Challenges and potential to improve airline safety and demonstrate resilience through monitoring

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ABSTRACT

Rasmussen (1997) shows how it may be possible to go beyond an acceptable safety boundary, and if crossing the boundary is irreversible, an error or an accident may occur. Organizations reside as a specific operating point within three specific boundaries. The three boundaries are: the economic failure boundary, the unacceptable workload boundary, and the boundary of functionally acceptable performance.

Safety Management System (SMS) regulations require that airlines look proactively at their operations through a monitoring process with the aim to react, learn, and anticipate before safety issues give rise to the potential of creating an accident.

The following thesis will look at airline's flight operations monitoring system to see if the organization uses Resilience Engineering concepts to enhance their ability to create work processes that are robust yet flexible enough to adapt to varying risk scenarios, and whether the organization is proactive in its approach when faced with disruptions and ongoing economic and production pressures before it goes beyond the boundary of acceptable performance.

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INTRODUCTION

Within any work environment, worker behavior is shaped by objectives and constraints. Examples of objectives and constraints are, inter alia, work load, economic constraints, risks, administrative constraints, management pressures, safety constraints, unacceptable work loads, and production and performance targets (Rasmussen, 1997). These objectives and constraints form a boundary of acceptable performance that organizations tend to operate within. Rasmussen (1997) succinctly portrays the goal conflict and the constant movement towards the boundaries of acceptable performance organizations constantly face. He refers to this as "systemic migration of organizational behavior toward accident under the influence of pressure toward cost-effectiveness in an aggressive, competing environment" (p.189). Organizations can either succeed or fail in balancing safety while facing external pressures.

In aviation, many operators have taken a reactive approach to safety by looking at past occurrences and focusing on whom is responsible rather than why the occurrence took place (Dekker, Cilliers, Hofmeyr 2011). This process has involved a mechanistic philosophy, use of hindsight bias, and linear Newtonian-Cartesian thinking. There are numerous examples of organizations that successfully balance objectives and constraints while maintaining a safe operation and those that could not, ending in failure because of a catastrophic occurrence.

Many air operators use a quality assurance program to meet minimum regulatory requirements believing that doing so will keep them safe. Unfortunately, strictly adhering to regulatory requirements, and when problems arise, developing additional regulations, or more procedures to "fix the problem", does not take into account the complexities and emerging properties of a complex organization. This approach can fall short in foreseeing and meeting the shifting demands of a resource-limited environment, and in how to deal with uncertainty, fundamental surprises and multiple conflicting goals (Woods and Shattuck 2000, Dekker and Lundstrom 2007). Cumulative regulations and additional operating procedures aimed to address "one of safety issues" may have a negative impact on safety by increasing violations of procedures, making employees become reluctant to report incidents, and add complexity to the safety monitoring strategy (Amalberti 2001, Dekker 2003).

Instead, there is a need to look proactively at complex organizations and monitor, react, learn, and anticipate before latent safety issues are allowed to fester and grow, giving rise to the potential of creating an accident. Rather than waiting for an event to occur before responding, the regulatory requirement for a Safety Management System (SMS) has helped certificate holders become more proactive through the implementation of legislative requirements that require an airline establish proactive systems that use risk management and other safety processes (ICAO 2012); although, much work to accomplish this shift remains to be done.

Many international regulators promulgated a regulatory requirement for operators to have a SMS. In Canada, regulations require that large, commercial air operators, have a SMS. The International Civil Aviation Organization (ICAO) has also asked member states to regulate their air operators to have a SMS. ICAO Safety Management Manual, Doc 9859, Third Edition – 2012, discusses the four underlying elements required in SMS. They are as follows:

1. Safety and policy objectives
2. Safety risk management
3. Safety assurance
4. Safety promotion (p.59)

Of particular interest to this thesis will be the focus on safety risk assessment and safety assurance, in which safety performance monitoring resides.

Research Question

Rasmussen (1997) shows how it may be possible to go beyond an acceptable safety boundary. This thesis will endeavor to show if resilience engineering (RE) concepts are present in an air operator's flight operations monitoring systems. In particular, I will see if the organization uses RE concepts to enhance their ability to create work processes that are robust yet flexible enough to adapt to varying risk scenarios, and whether the organization is proactive in its approach when faced with disruptions and ongoing economic and production pressures. To do so, I will investigate whether flight operations quality assurance monitoring takes complexity and emerging properties of a system into account, whether it relates the socio-technical interactions of an organization, and whether the use of resilience engineering principles exist.

My thesis question is: **Is there evidence of resilience engineering concepts within aircraft flight operation's monitoring systems and do they help aircraft flight operations stay within safety boundaries and also improve safety?**

Theoretical Framework

My theoretical framework will consist of the following:

1. Staying in a safe environment
2. Drifting towards the boundary of unacceptable performance
3. Monitoring the dynamics of the production point at the boundaries

Staying in a Safe Environment

Cook and Rasmussen (2005) indicate that all organizations reside as a specific operating point within three specific boundaries. They describe the boundaries as "difficult to manage technical situations…that because the environment is dynamic, the operating point moves continuously" (p130). The three boundaries are: the economic failure boundary, the unacceptable workload boundary, and the boundary of functionally acceptable performance. Socio-technical processes can push the system operating point towards an unacceptable boundary (Cook and Rasmussen, 2005). Rasmussen's (1997) diagram seen in Figure 1 below depicts these boundaries and shows that the workspace navigated freely by workers are bounded by administrative, functional, and safety related constraints. Dekker (2003) indicates that: "informal work systems emerge and thrive in the first place because procedures are inadequate to cope with local challenges and surprises" (p.234). Through normal changes found in local work conditions, workers influenced by management's cost gradient can define what effort they will provide (effort gradient). The requirement for an organization to be better, cheaper, faster than their competitors will squeeze the production point and push it towards the boundary of functionally acceptable performance. As Rasmussen indicates: "The result will very likely be a systematic migration toward the boundary of functionally acceptable performance and, if crossing the boundary is irreversible, an error or an accident may occur" (p.189).

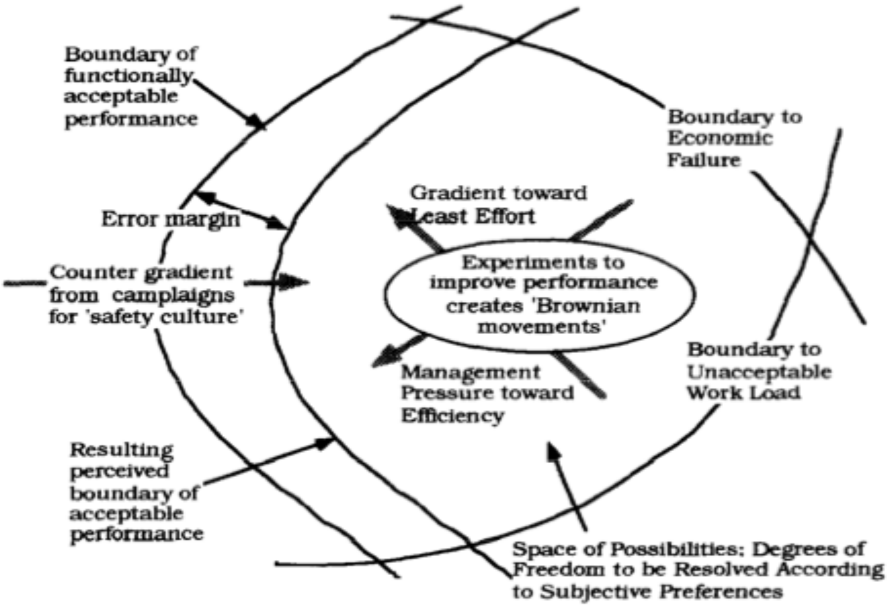

Figure 1. Under the presence of strong gradients behavior will very likely migrate toward the boundary of functionally acceptable performance. Rasmussen (1997, p. 190)

Organizations have tried to control worker behavior and system performance by imposing detailed procedures on how work is to be accomplished. Many of these procedures are developed to be very restrictive, with an aim to cover all aspects of an operation. Procedures that are overdesigned may not conform to actual work performed. In reality, gaps often exist between procedures and practice. Procedures become inadequate because their conception of work collides with the scarcity, pressure, and multiple goals of real work (Dekker 2003, Rasmussen 1997). Rasmussen prescribes a different view on system modeling by suggesting a change in approach to the control of system performance**.** Rasmussen describes this new approach as:

> Rather than striving to control behavior by fighting deviations from a particular pre-planned path, the focus should be on control of behavior by making the boundaries explicit and known and by giving opportunities to develop skills at boundaries. (p.191)

The difficulty lies in determining where the boundaries exist. Employees need to be aware of the boundaries so not to cross them, develop coping skills in order to operate at or near the boundary; thereby, optimizing work and making the organization more efficient. Resilience Engineering (RE) concepts can help with this aspect.

Resilience Engineering

According to Hollnagel, Nemeth, Dekker (2009): "Traditional theories focus on human failure and success as closely related phenomena…resilience is about having adaptable reserves and flexibility to accommodate those challenges"(p.1446). A working definition of Resilience Engineering (RE) by Woods and Hollnagel (2006) is: "the ability of systems to anticipate and adapt to the potential for surprise and failure"(p.4). The opposite of resilience is brittleness. Key elements of a resilient organization are the ability *respond, learn, anticipate and monitor* (Dekker, Hollnagel, Woods, Cook, 2008).

Woods (2006) indicates that: "Resilience Engineering provides organizations with help on how to decide when to relax production pressure to reduce risk" (p. 2239). The challenge is to recognize when to make the relaxation/sacrifice judgment, and in how an organization and its employees realize when it needs to be accomplished (i.e. through recognizing the boundaries and learning skills to adapt).

Control of System Performance

Management structures have fallen behind the development of complex technological structures. The command-and-control approach that uses top-down conduct rule making does not work effectively in dynamic situations (Rasmussen 1997). Individual workers need to adapt to their environment in order to make things more effective. The issue lies in how to make sure that it is done safely. For this to happen, a fundamentally different view on system modeling is required. The use of "new approach in the control of system performance" (Rasmussen 1997) is key.

Flight operations organizations that have established safety management processes stand a better chance of success at maintaining a safe operation with a new approach to control of system performance than organizations that strive to control workers by imposing more operational standards and norms, and are simply reactive in nature (Rasmussen, 1997, Snook 2000, Amalberti 2001, Leveson 2004, Dekker 2005). Rasmussen (1997) indicates that use of risk management will "increase the margin from normal operation to the loss-of-control boundary" (p192), in other words, the operation will have more capacity to absorb surprises.

There are a number of methods that can be used to accomplish a new approach to control of system performance. You must be able to explicitly identify the constraints of the work system and the boundaries of acceptable operation in a dynamic operation. For well-structured and tightly coupled systems protected by multiple, technical defenses, predictive risk analysis have been used successfully. During his discussion on using risk management to control the margins, Rasmussen (1997) indicates that:

> The most promising general approach to improved risk management appears to be an explicit identification of boundaries…making the boundaries visible may also increase system effectiveness in that operation close to known boundaries may be safer than requiring excessive margins which are more likely to deteriorate in unpredictable ways under pressure. (p.192)

Another method to accomplish a new approach to control of system performance is to make the organization and its workers aware of practical drift situations and understand that going beyond the boundaries may lead the organization into an unanticipated and unwanted failure.

It can be argued that feedback between all levels is essential within any system in order to ensure that interaction amongst key stakeholders will lead to the realization of the overall safety control requirements of an organization. Rasmussen (1997) discusses the abstraction hierarchy in which he shows the interaction conflicts between institutions and companies at various levels. Rasmussen reveals that:

> .. for human behaviour, we need a representation at the higher level of functional abstraction than the level used for task analysis. Such a representation involves identification of the boundary conditions of the work space and the gradients in terms of process criteria guiding the drift across this space….we need a framework for identification of the objectives, value structures, and subjective preferences governing the behaviour within the degrees of freedom faced by the individual decision maker and actor. (p.191)

Rasmussen's (1997) abstraction hierarchy is depicted in Figure 2 below. It shows that many disciplines and levels are involved in a dynamic socio-technical system. Simply relying on a top-down, command-and-control approach derived through regulatory reform or policy setting is inadequate in such a system simply because of all of the levels involved. For risk management to function properly, there must be vertical integration amongst the levels through adequate communication and documentation so as to ensure that the nature of the hazards are known and dealt with appropriately. If management crafts policies and procedures and forces them on the workers, the actual work done will most likely not reflect these policies and procedures due to the locality principle. Bergström (2012) defines the locality principle as the implication: “that all actions in a complex system are local…each actor in a complex system controls little, but influences everything” (p.15). An organization requires feedback channels so that workers have an opportunity to provide feedback on decisions imposed by management. Of course, feedback loops can be supplemented by monitoring processes. Without communication throughout the hierarchy, it can be argued that practical drift may occur because processes are not known or communicated throughout the levels thereby creating unnecessary risks by deviating from known processes and procedures.

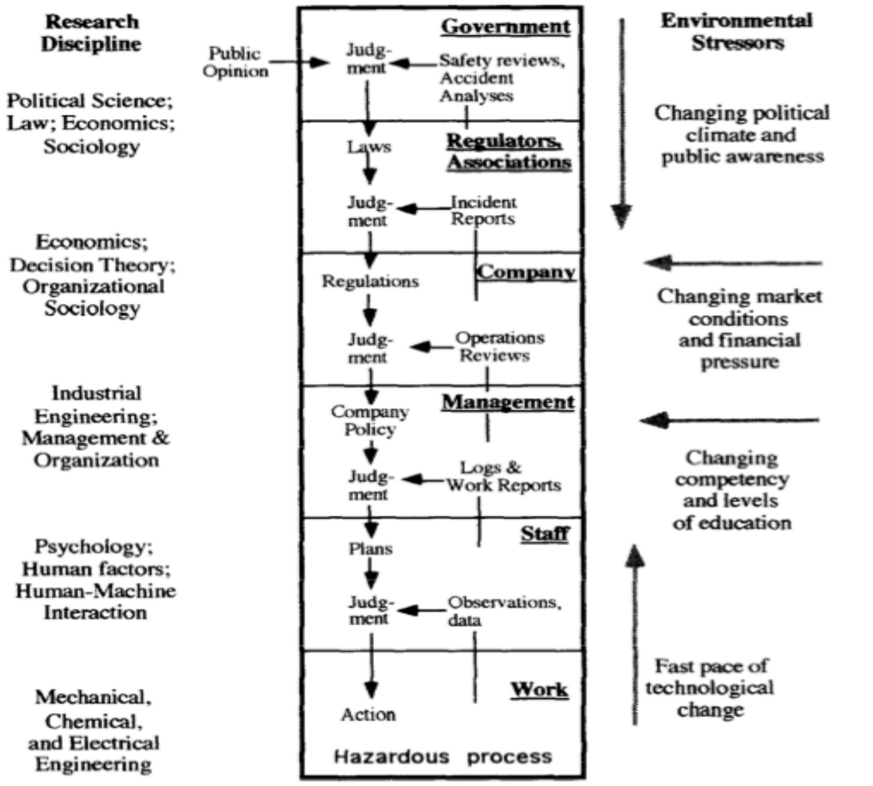

Figure 2. The socio-technical system involved in risk management. Rasmussen (1997, p. 185)

Drifting Towards the Boundary of Unacceptable Performance

Snook's (2000) discussion of practical drift in his book *Friendly Fire* provides another theoretical anchor. His explanation complements Rasmussen's model of boundary of functional acceptable performance and will enhance the discussion of how organizations may drift outside the boundary undetected and for locally good reasons. Both Rasmussen and Snook agree that the system deviates because of pressures. Usually workers and/or their organizations try to optimize getting the work completed while being influenced at various levels by local constraints. Snook describes this process by indicating that: "Over time, practical drift gradually transforms the system into a more stable state of affairs, where strong local task-orientations overtake overly burdensome global rules" (p200). In essence, Snook has operationalized Rasmussen's theory.

Dekker, Hollnagel, Woods and Cook (2008) indicate that:

> Perrow (1984) promoted the idea of system accidents. Rather than being the result of a few or a number of component failures, accidents involve the unanticipated interaction of a multitude of events in a complex system – events and interactions whose combinatorial explosion can quickly outwit people's best efforts at predicting and mitigating disaster (p. 26).

Snook (2000) developed a dynamic theory built upon Perrow's (1999) Interaction/Coupling theory. Snook's theory of "practical drift" captures "both contextual and temporal aspects" (p.186); the important contribution is the addition of organizational change over time. The theory of practical drift "captures three dimensions: situational coupling, logics of action, and time" (p.186). Situational coupling can be loose or tight, and the coupling refers to the level of interdependency between sub units. Logics of action can be defined as the work environment in which individual behavior is shaped by objectives and constraints. The third dimension, time, represents the cycle the organization follows during its lifecycle and how the interaction and mechanisms associated with situational coupling and logic of action drive operational performance. Time is also very important when dealing with operational drift. As organizations evolve from a paper concept into operational reality, many of the design features envisioned by the original planners require adaptation when faced with operational realities for a myriad of reasons.

Dekker (2011) defines a concept of drifting into failure as: “a gradual, incremental decline into disaster driven by environmental pressure, unruly technology and social processes that normalize growing risk” (p. xii). He indicates that no organization is exempt from drifting into failure.

The main concern is that local procedures used in the field are fundamentally different than were envisioned when designing the work to be done. It is important to note that not following procedures will not always lead to trouble. Dekker (2005) indicates that: “Maintaining safety outcomes may be preceded by as many procedural deviations as accidents are” (p.133). Deviations may be necessary to complete a project under restricted conditions. Perhaps the procedures did not account for the local environment and may need to be modified so as to keep the organization within the acceptable safety boundaries. Hollnagel (2009) indicates that: “Performance variability may introduce a drift in the situation, but it is normally a drift to success, a gradual learning by people and social structures of how to handle the uncertainty, rather than a drift to failure” (p.94). Notwithstanding, communication and knowledge of deviations must be shared throughout the hierarchy in order for the organization to either adapt to the situation, or define new levels of risk by either not accepting the deviations or mitigating the risk associated and learning to adapt.

Pidgeon and O’Leary (2000) discuss ‘organizational accidents’ that “stem from an incubation of latent errors and events which are at odds with the culturally taken for granted, accompanied by a collective failure of organizational intelligence” (p15). This argument is seen to have similarities to Snook’s contextual and temporal aspects of drift. Snook (2000) discusses practical drift as the “slow uncoupling of local practice from written procedure” (p.225); the incubation period forms part of the temporal aspects of drift. The incubation period of each deviation may eventually lead to failure when the system becomes tightly coupled. Starbuck and Milliken (1988) discuss how fine-tuning reveals that “past successes and acclimatization alter decision-makers’ beliefs about probabilities” (p319). This concept is prevalent in the belief of being able to practically drift away from established norms and procedures, each time doing so successfully, will not lead to catastrophic failures.

Hollnagel (2009) discusses Efficiency and Thoroughness Trade-Off (ETTO) in which he states:

> …in their daily activities, at work or at leisure, people routinely make a choice between being effective and being thorough, since it rarely is possible to be both at the same time. If demands for productivity or performance are high, thoroughness is reduced until the productivity goals are met. If demands for safety are high, efficiency is reduced until the safety goals are met. (p.15)

ETTO can place employees in a double bind situation. Workers may deviate from prescribed work practices because they believe that there is a need to become more efficient, specifically if they are not trained to cope with the realities of operating near the boundaries. It is necessary to make the boundaries explicit and known and provide opportunities to develop skills at boundaries; thereby allowing for the correct mix of efficiency and thoroughness.

Saurin and Carim (2011) quote Hollnagel indicating that resilience engineering "stresses understanding how success is achieved, how people and organizations learn and adapt, and thus create safety in an environment with hazards, tradeoffs, and multiple goals." (p.355)

Xiao, Sanderson, Clayton and Venkatesh (2010) reveal that "Hollnagel advocates a positive view of performance variability as a normal and necessary part of effective work practice" (p.144). Performance variability is defined as "largely a collection of well-learned and well-accepted strategies that people use proactively to maintain balance between efficiency and thoroughness demands" (p.144).

There are numerous tradeoffs of efficiency and thoroughness occurring daily within air operations; however, in order to maintain safety, there is a need to monitor these tradeoffs so that an organization can mitigate the associated risks, learn and adapt.

Monitoring the Dynamics of the Production Point at the Boundaries

Woods (2006) indicates that resilience is concerned with "monitoring the boundary conditions of the current model for competence (how strategies are matched with demand) and adjusting or expanding that model to better accommodate changing demands" (p.22). Both Woods and Rasmussen agree that monitoring operational decisions made within an organization is needed to assess the risk of how the system adapts to operating near the safety boundary.

Reiman and Oedewald (2007) indicate that there is a practical need to monitor an organization so as to establish a proactive and predictive accurate view of the organization and the demands of the work in question. They argue that safety in industrial organizations is based on static and rational model of an organization and are non-contextual, thus are reactive in nature and are disconnected from the actual work done in the organization (p.745-746). Air operations are considered to be complex and dynamic sociotechnical systems that are tightly coupled and have complex technology (Perrow, 1999). They are dynamic in nature and require the air operator's personnel to constantly modify and adapt to their work environment. This is consistent with Rasmussen's (1997) concept on controlling behavior by making the boundaries explicit and known and giving opportunities and the tools for workers to develop skills at the boundaries.

A resilient system must be able to monitor the system and its own performance within the system (Dekker 2003, Dekker et al., 2008). Dekker (2003) indicates that organizations need to:

> 1 - Monitor the gap between procedure and practice and try to understand why it exists (and resist trying to close it by simply telling people to comply). 2- Help people to develop skills to judge when and how to adapt (and resist telling people only that they should follow procedures. (p.236)

Assessment of health and safety management systems

Costella, Saurin and Macedo Guimaraes (2009) have introduced a method for assessing health and safety management systems (MAHS). Much like Snook (2000), they are concerned with the ability to develop strategies to deal with system variations that cannot be totally foreseen at the design stage and learn to develop skills at the boundaries. Costella et al., indicate that:

> Given that all control systems tend to deteriorate over time or become obsolete as a consequence of changes, continuous performance measurement is essential…Such measurements can occur at different levels, such as individual workstations, individual management processes or at the level of the HS management system as a whole. (p.1057)

Although Costella et al., (2009) use the term audit, I find that it connotes somewhat of a narrow interpretation of being restricted to only looking for non-compliance with, and deviations from, regulations and operational standards. In such, I will be using the term monitoring throughout my discussions as I believe this terminology encompasses looking at the socio-technical aspects of an organization for deviations, drift, ingenuity, adaptations, etc.

Saurin and Carim (2011) discuss the health and safety management systems (HSMS) assessment and use their experience over the past two years of undertaking assessments based on methodology of Costella et al., (2009) to modify their approach. As a result, they modified the process to include an analytical framework for assessing the sources of resilience or brittleness in HSMS as well as provided revised data collection tools so as to increase their ease of use and reduce subjectivity. Their work enhances Rasmussen’s (1997) theory and lends itself for assessments using the principles of resilience engineering.

Clancy, Leva, Hrymak, and Sherlock (2011) have developed a program to improve data monitoring of safety/hazard in an international energy company and have found that real-time review of current safety data provided through monitoring facilitate the identification of areas where modifications to working practices, equipment, training programs or standard operating procedures might be appropriate. This proactive approach also had implications for day to day operations efficiency as well. In essence, this shows how a good monitoring program can allow companies to be able to work near the safety thresholds described by Rasmussen thus allowing companies to become safer, more efficient and competitive with other companies.

Monitoring tools

Leva, Kay, Cahill, Losa, Keating, Serradas, and McDonald (2010) developed a unique form that reports on flight crew auditing of everyday performance in an airline safety management system. Leva et al. (2010), propose a new reporting concept that aims at enabling employees with the ability to audit the operations of the company so that: "existing threats are identified and corrective actions taken and potential threats are predicted and mitigated before they occur…by improved information sharing, performance management, operational risk management and process improvement" (p.164). Of particular importance is the research on line operation safety audit (LOSA), threat and error management (TEM), crew resource management (CRM) and the intelligent flight plan. Each of which, if properly used, arguably contribute to enhancing the safety of an organization (Leva et al., 2010, Helmreich, Klinect, and Whilhelm 1999).

Threat and Error Management and CRM

Helmreich et al., (1999) discuss threat and error management (TEM) and the use of crew resource management (CRM) to deal with threats encountered in flight operations so as to avoid errors or unacceptable situations. The threats can be either from expected or unexpected sources. Aviation is dynamic and complex in nature and routine flights can quickly become fraught with challenges and dangers that were not anticipated. TEM is about how aircraft crews can recognize threats and are able to deal with them successfully. The use of CRM, TEM briefings are all designed to help crews be cognizant of threats and either avoid error or deal with them, thereby recover to a safe flight situation (Helmreich et al. 1999). TEM in essence allows operations at the boundary, discussed by Rasmussen (1997), being able control of behavior of flight crews by making the boundaries explicit and known to them, and by giving them opportunities to develop skills at boundaries through TEM and CRM training.

Line Operation Safety Audits (LOSA)

Helmreich et al., (1999) indicate that: "Line Operation Safety Audits are programs that use expert observers to collect data about crew behaviour and situational factors on normal flights" (p. 678). The use of data collected by LOSA provides the air operator with "a picture of normal operations and allow estimation within organizations of the degree of risk associated with certain environments, fleets, or type of maneuvers" (p.680). LOSA satisfies Rasmussen's (1997) risk management requirements in that it allows the air operator to implement measures to manage risks in operational context, determine if risk mitigation measures are adequate and functioning properly and to adjust their risk profile if needed.

Intelligent Flight Plan

Intelligent flight plans allow flight crews the ability to determine if threats exist for their particular flight and also provide other flight crews with information of threats that may affect future flights. It uses existing, real time, information and conveys this information to flight crews in the flight planning and dispatch process. According to Leva et al., (2010): "personnel will obtain feedback about potential risks to be considered for: 1) route planning; 2) aircraft pairing and rostering process; and, 3) the development of particular flight plan by Dispatch" (p.178). All this information will help shape TEM briefings. In addition, following the flight, crews fill in voluntary reports describing near misses, TEM strategies used and recommendations for improvement. This is essential in closing the loop by providing feedback about what is actually happening at the coal face and allow operators to see if work as prescribed is the same as work as performed (Dekker, 2003, 2005, Woods and Shattuck, 2000).

Leva et al., (2010) reveal that: "Current performance management processes within airlines often neglected operational feedback" (p. 175). It can be argued that feedback is essential within any system at all levels in order to ensure that interaction amongst key stakeholders will lead to the realization of the overall safety control requirements of an organization. Feedback is a tennent in Rasmussen's (1997) abstraction hierarchy in order to control conflicts at various levels between institutions and companies. I will examine whether monitoring of an air operator's system will determine if the feedback loops are functioning as designed to prevent activities from being conceived in isolation.

I will use the standards and guidelines established in MAHS and modify them to take into account a control approach to safety management based on flight operation quality assurance and examine whether they are used by an air operator, and if so, what effect it has on the overall safety of the operations. In addition I will examine whether the use of LOSA, TEM, and Intelligent Flight Plan enhances safety in air operations. How this will be accomplished is discussed in the methodology section.

METHOD

Research Design

Much of my research involved qualitative methodology completed through interviews with operation personnel, company safety experts, as well as senior management and also involved documentation review to determine evidence sources. The research was ultimately aimed at viewing an organization's Safety Management System and examined if there evidence of resilience engineering concepts within flight operation's monitoring systems and whether they help flight operations stay within safety boundaries and also improve safety. In particular, I examined if the organization uses RE concepts to enhance their ability to create work processes that are robust yet flexible enough to adapt to varying risk scenarios, and whether the organization is proactive in its approach when faced with disruptions and ongoing economic and production pressures.

Qualitative research focuses on collecting and analyzing information in many forms, from small numbers of instances or examples, in order to achieve as much depth and detail as possible (Blaxter, Hughes, Tight, 2010). Woods (1993) defines the challenge in studies of complex behavioural situations as: "how does one achieve valid, generalizable results when examining complex behavioural situations" (p.229). He recommends a process-tracing approach in which the goal is to "externalize internal processes or produce external signs that support inferences about internal workings" (p.223). Woods recommends the following approach for data gathering:

1. Define the psychological issue being studied;
2. Connect the test situation to the natural context;
3. Collect data

Costella, Saurin and Macedo Guimaraes (2009) introduced a method for assessing health and safety management systems (MAHS) through the use of three main auditing approaches: structural approach, operational approach, and performance approach. Costella et al., (2009), indicate that the structural approach assesses the system prescribed; the operational approach assesses what is really happening in the operation at the coal face; and the performance approach, which assesses the results of performance indicators (p.1056). In addition, the methodology emphasizes the resilience engineering perspective on heath and safety (HS) management taking into account four major principles as follows:

1. Top management commitment: implies demonstrating devotion to the same extent as the company's other objectives;
2. Flexibility: work system design must be flexible and support the ability to cope with hazards;
3. Learning: involves understanding normal work as well as the ability to learn from incidents. Of important note is that learning must also take into account the way procedures are implemented. Monitoring the implementation of procedures should be considered as important as devising the procedures, since it may contribute to reducing the gap between work as prescribed and work as performed; and,
4. Awareness: actors should be aware of their own current status and the status of the defences in the system. This concept is critical for the ability to anticipate. (p. 1057-1058)

Saurin and Carim (2011) modified the process by Costella et al., to include an analytical framework for assessing the sources of resilience or brittleness in HSMS as well as provided revised data collection tools so as to increase their ease of use and reduce subjectivity.

I applied Wood's process-tracing approach and also used an adaptation of the methodology used by Costella et al., (2009) and by Saurin and Carim (2011) so as to take a system's approach. For example, through either structural, operational, or performance sources of evidence, the modified process will view whether an organization has LOSA, CRM, FOQA, non-punitive reporting systems, TEM, senior management commitment, flight data analysis, data management, hazard identification systems, risk assessment/management processes, feedback loops, training programs, safety policies, safety promotion, flight operations monitoring system, etc. I then determined if each can be linked to RE principles. I also investigated whether flight operations quality assurance monitoring takes complexity and emerging properties of a system into account and whether it relates the socio-technical interactions of an organization with the use of resilience engineering principles.

Participants

There were four Canadian airlines examined in my study. Two of the airlines are the country's largest scheduled airlines. The other two airlines are the country's largest non-scheduled charter airlines. Each airline uses similar and also different monitoring tools. In each airline, I interviewed the Vice President of Operations, the Chief Pilot(s), and the Safety Manager. The interviews consisted of eight semi-structured, open-ended questions that lead to a number of follow-up questions dependent on the answers to the primary questions. Each interview lasted approximately 1.5 hours in duration.

The Vice President of Operations (VPO) is the highest executive level in charge of all aspects of flight operations. The VPO is responsible for establishing the policy, philosophy, standards and performance measures required for flight operations. Most of the responses are expected to yield structural data.

The Chief Pilot(s) (some organizations have a chief pilot for each aircraft type when they operate multiple types) is responsible for administering the policies, procedures and putting them into practice for the pilots, flight attendants and other flight operations personnel. Most of the responses are expected to yield operational data.

The Safety Manager is the primary point of contact for safety information and is usually tasked with examining trends in safety data. Most of the responses are expected to yield performance data.

Some of the airlines with which I conducted my research had additional executives directly related to safety. In these cases, I also interview them.

Data Collection

Much of the data collected was done through interviews and documentation review. The interview questions were designed to ask the informants about the flight operations monitoring system as well as how risk management and decision-making processes and practices may have changed as a result of data they have gleamed through various sources.

Interviews

The interviews were conducted individually at the company's main base. Before commencing the interview, I obtained consent from the informants to participate in the study by having them complete a consent form. I asked each informant if I can record the interview. In addition, I supplemented the recordings by note-taking. According to Blaxter, Hughes, Tight (2010): "Note-taking gives you an instant record of the key points of an interview" (p.196). It has been my experience the informants may not want to be recorded or may feel anxious about being recorded. Blaxter et al., (2010) reveal that: "Recording, may, however, make respondents anxious, and less likely to reveal confidential information" (p.196). Should the informant not consent to the recording, note-taking was used to collect interview data. Notes and summaries of recordings (versus a detailed transcript) was given to the individual informant so that they can validate the content and accuracy of the data. Some of the questions (based on Dekker et al., 2007) used to assist in collecting the data can be found in Appendix A.

Documentation Review

In addition to the interviews, company documents were analyzed, in order to find support for the answers given by the informants. According to Blaxter, Hughes, Tight (2010) it may complement the primary data collected, and may confirm, modify, or contradict what was indicated during the interviews. Company documents were also analyzed to find evidence of resilience techniques as well as any changes to procedures that may have occurred as a result of monitoring of flight operations. Documents such as the operations manuals, risk management processes, safety data, management review committee reports, as well as findings from LOSA and other safety processes were examined.

Data Analysis

The data was examined to determine if the information from interviews and document reviews provided the researcher with the ability to determine if resilience engineering principles were present in an organization's flight operations and if flight operation's monitoring enhances safety benefits by allowing the workers within the organization to remain within the safety boundaries described by Rasmussen (1997). Woods (1993) outlines the basic set of steps to be followed for data analysis using process-tracing methodology. They are as follows:

1. document and interpret raw data into a data format that can be analyzed;
2. document and interpret refined data to construct a concept-dependent description or explanation of each main theme or phenomenon;
3. analyze these concept-dependent analyses with respect to cognitive questions of interest.

Braun and Clarke (2006), as cited in Blaxter et al. (2010), discuss a method to interpret and define themes from raw data through thematic analysis. They indicate the following steps (p.233):

1. Familiarize yourself with your data;
2. Code interesting features of the data in a systematic way;
3. Review themes;
4. Define and name themes;
5. Relate analysis to research question.

The steps discussed by Braun and Clarke (2006), as well as Creswell's (2007) analysis strategies that discuss reducing data into themes, was used to complement Woods (1993) process-tracing methodology.

Ethical Considerations and Confidentiality

The research was done strictly for academic and safety purposes. Ethical approval for my thesis was obtained from the Assistant Deputy Minister of Transport. In addition, ethical approval was obtained from each airline that will take part in the research. Appendix A is an e-mail that was sent to the Vice President of Operations of each airline. The e-mail served to introduce myself and indicate that I have support from my organization to conduct the research. The e-mail was used to brief the Chief Operating Officers and top executives of the airlines so as to ascertain if there were any objections or ethical concerns with my research. Agreement has been obtained from each airline to conduct the research with the assistance of key personnel. The airlines have responded in a supportive manner and agreed to provide full access to their personnel and relevant documents. Other than the informant's time, there is no cost or remuneration for this agreement.

Appendix B is a participant's package that was given to informants during my briefing prior to starting the interviews. The package contained background and information about the research, how they can get information about the results of the study, who I am and what my role is, how data and secrecy will be managed, a statement that notes taken during the interview and synopsis of the recordings (if recording was agreed to) will be sent to them for confirmation before the data is used, that participation is voluntary, and that they may withdraw at anytime during the process. Airline names will be kept confidential in order to protect the identity of the informants interviewed (i.e.: there is only one Vice President of Operations in an Airline).

RESULTS

Over several months, I conducted interviews with operation personnel, company safety experts, as well as senior management in the flight operations departments of four Canadian Airlines. Two of the airlines were the country's largest scheduled airlines while the other two were the country's largest non-scheduled charter airlines. In addition to the interviews, I conducted documentation review of the company's flight operations manuals, policies and procedures, as well as of the subject airline's SMS manuals.

The Context

Whilst conducting my research, I was made privy to how airlines monitor flight operations and make use of the data they have collected. During candidate interviews and company documentation review, it became evident that the methodology for monitoring and acquiring data was similar throughout all of the airlines involved in this study; nevertheless, there were some differences with what was done with the data once it was collected. The similarities in methodology for monitoring and acquiring data that each company demonstrated were, inter alia, an established Safety Management System; risk management processes; safety reporting system(s); quality assurance audits; intelligent flight plans; and, various monitoring tools.

The following will discuss the similarities and differences amongst the airlines involved in the study. One of the differences that existed is in how the subject airlines dealt with the data gathered during their Line Operations Safety Audit (LOSA) initiatives.

LOSA

Three of the four subject airlines used LOSA as a monitoring tool. The fourth company was about to embark on a LOSA initiative. Interviews with senior management of the four companies revealed that they used (or will use) LOSA with the intent of identifying inherent risks or deviations from procedures that may affect their operations.

The interviews revealed how the airlines handled their LOSA data. The three companies that underwent a LOSA initiative did so using the LOSA Collaborative. The LOSA Collaborative, led by James Klinect PhD, is a user-network of researchers, pilots, safety professionals, and airline representatives collaborating to provide oversight and the implementation of LOSA as a safety tool.

The Collaborative provided the airlines with two days of training in Threat and Error framework, which included, inter alia, how observers were to conduct inflight safety audits, how they gather data, how they code the data, and how to write the reports on the safety audits conducted. The observers attended formal classroom lectures and underwent practice evaluations and observations conducted by the Collaborative instructor. One of the instructor's main goals was standardizing how the safety audits were conducted, the data coded, and the reports written; therefore, trying to control performance variability.

The observers would then gather data through cockpit observations during actual line operations. One of the issues with having an observer in the cockpit is that the observer is said to influence the performance and actions of those being observed. Notwithstanding, evaluations and observations are a necessary part of a pilot's professional career. Pilots are constantly being observed, evaluated, and monitored through simulator checks, line indoctrination, line checks and other evaluation exercises in order to maintain their professional qualifications. The observers being used in the LOSA exercise were trained to be as unobtrusive as possible. Observation, nevertheless, does influence those being observed. The extent to which pilots are influenced by observation as a group or as an individual during the LOSA exercise is not known and was not measured as part of this research. I focused rather on the results of the LOSA exercise to determine what the subject airlines did with the resulting data.

A review of Company C documentation revealed that once the data is sent to the Collaborative, analysts read the report narrative and check that every threat and error has been coded accurately. Once the initial data check is complete, airline representatives, who are fleet experts, attend a data verification session with the Collaborative analysts so as to ensure data accuracy. Once the LOSA exercise was completed, each airline received a final report from the LOSA Collaborative that examined the data gathered during the LOSA exercises.

Company A implemented some changes as a result of the data contained in the report; however, proceeded to file the report for future reference before all the data could be reviewed. Interviews with company executives indicated that they did not complete a thorough review because of other priorities and that they were satisfied that the LOSA report confirmed what they already knew (company A, interviewee #2). Company B, interviewee # 3 indicated that their company became very busy with other initiatives and they did not have time to focus on doing further work with the LOSA report. Regardless, Company B indicated that their LOSA revealed that before departure, pilots were constantly being interrupted by others (maintenance personnel, fueling personnel, flight attendants, gate agents, operational control, etc.) while performing cockpit related duties. "The flight crews are most disturbed during pre-flight preparations in the cockpit." (Company B, interviewee # 5). These interruptions were a constant source of distraction to the pilots and sometimes occurred at critical moments during the preparation (i.e. loading the flight plan into the aircraft navigational computer, dealing with weight and balance issues, dealing with aircraft performance data), therefore increasing the risk that the pilots may commit errors. The company undertook a sensitization campaign with airline personnel to minimize disruptions of flight crew during ground preparations (company B, interviewee # 3).

Interviews with executives from company A revealed that they looked at the final LOSA report and saw a lot of symmetry between FDM material and the report. The LOSA report was then filed without further action being taken by the company (Company A, interviewee #2).

The third Airline (Company C) took the LOSA data and wanted to use it to develop training and implement changes as a result of the report. They quickly realized that the data of the LOSA report was provided in a more general, non-specific context, and did not offer clear guidance on what needed to be done. The following is taken from an interview revealing an example of what the airline did with the LOSA results:

> Our report with our data comes with some very broad strokes, very broad statements indicating the prevalent threats, most prevalent errors and your most prevalent undesirable aircraft states, and at first blush it looks like we can take this information and use it for training; however, as soon as you stop and look at it, you realize we do not know anything about what is behind the data. It turned into a very pain staking process of first targeting which areas of this report we are interested in, determining what is behind these airline operational pressures, threats and why do we have so

> many of those that resulted in additional errors and what are these errors? What is this telling us?
>
> Just the numbers themselves are merely pointing us in a direction that we have to do some research. It leads us back to the narrative and it is the context that gives us what we can take out of the report (Company C, Interviewee #1).

The airline changed procedures and adapted training to reduce errors. Company C (interviewee #1, #10) indicated that they made LOSA program content information available to crewmembers in classroom settings. Some of the issues discussed in the classroom were the most prevalent errors being committed, cross verification issues, checklist and automation issues; each being discussed with examples of countermeasures that could be used to reduce errors. In addition, ATC threats were discussed with examples of challenging ATC clearances that resulted in crew error. Managing ATC threats (e.g. challenging clearances, restrictions and late runway changes) became a large focus of the company's annual emergency procedures training program for pilots. The company also embarked on collaboration initiatives with the ATC service provider so that ATC could help minimize the threats by understanding the challenges faced by a flight crew that results from a challenging clearance, or last minute runway change.

Risk, Hazard Management, and Communication

Another safety tool used by all of the companies is the Risk Management process. Each subject airlines had mature Risk Management processes.

Hazards exist in every aspect of an organization. They are detectable through the use of reporting systems, inspections and audits. Hazards can also be identified or extracted from review of investigation reports and from analysis of safety data and FDA. The ICAO Safety Management Manual DOC 9859, pg 37, defines the term Predictive as "Analyzing system processes and the environment to identify potential future hazards and initiating mitigating actions."

An example of Hazard Identification and the Risk Management process is in how Company B used the Risk Management processes before beginning operations at an airport that is situated in a mountainous region. Another example would be the introduction of a new aircraft type (Company A, B and D). In each case, change management processes and risk assessments were used to determine what hazards existed and if the risk needed to be mitigated before beginning operations into the mountainous airport or introducing a new aircraft type to the airline.

Once a risk is identified, either through a safety report, threat assessment, audit finding, occurrence, or through FDA, each airline assesses the risk and determines if it is acceptable, or needs to be mitigated. Interviews with company officials revealed that all subject airlines would stop their activity if the risk is considered critical and would not resume operations until the risk was mitigated to an acceptable level (interviewee #1, 2, 3, 4, 7, 10, 12). Some examples are as follows: One of the airlines stopped operations into a foreign country because the security threats from an unstable government became too high (Company C, Interview #10). The same airline also cancelled a lucrative cargo contract because the cargo company did not want to have their cargo subject to Explosive Detection Testing or X-Ray screening. The airline believed that it was too much of a security threat not to screen the cargo and cancelled the contract (Company C, Interview #10). Company B refused to fly into a Caribbean destination during nighttime because of the threat of Controlled Flight Into Terrain due to the mountainous terrain around the airport. They restricted their operations to daytime only (Company B, Interview #3). Company A's marketing department wanted to operate into a mountainous airport with complex approach procedures; however, the flight operations department delayed the start of operations until they underwent a complete risk assessment process and undertook risk mitigation measures which included additional training, route checks and on-going monitoring of the flights operating into the airport to determine whether the measure in place were adequate or they needed to be modified, or if additional measures needed to be taken (Company A, interview #12).

Typical of all airlines, the subject airlines have individual departments that make up their organization. Examples of departments include, inter alia, flight operations, maintenance, operational control, cabin operations, flight safety, cargo, passenger, environment, marketing, finance, and human resources. Each department has specific duties to fulfill, and performance goals to achieve. Goals sometimes conflict between departments, and, without open communication, risks may not be discovered in time to counteract their perverse nature.

Company C, Interviewee #6 discusses:

> The real key is an open and honest communication line so that we are aware of what is going on in the first place. Once we are aware of it then managing the risk is very doable. It is the risk that you don't know about that is the hard one. By working together, we breakdown the barriers.

All the subject airlines have daily meetings to discuss previous day events that occurred within their operations. While these meetings discuss issues that have already occurred, and are therefore reactive in nature, they help establish lines of communications between operational branches. Operational branches will also use the information gleamed from the daily meetings to brief their staff. Interview #7, Company B, indicated that some of the items discussed at daily meetings are used in company awareness campaigns.

> Safety newsletters and company communications are used as a means of disseminating information to front line workers. The aim is to make employees aware of what is happening around them and in other parts of the organization.

One of the airlines provided examples of sharing experiences with other airlines at a manufacturer's conference. They discussed how pilots became distracted in the middle of programming and not re-starting the checklist from the beginning; thereby, increasing the threat of a checklist item being missed; how the aircraft rolled back at the gate because the pilots did not set the parking brakes or the wheel chocks were not put in by the ground crew; and, how smoke in the cockpit occurred after de-icing because the engine bleeds were not turned off during the procedure. These examples were discussed openly at a manufacturer's safety symposium so that everyone could learn from the events (Company B, interviewee # 7).

In addition to the daily meetings, SMS regulations require that the companies establish meetings between the Accountable Executive (AE) and senior staff to discuss operational safety issues. An example of communication required by SMS was taken from the documentation of a subject airline and supported by interviews from company personnel (Company A, interviewee #2, and 12). The following details their meetings:

a) There is an annual executive operation review in which the Accountable Executive reviews the Safety Management System to ensure its continuing stability, adequacy, efficiency and effectiveness. This is accomplished by reviewing current safety performance and then seeking and implementing improvement opportunities. The agenda consists of review of the previous year's objectives and goals, review of the safety risk profile, review of safety policy and safety reporting policy, and, setting objectives and goals for the incoming year. The meeting is attended by the Accountable Executive; chief commercial officer; chief financial officer; chief operating officer; senior vice president of operations; senior vice president customer service; senior director corporate safety; branch heads including flight operations; maintenance (person responsible for maintenance); flight dispatch; in-flight; security; airports; cargo; and, any other invitees as per the AE request.

b) There is a quarterly corporate safety board meeting which discusses the culmination of all relevant data from other management review meetings. The purpose of the corporate safety board is to review and approve company policies and standards related to the SMS, security, quality and occupational health & safety; to assess unresolved SMS, security, quality, occupational health & safety and environment issues, and determine accountability for actions; to review company SMS, security, quality, occupational health & safety performance based on established performance criteria/indices/targets, regulatory and company policies and standards; to review SMS, security, quality, occupational health & safety Objectives & Goals; to review and develop corporate positions on proposed changes to legislation and regulations that could affect the company's ability to effectively manage its responsibilities and obligations related to safety; and, to review and approve scientific studies/evaluations/investigations of employee health, safety problems or issues, as required. The meeting is attended by the Accountable Executive; Chief Operations Officer; Senior Vice President Operations; Senior Vice President Customer Service; Senior Director, Corporate Safety Environment & Quality; Branch Heads including Flight Operations, Maintenance (PRM), Flight Dispatch, In-Flight, Security, Airports, Cargo; and, any other invitees as per the AE request.

c) There is a quarterly Inter-Branch Safety Review Board (IBSRB) which analyzes documented safety deficiencies that involve multiple Branches and/or those that cannot be resolved within a singular Branch. The IBSRB has the authority to create working groups that would be responsible to address specific topics and report back the IBSRB. The IBSRB then develops and reviews action plans for the implementation of solutions and tracks those action plans to their timely completion. Updates and reports from various branches are discussed at the meeting. Attendees are Branch Department Heads of all branches including Flight Operations, Maintenance (PRM), Flight Dispatch, In-Flight, Security, Airports, Cargo, and any other invitees as per the Chair which is the head of Corporate safety on behalf of the AE.

d) There is a quarterly Quality Manager's Committee meeting to review Quality & Audit Issues and discuss Inter-branch Quality Management Strategy to ensure that all branches are conducting their Quality Management Systems in a consistent and effective way. They will review any significant branch quality and audit issues, discuss corporate quality issues and provide an update, give an update of the IBSRB meeting. Attendees are all branch quality managers.

e) There is a quarterly branch safety board meeting which provides a structure and process to manage all of the elements of safety, quality and the environment including SMS objectives & goals, and KPIs; maintains a process to monitor compliance, performance, program development, audits, and corrective actions; and ensures effective communication channels are provided at all levels of the organization with up to date information on safety problems/issues, performance and corrective actions/measures. Attendees are branch department heads and any invitees the chair (branch head) requires.

f) Lastly, there are weekly safety event review (SER) meetings which are intended to monitor the corporation's safety performance within the context of the Safety Risk Profile by reviewing incident and accident reports & investigation on a weekly basis to ensure corrective measures are initiated in a timely manner. The

> corrective action(s) are reviewed at the SER meetings to identify general trends that require further management of the Safety Risk Profile. The meetings consist of reviewing any new incoming incidents, occurrences, and hazards as well as discuss and the mitigation and corrective actions. Attendees are the branch safety representatives and the meeting is chaired by the senior director of corporate safety.

While I used Company A as an example to demonstrate communications through SMS, each of the subject airlines has similar meetings and communication processes. When discussing SMS meetings and the importance of communication, one of the airline's executive indicated the following:

> It brings everybody to the table, so that is right from network planning, IT (Information Technology), all the operations group, so inflight, pilots, OCC (operational control center) and everybody is at the table working together and sharing their challenges and their opportunities. Before we did that, the silos were, I do not want to say prominent, but there were silos. The natural thing in a silo is you say you are fine, but they are no good. When you breakdown those silos and you see the functionality that they are trying to do and you humanize it, you break down all those barriers. Not only do we share each other's communication, we strategize how we can communicate together, inflight and flight ops or flight ops and airports, we basically put out the same communication, but might have a very slight different flavor to it. By being together, by working together, we break down the barriers by sharing our actual communications, so airport leadership and inflight leadership are all on the pilot distribution list for our memos and I am on theirs. I see the communications that they put out and they see the communications I put out and we dovetail wherever possible. (Company C, Interviewee #6)

In addition to internal company meetings, external meetings with suppliers, stakeholders, government agencies, and other essential parties relevant to the operations of an airline continuously take place.

Another communication tool used by all of the airlines is through their flight plans and en route communication devices. Each of the subject airlines had intelligent flight plan capabilities; each airline had the capabilities to brief flight crews on issues that were encountered by previous flights on the same routes or keep the crews informed of any new development that may affect the safety of flight (such as significant weather changes). The use of ACARS, SATCOM, and other communication devices were used to keep flight crews informed of any development that could affect their flight while they were operating the aircraft. Pilots could also relay information about their flight to the Operational Control center so that it could be shared with other flight crews.

On Time Performance

Each airline is measured by their on time performance (OTP) for departures and for arrivals. This industry-wide measurement is used to rate airline efficiency; giving praise to airlines that maintain an on-time schedule; thereby attracting passenger confidence and loyalty, and increasing an airline's market share.

Trade-offs between production and protection (safety) are difficult because they occur within a highly demanding context which encompass pilot fatigue; weather conditions; stress of keeping to the schedule and making connections for on-going passengers; additional costs of operations by supplying hotels, meals, compensation to stranded passengers; and, the operational pressure of completing the flight safely.

Monitoring is a method for airline flight operations to keep informed of issues that result from maintaining OTP. Each subject airline discussed OTP as a hazard and a pervasive safety issue within the industry. During the interviews, each airline indicated that through safety monitoring they maintain an awareness of the pressures their pilots faced when confronted with OTP, giving specific examples.

Interviewee #2, Company A, indicated the following:

> The maintenance guys wanted a new policy on damage found within 30 minutes of departure. If you find something within 30 minutes of departure, don't worry about it. We are saying NO! If you find something that is wrong with that airplane you tell maintenance and they look at it before the airplane goes flying. You cannot ignore it because it is getting close to departure time. There is a fundamental misunderstanding;

> my concern is that I feel that at times there is a drift caused by OTP, operational concerns that allow safety to slide slightly to the left. It is not there all the time but when it is there it is evident and is uncomfortable.

Interviewee #5, Company B discussed OTP and went on to indicate that when he gives training or releases a new captain on the line, he tells them:

> On time performance is big in the industry, it can come back to bite you. You can rush, but only rush to reach the aircraft, once you are there, there is not much that you can cut. If you are going to leave late, too bad, you will leave late. You did your job. Once you get to the aircraft, take your time. If you cut steps, then you become culpable and get into a "no man's land".

Company C's flight operations had similar stories about OTP and indicted that they advocate to their pilots against being pressured to cut corners. Company C tried to make a cultural difference with how their flight crew handled OTP. The airline worked on modifying pilot behavior and organizational culture. They believed that OTP implies the wrong priority and felt it put undue pressures on their flight operations personnel. To try to modify organizational culture, they coined the term SPOT (Safely Perform On Time). A company executive, interviewee #14, Company C indicated the following:

> We were trying to improve our On Time Performance and there was a lot of push back that it is going to be unsafe. Instead of OTP, let's make sure we have an "S" in front of OTP, which is safely perform on time. This started a shift. What we were seeing is that through some groups, that as soon as they got behind their OTP, their discipline went away. You could see it with the data we had. What SPOT gave them the licence to do two things: 1) safety comes first, OTP comes second. 2) the permission to take a "safety time out". We're having a tough day and everything is running behind, you should back out of that pressure a lot, and be disciplined and say hey, things are moving too fast, you need to take a safety time out. Safety time outs are rewarded at our airline; although, we still meet with them to understand why they took the safety time out, not for discipline, but a better understanding of what we can change and what they saw. The final piece is that if you are disciplined in the work that you do and follow your procedures.

Interviewee # 10, Company C indicated that:

> It's important how you communicate to crews, how you encourage the ability to take the safety time out, that is why we do not use OTP (on time performance) because it implies the wrong priority, we use SPOT, safely perform on time. From an organizational perspective, as a crewmember, what is more important? Is it safety or getting out on time?

Documentation review from Company C discusses On Time Performance (OTP):

> Safety and OTP complement each other; the same actions that keep us and our operation safe are generally the very same ones that help improve our OTP. For example, a clear sense of purpose, the proper tools to do our job, appropriate checklists, clear and well-communicated processes and procedures, solid training, proper preparation and planning, etc. all promote safety and OTP.
>
> The intent behind safely performing on time -spot- is to ensure that our procedures support the safe and consistent on time operation of our aircraft and - with the help of crew input - make changes to procedures where needed. The use of checklists and SOPs are vital elements of spot. The potential to rush when behind schedule can lead to omissions and seriously affect safety.

In addition the company's documentation also indicated that:
Safely performing on time has a positive impact on passenger experience and cost efficiency because it:

a) provides passengers with the service they paid for and rightly expect from us;
b) can result in even more loyal passengers;
c) significantly lowers costs by reducing expenses such as passenger hotel and meal reimbursements, re-accommodation charges paid to other airlines, etc.; and,
d) allows our operational team members to go home or off duty when they

expect to versus working extra hours to attend to late flights.

The subject airlines are monitoring their OTP and are assessing if pressures caused by OTP are having a negative effect on safety. Pilot reports, safety reports, cabin crew reports, maintenance reports are all examined to monitor if OTP is diminishing safety according to front line operational employees.

I currently work for a large international airline as the Head of Safety, Security, and Compliance, and, inter alia, oversee the operations of our Ground Service Provider (GSP). If the GSP causes a delay from the departure time of more than 5 minutes, they are penalized by reducing 50% of the rate they receive for servicing the aircraft for the flight. Operational pressures exist to fulfill the on time performance obligations because of financial penalties assigned for delays. Nevertheless, the Ground Service provider turns around hundreds of flights per day on time. In 2014 they did not have any ground damage events. The GSP has systems, training, and procedures in place that complement safety and on time performance.

Flight Data Analysis

Another method used for monitoring by all of the subject airlines is the Flight Data Analysis (FDA) tool. The ICAO Safety Management Manual DOC 9859, pg 37, defines the term Predictive as "Analyzing system processes and the environment to identify potential future hazards and initiating mitigating actions." Predictive risk analysis is also useful in well-structured, tightly coupled systems protected by multiple, technical defenses (Rasmussen 1997).

Each airline determines the flight data parameters they wish to monitor and also set what limits will trigger an event in the data collected (an event will indicate when an acceptable state is exceeded). The following is an example of an event type measured: Indicated Airspeed greater than approach speed +15 knots at a radar altitude between 800 feet and 50 feet (IAS>Vapp+15kts (800ft>RALT>50ft)). Several events can be associated to unveil an undesirable situation. For example: path high during approach at 1,200 feet + path high during approach at 800 feet + path high during approach at 400 feet = continuously high path during final approach. This could signify an unstable approach and would require further review of the flight in question. Predictive risk analysis uses accumulated flight data and determine if any trends exist so as to be able to take action before an accident occurs.

Company A's program measures over 2,500 aircraft parameters. These parameters allow the airline to monitor 180 event types. According to the company, FDA examination of the flight operation is strictly controlled and the outputs of the program are used to improve processes, identify issues and operational efficiencies and enhance safety of their airline. Their company manual indicated that:

> FDA is recognized throughout the aviation industry as a critical element of any advanced safety program. It provides in-depth insight into a company's operation and allows them to focus on hazards and trends that can place their operation at risk. It also allows a company to track data over time in order to better understand trend information and use this not only to refine operational standards and procedures (and compliance to SOPs), but also to address aircraft maintenance issues and environmental factors (Company A).

It is important to note that FDA is not mandated by regulations in Canada at the time of this research. As such, Canada offers no formal definitions, policies, regulations or protections for FDA programs. Notwithstanding, the airlines involved in this study all chose to implement a Flight Operational Quality Assurance (FOQA) system using FDA. The interviews conducted and a review of company documentation supported the view that FDA programs are an integral part of being able to monitor what occurs in flight operations.

All four airlines discussed unstabilized approaches as being a major threat to safety; each having specific examples of changing procedures as a result of what was discovered (Company A, Company B, Company C, Company D; interviewee # 1,3,4,7). Ten percent of accidents between 2009 and 2013 cited an unstable approach as a factor (IATA Safety Report 2013, pg. 76).

The following is an example of how a company used FDA to modify their flight operations. Company C flew to a destination airport in a mountainous region. The company had approximately 19% unstable approaches when landing at the airport. It was discovered that in many cases the pilots had not stabilized their aircraft prior to landing (a stabilized approach is one that the aircraft is on flight path, within threshold speeds for the approach and is properly configured for the landing). Last year the company introduced LOFT training sessions with a Radio Navigation Performance (RNP) approach into the mountainous region airport. The unstable approaches were reduced to 6.5%. Originally, there was no instrument guidance for the approach and the pilots had to visually fly the approach resulting in a high rate of unstable approaches (approximately 1 in 5 approaches). In order to control performance variability, the company introduced a RNP instrument approach and trained their pilots to set up VOR bearings lines so that when you crossed them you could start turning to the final approach heading. They trained their pilots in the simulator with modified procedures, and as a result, the rates of unstable approaches decreased.

ANALYSIS

Data gathered during the field phase was analyzed in order to interpret if the subject airline's flight operations monitoring affected the resilience of the operating system. The data was also analyzed to interpret if the airline's flight operations use monitoring activities to manage performance variability; and, if adaptive capacity is being displayed.

The interviews conducted with company personnel and a review of company documentation demonstrated that the subject airlines have a vast array of tools to monitor their flight operations. Airlines are using monitoring tools to determine safety risks and when required, mitigate them so as to maintain safe flight operations.

The following analysis is framed within Rasmussen's 1997 Risk Management Framework and will reveal how the airlines use their monitoring system to make pressures visible, monitor the boundary of acceptable behavior and push back away from it with a counter gradient.

Monitoring the gradient towards increased efficiency and reduced workload

Rasmussen 1997 model demonstrates that because of the dynamic environment and operational pressures airline flight operations are subjected to on a daily basis, there "will very likely be a systemic migration toward the boundary of functionally acceptable performance" (Rasmussen 1997, p.190). Cook, Rasmussen (2005) indicate that:

> Because the environment is dynamic, the operating point moves continuously; stability occurs when the movements of the operating point are small and, over time, random. Changes in the gradients (for example, increased economic pressure) move the operating point. The risk of an accident fall as distance from the unacceptable performance boundary increases. (p.130)

Flight operations monitoring in the subject airlines is being used to better understand how performance can drift from the intended objective as a result of workload and how the airline can adapt.

Three of the four air operators used LOSA as a monitoring tool. Each of the three airlines used the LOSA collaborative to administer their LOSA program. Once the results were collated and the reports returned to the airlines, there were differences in what the airlines did with the data. Company A and B executives decided what to do with the data they received following the LOSA initiative and did not examine the LOSA data to a greater depth either because of performance shaping forces of financial constraints, management pressures, competing workloads, production and performance targets, or a combination of these. Real operational pressures caused these two companies to set aside the opportunity to further examine rich data that could be used to enhance the safety of their operation. Hollnagel's (2009) Efficiency and Thoroughness Trade-Off, is seen at the corporate level in the decision made by the executives of Company A and B.

The two airlines in question had mature operational monitoring tools that were used to determine if a safety issue existed. It is doubtful that setting aside the results of the LOSA alone would be enough to cause an accident to occur, as many flight operations do not yet have a LOSA program; however, rich data that could be used to examine deviations from existing standards and determine if pervasive safety threats exist were disregarded. Nevertheless, gradient pressures were present and as a result, Company A and B chose an efficiency trade-off. They chose to expend resources on operational pressures rather than dedicating them towards further analyzing LOSA. The gradient pressures that Rasmussen (1997) describes in his model can be seen to exist in this case.

Company C discovered that the aggregate totals provided in the report from the LOSA collective were meaningless without the context or the story behind them. The airline undertook an analysis of the areas of interest in the LOSA report and was able to get context, discover the challenges faced by flight crews, and how they were managed. Armed with this information, they changed procedures and adapted training to reduce errors. Company C used LOSA to define the marginal boundary and through analysis established measures to strengthen the gradient to push back from the safety margin.

The use of LOSA as a monitoring tool can give a company data that may be used to enhance safety. Company A and Company B chose to set aside the opportunity to expand on the LOSA data because of operational pressures; however, company C conducted an in-depth investigation of the data and related it back to the flights in question so as to make sense of what the LOSA report was describing. The airline discovered that the aggregate totals provided in the report were meaningless without the context or the story behind them. The airline undertook an analysis of the areas of interest in the LOSA report and was able to get context, discover the challenges faced by flight crews, and how they were managed. Armed with this information, they changed procedures and adapted training to reduce errors; thereby using LOSA to define the marginal boundary and through analysis established measures to strengthen the gradient to push back from the safety margin. It is only with this extra effort, additional research, looking for the "why" something occurred, that LOSA data is truly useful. Doing less will get you a report that only gives you high-level generic information. Company C demonstrated its pursuit of understanding data and taking appropriate actions as a result. They learned from the exercise and used the data to modify procedures even though they faced similar resource constraints and operational pressures as the other two airlines. Monitoring and learning are two cornerstones of resilience.

FDA is being used as a tool in which trends are identified, giving the ability to research why they occur. ICAO uses the term "predictive" when describing the ability to collate data and determine whether trends that could affect flight safety are happening. Woods, Cook (2001) indicated that "high-reliability organizations create safety by anticipating and planning for the unexpected events and future surprises" (p. 93). The terms anticipation and foresight are somewhat interchangeable. The issue is whether you can base future patterns based on analysis of past data. FDA analysis falls under the predictive tools that airline flight operations use to identify trends, giving the ability to research why they occur. It allows the airline to determine if flight operations are going outside of the performance and safety boundaries set by the airlines; to determine if there are patterns of exceedances that occur, thereby enabling the airline to see if deviations are occurring.

Rasmussen (1997) indicated that it was important to make the organization and its workers aware of practical drift situations and understand that going beyond the boundaries may lead to an unacceptable occurrence. Documentation and interviews confirmed that flight operations used FDA information to show a series of unstable approaches at an airport in a mountainous region. This data was then be corroborated through interviews with flight crew and through safety reports that were submitted. Risk was then determined through a risk analysis process and emergent properties were examined. The risks were found to be too high without mitigation. The company modified their training program and SOPs in the hope of lowering unstable approaches; thereby controlling performance variability.

Nevertheless, trying to extemporize the location of the boundary through the FDA process alone does not provide a complete picture. Other factors must also be part of the solution. Factors such as the examination of safety reports will also reveal when flight crews skirt the boundaries of acceptable performance; a more in depth investigations into known deviations from Operating Procedures may also reveal important safety information.

Leva et al. (2010), indicate that through monitoring: "existing threats are identified and corrective actions taken and potential threats are predicted and mitigated before they occur…by improved information sharing, performance management, operational risk management and process improvement" (p.164).   The data gathered during interviews and documentation review revealed that airlines flight operations have numerous threats and operate in a high-risk environment. The use of monitoring tools such as LOSA and FDA combined with the ability to perform risk management help the airline's flight operations remain within the boundary of functionally acceptable performance. Monitoring through LOSA and FDA makes the pressures visible and allow the airline to monitor when flight operations are getting too close to the boundary of acceptable performance; thereby allowing mitigation strategies to push back away from it with counter gradients.

Setting the marginal boundary

Cook and Rasmussen (2005) describe the boundaries as "difficult to manage…because the environment is dynamic." (p.130). Airlines need to set their marginal boundary and then monitor and adjust it as they understand why it is crossed. The use of Risk Management to determine if certain routes will be flown (i.e. flying into mountainous areas); or determining if the risk is too high to continue flying into a politically unstable country or over conflict zones; and, dealing the pressures of being on time are all good examples of an airline setting the marginal boundary.

A pervasive safety threat to airline flight operations, which is difficult to control, is the requirement to meet on time performance. OTP can put flight crews in a double-bind situation. OTP changes the operational dynamics of the system by making the system tightly coupled. Workers may vary from established work procedures because they feel that they must make up the lost time. The additional pressure OTP imposes on flight operations can cause employees to seek shortcuts to complete their work, thereby, creating gaps in operational procedures and increasing the likelihood of error. It is incumbent on flight operations to minimize flight crew performance variability and ensure that the pressures are fully understood by the flight crew so that they may adapt their operations and fine tune how they successfully and safely carry out their flights.

Rasmussen (1997) advocates that making the goal conflict obvious and showing where the boundaries are to the employees is imperative in increasing risk management. During interviews and documentation review, it became evident that each airline discussed OTP with their pilots. In two different studies, van der Lely (2009) and Parker (2010), indicated that flight crews have to deal with situations that are underspecified with operational procedures, they needed to extemporize, even invent procedures to accomplish multiple goals simultaneously, and to manage the negative side effects of procedures. Airline flight operations work in a dynamic environment rich with hazards and emerging risks.

Although each of the subject airlines discussed the hazards and emerging risks of OTP with their operation personnel, Company C, in particular, attempted to instill a culture shift within their operational branches by making the goal conflict obvious. Morel, Amalberti, and Chauvin (2008) indicate that: "resilience is related to the capacity for recognizing the problem and making a safe decision in adverse conditions, possibly giving up the potential benefits" (p. 2). Company C rebranded OTP to Safely Perform On Time (SPOT). Adopting a SPOT culture, the airline allowed their flight operations personnel to manage the side effects of the pressure. Company C chose to make marginal boundary more visible to their employees as they discovered that operational pressures placed on their flight crew to remain on time or to try to return to schedule times placed an inherent risk on the operations. SPOT allowed the flight crew to take a safety time out if they felt pressured or realized that their actions may cause unacceptable risks thus allowing the production point to migrate into an area of unacceptable performance. Company C mediated the pressures caused by OTP by allowing their flight crew to take a safety time out, and strengthen the gradient so as to remain within the boundary of acceptable performance.

Monitoring the gradients towards increased safety

Proactive identification of hazards and mitigation of risks at all levels and across all levels in an organization (i.e. within and between layers of the abstraction hierarchy) enables airlines to monitor the gradient towards increased safety. Safety management activities including hazard identification, risk mitigation and timely operational communication are strategies that are contributing to an airline's ability to increase safety.

In order to examine possible risks to the organization before commencing a specific operation, the use of requisite imagination will allow risk managers the ability to step "outside of the box" when it comes to identifying possible hazards. Risk managers can create realistic possible risk scenarios and provide risk mitigations before the actual operation begins. Westrum (2006) indicates that foresight may arise from "suspected trends and intelligent speculation" (p. 59). Rasmussen (1997) indicates that an important aspect of safety is the ability to use risk analysis and that the use of risk management gives the operator more capacity to absorb surprise.

SMS has mandated that the airlines have safety meetings involving the Accountable Executive. The subject airlines all have documented meetings discussing safety issues and the resolution of these issues. Presentation of Key Performance Indicators and other safety initiatives are discussed in depth at these meetings. The airlines have taken these meetings and have used them to keep the AE informed with what has been occurring in their organization.

Communication is a necessary tool to understand and know what is happening in flight operations. Rasmussen (1997) indicated that communication is an important requirement in the abstract hierarchy. For risk management to function properly there must be vertical integration through adequate communication and documentation so as to ensure that the nature of the hazards are known and dealt with appropriately.

Sheps, Cardiff, and Robson (2013), discussed communication within a socio-technical system and indicated that:

> Resonance is the extent to which consideration was given to the notion that threats to safety or accidents can result from a resonance within and across levels of a complex socio-technical system, not just from the deficiencies at any one level alone and where vertical and horizontal integration is not limited simply to linear, upstream, downstream or side-stream control of information. This is exemplified by how the lack (or poor communication) of information at various levels is understood and described; and, to what extent is there an understanding of the role of feedback loops (with both linear and non-linear pathways i.e. resonance) across levels of a complex socio-technical system that might cause the lack of vertical/horizontal integration or work processes. (p.25)

The time spent on integrated communications is vital for continued support and problem solving as risk changes within an organization. The use of SMS and risk management demonstrated that airline flight operations are involved in a dynamic socio-technical system because they rely on vertical integration amongst the various levels of the socio-technical network. Through the use of meetings, safety reports, risk assessments, airline flight operations personnel can monitor their operations and take appropriate actions. Communications through daily meetings and formalized SMS meetings are also used within the air operations to discuss possible threats and the requirement for risk management. Communication was shown as a powerful tool to control resonance within airline flight operations. Several examples of hazard identification combined with risk management processes were found in the airline's flight operations. The use of requisite imagination was also demonstrated when air operations had to use risk management techniques and imagine possible scenarios before starting an operation into mountainous areas or introducing new aircraft types to their fleet.

Notwithstanding, even if Airline Flight Operations anticipate that a hazard might occur, you may not notice it until the threat becomes serious, and therefore difficult to manage. In order to avoid such situations, you need to monitor whether or not the anticipated hazard is occurring in your flight operations.

High reliability or low reliability?

Airline flight operations are considered as having relatively fixed marginal boundaries and deliberately restricted operating point dynamics. Cook and Rasmussen (2005) reveal that commercial aviation are “capable of developing accurate, precise, and shared understanding of the current operating point location – factors that influence operating point movements and the distance between the point and margin” (p. 132).

During the interviews and document research, it became evident that certain aspects of the airline’s flight operations are operating in a tight space whereas others are moving widely and rapidly in the operating envelope. The use of standard operating procedures by flight crews is an example of when the airline flight operations have relatively fixed marginal boundaries and deliberately restricted operating point dynamics. Nevertheless, there can never be operating procedures built for every aspect of flight operations. Inherent threats, changing operating environments and the dynamics of aviation are all factors that can cause the operating point to move widely and rapidly in the operating envelope.

Airline flight operations use monitoring as a tool to identify when the operating point moves too close to the boundary of functionally acceptable performance. Airlines also use hazard analysis, FDA, Risk Assessments, LOSA, Communication techniques (which involves safety reporting) as predictive tools.

Analysis of company personnel interviews and of company documentation revealed evidence that the air operators used predictive analysis methodology with their FDA. Evidence was also found of changes to operational procedures as a result of FDA analysis. An example is the changes to operational procedures to reduce unstabilized approaches undertaken by a subject airline.

Airline operations also demonstrated the use of risk management to determine if mitigation measures needed to be implemented during their operations. Operations into mountainous airport environments and procurement of new aircraft types are examples of predictive risk management. Once operations into the mountainous terrain began, there was continuous monitoring to ensure the mitigation measures were sufficient and that new threats did not appear. Each airline operations had a mature reporting culture as well as vertically integrated communication procedures that provided communication feedback from the bottom-up, top-down, and across silos.

Enhancement of safety was demonstrated by Company C through an in-depth review of their LOSA report. They discovered that the aggregate totals provided in the report were meaningless without the context or the story behind them. The airline undertook an analysis of the areas of interest in the LOSA report and was able to get context, discover the challenges faced by flight crews, and how they were managed. They then modified their training curriculum and operational procedures to mitigate the risks discovered through their analysis of the LOSA data.

Even though on time performance can be pervasive and lead to a reduction of safety, Company C demonstrated that the vast majority of safety and on time performance elements complement each other: good pre-planning, forethought, clear procedures, good training and communication all lead to more safe practices and better on time performance. This concept was also demonstrated by flight crews taking a safety time out instead of continuing operations under pressures that could affect safety.

Monitoring is an important tool in the airline's flight operations ability to enhance safety. Each of the subject airlines had a mature monitoring system. Notwithstanding, monitoring by itself does not make an airline safe. The data gathered through monitoring was used by the subject airlines to conduct risk assessment, change operational procedures, learn from others, anticipate the emergence of hazards into risks, communicate, and respond to ongoing events in a timely manner.

Morel, Amalberti, and Chauvin (2008) indicate that: "the relationship between resilience and safety is much more complex than a simple, cumulative way of improving safety" (p. 3). I found that the dynamics of airline flight operations and how monitoring is used to enhance safety form a model of system resilience in the face of various pressures and goal conflicts.

Monitoring is just one part of resilience. What you do with the data you collect through monitoring is equally if not more important. Throughout this thesis, I gave various examples of how flight operations used the data gathered through monitoring and analyzed how it affects their operations. As a result, the companies sometimes modified their operating procedures, changed their training, and opened lines of communications within their organizations. Other influences such as LOSA, FDA, Risk Management, Learning, Anticipation, Communication, Response, Reporting safety issues, Cultural shifts (OTP to SPOT) are also involved in improving safety by keeping the production point inside the boundary of functionally acceptable performance. Through Rasmussen's theory, it can be seen that resilience is the system's capacity of keeping things safe while counterbalancing economical and workload pressures.

CONCLUSION

The topic of monitoring flight operations was chosen in order to examine how airline flight operations are able to understand and mitigate the threats and inherent risks they face. The topic is of interest to the aviation community because it has significance in improving safety by following adequate monitoring processes, thereby, provide the ability to identify and deal with inherent risks on a timely basis.

Rasmussen's 1997 model provides a framework that can be used to portrait how to maintain safe operations within a boundary of functionally acceptable performance. Notwithstanding, the framework is static in nature. The model does not show to what extent the operating point moves when a shock occurs, and how much pressure or combination of pressures will force the operations outside of the safe limits. The model also does not explain how to show workers where the boundaries exist. Nevertheless, I found the concepts in Rasmussen's model useful to apply to an operational environment. I can also see applications of the model for monitoring in the Medical field as well as for other transportation modes (shipping, rail).

APPENDICES

Appendix A: Semi-Structured Interview Questions

The interview questions and relevancy are as follows:

1. Tell me what is your primary method for monitoring flight operations activities in your organization and how do you apply it? Do you monitor on a frequency, or as things come up, in response to indications that something is not right?

   Relevancy of Question: The question is significant, as it will provide insight into what each candidate believes to be the primary method for monitoring flight operations. The response allows the researcher to understand how monitoring is applied in flight operations and seek benefits from the monitoring process. It will also allow the researcher to seek if there is company documentation that supports the response.

2. What other methods for monitoring flight operations activities does your organization use?

   Relevancy of Question: Since there is more than one method to gather data, this question will allow the researcher to grasp a complete picture of processes used in monitoring flight operations. It will also allow the researcher to seek if there is company documentation that supports the response.

3. How do you identify risk in your organization and how does your organization cope with it? What processes do you have in place?

   Relevancy of Question: A main part of Rasmussen's paper is associated with the risk assessment process. This question will allow the researcher to determine how the organization views risk and how they cope with it.

4. What communication strategies, products, or processes do you use so as to have open communication lines between silos and levels?

   Relevancy of Question: Another part of Rasmussen's paper deals with the abstraction hierarchy where integration amongst and between the levels is accomplished through effective communication and documentation so as to ensure that the nature of the hazards are known and dealt with appropriately. The response will allow the researcher the ability to view if the company has a system's approach to communication and will allow testing of the decision feedback loop process.

5. For the Vice President Operations: - How do you establish procedures, policies, and standards for your operation?

   For the Chief Pilot:- How do you promulgate the procedures, policies, and standards and put them into practice?

For the Safety Manager: - How do you measure if a gap exists in the policies, procedures and standards as written and as performed by flight crew and what do you do when you find gaps?

Relevancy of Questions: The response will give the researcher insight into how procedures, policies, and standards are developed and administered in the organization. It will allow the researcher the ability to view if there are gaps in how the procedures are used and if drift can exist. The question differs for each level since the formulation of policies, procedures and standards are done at the VPO level, the application is done at the Chief Pilot level, and the Manager of Safety can view if gaps exist through data collection.

6. On a number of occasions, flight crews may deviate from prescribed procedures to gain operational efficiency. How are gaps between procedures and practice identified and how are they coped with by management? What coping strategies do flight crew use? Does your flight crew use CRM/TEM briefings during the flight planning and pre-departure exercises?

   Relevancy of Question: The response to this question will allow the researcher to have insight into whether the company has the propensity to close gaps as they appear, or if they seek to understand why the gap exists before deciding on a strategy. Is the propensity to close gap at the individual level and not understand why they exist? It will also allow the researcher the ability to examine how practical drift is considered.

7. How does the crew learn to adapt in pressure situations when they are dealing with issues that are not normally encountered?

   Relevancy of Question: This question will allow the researcher to be able to view if the organization has trained their flight crew to have the ability to develop skills at Rasmussen's boundaries. It will also allow the researcher to see if the flight crew uses threat and error management, or intelligent flight plans. It will also demonstrate whether or not flight crews are open to generating and accepting fresh perspectives on a problem.

8. How is the data gleamed from LOSA, FOQA, safety reports, and other flight operations monitoring processes analyzed?

   Relevancy of Question: This question is significant in that it will allow the researcher to determine if the data is used to enhance safety versus being stored for future reference or closing gaps by making people follow procedures that do not make sense. The researcher can also find sources of resilience engineering. It will also allow the researcher to search company documentation for any modifications that were accomplished as a result of the data collected.

Appendix B: E-mail sent to Vice President of Operations in each airline

Dear XXXXX:

I am undertaking research in order to complete a MSc in Human Factors and System Safety. My thesis will focus on how an airline uses flight operations monitoring to enhance safety. I would appreciate the opportunity to work with your airline to learn what type of monitoring system(s) you have and how the data gathered is utilized.

I must declare that I am a senior executive with Transport Canada in the Safety and Security group. My position within Transport Canada, as the Director General of Aircraft Services Directorate, deals with the operational aspect of Transport Canada's aircraft fleet in that I am responsible for the safety and oversight of the air operations and services to Transport Canada, Canadian Coast Guard, Department of National Defence (412 Squadron), Environment Canada, and Ottawa Police Services. Although I do work for Transport Canada, the research I am doing is strictly for academic and safety purposes. All work and recommendations will be shared with your airline for use as you see appropriate. The information collected is not subject to Access to Information and will be de-identified. Ultimately, agreement must be given by the airline before I can include any of the information in my thesis.

I would need to spend some time interviewing senior executives within your company such as yourself and your Safety Manager, as well as be able to view documentation to support how your flight operations monitoring is working. I would plan to ask each candidate I interview approximately 10 open-ended questions about your flight operations monitoring system (questions will be sent before the interview). An information consent document explaining the purpose and benefits of the research, that participation is strictly voluntary, and the confidentiality aspect, will be presented to each candidate before beginning any interview. During the documentation review, I would need to be able to discuss various aspects of the documents with your flight safety professionals.

I look forward to doing work with your organization and hopefully publish results that will benefit safety within the entire airline industry. Should you have any questions or concerns, please feel free to contact me at the following:

Office: XXX-XXX-XXXX
Cell: XXX-XXX-XXXX
e-mail: xxxxxx.xxx
Thank you for your support.
Michel
Michel Gaudreau
Director General/Directeur général
Aircraft Services/Services des aéronefs
cc: Gerard McDonald
Assistant Deputy Minister Safety and Security
Transport Canada

Appendix C: Participant's package

The Participant package will consist of:

a) an information letter that will be sent to the informants with the questions before meeting with them. The letter is aimed at introducing the researcher and also discusses the research topic.
b) the informed consent form which discusses the purpose of the research, what the informant will be asked to do in the research, risks and discomforts, benefits of the research, voluntary participation, withdrawal from the study, confidentiality, who to contact should they have any questions about the research, and their written consent to participate through a signature block.

a) Information Letter

Is there evidence of resilience engineering concepts within aircraft flight operation's monitoring systems and do they help aircraft flight operations stay within safety boundaries and also improve safety?

Dear XXXXXX,

My name is Michel Gaudreau and I am working on a MSc in Human Factors and System Safety. I aim to complete my thesis by January 2014.

I am a senior executive with Transport Canada in the Safety and Security group and am an Airline Transport Pilot rated on a number of aircraft including the Airbus 320, 330, and 340. My position within Transport Canada, as the Director General of Aircraft Services Directorate, deals with the operational aspect of Transport Canada's aircraft fleet in that I am responsible for the safety and oversight of the air operations and services to Transport Canada, Canadian Coast Guard, Department of National Defence (412 Squadron), Environment Canada, and Ottawa Police Services. Although I do work for Transport Canada, the research I am doing is strictly for academic and safety purposes. The information collected during this interview is not subject to Access to Information and will be de-identified. Ultimately, I must obtain your agreement before I can include any of the information in my thesis.

With the support of Transport Canada and of my professors at Lund University, I have designed a qualitative research study aimed at viewing an organization's flight operations monitoring system to see whether or not there is evidence of resilience engineering techniques that allows an organization to stay within safety boundaries and that also improves safety. Your input into this process is invaluable, as it will help me gather data that I can review and analyze.

I look forward to meeting you soon.

Sincerely,

Michel Gaudreau

b) *Informed Consent Form*

Research Question

Is there evidence of resilience engineering concepts within aircraft flight operation's monitoring systems and do they help aircraft flight operations stay within safety boundaries and also improve safety?

Researcher

Michel Gaudreau, MSc Human Factors & System Safety (candidate), Lund University

Sponsors

Transport Canada and Lund University

Supervisor

Dr. Johan Bergström, Lund University, Sweden

Assessor

Dr. James Nyce, Lund University, Sweden

Background and Purpose of the Research:

Safety Management System (SMS) regulations require that airlines look proactively at their operations through a monitoring process with the aim to react, learn, and anticipate before safety issues give rise to the potential of creating an accident. The purpose of this research project is aimed at viewing an organization's flight operations monitoring system to see whether or not there is evidence of resilience engineering techniques that improves operational safety.

The research is for safety and academic purposes and also forms part of the fulfillment of the requirements to complete a Masters of Sciences in Human Factors and System Safety with Lund University in Sweden.

Who will be requested to participate in the study?

Senior executives and safety professionals within four different airlines will be taking part in this study. The goal is to interview the Vice President of Operations, Chief Pilot(s), and safety manager, as well as other senior executives within the airlines so as to achieve a sample size in the range of 14 to 16 (n=14 to 16) of individuals who deal with flight safety issues on a daily basis.

What will be asked of you during the research:

I am seeking your voluntary participation in an approximately 1.5 hour interview where I will ask for your insight concerning safety, monitoring processes, and risk management processes in your organization. The study will comprise of eight semi-structured interview questions that will be conducted face-to-face. I would ask your permission to record the interviews; however, if you are not comfortable with this, I will only take notes during the interview.

Risks and Discomforts:

Ethics approval has been given by Transport Canada and your airline. I do not see any risks or discomforts from your participation in the research.

Benefits of the Research and Benefits to You:

There are a number of benefits of participating in this research project. Individually, you will be able to gain insight into flight operations monitoring processes and its impact on safety. You will also be contributing to advancing aviation safety through your contribution, experience and knowledge of this important topic.

Voluntary Participation/Withdrawal from the Study:

Your participation in this study is completely voluntary and you may chose to withdraw from participating at any time. You can stop participating in the study at any time, for any reason, if you so decide. Your decision to not volunteer or to withdraw from the study will not influence the nature of the ongoing relationship you have with the researcher, his organization or supporters of the research either now, or in the future.

Confidentiality:

The information collected during this interview is not subject to government Access to Information laws. Ultimately, I must obtain your agreement before I can include any of the information in my thesis. The names and the specific content of the interviews will be confidential and only de-identified information will be used. Your data will be safely stored in a locked facility and only the research staff will have access to the information. Confidentiality will be provided to the fullest extent possible by law.

- The identities of participants will be protected by the assignment of a participant number and the destruction of any information linking the informant's name with the participant number will be done at the completion of the study.
- Notes of your interview and a summary of the recording (if taken) will be sent to you for verification and approval for inclusion in the study.
- Quotations will only be used with the permission of the individual and would cite their participant number.

Who can I contact to obtain additional information about the study?

If you have any questions or concerns and would like to discuss the study, please contact Michel Gaudreau at XXX-XXX-XXXX. If you are interested in receiving a copy of the research findings, please include your e-mail address in the space provided at the end of the form.

Consent:

Your signature below confirms that you have read the participant's package in its entirety, and that you agree to voluntarily participate in this study.

Participant Signature:
Participant name (please print):
Place and Date:
Permission to record interview:
Participant e-mail address should you wish to receive a copy of the final results:

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