensile overload* ***. The IMO inspection regime applied only to ladders used by pilots transferring to/from the ship and not to other ladders (such as this one) used regularly by the ship's crew. Cracks in the pad eye which had developed some time prior to the accident remained undetected.*** *Time constraints due to an exigent loading or unloading schedule, coupled with the position and the stowage of the ladder, make a thorough on-site examination of the ladder difficult, especially of the parts subject to wear and tear.*

[5] Classification societies are organizations that establish and apply technical standards in relation to the design, construction and survey of marine related facilities including ships and offshore structures. (Source: http://www.eagle.org/company/Classmonograph.pdf)

In another example cited earlier (**M05L0203**):

> *A bulk carrier ran aground following a power blackout and resultant loss of steering control. Sometime later it was discovered that the cargo hold was taking in water. This vintage of ship (built in 1967) was not subject to updated regulations requiring automatic restoral of steering capability following a power blackout.* ***Nor was the vessel subject to international regulations requiring it to have water-level detectors in the cargo hold and the capability to pump water from both forward and aft ends of the cargo hold. The ship's inability to pump water from the cargo hold (until portable pumps were obtained later) could have impaired the vessel's stability to a point where it could contribute to a more serious occurrence.***

My marine informants emphasized that most shipping companies do take safety very seriously. "It's their home. People live on these vessels for weeks at a time. (M-1O)" But, it was acknowledged that shipping companies do tend to focus more on compliance with existing regulations and standards or reactive identification of hazards in response to occurrences or 'near-misses' rather than search for hazards proactively, for example in advance of introducing new equipment on board a vessel (M-2S).

4.5.2 Weak Signals

By their nature, 'weak signals' may not be sufficient to attract the attention of busy managers, who often suffer information overload while juggling many competing priorities under significant time pressures. In several occurrences, early warning signs of a hazardous situation were either not recognized as such or not effectively addressed. Weick & Sutcliffe (2007:2) would likely describe this as evidence of the absence of "a mindful infrastructure".

In one case (**M02W0061**):

> *While discharging cars, a passenger/vehicle ferry spontaneously backed off the dock causing the shore-mounted vehicle ramp to fall below the level of the vessel's vehicle deck.* ***The operator's incident database for all nine similarly-equipped vessels in their fleet identified 10 occasions of the steering control systems behaving erratically in the preceding 4 years. Defective printed circuit boards had been identified as the most frequent cause of the steering system malfunctions.*** *The operator's SMS required that there be a planned*

> *maintenance system and that malfunctions be analyzed, with a view to optimizing performance and eradicating failures. At the time of the occurrence, the operator did not require that printed circuit boards be individually identified by serial numbers or that repairs to them were documented.* ***No trend monitoring was done on these failures and rarely were reports of the work done submitted to the engineering superintendent's office, or to the vessel's master or chief engineer.*** *Neither the operator nor the manufacturer of the automatic steering control systems had a planned maintenance system to replace the printed circuit boards.*

In another example *(***R05Q0010***)*:

> *A freight train derailed on a main track resulting in a subsequent fire and explosion of a propane tank car. Over 4000 feet of track and an adjacent mill were damaged or destroyed, and twenty people in the area were evacuated as a safety precaution.* ***The first car to derail when a wheel failed had undergone numerous repairs, especially to its brake system. These repairs were undertaken by different repair shops and had been entered into the operator's computerized maintenance system. Because the system did not have an automatic warning mechanism, the abnormally high number of brake shoes installed on the car during the 13 months preceding the accident was not noticed.*** *This system did not make it possible to alert the repair teams and to isolate a car with recurring defects in order to take corrective action.*

Organizational transitions sometimes contributed to a lack of effective follow-up on identified hazards *(***R03V0083***)*:

> *Two railway crew members were killed when a timber tie trestle bridge collapsed and their locomotive toppled off the bridge and was destroyed by fire.* ***Serious defects had been identified in the bridge four years before the accident. Despite subsequent inspections, the urgency and severity of the condition of the bridge was not recognized because of shortcomings in the inspection, assessment, planning, and maintenance process. A contributing factor was heavy workload and overlapping duties during job transitions involving the maintenance planning and inspection engineering group, as a result of a reorganization and workforce adjustment.*** *The investigation also observed variances between company operating procedures and actual field practices in conducting inspections which suggested that previous training provided did not meet its aim of enhancing the knowledge of all inspectors and ensuring cross-system uniformity of the inspection and reporting process.*

As these examples demonstrate, meaningful documentation and follow-up of known hazards was often found to be ineffective. Westrum (1993:404) maintained: "The failure to respond to indications of trouble is a standard feature of major technological accidents. Not asking critical questions and not investigating critical problems is typical of an organizational culture in which requisite imagination is not encouraged.” Further to this, in a recent article (2009), William Voss, President and CEO of Flight Safety Foundation said: “As random as these recent accidents look, though, one factor does connect them. We didn’t see them coming and *we should have*… the data were trying to tell us something but we weren’t listening.”

It may be a reflection of the limitations of information gathering and analysis capability in many organizations due to a lack of institutionalized structures and resources (people, time) to keep track of deficiencies and identify patterns. Perhaps the persons who should be in the best position to identify and act on known hazards are stretched too thin or focussed on other priorities.

Protection of safety data from indiscriminate use in litigation and enforcement activities by lawyers and regulators is also an ongoing concern. By promoting the collection of protected data from multiple sources, SMS is intended to provide an infrastructure in which ‘weak signals’ can be amplified to the point where they will be acted upon **before** an accident occurs.

4.5.3 Incorrect Assumptions

Starting assumptions exerted a big influence on whether or not a formal HIRA was conducted. In several cases, operators did not conduct a HIRA prior to changing operating practices because they did not consider these changes to be significant. For example *(***R05V0141***)*:

> *A freight train derailed after it stringlined to the inside of a sharp left-hand curve on an ascending mountain grade, spilling approximately 40,000 litres of caustic soda into a river causing extensive environmental damage.*
>
> *Approximately one year earlier, a national railway operator had acquired a regional railway which operated over this challenging, mountainous terrain. Following its acquisition, the regional organization was restructured to improve*

productivity. Operational staff reductions and retirements led to a shortage of train crews and a loss of corporate operational knowledge and experience. An operational decision was made to resume use of distributed power (DP[6]) locomotives to accommodate longer trains. The previous operator had conducted DP operations up until about two years before the accident, however, had discontinued this in favour of conventional trains of shorter length.

The railway operator did prepare a Safety Integration Plan for the acquisition of the regional railway. ***However, it did not conduct a formal risk assessment when it decided to resume operation of DP trains, since DP trains had previously been operated on this route in accordance with train handling instructions approved by the former provincial regulator, and therefore the operator did not consider this to be a significant operational change.***

The company did not recognize that the operational context had changed or the potential impact of equipment design factors, operator training/experience/workload or local adaptations and did not manifest Reason's "chronic unease" (Reason, 1997). By not conducting a HIRA involving local expertise, the company missed an opportunity to identify and mitigate the hazards associated with this proposed change.

4.5.4 Underestimating Risks

In other cases, hazards were known but risks were underestimated.

In one occurrence (**M03L0026**):

A bulk-carrier grounded on its return voyage through ice-infested waters when its main sea suction strainers became blocked by ice causing the vessel's generators to overheat and shut down, resulting in a loss of electrical and propulsion power. ***Having already successfully navigated in this area on the inbound voyage, the Master was confident the ship could handle the ice. But the cooling system was not designed for efficient navigation in ice.*** *The crew was inexperienced in ice navigation, and without adequate training and vessel-specific documented procedures/ directives in the Safety Management System manual, the crew was unable to readily recognize and prevent the blockage of the sea suctions.*

[6] Distributed power trains have additional operating locomotives positioned in the train; for example, at the midway point, two-thirds of the way back or at the rear. The distribution of power enables the operation of longer, heavier trains while providing a means to control or minimize in-train forces.

In another case *(***R01M0024***)*:

> *A passenger train carrying 132 persons derailed at a manually operated main track switch after the standard switch lock used to secure the switch in correct position had been tampered with.* ***The track owner*** *was aware of the possibility of vandalism and had installed high security locks at higher risk sites, but* ***believed the risk at this particular location to be low and that the switch target would indicate to crews if the switch was open. They did not know that simply raising the switch handle in its slot was enough to cause the switch points to open and flex under the vibration and weight of passing trains. Neither the railway signal system nor the switch target was capable of providing the crew with information that the switch was not properly lined and securely locked, so the approaching train did not receive an advance warning of the actual switch position.***

These examples support March's (1994:46) contention that persistent success (navigating ice infested waters, running trains over a manual switch) can lead to underestimating risk. They also show that, in spite of their best intentions, decision-makers are not always aware of the impact of certain design factors on the risks they assume (e.g. ship's cooling system not designed for efficient navigation in ice). Some researchers suggest that documenting the decision-making rationale for system design may help reduce the likelihood that future design modifications may set the stage for drift and future accidents (Daouk & Leveson, 2001).

My analysis suggested that some of the HIRAs that were conducted were either too informal or the participants were not sufficiently knowledgeable to identify potential hazards: e.g. the track owner/operator did not know the manual switch could be partially opened without activating the switch signal target indicating its unlocked status. The techniques and tools used in conducting a HIRA can significantly influence the rigour and, ultimately, the success of the process. If the process is informal, unstructured or undocumented, it may not be effective in identifying hazards, quantifying risks or establishing suitable risk mitigation strategies. The participants play a crucial role in identifying hazards and should be knowledgeable of relevant operational and technical factors and experienced in the activity or area under review. If the HIRA is conducted at too high a level, the lack of detail with respect to actual processes and practices may result in hazards being overlooked.

As Vaughan (1996:37) put it: “the organization has limited abilities to search for information and solutions to problems; individuals have limited knowledge of alternatives, access to and ability to absorb and understand information, and computational capacity; the decision-making process is influenced by deadlines, limited participation, and the number of problems under consideration.”

4.6 Resilience

An organization’s ability to contain an unexpected hazard and recover is an indicator of resilience and an objective of SMS. In one occurrence *(***M02W0135***)*:

> *A passenger cruise ship experienced a catastrophic failure of the main circuit breaker (CB) for one of its diesel generators (DG2), starting fires in the main switchboard room and the adjacent engine control room. Over a period of several hours, DG2 was started and then restarted five times, only to have it either stop, or trip off the switchboard and stop, for various mechanical or electrical reasons.* ***No attempt was made to analyze why this was happening in spite of an ongoing company initiative to develop and disseminate a Blackout Prevention and Recovery Plan. The senior engineers/electricians had not been formally trained in the newer technology of electric propulsion and medium voltage generation in use on this ship. Other company expertise was not brought to bear on analyzing the situation in spite of the company’s Rapid Reporting System designed to facilitate prompt verbal sharing of incident-critical information between the master and senior technical staff both on the ship and on shore.*** *The engineers felt a pressing need to reconnect DG2 so that the ship could travel at its maximum designed speed of 21.5 kn as soon as possible to complete some fuel consumption tests that were underway by hired private consultants prior to their being offloaded at the next stop; and they did not want to inconvenience or scare the passengers . The report noted that, in spite of the company’s efforts to address the serious threat posed by blackouts and circuit breaker trips, the prevailing circumstances appear to have influenced the engineering staff’s decisions on the night of the incident.*

In another example *(***R04T0008***)*:

> *A freight train derailed on an overpass in which some of the rail car platforms and containers fell onto the roadway below fatally injuring two occupants of a passing vehicle.* ***A progressively failing wheel (of a type known to have experienced manufacturing defects linked to other derailments) resulted in the display of a series of isolated, dispersed unidentified track occupancy (UTO) messages to a heavily occupied Rail Traffic Controller (RTC). The RTC dealt with each individual event. But because the UTOs behind this train were widely separated in time and distance, and only occurred on left-hand curves, it was difficult for the busy RTC to correlate this information with the occurrence train.***

In both these examples, the operators did not possess in-depth knowledge of the systems they were working on, which is required for effective trouble-shooting. Dekker stated (2003:235): “If adaptations to unanticipated conditions are attempted without complete knowledge of circumstance or certainty of outcome, unsafe results may occur….” Weick & Sutcliffe (2007:157) added that: “Resilience takes deep knowledge. Generalized training and learning that increase people’s response repertoires enlarge the range of issues that they notice and can deal with.” Of relevance for the harried RTC, they went on to say: “Don’t overdo lean, mean ideals…because leanness strips the organization of resilience and flexibility…Improve resilience by forming knowledgeable people into ad hoc networks that self-organize to provide expert problem solving.”

They also suggest that organizations need “to pay just as much attention to building capabilities to cope with errors that have occurred as to improving capabilities to plan and anticipate events before they occur.” (2007:80) SMS can help deal with such situations depending on the extent to which organizations develop and exercise emergency response plans e.g. by conducting simulations and table-top exercises. A recent high profile incident reinforces the value of training to promote resilience. “The hijacking of a Canadian airplane in Jamaica began with a massive security failure and ended with an astonishing success… The lesson to be drawn from the impressive conclusion of this episode is this: well-trained professionals can change the course of an incident."(Editorial, 2009)[7]

4.7 Multiple Accidents

During the period under review, a few companies experienced multiple accidents. This afforded the opportunity to see if there were trends and to review and compare the corrective actions taken following these accidents.

The TSB investigated three marine accidents between 2002 and 2005 involving a large ferry operator which had voluntarily introduced SMS. While the facts differed, the TSB noted deficiencies in the operator's maintenance practices in each accident report (**M02W0061, M03W0073** and **M05W0111**). In particular, report **M03W0073** found shortcomings in the monitoring, tracking and correcting of safety deficiencies. A review of the safety actions taken by the company following the first two accidents showed a focus on correcting the proximate causes. Following the third accident, the safety actions taken focused not only on the proximate causes, but also on the systemic risk factors (such as conduct of formal risk assessments, quality assurance activities and record keeping). This suggests the operator's SMS was evolving based on lessons learned.

A fourth accident occurred in 2006, involving a striking and subsequent sinking of a large ferry resulting in two fatalities. Maintenance practices were not a factor in this occurrence. However, the TSB investigation (**M06W0052)** found that the operator's internal safety audits had been "ineffective in identifying significant safety deficiencies on board (their) vessels...

[7] *Leadership qualities*, The Ottawa Citizen - Editorial, A-14, April 24, 2009.

(indicating) that measurement of the organization’s safety performance has been inadequate, undermining the objectives of the safety management system.” Following this accident, the operator convened and published an independent review of its safety policies, procedures and practices which “made 41 recommendations on issues such as safety management system and audits, crewing and training in operational safety, bridge resource management, crowd management and control, the familiarization process, and emergency drills.” The operator committed to work with the union to implement these and jointly “initiated a new safety program ...which allows employees to suggest improvements and highlight safety concerns”.

In another example, my review of reports involving a major national railway identified a number of occurrences where risk assessments were either not completed or did not identify or effectively control the hazard (**R03V0083, R04W0035, R05V0141, R06V0136 and R07V0213**). In report **R07V0213**, involving a collision and subsequent fire when management employees were switching train cars in a rail yard, the TSB found that:

> *The risk assessment conducted immediately prior to the accident was inadequate to identify the hazards and mitigate the risks of switching long, heavy, cuts of cars on the pull-back track’s descending grade.*
> *The lack of a formal quality assurance program to establish consistency in risk analyses increases the likelihood that the controls identified and implemented may not be sufficient to address the risks.*

Immediately following this accident, the regulator ordered the operator to limit the maximum number of cars switched in this yard and imposed other precautionary conditions governing switching operations and operator training. The final TSB report did not indicate what follow-up safety action was subsequently taken by the operator.

In a subsequent report about an earlier runaway train and derailment on a steep mountain grade that killed two crew members and seriously injured a third (**R06V0136**)**,** the TSB found that this operator had not conducted a risk assessment prior to removing locomotives equipped with dynamic braking from this extreme mountain territory. The TSB recommended that the operator take effective action to identify and mitigate risks to safety as required by its safety management system, and the regulator require the company to do so.

It is clear from this review of occurrence reports that implementing SMS does not and (realistically) cannot totally immunize organizations against failing to identify hazards and mitigate risks, ensure that goal conflicts are always reconciled in favour of safety or avoid insidious adaptations and drift. In fact, nothing can. Still, my interviews with a cross-section of senior managers and experts in the transportation industry, and other studies, do suggest that SMS is having a positive impact on reducing risk.

5.0 Industry Perspectives

5.1 General

Among my informants, several had implemented an early version of SMS in advance of any regulated requirement to do so, sometimes following a period of unacceptable losses, and at a time when there was a growing body of research findings emphasizing the role played by organizational and human factors in contributing to accidents. These companies recognized a need to manage safety risks differently.

Each organization had implemented safety policies, safety plans, criteria and tools for conducting risk assessments and systems for reporting, investigating and analysing accidents and incidents appropriate to the size and scope of their activities. All reported their safety performance to staff on a regular basis through a variety of formal and informal mechanisms, particularly challenging when dealing with employees who work irregular hours and are widely dispersed geographically. Internal SMS audits varied from checklist based hazard and compliance audits, to more formal assessments of the effectiveness of their safety processes. Some had started to integrate their safety planning and business/ budget planning processes and cycles. Most acknowledged that their processes were still evolving, and there was always room for continuous improvement.

In all cases, the senior ranking safety official in the organization reported directly to the President or the Chief Operating Officer or equivalent. This has the advantage of being able to communicate safety issues directly to the top of the organization. However, it can also pose a challenge since the safety official usually has no direct line authority to effect change and can only function effectively if they have the complete confidence and support of their boss. Additionally their success often depends on their own credibility and communication skills, and their ability to influence those who have the authority to make changes.

For the most part, formal safety culture surveys had not yet been conducted; but some were considering them, though a small air operator (A-1O) used more direct and informal ways to gauge employee attitudes and concerns.

5.2 Challenges of Implementing SMS

In April 2001, a major international survey of seafarers, ship's operators and other maritime stakeholders was launched by a then-PhD student[8] to assess how the implementation of the ISM Code was progressing and what issues might have arisen during the implementation process (Anderson, 2003). Almost 3000 completed questionnaires, including 800 detailed narrative comments from 54 countries were returned. Results were mixed. In many cases, "the

[8] Registered with National Centre for Work Based Learning Partnerships with the Middlesex University.

first real encounter they usually had with a (SMS) was when a rather large set of procedure manuals arrived on board. These tended to be accompanied by a message along the lines of ‘here is your SMS, now get on with it!’ The SMS was completely alien to those who were now being charged with its implementation. It is little wonder therefore that there was so much resentment and negativism being expressed.” (Anderson, 2003: v) A relatively small number of individuals and organizations reported a more positive experience. “The message coming from this group was that the ISM Code had not only made their ships and companies safer, but also more efficient, and interestingly, more profitable!” (Anderson, 2003: vi) It appears that bad implementation of the ISM Code produces resentment because “the procedures are not relevant, working practices are costly to change and check lists burden the system to satisfy the auditing requirement” while “good ISM Code implementation...when it is integrated into the working of the ship...provides positive encouragement to meet commercial objectives safely...undoubtedly a competitive advantage.” (Anderson, 2003: 2) The survey’s author concluded that: “The reason why there is such a diverse range of experiences of ISM implementation is directly attributable to the way in which the individual SMS was designed and put into practice.” (Anderson, 2003: 206) He outlined common factors identified with SMS which did not appear to be working satisfactorily:

- *too much paperwork*
- *voluminous and irrelevant procedures*
- *bought off-the-shelf systems resulting in no feeling of involvement in the system*
- *ticking checklists (without doing the required task)*
- *not enough people or time to undertake the extra work involved*
- *inadequate training and motivation*
- *no perceived benefit compared to the input required*
- *no respect for parties involved (external auditors, classification societies, port state control inspectors) and*
- *no mutual respect between seafarers and shore management.*

Those organizations who reported more success with ISM Code implementation demonstrated:

- *leadership and commitment from the very top of the organization (i.e. shipowner, chief executive, managing director throughout the management structure)*
- *paperwork reduced to manageable levels*
- *a sense of ownership/empowerment by those actually involved in the implementation process of the SMS*
- *continuity of employment of personnel ashore and aboard ship (which fosters commitment and ownership of the SMS)*
- *two way communication and mutual respect between ship and office, and*
- *awareness of the importance to the individual and the company of managing safety.*

This was echoed by my marine informants who confirmed that shipping operators may initially "have gone overboard...loading bookcases on ships... of incredibly complicated procedures" (M-2S). Over time, companies and crews were encouraged and empowered to take ownership of their system and simplify safety procedures so they were more applicable to their operation and more readily accessible (facilitated by improvements in electronic document management).

In December 2006, the Canadian Minister of Transport, Infrastructure and Communities initiated a review of the Railway Safety Act encompassing many key issues relative to railway safety (Railway Safety Review Panel, 2007). The final report noted (p. 67):

> *It has been nearly seven years since the railways have been required to implement SMS. While progress has certainly been made, in the Panel's opinion, the implementation of SMS across the rail transportation system and by the regulator has been inconsistent. The Panel expected that, after so many years, both the regulator and the industry would have made more progress...Maturity of SMS plans varies widely across companies, with progress being remarkable in some companies and uneven in others. The weakest component in SMS plans appears to be in the management of human and organizational factors, rather than in respect of technical or equipment aspects.*

Informants from air and rail modes reported that the initial and ongoing incremental costs of the infrastructure and programs to support SMS, and the additional workload on already busy executives and managers (particularly during the relatively short transition period to SMS for airlines) generated significant discussion and some pushback at senior levels. Even when they had committed to doing things differently, executives understandably wanted to see the evidence of ‘cost/benefit’ or ‘value added’. SMS champions (usually at the senior or executive management level) played a key role in convincing their colleagues about the need to invest in ‘doing the right thing’ (“medium-term pain for long-term gain”; A-2O; R-2O). Educational sessions with senior management were deemed crucial in helping them better understand the contributions of organizational factors to accidents/ incidents so they could ‘buy-in’ to the rationale behind SMS. This might be a somewhat easier “sale” in a company that had already suffered significant losses and was voluntarily adopting an SMS approach, compared to those implementing SMS without such understanding or vision, simply to be in compliance with new regulations. One informant (A-4S) had observed managers who believed: “Any margin above the (regulatory) standard was seen as a waste of money”. It was also noted that middle managers often feel “squeezed” between the ‘production’ goals of executive management and the ‘protection’ (safety) concerns of lower level supervisors and front line workers. Without real understanding and commitment from the top, it is highly doubtful that the rest of the organization will buy-in to SMS.

Another significant challenge faced in all modes was how to communicate the ‘what’ and particularly the ‘why’ of SMS through all levels of the organization (particularly to front-line workers) and to employee unions so that all could understand the benefits of a more formal, structured approach to managing safety, and their specific role in it. Interestingly, some operators chose not to call what they were doing ‘SMS’ when talking with front-line employees. One informant (M-2S) suggested it was a mistake to call it a safety *management system* since it could lead crews to think that safety wasn’t their responsibility too.

Informants emphasized the importance of creating simple but effective processes and tools that would really be workable in their organization. Once people started using these processes and tools and saw the benefits, this reinforced and tended to spread their use throughout the organization. Overly bureaucratic processes and documentation, which have been developed without consideration of, or input from, the end-user and with no perceived benefit, will not be used.

5.3 Hazard Identification and Risk Assessments

The Railway Safety Review Panel observed (2007:80):

> *The railways tend to employ risk assessments when a change in operations is contemplated...there are not many examples of risk assessments conducted on ongoing operations. Rather, risk assessments tend to be event-based and focus on technical aspects of operations. The identification and assessment of hazards and risks relating to human and organizational factors may be forgotten.*

Larger transport operators interviewed tended to have more formal guidelines, processes and tools for conducting risk assessments, but acknowledged that ensuring appropriate risk management processes were utilized throughout the organization was an ongoing challenge. One benefit of SMS cited by some informants has been an increased tendency to involve front-line workers in the identification of hazards and risks and to provide workers with formal and informal means to raise safety concerns to those with the authority to address these. This helps convince employees that the company is serious about safety, particularly when they see safety issues resolved and appropriate feedback occurs.

Informants were able to identify periods when their organizations were more vulnerable, (e.g. seasonal variations in operations, entering new markets, during economic downturns) and cited examples of steps taken to identify and mitigate the associated risks. For example, M-1O described seasonal hazards associated with higher silt levels during spring run-off and the steps they took to develop special procedures for their operations, including reminders to staff. M-1O also outlined ongoing concerns regarding the impact of the current economic downturn and what steps the company planned to take to mitigate the operational risks associated with the need to re-assign experienced personnel to jobs for which they did not have any recent experience. A-1O described how the risks shifted between pilots and maintenance personnel depending on seasonal activity and the need for continuous observation and training. A-2O described the steps his company took when route changes took them to unfamiliar airports, including conducting risk analysis on everything from operations to catering and using only senior pilots or adding extra pilots during initial flights until more experience was gained.

However as the review of TSB reports showed, sometimes HIRAs were not conducted because the operator did not believe a planned operational change warranted one. In contrast, when considering a change to levels of service, operational procedures or technology changes, a national air traffic services provider (A-3O) conducts a formal HIRA process. HIRAs often use a structured brainstorming technique involving local operational personnel delivering the service, local users of the service and other specialists as required. Other specialists might include those with expertise in: engineering, maintenance, procedures or human factors. Participants first receive a briefing on how the HIRA process works. The outcome of the HIRA process is intended to develop and implement risk control measures so that the risks are reduced to a level as low as reasonably practicable. Each planned service level change must have a documented safety management plan in place prior to implementing the change. Furthermore, there is a formal follow-up review ninety days and one year after the change is implemented to assess the situation, verify that risk mitigation strategies are working as intended and that no new hazards have been introduced.

Aviation and rail informants (A-2O, R-2O) described the development and use of simple tools designed to conduct a preliminary risk assessment which could then also be used to help decision-makers determine if a more in-depth risk analysis was warranted. A small air operator (A-1O) didn't usually do formal risk assessments but actively trained and encouraged staff to think automatically and reflexively about the physical risks and mitigation required for each mission. "We instinctively assess risk now in all facets of the operation and tend to err on the conservative side. We would not have done that in the past. (A-1O)" This same operator intends to develop risk scenarios for common mission types and expressed concern that some operators "may use a checklist approach to SMS to absolve themselves from the painful process of trying to figure out where their next hazard is coming from".

5.4 A Reporting Culture

Informants realized that hazards might not be identified despite the use of formal HIRA processes. They actively looked for 'signals' in occurrence and other information databases or sought feedback from front-line personnel or others with operational/ technical expertise. 'Gut instinct' from experts was often considered to be compelling in and of itself: "Often, problems could be detected even before they showed up in the data (R-2O)". This raised a concern that, in some cases, individuals promoted to certain key positions for which they don't have the technical training, expertise or experience may not fully grasp (in a timely manner) the safety implications of the issues with which they have to deal.

Employees have a responsibility to bring forward safety concerns. Companies should educate their staff in this respect. Since some employees may not use formal reporting systems, all informants emphasized the need to visit work sites and listen first-hand to front-line workers. "Crews really appreciate that. (M-1O)" The absence of reports may signify a number of things – lack of awareness of how or what to report, loss of interest in reporting especially if concerns appear to be ignored or, worse, fear of reporting. Lack of reports should not be equated to an absence of risk. "When everything is going well, I am looking over my shoulder. (A-1O)"

Several informants cited specific examples when their organizations had invested significant time and resources to trouble-shoot intermittent safety concerns (e.g. occasional fumes in the back of a vessel/aircraft). Even when they were not successful in finding the cause, the employees got the message that the company was serious about safety. Regardless of the credibility of the source or even if the issue turned out to be a 'false alarm', informants reported that it was important to follow through by investigating the report and providing feedback to the reporter. "What happens if they are right the next time? (A-1O)"

On the other hand, when a safety issue was addressed in one area (e.g. a ship, an operating base, a rail yard), informants suggested that the data wasn't always recorded appropriately and so organizations weren't always successful at transferring that knowledge and "fix" across their system or, where applicable, across the industry. Inadequate follow-up, particularly of reported maintenance issues was often found to be a contributing factor to occurrences in TSB reports. Informants emphasized the need to "close the loop" on audit findings and other reported safety concerns to avoid having these issues "fall off the table".

The biggest area of concern, particularly from railway industry informants, was the difficulty in collecting data on 'near-misses' given the "embarrassment factor" and/or the lack of trust about how the data would be used i.e. fear of reprisal (R-1S, R-2O). “In the effective organization, then, the person lower down in the hierarchy is encouraged by explicit management word and deed to take appropriate corrective action, even if that action means admitting a mistake. In contrast, ineffective organizations often prevent inquiry because it might conflict with vested interests. In such systems, admitting mistakes or pointing out problems often is political suicide, since retaliation is sure to follow...the will to think and the ability to act are closely related.” (Westrum, 1993:406)

This was echoed by political science Professor Scott Sagan who examined the history of U.S. nuclear weapons safety performance (Sagan, 1993). His research uncovered “a long series of close calls with U.S. nuclear weapons systems...that could have led to catastrophes had they occurred in somewhat different, but nonetheless plausible, circumstances” (P. 252). In particular, he noted that “the social costs of accidents make learning very important; the politics of blame, however, make learning very difficult.” (Sagan, 1994:238)

On a more positive note, a manager from one major airline (A-5O) wrote that they are now receiving reports about events they would have never even heard of a few years ago.

5.5 Culture or Process?

Much of the recent research points to the critical importance of organizational safety culture in effectively managing risks. Vaughan describes culture as: “… a set of solutions produced by a group of people to meet specific problems posed by the situations that they face in common. These solutions become institutionalized, remembered and passed on as the rules, rituals and values of the group.” She goes on to say: “In interaction, work groups create norms, beliefs, and procedures that are unique to their particular task....These collectively constructed realities constitute the work group culture. The work group culture contributes to decision making about the group's designated project by becoming a part of the worldview that the individuals in the work group bring to the interpretation of information." (Vaughan, 1996: 64-65)

Interestingly, but not surprisingly, my informants all suggested that the underlying culture was as important, if not more important, than the actual SMS processes adopted. One informant went so far as to suggest "it's 75% culture and 25% process" (A-2O). All emphasized that leadership and real buy-in from executives and senior management (not just lip service) was essential to successfully implementing an effective safety culture. "Cultures are bred and to breed a culture you need to see a leader." (Captain S.Nicholls, 2003:227) Westrum (1993:411) agrees: "Good top managers are present physically". Informants cited examples of leaders who were not only intellectually and emotionally committed to safety, but were able to convey that message in a convincing way. Conversely, even when safety risks have been well-managed and a good culture and effective processes are in place, it's conceivable that safety performance would degrade over time with the advent of a "rogue leader" who might dispense with these processes or otherwise negatively impact on the safety culture (R-2O).

One marine operator suggested that his company's safety culture had really changed with the introduction of the ISM Code, but acknowledged that some of that might have happened anyway under their previous CEO. This informant said: "I have never seen a guy more passionate about personal safety...Culture spilled from him...and cascades through the organization having a positive impact. (M-1O)" However, another marine informant (M-2S) suggested that the adoption of the ISM Code "gave a vehicle to put these sorts of risk management processes in place". In particular, the introduction of SMS can cause people to speak “in the language of risk”, about hazards, risk analysis and mitigations (A-2O, A-4S). And having a formal system in place helps to hold everyone (managers and workers) accountable.

A railway informant (R-2O) suggested that “culture change is pushed by process change and consistency”. In a SMS environment, culture and processes need to work together so they become self-reinforcing. “You need conspicuous and unwavering support from the top down to implement SMS, but you need committed action from the bottom up to make it work. (A-1O)”

While SMS cannot prevent local adaptations or drift, a number of SMS processes may help identify these phenomena, in particular: recurrent training programs, more focussed supervision, peer observation programs, documenting assumptions in system design (Daouk & Leveson, 2001), safety audits and evaluations, ‘near miss’ occurrence and other safety reporting systems, to name a few.

The most compelling messages from the top empower workers to raise concerns and “stop production” if it might compromise safety, even if it costs the company money. In one testimonial, an experienced former ship’s Master described his experience on an offshore oil rig (Captain S.Nicholls, 2003:218) which provided ongoing visible proof of senior management’s commitment to safety from the very first day he joined the company: by the messages they gave (“when safety and money have a conflict of interests, safety of personnel, environment and property will take priority in that order”), by their active participation in multiple safety training opportunities, and through routine daily practices such as peer-to-peer notification of ‘At Risk Behaviour’ activities. But one of the most powerful messages came when a Master supervising drydock repairs shut down the entire operation because of ongoing concerns about personnel safety and, within hours, received congratulations for doing so from all levels of managers throughout the company.

In another testimonial, Capt. S. Noonan (a former designated person ashore and marine superintendent) reinforced the need to eliminate a culture of blame to ensure that information flows freely and that Masters make decisions based on their best judgement of the situation. He described a situation wherein a ship's operator was unexpectedly charged a quarter of a million dollars after the Master ordered a precautionary tow by a tug operator following a temporary loss of propulsion. The technical director thanked the Master for his professionalism in controlling the risk and reassured him he had made the right choice. "This ensured that the Company safety management principles remained intact despite the cost and, I'm sure, would pay dividends to the Company in the years to come by furthering the trust and professionalism within the fleet." (Captain S.Noonan, 2003:282)

The Railway Safety Act Review Panel commented on the degree to which the various major railways seemed to be developing a healthy safety culture. For example, one major Canadian railway has adopted the following as part of its corporate safety policy: "No job on our Railway will ever be so important that we can't take the time to do it safely." However, the Panel's report noted the following with respect to another railway: "With some exceptions, employees recounted a culture based on fear and discipline... there appears to be a serious disconnect between (company's) stated objectives and what is occurring at employee levels. (It) manages safety through an "antecedent, behaviour and consequences" process, which the Panel feels is constructed as a traditional rules and discipline model. While rules certainly have had a positive impact on safety, rules *alone* may no longer be the most appropriate approach, given the modern understanding of accident causation" (P. 70). The Panel went on to say: “over-reliance on discipline does nothing to support healthy management-employee relationships so vital to an effective (SMS). Such relationships must be built on openness and trust and this is difficult or impossible to instil in an environment where employees are constantly fearful of disciplinary action. (P.71)”

SMS will not eliminate goal conflicts. But clear, unambiguous messages can help managers and employees make more informed choices about how to reconcile goal conflicts:

> *Top management sets the tone for operations. It determines what will be acceptable as standards of performance, and top managers show through example how tough situations are to be handled...This attitudinal tone percolates through the organization. But it is also communicated by important symbolic acts on the part of higher management. These include what types of behavior are rewarded and punished, how dissidents are treated, and above all the priority set for information flow versus respect for departmental and positional boundaries and perquisites. Top management must be the advocate of information flow, and it must back up that advocacy with structures and practices to ensure the flow is given priority over other concerns.*(Westrum, 1993:411)

As one informant succinctly put it: “People will respond to the stimuli they actually receive, regardless of what is said”. (R-1S)

5.6 Benefits of SMS

Informants gave examples of benefits their organizations had achieved since implementing SMS, though some were admittedly difficult to quantify. No one I heard from suggested they would abandon their SMS, even if there were no such regulations in force.

Prior to the introduction of the ISM Code (marine) and SMS (rail/air), many organizations were not formally analysing and documenting safety risks. They relied on a more intuitive approach, if any (A-5O). They recorded accidents/incidents but did not look for causal/contributory factors beyond human error or equipment breakdown. Now many (though not all) are providing more formal and informal channels for employees to bring forward safety concerns and looking not only at accident data but also at ‘near misses’ and analyzing these events for hazards. Several informants mentioned a significant increase in the number of occurrence reports received from employees (A-2O, A-5O, A-6S).

Having more data should help managers make better decisions, as does involving front-line workers in the identification of hazards and the analysis of risks. As such, SMS is helping to improve working relationships within and between management and staff, and improving communications and problem-solving across the organization (A-2O). Some companies are making conspicuous efforts to address employee safety concerns and to feedback the results to the reporter and across their organization.

One marine informant (M-1O) outlined how safety was front and centre in his company’s operational decision-making both on the ship and prior to sailing. There is more concern about personal safety and protective clothing and equipment (M-2S). They have made conscious efforts to “slow down and not rush” resulting in an almost 10-fold reduction in personal injuries attributed to “slips, trips and falls” over a 10 year period (M-1O).
One major railway company reduced the maximum speed while switching cars in a rail yard from 15 to 10 mph. Although some voiced objections about the potential for lost productivity, in fact, their experience showed that overall productivity increased, as a result of fewer accidents and reductions in associated ‘down-time’(R-2O).

Other informants also cited reductions in personal injuries, fewer equipment break-downs, reductions in down-time, fewer audit findings of non-compliance and significant financial savings (i.e. $ millions) by avoiding direct costs associated with accidents, as well as reduced insurance premiums.

Interestingly, customers (particularly major oil and chemical[9] companies) are becoming increasingly insistent that transportation companies demonstrate they have effective safety management systems before contracting with them for transportation of their employees and products. Thus, SMS provides at least a marketing advantage, if not a pre-requisite to doing business with these companies.

6.0 Conclusions and Summary

The concept of SMS has evolved from the best principles of high reliability organizations, strong safety culture and organizational resilience.

As TSB occurrence data has shown, implementing SMS is not a panacea against accidents. Goal conflicts, local adaptations and drift are naturally occurring phenomena in any complex organizational setting which regularly contribute to incidents and accidents. Organizations implementing SMS can and should learn from these occurrences since they also demonstrate patterns of accident pre-cursors (e.g. not thinking ahead to what might go wrong, not having

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[9] Responsible Care Program: a voluntary initiative in the chemical industry with a code of practice including: ***Transportation***

The Transportation Code requires that each member company transport chemicals and chemical products in a manner that minimizes environmental damages and risk of injury to people living along transportation routes. Selecting and assessing carriers and informing communities along the way of safeguards being taken are key aspects of this code.

an effective means to track and highlight recurrent maintenance or other safety deficiencies, insufficient training and/or resources to deal with unexpected events).

To date, the impact of implementing SMS has been mixed. “It has been 10 years since the ISM code was implemented in the international marine sector. The most prudent and best quality shipping companies followed the precise intention of the (ISM) code to undertake a closely scrutinised upgrade of the traditional standards, and reported back with the good news that they had achieved many operational benefits... the substandard companies continued their standard pattern of using the port state control and ISM audits as a substitute for an effective inspection policy... Accordingly, the distribution of the serious accidents follows a similar pattern. The best 25% of all ships represent only 7% of all ship accidents, while the worst 25% suffer 51 % of all accidents.” [10]

Don Arendt, Manager of the U.S. Federal Aviation Administration’s Flight Standards SMS Program Office claimed: “Companies that have (implemented SMS) have told us that they have found out a lot about their organizations and how they are or are not using resources effectively, how processes are being used in the field, and have learned how their processes are or are not working, how they are saving or wasting money. You can't separate safety management from other aspects of operation at a company. The smart people are finding SMSes are making their businesses better. But to achieve these results, they must incorporate it as a decision-making system and not over-document it. It has to be flexible, workable.” (Esler, 2009)[11]

[10] “Has the ISM code made shipping safer?” Arne Sagen – Thursday 9 April 2009; www.lloydslist.com/bulletin
[11] http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=busav&id=news/bca0409p1.xml

From my own review, there is lots of evidence to support that SMS is having a positive impact on the way organizations make decisions and manage risk. In particular, some organizations have adopted more formal, structured approaches to searching for and documenting hazards (i.e. a “mindful infrastructure”) causing decision-making criteria to shift conservatively. By implementing such process changes, thinking about what might go wrong becomes part “of the way people go about their work” and “part of (that) organization’s culture”. They are receiving more reports from employees about ‘near misses’, events they would not have heard about previously, but only when employees feel “safe” to report and confident that their reports will be acted upon. These reports can help organizations to identify “drift” and the “boundaries of safe operation”. Amplifying ‘weak signals’ and self-auditing their safety management processes continues to be a challenge but will likely improve as companies gain more experience and their SMS matures.

There is a complex relationship between culture and process. SMS is only as effective as the safety culture in which it is embedded. SMS won’t take hold unless there is a strong underlying commitment and buy-in to safety. But just wanting operations to be safe won’t create safety unless this commitment is also supported by ‘mindful’ processes such as formal risk assessments, increased reporting, tracking of safety deficiencies and effective follow-up. While these process changes can stimulate changes in culture, they will only be sustainable in the long term if they are seen to add value.

This has important implications for the successful implementation of SMS:

- Organizations must recognize it will take unrelenting commitment, time, resources and perseverance to implement an effective SMS.

- Regulators must be sensitive to the challenges companies face as they transition to SMS and diligent in how they conduct compliance and safety oversight activities. Based on the experience to date, there is a risk that some short-sighted companies will take a minimalist, bureaucratic or checklist approach to adopting SMS and yet believe they are ‘safe’ because they have a ‘compliant’ SMS.
- Inadequate policies covering the use of safety data (e.g. for litigation or enforcement purposes) and increased criminalization of human error will discourage open reporting (Dekker, 2007), a key component of an effective SMS.
- And accident investigators should continually strive to uncover the contextual drivers that influence decision-making, goal conflicts, local adaptations and ‘non-compliance’ with formally documented rules, procedures and safe practices to facilitate organizational learning and effective follow-up after an occurrence.

Future opportunities for research include: longitudinal studies of companies which have experienced multiple accidents to see how (or if) their SMS is evolving and development of performance indicators (beyond incident/accident rates) to measure the long-term effectiveness of SMS in a company or an industry.

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List of TSB Reports Reviewed

Marine

M01W0006	**09 January 2001** — Fatal Accident, Container Ship *Alligator Victory*, Deltaport, Vancouver, British Columbia
M02W0061	**13 April 2002** — Malfunction of Automatic Steering Control System, for Right Angle Drives, Ro-Pax Ferry, *Bowen Queen*, Gabriola Island, British Columbia
M02L0061	**16 July 2002** — Crew Member Lost Overboard, Bulk Carrier *Kent*, Near Verchères, Quebec
M02W0135	**04 August 2002** — Switchboard Fire, Passenger Vessel *Statendam*, Strait of Georgia, British Columbia
M03L0026	**26 February 2003** — Grounding, The Bulk Carrier *Great Century*, off Batiscan, St. Lawrence River, Quebec
M03N0047	**03 May 2003** – Collision Between CCG Sir Wilfred Grenfell and the Fishing Vessel Genny and Doug, St. John's Newfoundland & Labrador
M03N0050	**12 May 2003** — Fire on Vehicle Deck, Roll-on/Roll-off Passenger Ferry, *Joseph and Clara Smallwood*, 8 Nautical Miles South of Port aux Basques, Newfoundland and Labrador
M03W0073	**12 May 2003** — Engine Room Fire and Subsequent, Failure of the CO2 Distribution Manifold, Roll-on/Roll-off Passenger Ferry *Queen of Surrey*, Queen Charlotte Channel, British Columbia
M03W0237	**08 November 2003** — Grounding, Container Vessel *Cielo del Canada*, Fraser River, British Columbia
M04M0013	**04 March 2004 –** Furnace Explosion – RO-RO Passenger Ferry Caribou, 14 nm NNE of North Sydney, Nova Scotia
M04F0017	**27 July 2004 –** Grounding Tank Barge KTC 115 with Tug Salvor Alexandria Bay, New York, U.S.A.
M05W0111	**30 June 2005** — Loss of Propulsion, Subsequent Striking of Berthed, Pleasure Craft and Grounding, Roll-on/Roll-off Ferry *Queen of Oak Bay*, Horseshoe Bay, British Columbia
M05C0033	**19 July 2005 –** Collision Between the Tanker Jo Spirit and the Bulk Carrier Orla, South Shore Canal, St. Lawrence Seaway, Quebec
M05L0203	**26 September 2005** — Grounding, Bulk Carrier *Canadian Leader*, Off Cap à la Roche, Upstream of, Deschaillons-sur-Saint-Laurent, Quebec
M06L0004	**04 January 2006** — Fire, General Cargo Ship *Skalva*, Gaspé, Quebec
M06W0052	**22 March 2006** — Striking and Subsequent Sinking, Passenger and Vehicle Ferry *Queen of the North*, Gil Island, Wright Sound, British Columbia
M06N0014	**08 April 2006 –** Fire in Cargo Oil Tank, Shuttle Tanker *Kometik*, Conception Bay South, Newfoundland and Labrador
M08M0010	**29 March 2008** — Capsizing While Under Tow, Small Fishing Vessel *L'Acadien II*, 18 nm Southeast of Cape North, Cape Breton Island, Nova Scotia

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Rail

R01M0024	**12 April 2001** — Main Track Derailment, VIA Rail Canada Inc., Train No. VIA 15, Mile 46.45, Bedford Subdivision, Stewiacke, Nova Scotia
R03V0083	**14 May 2003** — Main-Track Derailment, Canadian National, Train No. 356-51-14, Mile 7.9, Fraser Subdivision, McBride, British Columbia
R04T0008	**14 January 2004** — Main-Track Derailment, Canadian Pacific Railway, Train No. 239-13, Mile 178.20, Belleville Subdivision, Whitby, Ontario
R04W0035	**17 February 2004** — Yard Derailment, Canadian National, Symington Yard Assignment YATS-02-17, Mile 145.20, Sprague Subdivision, Winnipeg, Manitoba
R04Q0047	**12 November 2004** — Main-Track Derailment, Canadian National, Train Q-120-31-12, Mile 114.8, Montmagny Subdivision, Lévis, Quebec
R05T0030	**17 February 2005** — Pedestrian Fatality, Canadian National, Freight Train Q-106-41-15, Mile 124.88, Kingston Subdivision, Brockville, Ontario
R05Q0010	**23 February 2005** — Main-Track Derailment, Canadian National, Train M-307-11-22, Mile 86.41, Drummondville Subdivision, Saint-Cyrille, Quebec
R05C0082	**27 May 2005 –** Main-Track Derailment, CPR Train 277-26 Mile 69.2, Red Deer Subdivision near Bowden, Alberta
R05V0141	**05 August 2005** — Derailment, Canadian National, Freight Train A47151-05, Mile 56.6, Squamish Subdivision, Garibaldi, British Columbia
R06H0013	**06 June 2006** – Risk of Collision Between GEXR Train 518 and VIA Rail Train 87, Mile 72, Guelph Subdivision New Hamburg, Ontario
R06V0183	**03 September 2006** — Runaway and Derailment, White Pass and Yukon Route, Work Train 114, Mile 36.5, Canadian Subdivision, Log Cabin, British Columbia
R06T0281	**11 November 2006** – Employee Fatality – Total Track (under contract to CN) Nordco Grabber Model A Spike Puller, Mile 223.0, Kingston Subdivision – Moira, Ontario
R06V0136	**29 June 2006 –** Runaway/ Derailment – CN Freight Train, Near Lillooet, B.C.
R07V0213	**04 August 2007-** Non-Main Track Collision, CN-Beltpack Operation, Prince George, B.C.

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Air

A04Q0041	31 March 2004 — Control Difficulty, Air Canada Jazz, DHC-8-300 C-GABP, Québec/Jean Lesage International Airport, Quebec
A04H0004	14 October 2004 — Reduced Power at Take-off and, Collision with Terrain, MK Airlines Limited, Boeing 747-244SF 9G-MKJ, Halifax International Airport, Nova Scotia
A04C0190	30 October 2004 — Collision with Terrain, Canadian Helicopters Limited, Bell 212 C-GMOH, Shepherd Bay, Nunavut
A04Q0188	01 December 2004 — Runway Excursion on Landing, Aviation CMP Inc., Beech B300 (Super King Air) C-FMHD, Saint-Georges, Quebec
A05F0047	06 March 2005 — Loss of Rudder in Flight, Air Transat, Airbus A310-308 C-GPAT, Miami, Florida, 90 nm S
A05O0112	02 June 2005 — Misrigged Elevator Trim Tabs, Flight Options LLC, Raytheon/Hawker 800XP N829LX, Toronto/Lester B. Pearson International, Airport, Ontario
A05A0155	07 December 2005 — Collision with Water, Transport Canada Aircraft Services, MBB BO105 (Helicopter) C-GGGC, Marystown, Newfoundland and Labrador,, 2.5 nm E

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