High Reliability Organization Theory and the San Bernardino City CA Fire Department.

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Abstract

The San Bernardino City CA. Fire Department (SBFD) was experiencing errors and near-miss incidents at a troubling rate. Research has found that certain organizations, called High Reliability Organizations (HROs), consistently maintain low error rates in operations similar to those undertaken by the SBFD. The purpose of this research was to identify the characteristics of HROs, determine SBFD's strengths and weaknesses in these characteristics, and identify how the SBFD could develop as a HRO. Descriptive methods were used to analyze each of these elements. A questionnaire was given to SBFD members to assess HRO factors in the department. The research found that the SBFD had moderate to strong HRO tendencies. Recommendations were made to enhance HRO characteristics in the SBFD.

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Introduction

The hazards associated with firefighting operations and emergency medical service (EMS) delivery are well documented, and generally understood even by those who are not affiliated with the fire service. However, the risks involved with engaging in those hazards, and the frequency in which some firefighting personnel choose to expose themselves to these risks unnecessarily or recklessly is a much more complex issue.

Operations carried out by the San Bernardino City (CA.) Fire Department (SBFD) are no exception. In addressing the safety dynamics involved with firefighting and EMS operations, the leadership of the SBFD has emphasized the need for safe operations through risk identification, safety policy development and enforcement, training, and encouraging safe behaviors. Even with these efforts, however, the SBFD is experiencing accidents and near-miss events at a rate that is considered unacceptable by the department's administration.

In analyzing these troublesome events, it is evident that there are lapses in communication and decision processes that appear to be significant contributing factors. Although efforts have been made to address these factors and create organizational learning opportunities following near-miss occurrences, the operational flaws and behavior patterns identified through the process tend to be repeated in similar ways during subsequent incidents.

This trend does not appear to be unique to the SBFD. A report by the United States Fire Administration (2004) indicates that fire incident related firefighter fatalities per 100,000 reported incidents have risen approximately 27% between 1992 and 2001. The report further points out that firefighters are injured during firefighting operations at a rate of 21 injuries per 1,000 structure fire incidents.

As this research will show, some theorists suggest that trends such as these in high-risk occupations, including firefighting, are unavoidable. Therefore, the losses involved in conducting such operations must simply be accepted. However, the research will also point out evidence that certain organizations, referred to as High Reliability Organizations (HROs), are able to perform such high-risk operations relatively error free over long periods of time, making consistently good decisions that result in higher quality, safer, and more reliable operations. Studies of HROs have revealed that they have specific, common characteristics that can be developed within an organization to reduce error and accident rates.

It is not clear whether the SBFD has the characteristics of an HRO, and if it does, which ones are strong in the organization, and which ones could be developed further in order to reduce error rates and strengthen safe operations and behaviors. The purpose of this research is to identify the specific characteristics of HROs, determine the organizational strengths and weaknesses of the SBFD in relation to such characteristics, and to determine what steps could be taken to develop or strengthen the characteristics of a HRO within the SBFD.

Descriptive methods will be used in conducting this research. Through a review of existing literature and applications of HROs, the research will first answer the question of what primary characteristics define HROs. Next, using data from a questionnaire given to members of the SBFD that identifies the strengths and weaknesses of HRO characteristics, the research will determine SBFD's strengths in relation to the identified HRO characteristics. Using the same survey, the research will also determine SBFD's weaknesses in relation to the identified HRO characteristics. Once these strengths and weaknesses are identified, the research will then determine which specific HRO characteristics the SBFD should focus their efforts on developing in order to move closer to becoming a sustainable high reliability organization. Based on the

findings of this research, recommendations will be made on how the SBFD could improve the safety and efficiency of emergency operations by applying HRO practices and concepts.

Background and Significance

The San Bernardino City Fire Department is one of the oldest and largest fire departments in San Bernardino County, CA. Established in 1878, the department has a long and proud heritage of service to the community. The department's operations division consists of 156 personnel who are responsible for delivering fire and emergency medical services for nearly 200,000 citizens. During calendar year 2005, the department responded to 4,640 fire calls for service and 21,700 EMS calls for service (Karschner, 2005).

Each response to an emergency call for service carries with it a variety of complex hazards, each of which have a high potential for injury to firefighters or damage to equipment. The challenge of engaging with these hazards requires an equally complex approach that ensures operational effectiveness, efficiency, and firefighter safety. The elements of such an approach includes structured communication between crewmembers, timely adjustments to rapidly changing environments, pre-established systems for incident command, and the ability to make critical decisions with only limited or incomplete inputs. In such a complicated environment, it is not surprising that events often unfold in a way that can place firefighting personnel in peril.

Although the SBFD has not suffered an incident related firefighter fatality in its history, a series of events that began in mid 2004 suggest that the SBFD may be experiencing lapses in its approach to emergency operations that may have contributed to near-miss situations. The precursors to these events included individual errors, series of errors, ineffective communications, and tactical decisions that placed several firefighters at risk. One of the subtler, yet significant indicators of the SBFD's safety climate included casual statements and

observations made by department personnel indicating a general willingness to take greater and possibly unnecessary risks. Collectively, these observations provided a gauge of the attitudes and beliefs of SBFD members regarding their operational approach to risk, and their perceived vulnerability (or lack of) to significant errors.

A vivid illustration of the impact of these operational lapses came from two near miss events in 2005 that occurred less than 6 months apart. Both of these were captured on video. Fortunately, no personnel were injured during these incidents. However, it became clear after analyzing the first event that a series of small errors and events aligned themselves to create the mishap. Retrospectively, crewmembers involved were able to identify individual errors, but did not believe that they were significant at the time of the incident. Furthermore, the level of risk that personnel were willing to take did not match the potential gain of operating in offensive positions. Consequently, tactical decisions and actions were not commensurate with providing for firefighter safety, and would therefore be considered in error.

In this incident, personnel initiated an offensive, interior attack on a vacant boarded up residential building that had heavy, boiling smoke showing throughout. Shortly after initiating the attack, the video showed a rapid ignition of the entire front interior of the structure, which enveloped crews working in that area with fire. Although the deteriorating conditions were evident before the mass ignition, there was no evidence that anyone openly questioned the tactics that were being used, or expressed concern with the level of risk that was taken. After the incident, however, several individuals commented that during the incident, they felt that the tactics might not have been appropriate for the fire conditions. Even so, they did not feel compelled to stop or modify operations. Fortunately, all personnel were able to exit the involved area without injury.

After this first videotaped near miss, the administration of SBFD held department-wide training sessions that focused on the issue of risk assessment during emergency operations and expectations of safe practices. This training began with a critique of the video from the aforementioned incident, and stressed the need for all personnel, regardless of rank, to communicate their observations and concerns to other team members, especially to senior officers in charge of coordinating tactics.

However, within 4 months of the training, another fire incident was captured on video that was as disturbing as the first. In this incident, a single firefighter entered a burning building that, unbeknownst to him, had already experienced an explosion and partial collapse in an area that was not visible from his location. This collapse was a result of the ignition of a large quantity of natural gas that had been released inside the structure. Although debris from the explosion was present all the way out to the street, the front of the structure remained largely intact.

The video showed the firefighter leaving the building only seconds before a catastrophic collapse of the remainder of the building occurred. This collapse would have certainly buried the firefighter under the debris, and could have caused significant injury or death. Personnel observing the fire from the opposite side of the building noticed the partial collapse, and attempted to communicate the conditions to the incident commander. Meanwhile, the firefighter became impatient and assumed he could safely enter to building to attack the fire.

An internal investigation of this incident (Drasil, Husted, & Parker, 2006) found that many of the operational approaches and systems of communications that were taught during the training just 4 months prior had not been used. The report further concluded that if these elements had been applied, the near miss situation might not have occurred.

Clearly, the department's administration had placed heavy emphasis on risk assessment, recognizing and communicating hazards, and firefighter safety. However, after collecting input from department personnel and observing emergency operations, it appeared that there were deeper organizational systems in place that may have been inhibiting progress toward the desired outcomes.

These systems appeared to be grounded at least to some degree in the department's past successes in dealing with incidents such as those mentioned by using aggressive, higher-risk tactics. These successes then seemed to create a belief that events would evolve in a predictable, positive way, reducing the need for skepticism or contrary input. Furthermore, it appeared that skeptical opinions regarding tactical decisions were not highly valued, promoting tacit compliance rather than open communications. These beliefs, whether officially recognized or not, appeared to have had a great deal of influence on safety behaviors of SBFD personnel during emergency operations.

In analyzing these occurrences, there is no indication that SBFD personnel were unaware of the risks, or that they were not trained to recognize and deal with them safely. As such, it is reasonable to conclude that ultimately, all personnel possess the capacity to protect themselves and others from injuries resulting from unsafe actions. However, it also appeared that the dynamics of SBFD's organizational culture, and the complex feedback processes that were occurring in both emergency and non-emergency environments might have been generating problematic patterns of behavior that were not safe.

These complex organizational systems associated with high-risk operations are not unique to the fire service. Other examples of complex high-risk systems in organizations include military combat operations, nuclear power plants, hospital emergency room teams, and aircraft

carrier flight deck operations. Like fire service operations, these systems have the inherent opportunity for frequent errors that can lead to catastrophic outcomes

However, studies of fast-paced, high-risk organizations such as these have found that many of them manage to carry out relatively error free operations in spite of the odds against it. Research in this area has revealed specific organizational characteristics that appear to be common among those organizations that have the lowest error rates. These characteristics include seeking out and addressing latent errors, resiliency when errors do occur, placing decision making responsibilities on those most qualified individuals, and valuing input from all levels of the organization, particularly input suggesting that things may not be going as planned. This body of research refers to organizations that exemplify such characteristics as High Reliability Organizations, or HROs.

Because of the documented success of HROs in improving the safety and effectiveness of high-risk operations, it seems to be a logical avenue for the SBFD to explore in their attempt to improve operational safety. HRO research offers evidence that organizations like the SBFD could reduce errors, such as those that occurred in the incidents described earlier, by developing and/or strengthening HRO characteristics throughout the organization. Doing so may also improve the department's ability to identify and correct latent errors before they occur, and recover without significant disruption to operations when errors do occur.

Collectively, these improvements would lead to improved firefighter safety, and a more efficient level of fire department related emergency services delivered to the citizens of San Bernardino City. Each of these benefits reflects the desired outcomes of the Executive Analysis of Fire Service Operations and Emergency Management course at the National Fire Academy (Department of Homeland Security, 2005, December). Furthermore, improving firefighter safety

through reduced error rates is a positive step in meeting the United States Fire Administration's operational objective of reducing the number of firefighter deaths by 25% over 5 years (United States Fire, 2001).

Literature Review

The literature review for this applied research project focused on the theory of high reliability organizations, the arguments that support its validity and how its application could lead to more efficient and safer high-risk operations such as those that are typical in the SBFD. The literature review also looked at the specific characteristics of organizations that theorists would classify as a HRO, and how those characteristics manifest themselves as a causal factor in how such organizations have fewer accidents or unwanted outcomes.

High reliability theory

The evolution of high reliability theory began as a quest for a risk mitigation model that could effectively address the complexities of operations in organizations where even small errors can bring disastrous consequences. Examples of such operations would be those that exist in aircraft carriers, air traffic control systems, nuclear power plants, emergency medical treatment, and firefighting crews (Weick & Sutcliffe, 2001).

In analyzing such high-risk organizations, Perrow (1984) noted that as the complexity of an organization's operational systems increase, the interdependency among the system's components strengthens. Perrow theorized that in highly complex systems, the implication of a failure in one area of the system is compounded substantially as other tightly intertwined systems are impacted as well. This may trigger a chain of rapid and catastrophic systems failures, often before the first error is detected. Based on these findings, Perrow concluded that errors in these

high-risk operations were not only inevitable, but that the likelihood of the catastrophic errors was so great that some organizations should not be allowed to conduct these operations at all.

Although Perrow made a significant contribution in identifying characteristics that may increase risk within a system, some found his argument that these inherent risks could only be mitigated by ceasing operations to be overly pessimistic (Marais, Dulac, & Levenson, 2004). Several researchers from University of California, Berkeley also found the notion of simply shutting down high-risk organizations to be impractical and unrealistic (Roberts, Yu, & van Stralen, 2003). This prompted further research into specific high-risk organizations that seemed to defy Perrow's hypothesis by maintaining error rates that were much lower than their counterpart organizations.

Roberts (1990) stated that the basic criterion for identifying such high-risk, low-error organizations was "by answering the question, 'how many times could this organization have failed resulting in catastrophic consequences that it did not?' If the answer is on the order of tens of thousands of times, the organization is high reliability" (p. 160). An example of such an organization that provided a great deal of usable data for these researchers was Naval Aviation, which had managed to decrease accidents involving a fatality or significant property damage from 55 accidents per 100,000 flight hours in 1955, to only 3 accidents by 1993 (Roberts & Libuser, 1993). Another example was the Diablo Canyon nuclear power plant in San Louis Obispo CA. which has been considered to be one of the country's best run and safest nuclear power plants since its opening in 1985 (Pool R, 1997).

These types of organizations, categorized by researchers as *high reliability organizations* (HROs) (van Stralen, 2003, Roberts & Bea, 2001, Libuser, 1994, Weick & Sutcliffe, 2001), became the focal point for a growing body of research that sought to identify the specific

characteristics that contributed to these low error rates. Although HRO theorists recognize that human error in high-risk environments is inevitable to some degree, their approach centers on an organizational design that allows members to recognize and avoid mistakes that could otherwise have disastrous results (LaPorte & Consolini, 1991). The components of such an organizational design include training members to quickly identify a variety of potential problems and empower them to react in a timely fashion (Roberts & Bea, 2001), a focus on subtleties that may lead to unexpected events (Weick & Sutcliffe, 2001), reward systems that promote desired behavior (Libuser, 1994), diverse decision making styles and strong safety cultures and norms (Grabowski & Roberts, 1997), and an emphasis on teamwork and system redundancies ("High Reliability," 2005a).

Weick & Sutcliffe (2001) narrowed down these characteristics into what they termed the five hallmarks of HROs. These five characteristics including having a preoccupation with failure, a reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise.

Preoccupation with Failure

Weick and Sutcliffe (2001) describe preoccupation with failure as “treat(ing) any lapse as a symptom that something is wrong in the system, something that could have severe consequences if separate small errors happen to coincide at one awful moment.” (pg. 10). A key piece of preoccupation with failure is paying attention to near-miss events, and treating them as a kind of failure. Reason (2000) identifies such near-miss reporting as one of the four subcultures that must be established to create a safety culture in an organization.

The United States fire service has also recognized the value of emphasizing near miss reporting by establishing the National Firefighter Near-Miss Reporting System. The system,

administered by the International Association of Fire Chiefs, is a voluntary, confidential, non-punitive and secure reporting system with the goal of improving fire fighter safety (National Firefighter, 2006). Fire personnel nation-wide are encouraged to confidentially share their near-miss experiences using an on-line reporting system. Each near-miss report is then made available to the public on-line.

Reluctance to Simplify

By their nature, HROs typically operate in complex environments. To remain effective, they understand that the complexities associated with their operations are not compatible with simplified approaches. Therefore, HROs take deliberate steps to encourage diverse thought, challenge conventional wisdom, and work to create a more complete view of operations that emphasizes subtleties (Weick & Sutcliffe, 2001).

The concept of reluctance to simplify emphasizes that focusing too heavily on organizational successes leads to complacency, and further simplifications (Miller, 1993). These simplifications can ultimately lead to organizations experiencing a decreased awareness of unfolding complex events, and more likely to be caught off guard when unexpected, dynamic changes occur. Collins (2001/2005) summarized this course of thinking in his observation that "the moment you think of yourself as great, your slide toward mediocrity will have already begun" (p. 9).

An example of how oversimplification can lead to catastrophic failures can be found in NASA's investigation report of the space shuttle Colombia breakup (National Aeronautics, 2003). According to the report, foam strikes similar to the one that was identified as a primary causal factor in the Colombia crash had been occurring for over 22 years without major incident. Investigators believe that this led to the normalizing of the event, that is, it prompted the belief

that it was simply a maintenance issue, and did not threaten the success of the mission. The report referred to this as "an unfortunate illustration of how NASA's culture bias of optimistic thinking undermined effective decision making" (p. 181).

Sensitivity to operations

A distinctive characteristic of HROs is their emphasis on work performed at the front-line, and the empowerment of those front-line workers. Through increased attentiveness in these areas, they are able to identify subtle anomalies in operations and deal with them before they become system malfunctions (Weick & Sutcliffe, 2001). In analyzing these type of interactions in firefighting operations, McDonald & Shadow (2005) found that communication and trust between upper and lower organizational levels during dynamic, time sensitive operations is key to maintaining safe and effective operations. With this, they note that organizational attitudes that negatively impact the flow of communication can eventually contribute to the development of latent errors, which can then lead to catastrophic failure.

Latent errors have been defined as deviations from expected operations that do not result in direct consequences (Ramanujam & Goodman, 2003). This lack of consequence can make flaws in the safety systems more transparent. In addressing such latent conditions, Reason (2000) used the analogy of slices of Swiss cheese to illustrate the potential effect of how relatively small errors can line up and result in larger failures. According to Reason's theory, key elements consisting of safeguards, defenses, and barriers create layers that provide for safe operations. When each layer is intact, it creates a strong resistance against failures. Even a *hole*, or failure, in any single layer (or *slice*) would usually not result in a catastrophic system failure.

However, as these holes in individual layers move, occasionally they will line up, allowing for a significant failure in multiple layers of the safety system. Wiegmann, Zhang, von

Thaden, Sharma, & Mitchell (2002) concluded that breakdown of this type and magnitude in high-risk systems can cause catastrophic failures that pose serious threats to the organization, and the public as well.

Roberts and Bea (2001) cite the 1994 South Canyon fire in Colorado as an example of how a lack of sensitivity to operations on a grand scale contributed to the 14 fatalities that occurred in that incident. They point out that a lack of effective briefings, ineffective communication styles, and lack of incident command were components that were apparently viewed as individual, unrelated, low priority factors during the incident. Eventually, however, they connected with such momentum that the system, and the players within the system, could not effectively recover from the ensuing catastrophe that these components collectively brought about.

Realizing that subtle indicators typically precede catastrophes such as this, HROs will actively seek out the subtleties, and pay close attention to them. Thus, HROs will view any lapse in the system as an indicator of a potential failure, and take action to correct it before a predictable accident occurs (Weick & Sutcliffe, 2001).

Commitment to resilience

Weick and Sutcliffe (2001) describe organizations that have a commitment to resilience by placing them in contrast to organizations that commit instead to anticipating unplanned events. They argue that it is nearly impossible to predict, and therefore prepare for, every potential unplanned outcome that can occur in complex environments. Therefore, focusing on anticipating unplanned events gives organizations a false sense of control. These organizations believe that they will be able to successfully employ procedures developed through anticipating the event that will mitigate an unexpected outcome, when in fact, their fixed plans and

procedures lack the flexibility needed to be successful in dealing with the pace and complexity of such events.

HROs, on the other hand, approach unplanned events in terms of mitigation and rapid recovery. They make use of multiple organizational structures, which allows the system to effectively adjust to fast-pace changes in the operational environment (Grabowski & Roberts, 1997). This flexibility in operations becomes a key component in their response. In studying operations on aircraft carrier flight decks in the context of HROs, Rochlin, LaPorte, & Roberts (1998) noted that the importance of flexibility was "essential in performing operational tasks that continue to increase in complexity as technology advances." (p. 109).

In his observations of the 2003 Cramer fire, which claimed the lives of two United States Forest Service firefighters, Close (2005) suggests that a lack of commitment to resilience became a significant contributing factor in the chain of events that led to the tragedy. Personnel working on the Cramer incident had developed certain expectations about the weather, the availability of resources, and the behavior of the fire. These expectations became the basis for their perceptions of what to expect, and what strategy and tactics would be most appropriate.

However, the reality of the situation at Cramer was quite different from their perceptions, and when conditions rapidly changed, they were ill prepared and equipped to adjust their tactics accordingly. Close (2005) further points out that because of their narrowly focused perceptions, they fell prey to what he described as cognitive dissonance.

Cognitive dissonance occurs when the divergence between one's perception of reality and true reality becomes so great that the resulting confusion that the individual experiences can impair the decision-making process, leading to inappropriate or ineffective decisions (Harmon-Jones & Mills, 1999). Close (2005) suggests that it was conditions like these that caused the key

decision makers in the Cramer incident to miss several important cues that their operational plan was building up to disaster.

By understanding the dynamics and difficulties of trying to capture true reality, HROs accept the fact that there will be inaccuracies in individual's perceptions that, when acted upon, may result in unplanned events. Therefore, they look for ways to reduce the confusion that is often associated with the occurrence of such events (Weick & Sutcliffe, 2001). HROs train their personnel how to respond when unplanned events occur, and how to react when the response to such events is simply not covered in any policy or procedure (Roberts & Bea, 2001). HROs structure flexibility into their operations so that rapidly changing conditions can be addressed with a timelier, and therefore a more effective response (Roberts, Yu, & van Stralen, 2003).

Deference to expertise

The process of deferring to expertise involves placing decision-making authority on individuals in the organization who have the greatest expertise in the matter at hand, regardless of their hierarchal position within the organization (Weick & Sutcliffe, 2001). This does not mean that the organization's hierarchy is abandoned, or that higher-ranking individuals abdicate their responsibility for the outcomes of the decisions made. The balance is struck by defining whom the important decision maker is based on the nature of the decision and the level of expertise of the potential decision makers. As Weick & Sutcliffe (2001) point out:

> "The decision structure is hierarchical in the sense that important choices must be made by important decision makers, and important decision makers can participate in many choices. But the distinctive twist in HROs is that the designation of who is the 'important' decision maker keeps changing depending on the decision maker's specialty" (p. 74).

Roberts and Libuser (1993) refer to this process of allowing the most qualified individuals make key decisions as "migrating decision making" (p. 24). In many cases, this process means allowing decisions to be made at the lower levels of the organization. However, it also allows decisions to be migrated upward or laterally, depending on who in the organization has the greatest level of expertise on the subject at hand. This improves operational efficiency in two ways. First, it helps ensure that a person who may have rank, but little or no expertise, does not make the key decisions (Roberts, Yu, & van Stralen, 2003). Second, because people on the front lines are given the latitude and authority to make the decisions, they are more likely to do so in a more timely fashion than if they were required to move the decision up through one or more layers of the organization (Rochlin, LaPorte, & Roberts, 1998).

Bigley & Roberts (2001) cited the concept of deferring to expertise as one of several factors that lend to the operational reliability of the Incident Command System (ICS), which is commonly used by fire service agencies during large-scale emergencies. They note that although formal authority relationships are fixed within the system, decision-making authority can quickly become decoupled from the organizational hierarchy to move through appropriate positions to individuals who possess the expertise in the issue at hand.

The benefits of allowing decisions to migrate to appropriate levels of the organization can be found across several different organizational types. Flin and Yule (2004) found that organizations that allow critical decisions to be made at an appropriate level tended to be associated with the highest safety performing business units. Donahue (2004) determined that fire service organizations that encouraged decision involvement from all levels of the organization operated in a more cost effective manner than those that retained centralized authority. Other examples of the benefits of deferring to expertise can be found in pediatric

intensive care units (Roberts, Madison, Desai, & van Stralin, 2005), flight operations aboard United States Navy aircraft carriers (Roberts, Yu, & van Stralen, 2003), and in prescribed fire and fire use operations in the wildland fire management setting (Weick et al. 2004).

Examples of HRO concepts in practice

Since the original development of high reliability theory, its use has expanded into several different organizational fields and applications. Bigley and Roberts (2001) cite the Incident Command System (ICS) used by fire service organizations to run emergency incidents as one example of HRO concepts in practice. Their research found that ICS provides for organizational reliability by making use of structuring mechanisms, cognition management tools, and constrained improvisation. Because of this, ICS provides an effective balance between the formal structures needed to accomplish organized movement, while still providing the flexibility needed by those tasked with carrying out operational objectives to address unexpected events.

The United States Forest Service (USFS) has also found HRO concepts to be effective tools for in improving operational effectiveness and firefighter safety. Findings from the 1995 Wildland Firefighters Human Factors Workshop (Putnam, 1995) suggest that HRO concepts should be used as a model for reorganization strategies in wildland fire agencies in order to reduce accident rates on fire incidents. HRO concepts were also identified as a mechanism to improve the efficiency of the forest service's prescribed fire and fire use operations (Weick et al. 2004).

The healthcare industry is another field that has been identified where the application of HRO concepts could be beneficial in improving patient safety, improving resiliency in the wake of problems, and improving interpersonal responsibility ("High Reliability," 2005b). Examples include mechanical ventilation practices in pediatric nursing homes (van Stralen et al. 2006),

improving teamwork and communication in surgical teams (Beyea, 2005), and providing rehabilitation for emergency personnel during physically demanding operations (Heightman, 2006).

Other areas where research suggests that the application of HRO concepts could improve efficiency include airport security operations (Fredrickson & LaPorte, 2002), management of critical services infrastructure (Schulman, Roe, van Eeten, & Bruijne, 2004), early detection and intervention of learning disabilities in public schools (Bellamy, Crawford, Marshall, & Coulter, 2004), and in identifying strategies for improving performance in human resource management (Vogus & Welbourne, 2003. Center for Advanced, 2004).

Collectively, the literature reviewed indicates that HRO concepts have potential applications in a variety of fields. Furthermore, there is evidence that the application of these concepts could reduce failure rates when applied to high-risk operations such as those undertaken on a regular basis by the SBFD. Creating more reliable operations in this fashion would be a positive step in reducing accidents and near-miss events.

Procedures

Descriptive research methods were used to identify the primary characteristics of HROs, to assess the strengths and weaknesses of HRO characteristics are in the SBFD, and to determine if the SBFD could improve the safety of emergency operations by integrating and/or strengthening these characteristics.

The process used to identify the primary HRO characteristics consisted primarily of reviewing existing research and literature on the subject. The reviewed materials consisted of a selection of textbooks, journal articles, periodicals, news sources, databases, and Internet articles.

These sources came from the National Fire Academy's Learning Resource Center (LRC), ProQuest® on-line database, related books in print, and various Internet sites.

The next step in the research project was to assess the strengths and weaknesses of specific HRO characteristics in the SBFD. This was accomplished through the use of an organizational audit (see Appendix A). This audit was developed by Weick and Sutcliffe (2001) as a mechanism to assess specific HRO related qualities within an organization. It was designed to be delivered in a questionnaire format. The author contacted the developers of the audit instrument and obtained permission to use it in this research (K. Weick & K. Sutcliffe, personal communication, May 15, 2006).

For the purpose of this research, five different item sets were used. Each item set focused on one of the five specific hallmarks of HRO's as defined by Weick and Sutcliffe (2001). Collectively, there were 47 items in the audit. The audit items were designed to evaluate the organization's preoccupation with failure (9 items), reluctance to simplify interpretations (12 items), sensitivity to operations (8 items), commitment to resilience (10 items), and deference to expertise (8 items).

Each item was phrased as a statement about general organizational characteristics. Respondents were given instructions to read each statement and select the corresponding forced-choice response that they felt best described their organization. The item sets regarding preoccupation with failure, reluctance to simplify interpretations, commitment to resilience, and deference to expertise were given three possible forced choice responses, each having a different point value. The response choices consisted of *not at all* (1 point), *to some extent* (2 points), and *a great deal* (3 points). In the final format of the audit used for this research, the items from these

four sets were mixed and placed in random order to minimize recognition of trends in the item contents by the respondents.

Before the audit was formally administered to SBFD members, two captains from the department reviewed it to evaluate the clarity of the statements for each item and response choices. Although both evaluators agreed that the content of the statements was appropriate and understandable, there was a consensus that the wording of the forced-choice responses may be confusing to the respondents when applied to certain statements. For example, item number 6 reads *forecasting and predicting the future is not important here.* Using the given response options, a respondent would have to consider that a response of *not at all* implies that this statement actually is characteristic of the organization.

In order to clarify the intent of each response, the wording of the response options was modified to read *does not describe my organization* (1 point), *describes my organization to some extent* (2 points), *and describes my department very well* (3 points). Although these modifications represent a slight variation from the designer's original wording, the intent was for clarification only and should not change the meaning of the responses or the outcomes of the audit.

Once the response wording was modified and the items placed in random order, they were then transferred to an on-line survey service called *SurveyMonkey.com*. This pay service provided for the distribution of the questionnaire to selected potential respondents through electronic mail (e-mail) and the Internet. The author used the City of San Bernardino e-mail system to invite all members of the department's operations division to participate. A total of 153 requests to take the questionnaire were sent out.

The e-mail sent to each prospective respondent explained the nature of the questionnaire, and provided an Internet link to the questionnaire Internet site, with brief instructions on how to access the questionnaire (see Appendix B). Once on the prospective respondent reached the questionnaire Internet site, they were provided with written instructions on how to proceed through the entire process (see Appendix A). Respondents were required to answer each item before being allowed to submit their responses. The questionnaire was configured through SurveyMonkey.com such that once a respondent completed and submitted a questionnaire, they could not access their questionnaire, or an additional questionnaire, again.

The questionnaire was made accessible to prospective respondents for 28 days, after which access was blocked. From there, the questionnaire responses were downloaded by the author, and placed in an Excel spreadsheet for scoring and analysis.

Scoring for item sets using the 1-3 point system was done by first determining the mean score for each individual audit item. This would give each item a final point value of 1 through 3 based on the responses. The average point values were then totaled in each item set. According to the audit designers, there are specific point ranges for each item set that will indicate how strong the characteristic measured in that set is in the assessed organization. The point ranges and their meanings are outlined in Table 1.

The fifth item set was designed to assess the organization's sensitivity to operations. This item set differed from the other four in that it gave a response choice of agree, or disagree. Scoring for this section was done by counting the number of agree and disagree responses. According to the audit designers, the greater the number of disagree responses, the less sensitive to operations you organizations is likely to be. For the purposes of this research, a score of less than 50% agree responses would suggest a weakness in this area.

Three additional questions were added to the beginning of the audit by the author to obtain general information about the composition of the respondent pool, bringing the total number of items to 50. These additional questions asked for the rank of the respondent, the number of years they had been employed by the SBFD, and which shift they had been assigned to during the previous 12 months or longer.

Table 1

HRO Audit Scoring Criteria for Item Sets Using the 1-3 Point Scoring Criteria.

Total score per item set	Score definition by item set
	Preoccupation with failure
>18	Healthy preoccupation with failure.
18-11	Moderate preoccupation with failure.
<11	Preoccupied with success. Need to focus on failure.
	Reluctance to simplify operations.
>24	Strong potential to avoid simplification.
14-24	Moderate potential to avoid simplification.
<14	Need to improve capabilities to prevent simplification.
	Deference to expertise.
>16	Strong deference to expertise.
10-16	Moderate deference to expertise.
<10	Need to improve deference to expertise.
	Commitment to resilience
>20	Strong commitment to resilience.
12-20	Moderate commitment to resilience.
<12	Need to begin building resilience.

Because the statement regarding shift assignment was intended to identify any trends that may have developed on individual shifts, personnel who had been assigned to a specific shift for less than 12 months were instructed to leave this item blank. The purpose of these questions was to assist in future research to identify potential target groups that may show a specific strength or weakness in HRO characteristics.

The final step in the research was to determine what steps could be taken to strengthen HRO qualities in the SBFD. This was done by evaluating the responses to individual statements used in the HRO audit. Because the statements used for each item reflect characteristics typical of HROs, the responses to the statements provides a mechanism for prioritizing where the department could begin focusing efforts in order to enhance HRO characteristics.

Specifically, a higher number of responses indicating that a statement does not describe the SBFD suggest that a focus on improving this area could strengthen HRO characteristics. Conversely, responses indicating that the statement describes the department very well suggest that the content of the statement represents a stronger characteristic of the organization, and the behavior should be encouraged and continued.

Focus areas were placed into two categories. The first category represented those areas that appear to be the weakest in terms of HRO characteristics. These would represent areas that should be a high priority focus for HRO implementation. For items using the 1-3 point response format, any statement where greater than 50% of the respondents gave a score of 1, indicating that the item did not describe the SBFD, would fall into this category. Therefore, the statement made in that item would provide specific direction for corrective action that would enhance HRO qualities in the SBFD.

For example, item number 39 of the questionnaire stated *we appreciate skeptics*. If the majority of respondents felt that this statement did not describe the SBFD, then it would be considered an indicator that perhaps the department needs to analyze their acceptance of healthy skepticism, and develop a system that encourages it. For items using the agree/disagree format, any item where 50% or fewer of the respondents agreed with the statement would also be considered in the high-priority category.

The second category represented areas that appear to be developing, but that may need further analysis and intervention to strengthen them if the SBFD is going to become a sustainable HRO. For items using the 1-3 point format, any statements where the combined percentage of 1 and 2 responses was greater then 90% of the total responses would fall in this category. Items using the agree/disagree format where less than 75% of the respondents agreed with the statement would also fall in this category.

Assumptions and limitations

According to the authors of the HRO audit used in this research, the audit itself has not been through a formal validation process (K. Weick & K. Sutcliffe, personal communication, May 15, 2006). Therefore, any correlation between the outcomes of the audit and the actual behaviors of members of the SBFD is not guaranteed to be accurate or predictive. However, the audit does identify and focus on specific behaviors typical of HROs. Therefore, it is reasonable to conclude that the application of the audit does produce usable data that can be used to improve HRO characteristics within an organizational structure.

Another possible limitation to the research was the number of respondents to the HRO audit. Although 66% of the members of SBFD's operations division responded, additional responses from the remaining 34% could have resulted in different findings. The degree to which

this limitation will impact the audit outcome is uncertain until the completed audits are analyzed, and even then it will be difficult to quantify a precise impact.

Definitions

Audit: A methodical examination and review (Merriam-Webster's, 2006)

HRO: High Reliability Organization

Item: A single question or exercise on an assessment instrument (Glossary of, 2006).

Item set: A group of items that collectively focus on a specific category or characteristic.

Results

Through a review of the data gathered, and with the supporting information found in the literature review, answers to the specific research items were established. In order to establish a framework for interpreting the data gathered, the first step was to establish a working definition of an HRO.

Defining HROs

As discussed in the literature review, HROs are generally defined by a set of characteristics, philosophies and processes that function to reduce an organization's error rate. Weick and Sutcliffe (2001) encapsulated the primary characteristics of HROs through what they referred to as the five hallmarks of HROs. Collectively, these characteristics produce what they refer to as mindfulness.

Mindfulness has been described as a process of being self-conscious about the human tendency to seek evidence that confirms their desires or expectations about how events will unfold, and avoid evidence that disconfirms it (Weick & Sutcliffe, 2001). At a workshop on high reliability organizations, Sutcliffe further clarified the concept of mindfulness by viewing the

opposite state, which she referred to as *mindlessness* (Weick, Sutcliffe, Saveland, Lahey, Thomas, & Nasiatka, 2004):

> "Mindlessness" is being tuned out, being on autopilot. "Mindful" is being aware of the context, of paying attention in a different way. You STOP concentrating on those things that confirm your hunches, are pleasant, feel certain, seem factual, and explicit, *-and that others agree on*. You START concentrating on things that disconfirm, are unpleasant, feel uncertain, seem possible, are implicit, - *and are contested* (p. 17).

The five hallmarks of HROs that Weick and Sutcliffe's (2001) state produce mindfulness include a preoccupation with failure, a reluctance to simplify, sensitivity to operations, a commitment to resilience, and deference to expertise. Each of these elements are described in detail in the literature review.

Using these five hallmarks of HROs as the foundation of a working definition for this research is important, as the HRO audit focuses specifically on these areas. It is also important, however, to recognize HRO characteristic as defined through the findings of other HRO researchers as well.

Libuser (1995) summarized findings from her HRO research in a framework of 10 primary elements of HROs. These elements include process auditing, avoiding quality degradation, rewards systems, perception of risk, and command and control.

Table 2

Libuser's (1995) Identification of Basic HRO Elements.

HRO Element	Definition
Process auditing	An established system for ongoing checks designed to spot expected as well as unexpected problems.
Reward system	The payoff an individual or organization receives for behaving one way or another
Avoiding quality Degradation	Avoiding degradation of quality and/or avoiding developing inferior quality. Refers to the essential quality of the system as compared to the referent generally regarded as the standard of quality.
Perception of risk	Whether or not there is knowledge of risk, and if there is knowledge that risk exists, the extent to which it is acknowledged and appropriately mitigated.
Command and control (Five elements)	1. Migrating decision-making: The person with the most expertise makes the decision. 2. Training: Appropriate, consistent and realistic. 3. Redundancy: Back-up systems that are dissimilar, but complementary. 4. Senior managers who see the big picture: High trust in subordinates. They don't micromanage. 5. Formal rules and procedures: Clear structure for processes and expectations.

The element of command and control also contains five sub-elements including migrating decision-making, training, redundancy, formal rules and regulations, and managers who see the big picture. Brief descriptions of these elements are contained in Table 2.

Although Libuser's (1995) definition appears to have slight variations from Weick and Sutcliffe's (2001) analysis, the research found that fundamentally, the definitions complement and build upon each other. Collectively, the definitions establish a common understanding of HRO concepts that was found in nearly all of the HRO literature reviewed through this research. A comparison of the models suggests that neither model introduces substantive changes from the other.

Table 3

Comparison of Weick & Sutcliffe's (2001) Five Hallmarks of HROs with Libuser's (1995) Elements of HROs.

Weick & Sutcliffe's five hallmarks of HROs	Corresponding HRO elements from Libuser
Preoccupation with failure	Perception of risk
Reluctance to simplify	Process auditing
Sensitivity to operations	Avoiding quality degradation. Senior managers who see the big picture. Reward systems. Formal rules and procedures.
Commitment to resilience	Redundancy. Training.
Deference to expertise	Migrating decision-making

Table 3 offers a side-by-side comparison of the two models that shows their conceptual similarities. Based on this analysis of HRO definitions, the five hallmarks of HROs as developed by Weick and Sutcliffe (2001) appear to be a solid definition to use in determining SBFD's strengths and weakness in HRO characteristics as they offer a common, comprehensive view of HRO fundamentals.

Identification of HRO strengths in the SBFD

As identified in the procedures section, Weick and Sutcliffe's organizational audit was distributed to all members of the SBFD operations section to determine areas of strength in relation to the five hallmarks of HROs.

Table 4

Results of SBFD HRO Audit.

HRO Element	SBFD Score	Score range and definition
Commitment to resilience	22.2	>20 = Strong commitment to resilience.
Sensitivity to operations	68.7% agree responses	Higher percentages of agree answers indicates a higher sensitivity to operations
Preoccupation with failure	18.1	>18 = healthy preoccupation with failure.
Deference to expertise	16.9	>16 = Strong deference to expertise
Reluctance to simplify	22.2	Between 14 and 24 = Potential to avoid simplification is moderate.

The audit questionnaire was distributed to a total of 153 members of the SBFD. Of those, 105 were at least partially completed and submitted back to the author, 101 of which contained enough information to be used in the research. The results of the audit are shown in Table 4 (see Appendix A for detailed breakdown of results).

According to the audit results, SBFD showed strength in the areas of commitment to resilience, preoccupation with failure, and deference to expertise. Of these three elements, the strongest appeared to be commitment to resilience. Some of the highest scoring statements were found in this category. As Table 5 shows, four of the ten statements in the commitment to resilience category received 90% or more 2 and 3 point responses. This would indicate that 90% or more of the respondents felt that the statement described the SBFD very well, or to some extent.

Table 5

Statements Regarding the SBFD's Commitment to Resilience where 90% or More of the Point Scores were in the Response Category of 2 (describes the department to some extent), or 3 (describes the department very well).

Item #	Statement	% of responses receiving a point score of 2 or 3
40	People are able to rely on others.	92%
38	People learn from their mistakes.	94%
34	People have a number of informal contacts that they sometimes use to solve problems.	91%
26	People around here are known for their ability to use their knowledge in novel ways.	90%

Although the scores for the elements of preoccupation with failure and deference to expertise also indicate strength in these areas, it should be noted that each one scored on the lowest threshold of the scoring rage for those elements. Nonetheless, there were areas within these categories that showed notable strengths based on responses to certain statements.

In the area of preoccupation with failure, 90% of the respondents felt that the statement *we treat near misses and errors as information about the health of our system and try to learn from them* (item 12) described the SBFD very well or at least to some extent. In the area of deference to expertise, 97% of the respondents felt that the statement *People are committed to doing their job well* (item 7) described the SBFD very well or at least to some extent. This statement also received the highest percentage of 2 any 3 point responses of any statement in the audit. Also in the area of deference to expertise, 94% of the respondents felt that the statement *if something out of the ordinary happens people know who has the expertise to respond* (item 15) described SBFD very well or to some extent.

Identification of HRO weaknesses in the SBFD

The audit used in the research did not indicate that the SBFD had any substantial weaknesses in relation to any of the five hallmarks of HROs. However, in the area of reluctance to simplify, the department received a score of 22.2. A score in this range indicates that as an organization, there may be the potential for members to simplify interpretations of events that could be addressed more effectively through a more complex approach. Although this score does not suggest a strong propensity of oversimplification, the moderate level score suggests that it is an area to be particularly vigilant in to avoid further degradation.

A second area that was not necessarily identified as being substantially weak, but worthy of attention was the SBFD's sensitivity to operations. In this category, the audit showed that

68.7% of the respondents agreed with the statements in this section. According to Weick and Sutcliffe (2001) scoring criteria, the greater the number of agreeing responses, the more sensitive to operations the organization is. High scores in this area suggest that an organization is more likely to catch small errors before they are allowed to accumulate into a larger chain of errors. The score of 68.7% from the SBFD audit suggests that although the SBFD may not be deficient in this area, the organization would likely benefit by focusing on this area in order to improve their sensitivity to operations.

Specific focus areas for improving the SBFD as an HRO

Responses from specific statements used in the HRO audit showed four statements that met the criteria described in the procedures section to be categorized as a high-priority focus area. These statements and the percent of respondents that did not agree with the statement, or did not feel that the statement described the SBFD are shown in Table 6.

The nature of each of these statements provided direction that the SBFD could take in order to strengthen HRO characteristics. The statements *we appreciate skeptics* (item 39) and *people are always looking for feedback about things that aren't going right* (item 47) show a common theme in that they all suggest that the SBFD may benefit by emphasizing the value of honest feedback from department members, even when the feedback may include bad news. Attention to these areas could improve SBFD performance in the areas of reluctance to simplify (item 39) and sensitivity to operations (item 47).

Table 6

Low Scoring HRO Characteristics Categorized as High-Priority Focus Areas for the SBFD

Item #	Statement	% of responses that did not feel statement represented SBFD	% of responses the disagreed with statement
36	People are rewarded if they spot problems mistakes errors or failures.	56%	
39	We appreciate skeptics.	55%	
47	People are always looking for feedback about things that aren't going right.		50%
50	Managers constantly monitor workloads and are able to obtain additional resources if the workload starts to become excessive.		50%

The responses from the statement *people are rewarded if they spot problems, mistakes, or errors* (item 36) suggest that rewarding honest feedback from department members could improve the quality and accuracy of information exchanges. Improvement in this area would improve SBFD's overall score in the area of preoccupation with failure.

The responses to the statement *managers constantly monitor workloads and are able to obtain additional resources if the workload starts to become excessive* (item 50) indicated that the SBFD might not be sensitive enough to the workload placed on department personnel. In addition, the responses suggest that personnel are not getting the resources necessary to

effectively deal with the workload. By monitoring the amount and distribution of work, and the availability of resources needed to accomplish it, the SBFD would likely realize improvements in the area to sensitivity to operations.

In addition to the high-priority category, the research also identified areas where further analysis and possible intervention should be considered in order to move closer to becoming a sustainable high reliability organization. Using the criteria described in the procedures section, nine statements were identified that would fit in this category. It should be noted that the criteria for the high-priority category would, by default, also fit the numerical criteria for this category. Because these statements were already listed in the high-priority category, they were not included as part of these nine.

Six of the statements in this category used the 1-3 point scoring system. These statements, along with the combined percentage of 2 and 3 point responses are shown in Table 7. The remaining three statements used the agree/disagree format, which was used to assess the area of sensitivity to operations. As described in the procedures section of this document, if fewer then 75% of the respondents agreed with the statement, it would fall in the category of needing further analysis and intervention. These statements, along with the percentage of agree responses are shown in Table 8.

A significant finding here was that four of the nine statements in this category (items 21, 25, 29, and 37) were based on the HRO concept of reluctance to simplify. This same element was also identified as one of the weaker HRO areas in the SBFD. The pattern of scores in this area suggests that members of the SBFD might have a tendency to accept or act on assumptions, ignore disconfirming evidence, or put too much emphasis on what they perceive to be the predictable outcome of events.

The responses to the statement *people are inclined to report mistakes that have significant consequences even if nobody notices* (item 24) offered additional evidence that supports the need for the SBFD to encourage and reward those who will bring unpleasant or unpopular information or observations. Attention to this area could improve SBFD's overall score in the area of preoccupation with failure.

The statement *if something unexpected occurs the most highly qualified people regardless of rank make the decision* (item 27) referred to the HRO area of deference to expertise. The responses to this statement indicate that the SBFD may benefit by placing less emphasis on rank, and more on capabilities and experience when complex decisions need to be made. Although the department's overall score in this area indicated a strong deference to expertise, the score was only one point away from falling into the next lower category. Therefore, it appears that this area should be considered for further analysis and possible intervention.

The three remaining statements with scores suggesting a need for further analysis and possible intervention came from the area of sensitivity to operations (agree/disagree format). This included items 43, 45, and 46 (see Table 8). Collectively, these responses suggest that there might not be a sufficient level of contact between managers in the organization and operations occurring at the field level. HRO research suggests that deficiencies such as these can create an environment where latent errors can build and eventually manifest in a catastrophic manner.

Table 7.

Statements where 90% or More of the Response Were Either 1 (does not describe my department) or 2 (describes the department to some extent).

Item #	Statement	% of responses receiving a score of 1 or 2
21	People generally prolong their analysis to better grasp the nature of the problems that come up	92%
24	People are inclined to report mistakes that have significant consequences even if nobody notices.	90%
25	People are encouraged to express different views of the world.	90%
27	If something unexpected occurs, the most highly qualified people regardless of rank make the decision.	94%
29	People listen carefully; it is rare that anyone's view is dismissed.	93%
37	When something unexpected happens people are more concerned with listening and conducting a complete analysis of the situation rather than with advocating their view.	92%

Table 8

Statements where Less Than 75% of the Respondents Agreed with the Statement, Suggesting a Need for Further Analysis and Possible Intervention by the SBFD in This Area.

Item #	Statement	Agree responses <75% of total
43	On a day-to-day basis, there is an ongoing presence of someone who is paying attention to what is happening and is readily available for consultation if something unexpected arises.	71%
45	Supervisors readily pitch in whenever necessary.	70%
46	During an average day people come into enough contact with each other to build a clear picture of the current situation.	65%

Discussion

Analysis of the data collected offered insight into several areas that may help the SBFD strengthen HRO characteristics in the organization. The research suggests that by doing so, the SBFD will likely experience safer, and more efficient emergency and non-emergency operations. The research also suggests that there are steps that the SBFD could take to respond more effectively when faced with unexpected events such as those mentioned in the background and significance section.

There are distinct similarities between the nature of operations that are typical in the SBFD, and the nature of the operations described in the organizations that HRO researchers focused their early studies on. Examples of such organizations found through the literature

review include military aircraft carriers (Rochlin, LaPorte, & Roberts, 1998, Weick & Roberts, 1993), nuclear power plants (Weick & Sutcliffe, 2001, Pool R, 1997), commercial air traffic controllers (Roberts, 1990), healthcare units (Roberts, Madison, Desai, & van Stralin, 2005), wildland firefighting (Weick, Sutcliffe, Saveland, Lahey, Thomas, & Nasiatka, 2004), and commanding large scale emergency incidents (Bigley & Roberts, 2001).

The common thread to the operations that these types of organizations perform and the operations performed by the SBFD is that failures, even small ones, can have catastrophic results. Inherently, however, simply operating in this type of environment by no means suggests that the organization is an HRO. According to Weick and Sutcliffe (2001), what sets HROs apart is what is that they are *mindful* of weak signals pointing to possible failures in the system, and prepare their organization to effectively manage the unexpected events that the failures could cause.

This is an important factor to consider, particularly when put in the context of incidents where firefighters were either seriously injured or killed. One only needs to review any number of after action reports involving firefighter fatalities to see that an overwhelming number of them reportedly occurred suddenly and unexpectedly. Upon deeper analysis, however, the subtle indicators that catastrophe was about to happen can usually be identified. As Reason's (2000) Swiss cheese analogy would describe it, the holes were always there; they simply lined up and resulted in a negative outcome. HROs obsess about the holes.

Based on the results of the HRO audit, it appears that as an organization, the SBFD possesses several of the traits typical of an HRO. In particular, the SBFD showed strength in the area of commitment to resilience. In one perspective, this would appear to be a correct observation of the SBFD. An important piece of resilience was identified by Grabowski &

Roberts (1997) as the ability to make use of multiple organizational structures, and allowing the system to effectively adjust to fast-pace changes in the operational environment. An example of this can be found through the SBFD's use of the Incident Command System (ICS) on all emergency incidents where multiple resources must operate. Roberts and Bea (2001) identified the ICS as a strong tool for promoting the type of flexibility needed for organizational resilience. Furthermore, the type and level of flexibility that the ICS affords contributes to the ability of SBFD members to effectively respond to events where standard rule and tactics may not apply.

In another sense, however, the SBFD's approach to planning for large-scale incidents may seem to go against some of the basic elements of a commitment to resilience. Specifically, the SBFD has historically placed emphasis on pre-incident planning to a level that often identifies detailed strategies and tactics, and pre-designated assignments for a number of scenarios. It is not surprising then to see 67% of the audit respondents stated that they felt that forecasting and predicting the future (item #6) describes the SBFD very well or to some degree. However, as Weick and Sutcliffe (2001) point out, it is nearly impossible to identify and pre-plan for all the possible permutations of how an event can unfold. Therefore, although pre-incident planning is an integral part of preparedness, it may actually be counterproductive to put too much emphasis on very detailed or inflexable pre-defined operations.

Another area of strength for the SBFD involved their preoccupation with failure. Although the audit score in this area was only slightly over the threshold from being considered a moderate trait, the implications are that it is a positive point for the department to build upon. Some of the strongest scores came from statements that referenced a general practice using operational errors as a foundation for organizational learning (items 8, 12 and 16).

This is not surprising, as the department emphasizes post-incident critiques for both large and small incidents. In 2005, the SBFD instituted a policy for establishing an Incident Review Team (IRT) to investigate and report in writing the findings surrounding any incident where unexpected events imperiled SBFD members during operations. As discussed in the literature review, this practice of post incident analysis is what Reason (2000) described as a key element of establishing a culture of safety in an organization.

Even with SBFD's strengths in the area of preoccupation with failure, one area of concern came from the responses to audit item number 24. Here, 41% of the respondents felt that the statement *People are inclined to report mistakes that have significant consequences even if nobody notices* did not describe the SBFD. Although determining the basis for this opinion was not within the scope of this research, one possible reason could be that personnel feel intimidated, or fear some kind of retribution if they report an error. It would appear that this could be a common impediment to effective reporting. Recognizing this, the National Firefighter Near-Miss Reporting System model (National Firefighter, 2006) emphasizes the need for a strict non-punitive approach to receiving reports of errors in order to encourage involved parties to be completely candid about the details of near miss events.

Another area that was identified as a strength, but was on the lower threshold of the strong scoring range, was deference to expertise. As Roberts, Yu, & van Stralen (2003) describe this trait, a strong deference to expertise ensures that a person of rank, but no experience, does not become the decision maker. When viewed this way, deferring to the expert would not be considered a traditional practice of a fire department, primarily because of the fire service's perceived paramilitary structure.

Even so, SBFD's high score in this area could be a result of the department's compliance to State and Federal requirements that people who hold emergency incident management positions go through a specific qualification process, which includes demonstrating competency on actual incidents. Because this widely used system emphasizes experience and training over rank, it may also create a wider acceptance of the concept of deferring to expertise throughout the fire service.

Although areas of strength must be identified and nurtured in order to maintain strong HRO characteristics, the research also identified weaker areas to which SBFD should give strong consideration. One such area that was revealed by the audit was a propensity toward simplifying interpretations. The SBFD's score of 22.2 in this area identifies a moderate willingness to simplify. Although this does not appear to be a substantial downfall for the SBFD, there are areas of insight within the specific responses to audit items relating to the organization's tolerance to simplifying interpretations that are worthy of note.

Weick and Sutcliffe (2001) identify some of the desirable traits of an organization that is reluctant to simplify interpretations as one that encourages divergence in viewpoints, makes fewer assumptions, and values the input of skeptics without regard to their position in the organizational hierarchy. Based on the responses to some of the audit items, these appear to be underdeveloped traits of the SBFD. The most dramatic example of this came from the audit item number 39, which stated *we appreciate skeptics*. Here, only 3% of the respondents felt that the statement described the SBFD very well, which was the lowest percentage of any response in the audit. This evidence suggests that the culture in the SBFD is to seek confirming evidence that operations are moving in a desirable or expected direction, and to shun or rationalize away disconfirming evidence and those who provide it.

There are similarities in some of the visible evidence of SBFD's tendency toward simplification, and what was found in the analysis of the space shuttle Colombia disaster. As noted in the literature review, the frequency of foam strikes during past space shuttle flights led to a simplified belief that these were normal events. Therefore, when the foam strike that was eventually identified as a primary causal factor in the Colombia crash was first noticed, it was viewed as inconsequential.

Similarly, in the report of SBFD's Temple Incident (Drasil, Husted, & Parker, 2006) that was discussed in the Background and Significance section of this document, several key indicators of unique and extreme hazards were also noticed, but rationalized away. In this case, what appeared to be a typical structure fire was actually only a partially standing remnant of a structure that was ready to collapse. The report summarizes the findings in this area.

> Most of the personnel interviewed were not aware that they were responding to an explosion, and some of the signs went unnoticed:
>
> 1. It was stated in the dispatch that there was an explosion, but most personnel did not hear this due to the noise level in the station and poor sound quality of the speaker system.
> 2. There was debris in the street such as blown in insulation, but because it was dark and crews were accustomed to seeing trash and debris in area streets, this went unnoticed.
> 3. The garage door was lying on the hood of a car in the driveway, but because crews were accustomed to seeing houses in various stages of disrepair, this also went unnoticed. (pg. 3)

It does not seem unreasonable that crews responding to the Temple incident could miss clues that were not put into perspective until after the incident. However, the research suggests that if the SBFD were to work toward a culture that values healthy skepticism and input from different viewpoints, subtle clues such as those found on the Temple incident would take on a new significance that could contribute to safer operations and outcomes in the future.

Another area identified by the research where the SBFD should consider further analysis involves reward systems. Evidence of this was found in the responses to audit item number 36, which read *people are rewarded if they spot problems, mistakes, errors, or failures*. Fifty-six percent of the respondents felt that that this statement did not describe the SBFD, which was the highest number of this type of response in the audit.

Findings in the literature review identified effective reward systems as a key element in an HRO (Weick & Sutcliffe, 2001, Roberts & Libuser, 1993). This includes positive incentives for those who will bring bad news forward. The strong response to this concept in the SBFD audit indicates that there is either a lack of incentive for bringing problems forward, or a specific disincentive that leave personnel fearful of a real or perceived negative outcome from doing so.

Formally, there are no policies that would preclude or discourage SBFD personnel from bringing problems or errors forward. Furthermore, there is no evidence that any members of the SBFD have ever had formal adverse action taken against them for exposing problems or errors. Therefore, it seems more likely that the reluctance to openly identify problems is grounded in the informal part of the organizational culture. As such, it may be difficult to identify its sources and effectively modify the beliefs.

As with many practices that stem from an organization's culture, there are likely elements of perceived expectations, peer pressure, and self-perception that contribute to an individual's

choice of behaviors. These powerful motivators are capable of driving behaviors against the established expectations. To be effective in getting members to be candid about observed or committed errors, SBFD leaders will need to provide vivid and consistent evidence that error recognition and exposure is highly valued in the organization. Success in this area would likely expose the type of latent errors that Ramanujam & Goodman (2003) describe as contributing factors to extreme adverse consequences. Clearly, the potential benefits of opening up this type of information exchange is worthy of further research and intervention by the SBFD.

As noted in the procedures section, one of the potential limitations of the audit instrument was the fact that only 66% of personnel in SBFD's operations division chose to participate. However, in analyzing the outcome of the audit, it does not appear that the participation of the remaining 34% would have had a substantial impact. In the agree/disagree responses for example, the number of agree responses to statements determined in the findings to be high-priority focus areas fell more than 2 standard deviations below the mean of all agree responses combined. Similarly, for items using the 1-3 point system, statements considered high priority focus areas had less than 9% of the respondents indicating that the statement described the SBFD. Even in the unlikely event that all 34% of those who did not participate in the audit would have given answers opposing the trends identified; there would still be evidence that the same areas may be deficient, although not to the degree identified in the research findings.

Recommendations

The findings of this applied research project suggest that the SBFD could enhance the efficiency and safety of emergency operations by implementing HRO concepts into its organizational structure and culture. There is also evidence that applying HRO principles to non-emergency functions could result in more effective service delivery to the community, as well as

more effective use of the resources that are allocated to the SBFD to deliver those services. Each of these represent positive steps toward making the SBFD a highly efficient asset to the community it serves, while actively providing a safe and rewarding work environment for its employees. To that end, several recommendations should be considered, based on the findings of this research.

1. As an organization, the SBFD should look for ways to integrate HRO concepts into its operating environment. To do this, key leaders in the organization (chief officers, administrative captains) need to receive training in HRO theory, its background, and its successes in operational environments similar to those of the SBFD. The findings of this research should be shared with those in key leadership positions as part of a training and implementation process in order to establish a starting point for maintaining strengths, and refining areas that are still developing.
2. Once key leaders are comfortable with HRO concepts, training should take place at all levels of the organization. This should include new recruit orientation, department sponsored officer academies, and general department-wide training. Because HRO implementation in the SBFD will likely require the need for cultural changes in certain areas, it is important that the key leaders in the organization take an active role in presenting the training. Training should include extensive explanation of HRO concepts, its applications, its successes, and how the model will look in the SBFD specifically. As part of the training, department personnel should be exposed to the findings of this research. This will likely provide some motivation, as the department can see that they have already developed some of the hallmarks of HROs. Even so, the leaders of SBFD must exercise patience, as some of the changes will likely challenge long held beliefs and practices of the SBFD.

3. The SBFD should recognize and encourage HRO behaviors and practices that appear to be well developed in the organization. Several organizational strengths were identified through the HRO audit. These included member's ability to rely on others, making effective use of multiple informal contacts, and the ability of SBFD personnel to use their skills and knowledge in novel ways. This is an encouraging finding that offers a good foundation to further develop the SBFD as an HRO. SBFD leaders should also recognize and encourage developing areas of HRO as identified in this research as well so that they continue to improve. To do otherwise would likely lead to complacency, which would be contrary to the goals of HRO.
4. The SBFD should continue emphasizing the value of near-miss events. The department's establishment of the incident review teams (IRT) is a good example of a tool that uses recognized failures as a mechanism of organizational learning. Currently, this system is primarily used for events of significant size and loss potential. To enhance this learning process further, the department may consider expanding the program, or similar programs, to document errors on smaller scale incidents as well.
5. The SBFD should develop and implement a formal reward system that includes encouraging personnel to speak up when they discover errors or potential errors. This system should be developed with input from leaders of both labor and management groups. Including this input would promote a common understanding of what the target behaviors are, and which rewards are most valued by personnel in the different factions of the department. This may also instill more trust in the system as programs that are sanctioned by the labor leaders tend to be accepted more readily by SBFD members. A high level of trust will be critical for this reward

system, as personnel must be confident that there will not be any negative repercussions for bringing potentially bad news forward.

6. The SBFD should try to encourage acceptance of diverse thinking in order to guard against simplifying interpretations. This will be a challenging task, as it will require a great deal of organizational maturity, and a strong understanding of organizational dynamics. To accomplish this, SBFD leaders should first emphasize ongoing training on organizational leadership that focuses on the value of accepting and using input from diverse sources. This should begin with chief and company officers, and eventually be given all department members and recruits. Although this type of training is a necessary first step, it will not, by itself, cause diverse input regarding organizational issues to become a deeply held value. This can only be done through the SBFD's leaders modeling the way, and making sure that the content of the training is clearly visible in daily operations.
7. Whenever possible, the SBFD should defer decisions to those who have the most experience and knowledge about the issue at hand. Although this practice is typical in the incident command system used by SBFD during emergency incidents, the responses to the audit indicate that the department may not be taking full advantage of this concept. As service expectations of the SBFD continue to broaden, it is unrealistic to believe that a single commanding officer can have the expertise needed to address all the possible scenarios that they could be faced with. Furthermore, the depth of knowledge and experience spread throughout the ranks of the SBFD is a tremendous resource for both emergency and non-emergency decision-making scenarios. If properly used, these resources could help provide for more effective and dynamic decisions. Expanding decision making to include those with specific knowledge or experience should be practiced and encouraged by SBFD leaders. The

practice of limiting decision making input based on rank or organizational position should be discouraged.

8. SBFD leaders should advocate and support an environment where skeptical views of operations are allowed and encouraged. This is, however, an area that requires a balance between evaluating the merit of dissenting points of view, and keeping emergency decisions timely. The key to success here will likely be on how skeptical views are either used to modify operational plans, or dismissed in favor of leaving the plan as it is. Either option may be appropriate depending on the situation. However, the approach must be somewhat structured to ensure continuity, and to clarify what SBFD members may expect if they suggest that there is a flaw in the current plan. Such a structure should be placed in the format of a standard operating procedure (SOP) so that is accessible, and carries the weight of a policy. When approached with a dissenting view, incident managers must ensure that they listen thoroughly, and provide feedback, either for or against the alternative view, in a professional and respectful manner. To do otherwise will likely result in personnel feeling apprehensive about advocating their views in the future.
9. SBFD managers need to monitor the workload of department personnel closely. Efforts should be made to alter or redistribute workloads when they begin to overwhelm a workgroup's (station, division, etc.) ability to remain productive and attentive to operations. Based on the results of the HRO audit, there is a strong feeling among department personnel that managers do not give enough consideration to the amount and type of work that personnel are tasked with. Given the nature of emergency operations, adjusting workloads can be very challenging. However, careful analysis and creative resource use can go a long way toward keeping the workload at an effective pace, without compromising standards.

Being alert to the impact of increasing workloads and making timely adjustments is a key piece to improving the SBFD's sensitivity to operations.

10. Pre-incident planning should focus on broad objectives and ways to adapt to unexpected events, not attempt to eliminate them. The goal of an HRO is not to eliminate errors or unexpected events. HROs understand that it is impossible to predict and prepare for every potential outcome of an emergency incident. Therefore, SBFD's practice of pre-planning detailed strategies and tactics should be modified to emphasize flexibility in applying strategy and tactics. This would allow for rapid and effective adjustments to be made during rapidly changing environments. Doing so promotes resiliency when unexpected events occur.

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APPENDIX A

SAMPLE OF HRO AUDIT DELIVERED TO SBFD PERSONNEL WITH SUMMARY OF RESULTS

The following is a list, by item number, of the items in the HRO survey used in this research. The left column contains abbreviations for each HRO category. Each category is defined by three letter designators, which are defined below. This information was not shown to the respondents when they completed the audit.

HRO category definitions:

POF = Preoccupation with failure

RTS = Reluctance to Simplify

STO = Sensitivity to operations

CTR = Commitment to resilience

DTE = Deference to expertise.

INSTRUCTIONS:
The survey you are about to take consists of 50 questions in a multiple-choice format. It should only take about 10 minutes to complete. It is designed to collect your opinions regarding department operations at all levels. Therefore, there are no right or wrong answers, and you should answer based on your personal observations and experiences. The responses are completely anonymous. Although the responses will be broken down by rank, years on the job, and shift for specific analysis, individual responses are not the focus, and will not be evaluated as such.

The layout is a simple “click on your response” format, and the program will walk you through until you have completed all the questions. After you have completed the last question, click on “Submit”, and you’re done!

Thank you for taking the time to participate in this survey. The results will be available for those who wish to see them when the research is completed.

HRO Category	Survey Item #		
	1	What is your current rank?	
			Response Total
		Chief Officer	9
		Captain	30
		Engineer	23
		Paramedic/Firefighter	24
		Firefighter	19
		Total Respondents	105
		(skipped this item)	0
	2	How many years have you been with SBFD?	
			Response Total
		<1	3
		1-5	19
		6-10	19
		11-15	18
		16-20	18
		21-25	16
		26-30	12
		Total Respondents	105
		(skipped this item)	0
	3	Indicate which shift you are assigned to ONLY IF YOU HAVE BEEN ON THAT SHIFT FOR THE LAST 12 MONTHS OR MORE. Otherwise leave blank.	
			Response Total

		A	27
		B	24
		C	40
		Total Respondents	91
		(skipped this item)	14
POF	4	We focus more on our failures than our successes.	
RTS	5	People around here take nothing for granted.	
CTR	6	Forecasting and predicting the future is not important here.	
DTE	7	People are committed to doing their job well.	
POF	8	We regard close calls and near misses as a kind of failure that reveals potential danger rather than as evidence of our success and ability to avoid disaster.	
RTS	9	Questioning is encouraged.	
CTR	10	Resources are continually devoted to training and retraining people on the properties of the technical system.	
DTE	11	People respect the nature of one another's job activities.	
POF	12	We treat near misses and errors as information about the health of our system and try to learn from them.	
RTS	13	We strive to challenge status quo.	
CTR	14	People have more than enough training and experience for the kind of work they have to do.	

DTE	15	If something out of the ordinary happens people know who has the expertise to respond.	
POF	16	We often update our procedures after experiencing a close call or near miss to incorporate our new experience and enriched understanding.	
RTS	17	People in this organization feel free to bring up problems and tough issues.	
CTR	18	This organization is actively concerned with developing people's skills and knowlege.	
DTE	19	People in this organization value expertise and experience over hierarchical rank.	
POF	20	We make it hard for people to hide mistakes of any kind.	
RTS	21	People generally prolong their analysis to better grasp the nature of the problems that come up	
CTR	22	This organization encourages challenging assignments.	
DTE	23	In this organization the people most qualified to make decisions make them.	
POF	24	People are inclined to report mistakes that have significant consequences even if nobody notices.	
RTS	25	People are encouraged to express different views of the world.	
CTR	26	People around here are known for their ability to use their knowledge in novel ways.	

DTE	27	If something unexpected occurs the most highly qualified people regardless of rank make the decision.	
POF	28	Managers seek out and report bad news.	
RTS	29	People listen carefully; it is rare that anyone's view is dismissed.	
CTR	30	There is a concern with building people's competence and response repertoires.	
DTE	31	People typically "own" a problem until it is resolved.	
RTS	33	People are not shot down for surfacing information that could interrupt operations.	
CTR	34	People have a number of informal contacts that they sometimes use to solve problems.	
DTE	35	It is generally easy for us to obtain expert assistance when something comes up that we don't know how to handle.	
POF	36	People are rewarded if they spot problems mistakes errors or failures.	
RTS	37	When something unexpected happens people are more concerned with listening and conducting a complete analysis of the situation rather than with advocating their view.	
CTR	38	People learn from their mistakes	
RTS	39	We appreciate skeptics.	
CTR	40	People are able to rely on others.	
RTS	41	People demonstrate trust for each other.	
RTS	42	People show a great deal of mutual respect for each other.	

STO	43	On a day-to-day basis there is an ongoing presence of someone who is paying attention to what is happening and is readily available for consultation if something unexpected arises.	
STO	44	Should problems occur someone with the authority to act is always accessible and available especially to people on the front lines.	
STO	45	Supervisors readily pitch in whenever necessary.	
STO	46	During an average day people come into enough contact with each other to build a clear picture of the current situation.	
STO	47	People are always looking for feedback about things that aren't going right.	
STO	48	People are familiar with operations beyond one's own job.	
STO	49	We have access to resources if unexpected surprises crop up.	
STO	50	Managers constantly monitor workloads and are able to obtain additional resources if the workload starts to become excessive.	

APPENDIX B

E-MAIL INVITATION TO PARTICIPATE IN THE HRO AUDIT

From: Fratus_Ma

Sent: Wed 7/26/2006 4:40 PM

To: Members of the SBFD Suppression Division

Cc:

Subject: Why DON'T we have more accidents??

Every day in the SBFD, there are a hundred opportunities to get someone hurt, or damage equipment. Every wonder why we manage to stay safe in spite of these odds?

We've asked this question in training before, and the answers range from good training, to experienced people, to just plain LUCK.

It's possible that it could be a combination of these. However, there has been a great deal of research on high-risk organizations like ours that have hundreds of opportunities for failure, but their failure rate is impressively low compared to others in the same line of work. This is a chance to see if the SBFD shares some of the characteristics of these "reliable" organizations. BUT IT WILL TAKE SOME INPUT FROM ALL OF YOU.

The link below will take you to an Internet based survey that was designed at the University of Michigan. Its purpose is to assess an organization's strengths in maintaining safe, reliable operations. It only takes about 10-12 minutes to complete, and I think the information we extract from it will be useful in guiding our operations, particularly as they relate to safety practices. The data extracted will be put in a report that will be submitted to the National Fire Academy.

I'd really appreciate it if you could take just a few minutes to fill this out. It is completely anonymous.

Click on this link <http://www.surveymonkey.com/s.asp?u=897602339917> to get to the survey.

Instructions are provided, and when you're done, just click "Submit". After you click "submit", you will be able to see a summary of the survey results thus far.

I'd like to get the responses in by August 21, 2006.
IF YOU DO NOT HAVE INTERNET ACCESS, please have your captain, or someone else who has access, log you on.
Captains, if you have your entire crew fill it out, and maybe discuss some of the questions afterwards, you can log the time for training.

Thanks in advance for your time on this.

Mat