ROADMAP TO THE IMPLEMENTATION OF BEST PRACTICES IN HUMAN FACTORS VOLUNTARY REPORTING FOR SAFETY

A thesis

submitted by

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In partial fulfillment of the requirements

for the degree of

Master of Science

in

Human Factors Engineering

TUFTS UNIVERSITY

May 2015

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Abstract

Federal agencies responsible for defining standards in high-risk industries (such as aviation, rail, and healthcare) promote voluntary reporting of personally committed errors and violations as a way to meet safety management system requirements. Although voluntary reporting systems are valuable tools for uncovering error causal factors, they are often underutilized. This thesis identified barriers and facilitators to effective voluntary reporting practices through a literature review and interviews with industry professionals. Identified barriers include insufficient organizational commitment to safety culture, lack of user trust in voluntary reporting systems and in management, unclear system policy and procedure definition, inadequate training techniques, and ineffective use of voluntary reports to implement meaningful solutions.

Following the identification of these barriers, a questionnaire was distributed to test for statistically significant variations in reporting perceptions between system users and management. Responses from 30 mechanics and 27 managers revealed vast underreporting of reportable events and significant discrepancies in reporting perceptions based on age, work experience, and familiarity with voluntary reporting systems. Results also showed inconsistent views of justification for non-reporting. These findings were used to quantify the relative magnitudes of the identified barriers and to offer recommendations for minimizing their effect on voluntary reporting.

Acknowledgements

I would like to sincerely thank all of those who have supported me both personally and professionally throughout my three years in this program. Thank you to my colleagues in the Flight Safety and Reliability group at GE Aviation for enthusiastically supporting my thesis efforts and connecting me with professionals throughout the industry who provided invaluable insights.

Thank you to Thomas James for your support of this project and for your valuable recommendations with regard to the writing process. Thank you to my advisor, Dan Hannon, for sparking my interest in Human Factors as an undergraduate and for guiding me through an exciting and fulfilling three years in this Master's program. You taught me to think from a Human Factors perspective and inspired me to tackle an open-ended thesis problem – the element of uncertainty made the experience that much more rewarding.

Thank you to Kurt Rever - my colleague, mentor, and friend - for your unwavering support and guidance with regard to both my education and my career. Your passion for Human Factors is not only inspiring, but also contagious. Your kindness, encouragement, and care for your colleagues are more appreciated than you know.

And finally, thank you to my wonderful friends and family for your steadfast love and support. LG, thank you for your endless compassion, patience, and selflessness over the course of the last year. You kept a smile on my face even on the toughest days, and your faith in me motivated me to reach each

milestone. And finally, to my parents – my proofreading team, my biggest fans, my best friends – thank you for inspiring me to pursue engineering and unknowingly instilling in me a love of psychology. Thank you for the stimulating late night discussions about my research, the many much needed pep talks, and the constant shoulder to lean on. I could never adequately thank you for all of the sacrifices you've made for my education, but I hope you know how truly appreciative I am. Your love and belief in me has always been my greatest motivator. I couldn't have done this without you.

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ROADMAP TO THE IMPLEMENTATION OF BEST PRACTICES IN HUMAN FACTORS VOLUNTARY REPORTING FOR SAFETY

1. Introduction

A growing concern in high-risk industries is the potentially significant cost of human error. While some errors can be remedied quickly and economically, others may be costly, harmful, or even catastrophic to large populations and/or geographic regions (Reason, 1990). Up to 98,000 deaths occur in United States hospitals each year due to preventable human errors (Allen, 2013) and more than two-thirds of aviation incidents and accidents can be attributed to human performance errors (Carmona, 2015). While federal agencies, such as the Federal Aviation Administration (FAA), establish requirements and guidelines designed to ensure safety, some incidents of human error may remain undetected and, often, their underlying causes are unknown.

Organizations establish safety management systems to mitigate risk by defining responsibilities, and by implementing appropriate policies and procedures. The most successful safety management systems strive not only to record and address committed errors, but to investigate trends in reported errors and "near misses" (errors caught before resulting in a negative outcome) that provide insight into underlying causes and, therefore, opportunities for prevention. In addition to allowing for trend analysis of more common errors, robust safety management systems are equipped for meaningful investigation into the causes of rare, highly unpredictable errors so that permanent solutions can be implemented to eliminate the risk of future occurrence.

Error investigation and tracking requires a comprehensive data set with in-depth descriptions of each error event. The disclosure of near misses is not required, but there is increasing support for the value of this knowledge. Many organizations in the aviation, rail, and medical industries are establishing "voluntary reporting systems" that allow employees to disclose personally committed errors and violations. These systems provide the organization with critical awareness of day-to-day errors and near misses, which would be otherwise difficult to obtain. Without addressing the causes of near misses, a catastrophic incident might result in the future. Individuals who submit error reports that meet certain criteria are guaranteed immunity from punitive action for contributing to this vital pool of knowledge.

Voluntary reporting allows for efficient problem detection and resolution and establishes a framework for identifying root causes so that appropriate, permanent solutions can be devised and implemented. These systems reflect a shift away from the outdated and potentially dangerous "blame and train" mindset in favor of an open dialogue about human error. Voluntary reporting encourages all employees in an organization to recognize that they share responsibility for contributing to a situation and an environment in which errors may be committed.

Interest in this topic was the result of working in the Human Factors group under Flight Safety and Reliability at GE Aviation. A comprehensive analysis of engine maintenance error trends using airline data prompted the consideration of the knowledge to be gained if a greater percentage of known errors and near misses were reported and discussed openly without fear of punitive action. These

questions led to a search for existing confidential reporting systems to understand how they function and to learn what obstacles limit the utility of such systems. A key to predicting the success of a voluntary reporting system is studying the corporate culture in which it operates, including the needs and goals of leadership, management, and the user population.

Investigation into the varied environments in which voluntary reporting systems are used will expose "barriers", defined as impediments to the effective implementation of and participation in these systems. "Facilitators" are defined as opportunities to minimize the effects of these barriers. The potential for barrier formation and facilitative action exist within each level of corporate structure, demonstrating that an entire organization plays a role in the success of voluntary reporting.

This study evaluates human error, deficiencies in corporate structure and culture, and lessons learned from existing voluntary reporting system implementation to (1) identify and thoroughly define the full scope of barriers and facilitators to successful voluntary reporting practices, and (2) offer recommendations for the establishment and continued use of a voluntary reporting system that provides maximum benefit to safety culture.

2. Survey of Literature

2.1. Safety Management System (SMS)

A safety management system (SMS) is a method used to identify hazards and to mitigate both product and personal safety risk within an organization.

Policies and procedures are implemented to maintain an acceptable level of risk, and performance is measured against established goals. SMS becomes part of organizational culture. It defines the way employees think about safety, interact with their work environment, and make decisions related to the product or system with which they interact. According to the FAA, "SMS is the formal, top-down business approach to managing safety risk, which includes a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures" *(Safety Management System,* 2015).

A core principle of SMS is that organizations are required to uphold safety standards with a focus and urgency equal to that of all other business processes. SMS has become a standard in areas of high-risk industries such as quality, occupational health and safety, security, and the environment. The FAA defines the goals of SMS as follows:

- A structured means of safety risk management decision-making
- A means of demonstrating safety management capability before system failures occur
- Increased confidence in risk controls through structured safety assurance processes
- An effective interface for knowledge sharing between regulator and certificate holder
- A safety promotion framework to support a sound safety culture (*Safety Management System*, 2015*)*

A robust SMS is designed not only to identify and respond to active failures – a specific action (error or violation committed by an individual) that has an immediate impact, but also to latent failures – underlying weaknesses in the system that may go unnoticed until triggered by a situational factor, resulting in an error event (Van der Schaaf, Lucas, & Hale, 1991). According to Chris Johnson (2003), "high reliability organizations" actively contribute to the data set that supports their successful SMS. Differentiation between high reliability organizations and "normal accidents theory" can be seen in Table 2.1.

Table 2.1

Competing Perspectives on Safety with Hazardous Technologies (Johnson, 2003)

High Reliability Organizations	Normal Accidents Theory
Accidents can be prevented through good organizational design and management.	Accidents are inevitable in complex and tightly coupled systems.
Safety is the priority organizational objective.	Safety is one of a number of competing objectives.
Redundancy enhances safety: duplication and overlap can make a reliable system out of unreliable parts.	Redundancy often causes accidents: it creates interactive complexity and encourages risk taking.
Decentralized decision-making is needed to permit prompt and flexible operating responses to surprises.	Decentralized control is needed for complex systems but centralized control is needed for tight coupling.
A culture of reliability enhances safety by encouraging uniform and appropriate responses by operators.	A military model of intense discipline and isolation is incompatible with democratic values.
Continuous operations, training and simulations can create and maintain high reliability operations.	Organizations cannot train for unimagined, highly dangerous or politically unpalatable operations.
Trial and error learning from accidents can be effective and can be supplemented by anticipation and simulations.	Denial of responsibility, faulty reporting, and reconstruction of history cripple learning efforts.

Organizational culture defined by the characteristics of a high reliability organization can support a thriving voluntary reporting system within a successful SMS.

According to SMS policies, certain events, especially those that result in injury, must be reported for legal or insurance-related purposes. However, many non-injury accidents and near misses would not be exposed by a mandatory reporting system. It is important to define the terms "accident", "incident", and "issue" or other occurrence. An accident is a major event, such as a collision, that causes injury or death. An incident is a failure of personnel or equipment, or a deviation from normal operations, which has safety implications. An issue is a concern about the possibility of personnel or equipment failure but without the occurrence of a specific event (Davies, Wright, & Reid, 2000). Table 2.2 highlights the differences in these three occurrences with examples from the aviation industry:

Table 2.2

Distinctions between Accidents and Incidents in Air Traffic Control (Johnson, 2003)

Occurrence	Category	Definitions of an Occurrence
Accidents	Mandatory	Mid-air collision, controlled flight into terrain, ground collision between aircraft, ground collision between aircraft and obstruction, loss of control in flight due to vortex or meteorological conditions
Incidents	Mandatory	Loss of air separation, near controlled flight into terrain, runaway incursion, breach in air traffic management system security
Other Occurrences	Voluntary	Anything which has serious safety implications but is neither an accident nor an incident

Near misses, which fall into the "other occurrences" category, provide valuable insight into hazards, unsafe conditions, and latent system failures that could contribute to a future incident under particular circumstances. Voluntary reporting exposes these issues, providing a data set that allows for unique problem detection, monitoring of known deficiencies, and trend analysis (Clarke, 1998). Johnson (2003) adapted Heinrich's Iceberg Model of incident data, seen in Fig. 2.1, to prove the importance of understanding near misses.

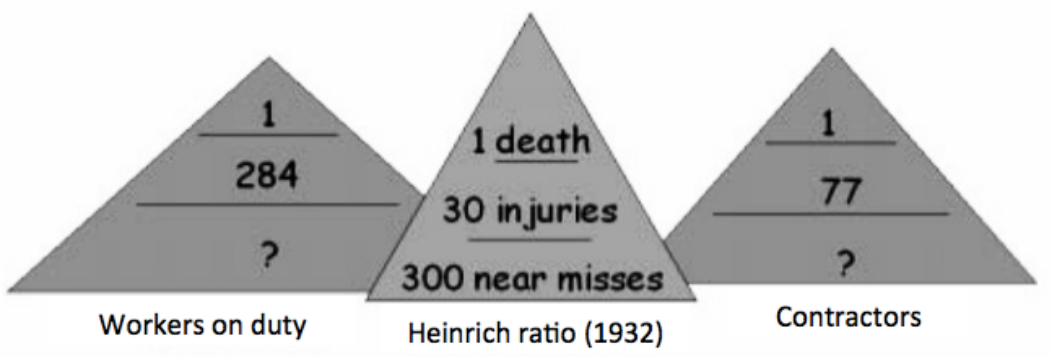

Fig. 2.1 Federal Railroad Administration Safety Iceberg Model (Johnson, 2003)

A major accident is the result of a larger sum of incidences, and a substantial quantity of near misses. The pyramids to the left and right of Heinrich's initial study are based on reported Federal Railroad Administration (FRA) data from 1997 to 2000. Unfortunately, there is no reliable method for calculating near misses for contractors and workers on duty, limiting the FRA's ability to predict the risk exposure of either group. These gaps in knowledge are represented by the lack of data at the bottom of the pyramids on the left and right side of Fig. 2.1.

2.2. Voluntary Reporting

2.2.1. Overview and Importance

Voluntary reporting is not new to the aviation industry. The Aviation Safety Reporting System (ASRS) was established in 1976 as a means of collecting voluntary reports of safety incidents from pilots and air traffic controllers to identify problem areas within the National Aviation System (NAS). Because more than two-thirds of aviation incidents and accidents can be attributed to human performance errors, this type of system is crucial to aviation human factors safety research. The ASRS determines system flaws and develops solutions to alert other similar personnel who may be subject to the same deficiencies. Another important goal of the system is to promote in-flight research and safety through newsletters, journal articles, and public access to the database of events (Carmona, 2015).

Due to the success of ASRS and other early demonstration programs, the FAA continued to improve the dissemination of safety information to its affiliated air carriers. The Aviation Safety Action Program (ASAP) was established in 1997 by the FAA as a voluntary reporting system similar to ASRS. The goals of ASAP are more lofty: to uncover accident and near miss root causes in order to determine corrective actions, to identify trends, and to track the effectiveness of the solutions (Federal Aviation Administration, 2002). An additional goal of this system is to strengthen safety culture by improving trust between management and their subordinates (Federal Aviation Administration, 2012).

Certificate holders (such as an air carrier or repair station) enter into a partnership with the FAA that allows employees to self-report errors that might otherwise be a violation of safety regulations within Title 49 of the United States Code, Subtitle VII (Aviation Programs) or Title 14 of the Code of Federal Regulations (Aeronautics and Space). If the description of the event is determined to be accurate, does not involve a blatant disregard for safety, meets time-sensitive criteria, and does not involve criminal activity or substance abuse, the ASAP report will be accepted and the employee will not be subject to disciplinary action by either the FAA or the employer. A joint report may be filed by multiple employees. Or, if one employee mentions the involvement of others in his or her report, each named employee must subsequently file a report. Once corrective actions and/or recommendations have been determined, the employee who submitted the report is notified and information regarding the solution is disseminated throughout the organization (Federal Aviation Administration, 2002).

The prevalence of voluntary reporting is increasing not only in the aviation industry, but also in the railroad industry, in the medical field, and within the Federal Drug Administration (FDA). In 2007 the FRA launched the Confidential Close Call Reporting System (C^3RS) to improve safety through more effective error reporting and as a means of developing more meaningful corrective actions. As reflected in the name, the focus on "close calls", or near misses, rather than accidents/incidents, shows a commitment to improving safety by identifying and eliminating potential hazards before they lead to disastrous

consequences (Multer, Ranney, Hile, & Raslear, 2013). Like the C^3RS, the Patient Safety Reporting System (PSRS) is a non-punitive confidential reporting system used by healthcare professionals to report incidents and close calls in medical environments, as well as to offer suggestions for improving patient safety. PSRS is an external system administered by NASA that may be used by both private and federal medical organizations. NASA developed this program based on experience implementing and overseeing the ASRS (Carmona, 2010). The FDA has established an Adverse Event Reporting System (FAERS) as a way of both capturing product safety concerns and assessing manufacturers' compliance with reporting regulations. Consumers and healthcare professionals may report adverse events and medication errors directly to the FDA for evaluation (*FDA Adverse Event Reporting System,* 2014).

Johnson (2003) states that voluntary reporting systems allow for improved problem detection and resolution by promoting an open dialogue about error events, resulting in a more descriptive account and detailed understanding of underlying causes. Continued use of voluntary reporting provides a comprehensive data set for more reliable trend analysis. The flexibility of such systems allows an organization to identify new, rare, and/or unknown issues, and to track frequently occurring events. System-wide safety matters, including operating procedures, training, human performance, and equipment sustainability, may all be uncovered using one centralized tool. Alternatively, voluntary reporting provides insights on why accidents *do not* occur and illuminates the effectiveness of existing safeguards that prevent near misses from becoming

major events. Voluntary reporting allows agencies with similar safety issues to compare data and collaboratively search for solutions. In addition to the benefits of acting in accordance with federal regulatory agencies, the financial benefit of these systems can be proven. The costs of maintaining these systems are offset by eliminating the financial risk of the accidents/incidents they prevent.

2.2.2. Just Culture

Just Culture is a philosophy that has become an established method of practice in aviation regulations in Europe, Canada, Australia, and, more recently, in the United States. It promotes open and honest communication about human error to improve the ability of aviation organizations to detect and learn from maintenance-related errors and violations (Just Policy, 2011). The concept of Just Culture was first studied in the mid 1990s. Outcome Engineering, LLC furthered these studies by applying engineering, human factors, and legal principles to develop a uniform, fair method for evaluating system flaws and the decision-making of employees. Outcome Engineering, LLC defines Just Culture as:

> A values supportive system of shared accountability where the organization is accountable for the systems that are designed and for responding to the behaviors of their employees in a fair and just manner. Employees, in turn, are accountable for the quality of their choices and for reporting both their errors and system vulnerabilities.

American Airlines Maintenance and Engineering Organization (M&E) officially founded "Just Policy" in 2011 based on the principles of Just Culture.

The policy promotes the type of communicative culture necessary for a voluntary reporting system to provide valuable information about human error and organizational deficiencies (Just Policy, 2011). Rather than intimidating and isolating employees in the pursuit of this knowledge, a Just Culture environment provides employees with the comfort and confidence to be at the forefront of this endeavor. "A Just Culture will place less focus on errors, events, or outcomes and more focus on risk, system design, and managing quality behavioral choices" (A Just Policy for a Just Culture, 2011).

Applying the principles of Just Culture to the ASAP program at American Airlines resulted in significant improvements to the acceptance of and use of ASAP, thus supporting the value of this philosophy in voluntary reporting systems. The relevance of Just Culture to voluntary reporting is most evident in the Just Policy for Maintenance Errors and Violations' four core principles:

- Recognition that not every system is perfect, to err is human, to drift from what we know to be safe or compliant is human, and that risk is everywhere.
- Interest in learning as much as possible after an error or event in order to understand risk at the individual and the organizational level.
- Willingness to investigate, learn from our mistakes and share what we have learned.
- Determination to balance accountability with justice (A Just Policy for a Just Culture, 2011).

The Just Culture algorithm is a tool developed to assess the choices made by individuals leading to a maintenance error event so that responsibility for the event may be appropriately allocated. At-risk behaviors are common, but reckless disregard for safety is rare. This algorithm provides a consistent tool for determining appropriate action following an error event, whether it be supporting the employee and focusing on system deficiencies, training the employee, or taking disciplinary action. This algorithm is used when reviewing ASAP reports, and a similar technique should be standard practice in any voluntary reporting system. This approach to understanding the underlying causes of errors and violations allows for the identification of the most effective corrective actions to prevent future error events (Just Policy, 2011).

2.2.3. Considerations for Implementing a Voluntary Reporting System

Best practices for the implementation of a voluntary reporting system are dependent on several variables. The current level of executive leadership, management, and user buy-in should be assessed. There are generally three scenarios that define the scope of organizational barriers:

1. Executive leadership only supports the effort to appease federal regulatory agencies, but does not champion the effort through formal communications and/or visibility.
2. Executive leadership supports the endeavor, but management is resistant to following the established policy and facilitating the effort as needed.

3. Both leadership and management are supportive, but there is still insufficient participation.

Each scenario presents a unique set of barriers and requires facilitators designed to improve buy-in at specific levels.

To be successful, the type of reporting system to be implemented must be well defined and marketed to the user population. An anonymous system, in which employees do not identify themselves, provides the most confidence in the promise of non-punitive action. Personal identifiers are never attached to an error event report, and there is no follow-up communication. This method, however, allows for the possibility of false or highly insignificant reports, and genuine reports are limited by the level of description provided. In a confidential system, only "necessary" parties, typically a 3rd party review team, will be aware of the reporter's identity. This allows for follow-up conversations for the review team to request additional details of the event, resulting in more effective recommendations. When the report and recommendations are returned to the reporter's organization, all identifying information is removed (Johnson, 2003).

Open reporting systems can be the most effective voluntary reporting system, but they are the most difficult to implement. In this type of system, the reporter's confidentiality is not preserved, and open dialogue provides in-depth descriptions of error events. This leads to the most comprehensive list of causal factors, and potentially the most effective corrective actions. The type of

organizational climate needed to sustain an open system may be achievable, but only after the benefits of voluntary reporting have been proven over time.

Once the type of error reporting system to be used has been identified, the scope and goals of the system must be defined. Considerations include identifying the user population so that all users receive an appropriate level of training and determining how widely the information will be shared. Based on the industry and the types of events being targeted for reporting, the breadth of the tool and the extent of the analysis should be clearly established before implementation. The system may be used for individual investigations, to populate a large database of events for trends analysis, or both. There may be limitations on the type of events that should be reported (less significant vs. more significant, ongoing vs. new/unique, personal safety vs. product safety, etc.). System versatility may be necessary to determine if immediate action should be taken in response to a report, or if it would be more valuable, but safe, to delay a response in favor of obtaining additional information (Woods & Cook, 1999).

2.2.4. Reporting Process

Once the type, scope and goals of the voluntary reporting system have been defined, the specific method by which the system operates must be strategized. This process includes the way in which reports are to be submitted, who is to receive them, whether or not a follow-up interview is required, and the way in which the reports will be used by the organization to develop and implement corrective actions. A well-defined reporting process must be clearly

communicated to both users and those involved with system operation and management. The most successful models contain common design features and information pathways that will be discussed in this section.

Non-punitive, confidential, voluntary reporting systems, such as the ASAP and C^3RS, have seen the most success and have become the standard across their respective industries. Specific policies and procedures may vary, but the general framework is consistent. A voluntary reporting system is a joint venture among several stakeholders – the employer (airline, railroad, hospital, etc.), the regulatory agency (FAA, FRA, FDA, etc.), a third-party review team, and representatives from a labor organization or employee group (if applicable). Prior to the launch of the system, stakeholders meet to define the scope and goals of the system and to develop a framework for how the system will operate (Federal Aviation Administration, 2012).

Generally, a confidential voluntary reporting system follows the following process:

1. An employee voluntarily submits an error report (after committing an error or violation).
2. A third party group reviews the report and interviews the employee to identify the underlying causes of the error/violation event.
3. The employee's organization receives a de-identified version of the third party's report, and the report is analyzed (usually by a cross-functional group within the organization) to develop corrective actions.

4. The employee's organization reviews, prioritizes, and authorizes the recommended corrective actions.
5. The employee's organization implements the corrective actions and monitors their impact.
6. Management disseminates these changes across the organization.
7. The third party analyzes trends across the industry and communicates this information to stakeholders.

The process followed by the C^{3}RS confidential reporting system is depicted in Fig. 2.2.

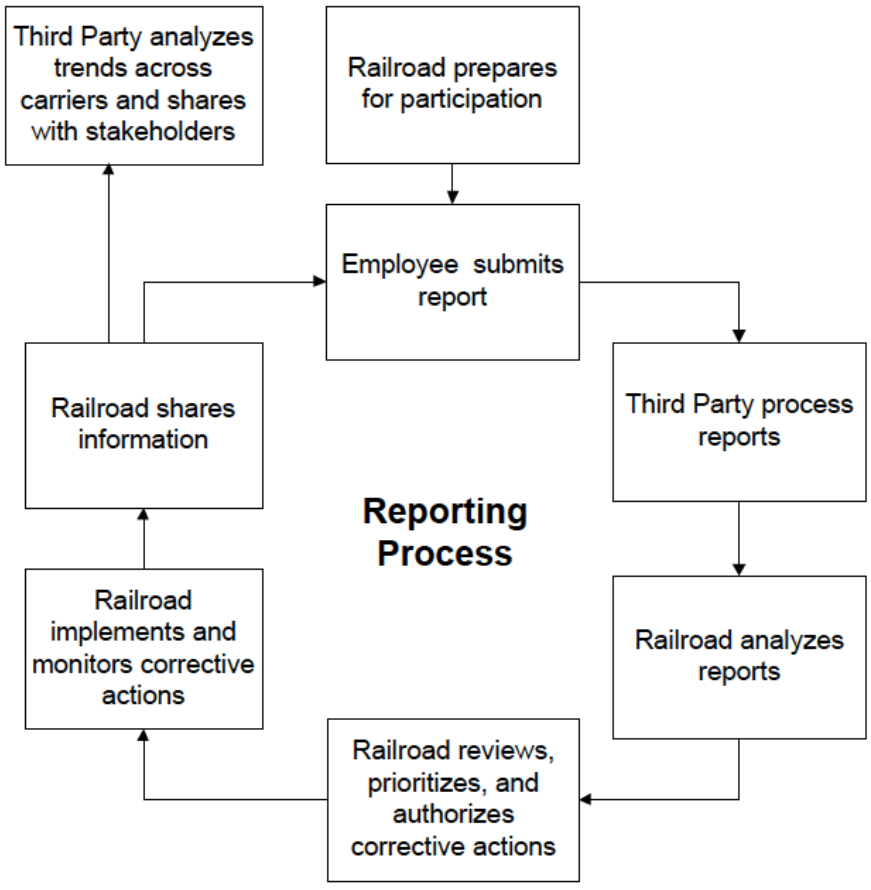

Fig. 2.2 C^{3}RS Voluntary Reporting Process (Multer et al., 2013)

Multer et al. (2013) describes the process followed by a standard confidential reporting system, such as the C^3RS. Employees can submit reports of errors and violations by phone, online, by paper submission, or by other means. All reports are sent to the third party review team. This group then interviews employees to improve the clarity of the report and to obtain any missing information relevant to the event. The review team prepares an unattributed version of the report to be sent back to the organization. Depending on the particular system and industry, the identification of error causal factors and the recommendation of corrective actions may be completed by the third party review team, by the organization itself, or by a combined group. In some cases, especially for a pilot program, a peer review team (PRT) may also be assembled. Comprised of representatives from each stakeholder group, the PRT may be involved in initial event report analysis, and may assist in the development of materials and communication strategies for educating employees and managers on the use of the system.

Multer et al. (2013) explains that the organization is responsible for implementing the recommended corrective actions and monitoring their impact. When a corrective action has been identified and implemented, the person who submitted the report receives immediate feedback and the improvement is disseminated. Recommended and implemented corrective actions are also shared with the third-party review team so it can investigate trends across an industry to share with the other stakeholders. Broadcasting corrective actions is an important way to drive participation in voluntary reporting. It builds trust that management

is committed to the system and that submitting reports is a worthwhile effort that results in meaningful change.

2.3. Shared Responsibility

Many parallels can be drawn between James Reason's "Swiss cheese" model and the concept of shared responsibility, which is crucial to the success of a voluntary reporting system. The Swiss cheese model describes four areas of possible opportunities for failure. These levels ("Organizational Factors", "Unsafe Supervision", "Pre-conditions for Unsafe Acts", and "Unsafe Acts") are each represented by a piece of Swiss cheese, and holes in each slice symbolize specific opportunities for failure (Reason, 1990). Reason's Swiss cheese model is depicted in Fig. 2.3.

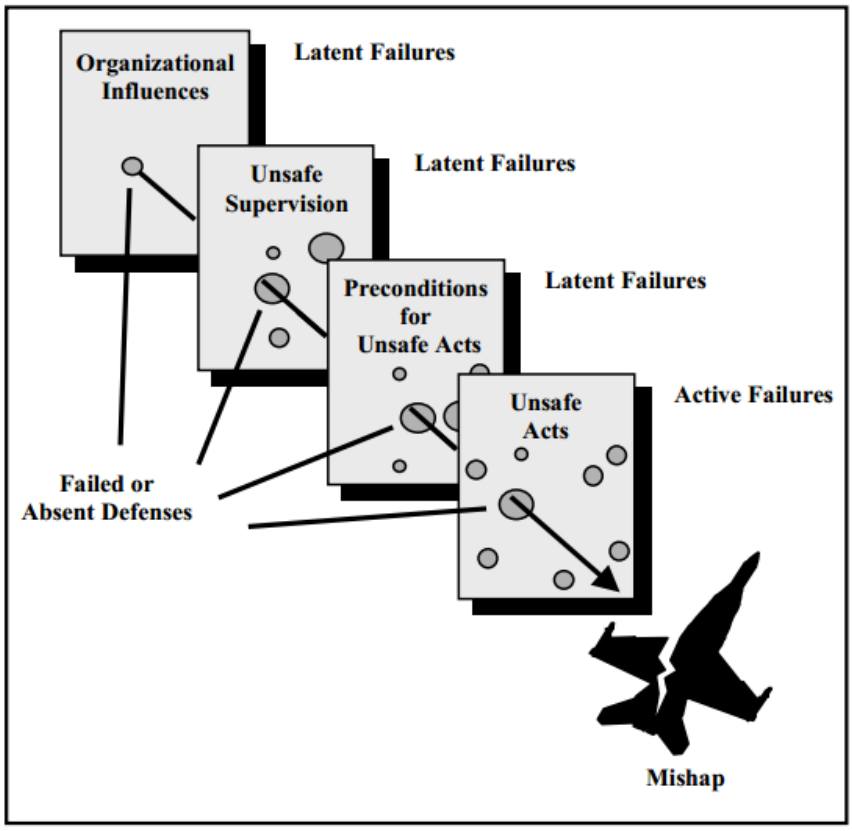

Fig. 2.3 The "Swiss Cheese" Model of Human Error Causation (Shappell & Weigmann, 2000, adapted from Reason, 1990)

The top 3 levels represent latent failures that, coupled with an active failure on the part of the individual, cause an error event. In other words, when failed defenses exist at four consecutive levels, there are opportunities for these weaknesses to align, leading to a mishap (Shappell & Weigmann, 2000). The same way that factors at each level can contribute to an error event, barriers to voluntary reporting can exist at each organizational level.

The Human Factors Analysis and Classification System (HFACS) builds on Reason's Swiss cheese model and the concept of active and latent failures. HFACS identifies specific error causal factors within each of Reason's slices,

resulting in an active error or violation occurring at the "unsafe act" level of the Swiss cheese model shown in Fig. 2.3. During interview discussions, it became apparent that many of the same "Organizational Factors" defined by HFACS influence the successful implementation of voluntary reporting. These factors include improper distribution of resources (staff, monetary, materials), inadequate training, organizational climate, and organizational processes (company policies/procedures, lack of formal communications, and lack of formal accountability for actions) (Shappell & Weigmann, 2000).

2.4. Initial Overview of Barriers and Facilitators

2.4.1. Five Characteristics of Safety Reporting

A review of safety reporting literature provided an overview of the elements of an effective voluntary reporting system. The International Civil Aviation Organization (ICAO) Safety Management Manual (2013) defines five characteristics associated with effective safety reporting systems: information, flexibility, learning, accountability, and willingness. Similar to the categories that will be described in Sections 2.4.3 through 2.4.10, these five areas present opportunities for organizations to support, but also to inhibit, participation in both voluntary reporting and in corrective action development. The five categories associated with effective safety reporting are described in Fig. 2.4.

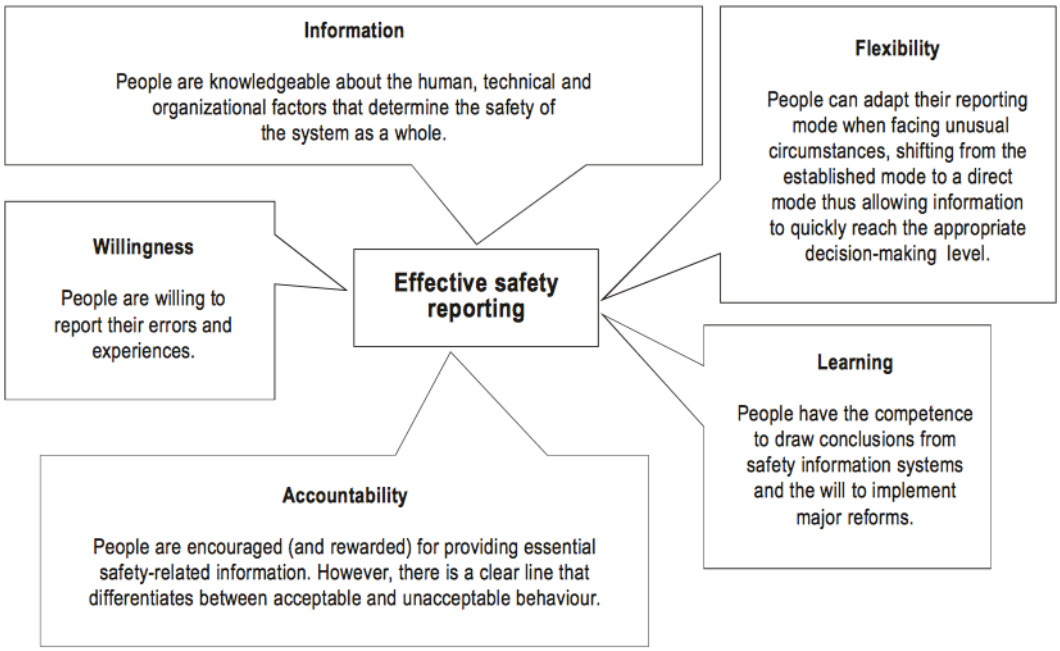

Fig. 2.4 Five Basic Characteristics of Effective Safety Reporting (*Safety Management Manual,* 2015)

Initial discussions with industry professionals suggest that the most significant challenge to the effective reporting of safety issues is "willingness", as reflected by a lack of participation. Insufficient participation may be due to non-existent or ineffective training on the importance of the system and the types of events to report (lack of "learning"), distrust between management/leadership and the labor force due to unclear expectations (lack of "accountability"), and personnel changes that can affect the process and even the integrity with which the system is run (possibly related to "flexibility"). The "information" category affects all of these factors. The entire organization, from the labor force to executive leadership, must be well educated on safety culture, the inevitable role of human error, and risk mitigation in order to tap the true potential of voluntary

reporting. Members of each level of hierarchy must believe their respective roles and responsibilities to safety and to the success of the system.

2.4.2. Definition of "Barrier" and "Facilitator"

The recommendation of best practices for voluntary reporting systems is contingent upon the identification of issues that inhibit progress in both the development of and the ongoing use of these systems. For this study, a "barrier" will be defined as any obstacle affecting the initial establishment of the system, employee participation, or the use of error event reports to develop meaningful corrective actions. Helmreich (2000) describes non-punitive incident reporting systems as an important error management tool for "understanding the nature and extent of error, changing the conditions that induce error, determining behaviors that prevent or mitigate error, and training personnel in their use." However, he also warns of the existence of "legal and cultural barriers to the disclosure of error." According to Helmreich, such barriers are inherent to organizations and hinder the disclosure of a wide range of latent conditions that influence error.

Alternatively, "facilitators" will be defined as opportunities to minimize the effects of these barriers. The relative impact of each barrier will be assessed to determine which facilitators are most instrumental to the success of the system. The following list of eight barrier and facilitator opportunity areas is derived from the literature survey and will be explained in detail in the following sections. The section numbers are included in parentheses.

- "Blindness" to Human Error and the Impact of Local Perspective (2.4.3)
- Organizational Commitment to Safety Culture (2.4.4)

- User Trust in Voluntary Reporting Systems and in Management (2.4.5)
- Voluntary Reporting System Training Techniques (2.4.6)
- Personnel Changes that Influence Voluntary Reporting (2.4.7)
- Voluntary Reporting System Policy and Procedure Definition (2.4.8)
- Voluntary Error Reports and Interviews (2.4.9)
- Analysis of Error Reports and Development of Corrective Actions (2.4.10)

2.4.3. "Blindness" to Human Error and the Impact of Local Perspective

According to Barry Oshry (2007), all humans are subject to various forms of "blindness", which are a result of our own unique surroundings and pressures. We may be focused on our own localized role but "blind" to its context in the greater picture. We may see the present without considering lessons learned in the past, or we may be too focused on the future to recognize important elements of the present. We may have difficulty relating to our peers and being cognizant of how our actions and words affect others. All of these inherent faults are exacerbated by our unique roles within an organization.

When employees' views or understanding of the organization are confined to their particular organizational level, they have only a limited, or "local", perspective of issues affecting the company. In any workplace interaction, employees assume the roles of "tops", "middles", and "bottoms". Generally, tops are over burdened with responsibility while maneuvering in fast-paced, unpredictable conditions. Middles are caught in a constant battle between the

priorities and needs of their superiors and their subordinates. Bottoms feel oppressed and powerless in a system where decisions are made for them, and they rarely see the benefits of their work in the larger context of the organization (Oshry, 2007).

According to Albert and Geller (1978), this "perceived lack of control over circumstances" often triggers a condition known as learned helplessness. Learned helplessness is a psychological state in which repetitive exposure to unpleasant or aversive stimuli results in the potentially false assumption that the stimuli cannot be avoided. Those who fall victim to this state become disinclined to actively evade the stimuli, suggesting that this exposure has significantly influenced their behavioral choices. This phenomenon explains why individuals may choose a more passive role of acceptance when facing an adverse situation, even if they have the ability to influence positive change. With regard to safety, learned helplessness may promote the false assumption that a desired level of risk prevention is unattainable.

James Reason (1998) claims that "safety is invisible" and despite an awareness of the potential problems associated with short cuts and day-to-day mistakes, workers will continue to operate in the same risky manner, oblivious to any foreseeable harm. Many are influenced by their own shortcomings – blind confidence, arrogance, and ignorance – all of which suppress the instinct to fear negative outcomes. Many workers are subject to a false perception of invulnerability to errors resulting from continual routine violations that have yet

to result in negative consequences. When error events do occur, a common excuse is that the incident was unpreventable (Clarke, 1998).

It is important to strive for the formation of a partnership where each party involved recognizes the importance of maintaining an appropriate balance of responsibilities and working toward a unified goal (Oshry, 2007). A study was conducted by the Volpe National Transportation System Center that examined the effects of peer observation and feedback regarding safety behaviors, enhanced safety data collection techniques, and improved management training. The study found that increased communication about safety and visible management commitment lead to improved trust and cooperation between workers and management. Most notably, workers cited an increased sense of management fairness and gratitude for suggested process improvements (Coplen, Ranney, & Zuschlag, 2009A).

Additional recommendations for minimizing the effects of local perspective include utilizing strong, integrated middle management teams comprised of individuals who communicate well to both superiors and subordinates, and are viewed as fair and consistent. Encouraging individualism in labor groups promotes risk taking and combats the often-negative effects of a "tribal", "macho" work environment (Oshry, 2007). Management should seek to understand routine violations in order to identify deficiencies in resource allocation, time management, or clarity of procedures/other documentation, all of which can contribute to errors (Reason, 1998).

2.4.4. Organizational Commitment to Safety Culture

The safety culture of an organization is defined by the values and integrity of executive leadership, whose message defines initial receptiveness to voluntary reporting. Leadership may fear that active pursuit of safety failures will tarnish their safety record or cause unnecessary financial losses (Johnson, 2003). Such an organizational climate places greater importance on production goals than safety. James Reason suggests that errors not resulting in a discernable event (near-misses) are often disregarded in favor of meeting deadlines and achieving metrics. These at-risk behaviors occur when short cuts become a comfortable, standard practice necessary to meet goals. In reality, many violations occur as the result of organizational deficiencies, such as inadequate resources or an unsatisfactory work environment. Supervisors often have an understanding of and experience with such pressures, but either lack the interpersonal skills to address the violations with subordinates, or fear a decline in productivity if violations are addressed (Reason, 1998).

A unique culture is required for employees to feel comfortable participating in a program that exposes their flaws. Johnson (2003) claims that employees fear being labeled as "weak" for reporting their own concerns or being branded a "whistle blower" if the event involves others. They may be concerned for job security or future career opportunities if the report mentions the involvement of a person of authority. Young or new staff may fear that the report exposes a lack of knowledge or experience (Johnson, 2003). Most importantly, the organizational climate may lack the necessary focus on safety needed to

motivate employees to take the system seriously. If implemented solutions are not broadcast effectively and/or management is believed to either react negatively or ignore corrective action recommendations, employees will not be motivated to participate (Davies et al., 2000).

Rather than remaining complacent with a "risk management culture", Clarke (1998) suggests that organizations work toward achieving a "systematic safety culture" which encourages the reporting of all types of potential problems, no matter how seemingly insignificant. This requires a commitment to Just Culture, discussed in Section 2.2.2. Another possible strategy for strengthening safety culture is to implement peer review programs that encourage an open dialogue about errors, near misses, and potentially hazardous situations. It is important for all employees to realize their common susceptibility to the same issues, to understand the potential significance of these issues, and to feel comfortable discussing them (Coplen et al., 2009A). A final strategy for encouraging a reporting culture is to provide incentives for active reporting, at least until the system has become well known and has produced meaningful change (Clarke, 1998).

2.4.5. User Trust in Voluntary Reporting Systems and in Management

The literature review and interviews revealed the common belief that lack of trust between labor and management is the most significant barrier to a lack of participation in voluntary reporting. The most difficult obstacle for workers is recognizing the shift toward Just Culture when the history of incident data

collection resulted in blame and disciplinary action (Clarke, 1998). Leadership and management face the challenge of communicating their intentions frequently and effectively. Even with the promise of immunity from punishment, potential reporters fear a negative reaction or retaliation from management, who are under strict deadlines and metric pressures (Davies et al., 2000). Employees also lack trust in the system to protect them if reported events involve coworkers, especially superiors. Clarke (1998) states,

> Incident reporting might be viewed as an objective indicator of employees' perceptions of manager's commitment to safety. These perceptions underlie a lack of mutual trust between staff and managers, which has implications for the fostering of open and honest communications within the network, and for the development of a positive safety culture.

In addition to upholding disciplinary policy, an important element of maintaining this trust is ensuring the confidentiality of the system. This may take time and may require the assistance of employees to communicate their positive experiences to others. Trust is truly the foundation on which a safety culture is built and the binding force that keeps employees committed to its preservation.

A key to improving trust within an organization is encouraging open dialogue. Several studies conducted by Michael Coplen, Joyce Ranney, and Michael Zuschlag with the Volpe National Transportation Systems Center and the FRA have demonstrated that improved communication between management and

their subordinates boosts trust and improves morale. These studies show that improved trust enables workers to feel more comfortable approaching management with issues, which in turn indicates to management that workers are committed to doing their jobs as effectively and efficiently as possible. Improved communication can establish a relationship where management not only appreciates but also seeks the advice of their employees to refine processes and systems (Coplen et al., 2009A).

2.4.6. Voluntary Reporting System Training Techniques

Early conversations between the author and industry professionals exposed several recurring themes with regard to inadequate training techniques that hinder participation in reporting and obstruct robust corrective action development. Users of a reporting system may feel burdened by a complex interface or may be unsure of the scope of an acceptable report. Training often lacks examples of everyday actions linked to future safety issues. Management may be unaware of how the system works, unclear about their role in developing corrective actions, or unable to provide meaningful feedback to those who file reports.

These conversations revealed that in order for voluntary reporting systems to operate successfully, both an organization's management and its user population must be thoroughly trained in the scope of events to be reported and the involvement of key stakeholders at each stage of the review and analysis process. Additionally, users should be trained on exactly how to report errors,

with detailed visuals highlighting each method (such as an online interface). Management must accept training to support the entire process, to continuously encourage reporting, and to effectively interface with groups involved in the development of corrective actions. The success of the reporting system is largely dependent on the quality of the solutions it generates.

Van der Schaff et al. (1991) add that ongoing training for both management and users is a reminder of the importance of safety. With examples of and statistics describing common at-risk behaviors and their outcomes, both management and workers are exposed to the extent of possible safety issues that voluntary reporting aims to track. With unique, compelling examples of failures, trainees observe how a seemingly improbable combination of factors can result in an error event that threatens safety. Visuals, interactive activities, and consistent feedback are useful training tools to keep audiences engaged. Such techniques are also useful for proving, rather than simply voicing, the threat of everyday actions to serious safety consequences.

2.4.7. Personnel Changes that Influence Voluntary Reporting

According to Multer et al. (2013), the loss of project champions can negatively affect the strength of a voluntary reporting system and the trust of its users. As managers retire, change jobs, or are promoted, new individuals step into roles that may have been previously filled by committed advocates of voluntary reporting. New employees' outlooks on safety management and their level of buy-in to voluntary reporting may differ from those of their predecessors.

This may be reflected in poor knowledge of system policies, decreased output of corrective actions, and lack of overall communication regarding the system and its benefits. Such changes could lead to a decline in motivation to participate. More importantly, these changes may trigger fear among users that this new management lacks commitment to the established punitive action policies.

Multer et al. (2013) explain that a considerable amount of time is required for individuals to grow from interested bystanders to active supporters to passionate champions of voluntary reporting systems. Succession planning is vital preparation for unforeseen circumstances where a leadership role must be quickly filled in any of the stakeholder groups. It is important for successors to have been involved with the system and to have witnessed its benefit to their group and to the entire organization. Organizations that are cognizant of maintaining leaders who are experienced champions of voluntary reporting practices have the greatest success with such systems.

2.4.8. Voluntary Reporting System Policy and Procedure Definition

Related to the concept of trust, Reason (1998) says that employees may be hesitant to use a voluntary reporting system if its policies and procedures have not been clearly outlined. This may be a negative reflection on the quality of the reporting system training and/or management/leadership communication. It is unreasonable to expect employees to read lengthy, detailed government documents describing a particular policy. Aside from the complicated language, a written promise of exemption from punitive action is far less convincing than a

personal commitment from a manager. It is difficult for many employees to embrace the concept that previously punishable actions, such as clear violations, are acceptable to report and carry no threat of penalty.

In order to enforce this concept, there must be a clear delineation between acceptable and unacceptable behaviors - those that will be accepted into the reporting system and those that will prompt disciplinary action. A document outlining this distinction should be distributed and be accessible via several media. Reason (1998) argues that clearly delineating between acceptable and unacceptable behavior is a key foundation of Just Culture. When reviewing an error event report, the focus should not be on the resulting error or the magnitude of its consequences, but rather, the behavior of the individual that led to the event. A thorough investigation into the assumptions, goals, and ultimate decision-making process of the individual can be achieved using the Just Culture algorithm, which ensures that assessments are fair and consistent.

2.4.9. Voluntary Error Reports and Interviews

Multer et al. (2013) claim that the purpose of voluntary reporting is to understand the full scope of causal factors that contribute to every error event. This requires a significant level of detail obtained through submitted error reports and follow-up interviews. Unfortunately, this information can be difficult to obtain, depending on employees' recollection and awareness of the situation at the time of the event. Poor writing ability, limited motivation, lack of variety in reporting methods, complex interfaces, and perceived lack of time are common

factors that affect employees' ability to submit an accurate and robust report. Additionally, employees may purposely withhold details to protect themselves or others. If a group involved in an incident chooses to file individually, reports must be combined into one uniform document containing details consistent with each individual report. Employees may have varied perceptions of the situation depending on their proximity and level of direct involvement with the event.

Pronovost et al. (2008) state that with respect to the reporting form, one highly debated subject is the relative value of using structured data entry vs. open text fields. Structured entry ensures comparability of responses, which improves statistical analysis capabilities. Unfortunately, this approach limits the amount of information that can be provided by the user. A common solution involves combining both structured and open data entry, but this technique increases the probability of human error. Users may select structured answers that contradict information provided in narrative form or in follow-up interviews. Depending on the scope of the system and the resources available for analysis, it might be appropriate to use a data analyst to retroactively generate structured responses based on open text responses and follow-up questions, if needed. Alternatively, all "open ended" responses could be confined to the interview process to improve the likelihood of obtaining accurate information.

Missed opportunities for information gathering also exist within the interview process. Woods and Cook (1999) claim that both interviewers and interviewees are subject to hindsight bias – the perception that an outcome was probable over other possibilities, which is directly influenced by knowledge of

that outcome. Individuals are unaware that this phenomenon affects their own foresight and, therefore, their recollection of an event. Hindsight bias explains why employees may have been unable to utilize relevant knowledge during an error event, but clearly recognized their mistake shortly after. This phenomenon presents a disadvantage during interviews. Employees are more likely to demonstrate the knowledge or skill that they lacked at the time of the event, calling their competence into question.

It was suggested by Woods and Cook (1999) that knowledge gained and utilized in one context may not be readily accessible in a new or unfamiliar situation. Rather than considering this possibility, interviewers may be quick to assume the error was caused by a lack of motivation or effort on the employee's part. A decision resulting in a negative outcome is often criticized more heavily than the same decision resulting in a positive or neutral outcome. It is, therefore, critical that interviewers gather all details necessary to fully grasp the event, rather than solely focusing on the error. Interviewers may also be subject to the concept of "fixation." Fixation occurs when an initial evaluation of the situation seems appropriate but even as new information emerges that would imply a different explanation, the interviewer is biased toward his or her initial opinions.

According to Pronovost et al. (2008), the goal of the Just Culture algorithm is to counteract these flaws by focusing on the specific behaviors and decision-making patterns of the individual, rather than on the outcome of the error. If events are coded based on a particular taxonomy, the classification should be based on the decisions involved, rather than on outcomes. This can be

accomplished by utilizing clear process maps to understand upstream conditions and decisions that are separate and distinct from the event itself.

Multer et al. (2013) suggest eliciting the opinions of subject-matter experts to better understand the technical environment and the task being performed at the time of the error or violation. A process should be established for employees to submit supplemental information such as written documentation, maps, or visuals. Providing employees with example reports gives them a quality benchmark and can save them time. The evaluation of error event reports and follow-up interviews should serve to uncover the real uncertainties, demands, and system deficiencies that contributed to the development of an unsafe situation.

2.4.10. Analysis of Error Reports and Development of Corrective Actions

Multer et al. (2013) describe the analysis of de-identified error event reports as an important final step that culminates in the recommendation of corrective actions for the organization. The group developing corrective actions must understand the task and environment (local factors) in which the error was committed. The organizational perceptions of staff (rather than simply from an outside group) provide local knowledge of organizational dynamics and common practices, and increases the likelihood of implementation. Involving front-line employees and management can offer valuable insight, but neither the manager nor the union representative of the particular reporter should be involved.

Assembling cross-functional groups that include members of the Engineering, Finance, Safety, and Training departments results in a richer analysis and recommendations for solutions that span several domains. A small group with similar experiences may only focus on local fixes, while a diverse group is able to enrich the analysis beyond the report itself and consider the effects on core business and operational practices (Multer et al., 2013). Cross-functional participation provides greater access to cost data, which can be used to develop useful cost-benefit analyses that support the recommended corrective actions. These analyses become key elements to promote recommended corrective actions and combat management pushback. Cross-functional analysis groups expand the opportunity for corrective action implementation beyond the immediate group within which the error event occurred. This inclusion model can lead to a larger, more broadly supported tracking system for corrective actions and perhaps a greater budget for implementing solutions (Ranney & Raslear, 2012).

With regard to data analysis, Pronovost et al. (2008) urge that caution be taken when calculating incidence rates for aggregated data. These rates will vary significantly based on the culture and reporting practices at distinct organizations, so they should not be used as a valid measure of risk across the industry. Additionally, fluctuations in reporting volume and bias will cause these rates to vary over time. Hazard reports represent a non-random sample within a far greater population. Although error rates calculated from these data sets may not

be very accurate as an industry standard, localized trends and other findings are extremely valuable in safety improvement.

When a voluntary reporting system has been implemented and corrective actions are being taken, Pronovost et al. (2008) indicate that it is important to track the effectiveness of the system in order to make improvements to both the reporting process and corrective action development and implementation. This could involve measuring the types and value of lessons learned, the number and types of tangible interventions, and/or the magnitude of risk/harm reduction. Corrective actions should be categorized and arranged based on their impact on improving a hazardous situation. The strongest interventions, such as a mechanical re-design, are devised to eliminate or prevent mistakes. Moderately strong interventions are designed to catch mistakes by improving their visibility or by adding safeguards (e.g., the placement of a caution sign). Weaker interventions strive to mitigate risk (e.g., adding or improving training on the task that resulted in an error). Stronger interventions are more costly, but are more effective and require less follow-up evaluation (Pronovost, et al., 2008).

3. Knowledge Elicitation

3.1. Overview

After articulating the eight voluntary reporting barrier and facilitator opportunity areas (Section 2.4), it was necessary to gain deeper insight into the implications of the concepts. An understanding of the barriers to voluntary reporting in practice could only be obtained from those who are intimately

familiar with such systems. Several data collection methods were considered, and it seemed most appropriate to interview system developers, overseers, and users who would represent a range of perspectives from each phase of the voluntary reporting process. A semi-structured interview targeting perceptions of and experience with voluntary reporting was devised to expose barrier prevalence in each interviewee's respective industry without limiting the scope of responses.

3.2. Goal of Interviews

The goal of interview discussions was to provide information necessary to refine the list of barriers and facilitators by supporting the knowledge gained from the literature review and by improving the level of detail through industry examples. Additionally, comparing the number of mentions of each barrier/facilitator provided an initial estimate of the relative magnitude of such issues, and their shared or individual importance to distinct groups within the organization. The knowledge gained from these interviews finalized an already defined list of often-cited barrier and facilitator opportunity areas. This list would be used to develop a questionnaire to statistically test the differences between the relevance of these concepts to system users and their management.

3.3. Choosing Interviewees

Industry professionals involved in various stages of the reporting process were consulted. Targeting professionals with unique roles across several industries that utilize voluntary reporting, such as aviation and rail, provided multiple perspectives from each organizational level. A moderate to high level of

familiarity with voluntary reporting systems was preferable, but some variation in experience was expected. Such diversity, coupled with different job titles, would expose any weakness in the presentation of voluntary reporting to new users, as well as reveal deeper system flaws that are typically understood by only those significantly invested in such systems. A diverse group of interviewees would also allow for a comprehensive assessment of elements of an organizational culture that either promote or hinder voluntary reporting.

Three general groups of individuals were identified as study subjects: (1) executive leadership/senior management, (2) supervisors/middle management, and (3) mechanics/technicians. These three groups represent the "tops", "middles" and "bottoms" described by Oshry (2007) and articulated in Section 2.4.3. Executive leadership and senior management of any industrial organization that utilizes voluntary reporting could provide valuable insights into the goals and frustrations of both promoting the system and providing ongoing support to maintain successful operation. Contacting and eliciting help from this group would prove to be difficult. Middle managers and supervisors could provide the perspective of those responsible for creating an atmosphere that fairly addresses penalty while promoting Just Culture and the pursuit of understanding system-wide deficiencies. Finally, mechanics and technicians (the user population) would offer the unique perspective of those who ultimately define the effectiveness of the system. This group could evaluate its ease of use, ability to influence change, and level of support from superiors. Also, the latter two groups

(management and mechanics) would be more likely to participate in study interviews.

An eclectic group representing several industries and varying levels of corporate structure were interviewed over a period of three months. Mechanics/former union workers (3), Quality and Environmental Health and Safety (EHS) management (5), directors of various Human Factors groups (3), and corporate leaders (3) comprised the interviewees. Additionally, two interviewees were involved in the implementation of the ASAP and C^3RS voluntary reporting programs. Participants included GE Aviation employees, airline and air framer customer contacts, and members of the Transport Worker's Union (TWU).

Specifically, individuals holding the following positions (with details withheld to preserve identity) were interviewed:

1. A former Director of Maintenance Human Factors at a major airline
2. The current Director of Maintenance Human Factors at a major airline
3. A director at the Air Force Safety Center
4. Five Global Quality Leaders for On-Wing Support at GE Aviation
5. A program manager at the Volpe National Transportation Systems Center
6. A Transportation Safety of Flight and Compliance Coordinator
7. A Global Manager of Safety and Health Excellence Programs at GE Aviation
8. An EHS Union Leader at GE Aviation

9. A GE Corporate EHS Operations Leader
10. A union assembly worker a GE Aviation
11. A former TWU mechanic and member of an ASAP event review team
12. A GE EHS Vice President of Global Operations

These individuals were contacted with the help of coworkers in the Flight Safety and Reliability group at GE Aviation and through contacts in the Maintenance Human Factors group at Boeing. Each volunteer interviewee received a prompt describing the effort and a general list of discussion topics. This prompt can be found in Appendix A.

3.4. Development of Guided Discussion Questions

Discussion topics were chosen to investigate the relationship between interviewees' characteristics and their views on voluntary reporting systems. The majority of discussion questions encouraged interviewees to elaborate on the barriers and facilitators defined in Section 2. Introductory questions focused on the interviewees' current roles and responsibilities, professional background, and familiarity with voluntary reporting. Subsequent questions were tailored to each individual's unique experiences and knowledge of this topic. Flexibility in the structure of the interviews permitted interviewees the latitude to provide a range of perspectives that mirror the variations in knowledge and buy-in found in the user population and their management.

Interview questions chosen to further detail the barriers and facilitators included (1) personal experience using a voluntary reporting system or managing

the user population of such a system, (2) personal receptiveness to known voluntary reporting systems and suggested opportunities for improvement, (3) perceived outlook of coworkers on voluntary reporting, (4) experience committing or observing an error that had impactful results, and (5) what changes (if any) would be required within the current organizational culture to strengthen voluntary reporting practices. For any interviewees directly involved in the development and implementation of a voluntary reporting system, an additional discussion took place to identify specific barriers, lessons learned, and best practices for maximizing buy-in across the organization. See Appendix A for the full list of interview discussion topics.

3.5. Interview Results

3.5.1 Overview of Results

An individual involved in the implementation of the ASAP program at a major airline (personal communication, November 4, 2014) shared a critical statistic supporting the importance of voluntary reporting. Three years after Just Policy was implemented at this organization, only 12 of roughly 700 report investigations involved events in which proven reckless behavior required disciplinary action. The majority of the remaining events involved at-risk behavior (such as routine violations), and a small percentage of events were attributed to legitimate human error. From these 700 reports, roughly 1600 corrective action recommendations were developed and implemented. The ratio of corrective action recommendations to reported investigations (2.29)

demonstrates that, on average, multiple causal factors influence a particular safety concern, and that substantial change is possible with an organizational commitment to Just Culture.

To compare the relative magnitude of each barrier/facilitator opportunity area, responses associated with each category were recorded and tallied. An "X" was placed under a barrier category if the interviewee verbalized knowledge of and/or concern about issues related to it. Marked responses included those that aligned with evidence gleaned from the literature review (Section 2) and other unique examples found to be relevant to each barrier/facilitator category. Table 3.1 demonstrates the consistency of interview responses and their alignment with the opportunity areas determined by the literature review. "Personnel changes" was the only area mentioned by fewer than 11 of the 12 interviewed (n = 8).

Table 3.1

Barrier/Facilitator Opportunity Areas Mentioned During Interviews

Interviewee Position	1. Blindness/ Personal Perspective	2. Safety Culture	3. Trust	4. Training Techniques	5. Personnel Changes	6. Policy and Procedure Definition	7. Event Reports and Interviews	8. Analysis/ Corrective Actions
Former Director of Maintenance Human Factors	X	X	X	X	X	X	X	X
Director of Maintenance Human Factors	X	X	X	X	X	X	X	X
Director at the Air Force Safety Center	X	X	X	X		X	X	X
GEA On-Wing Support Quality Leaders	X	X	X	X		X	X	X
Transportation Safety of Flight and Compliance Coordinator	X	X	X	X		X	X	X
Program Manager at the Volpe Center	X	X	X	X	X	X	X	X
GEA Manager of Safety and Health Excellence	X	X	X	X		X	X	X
GEA EHS Union Leader	X	X	X	X	X	X	X	X
GE Corporate EHS Ops. Leader	X	X	X	X	X	X	X	X
GEA Union Assembly Worker	X	X	X		X	X		X
Former TWU Mechanic, ASAP review team for major airline	X	X	X	X	X	X	X	X
GE EHS VP of Global Ops		X	X	X	X	X	X	X

Conversations with these industry professionals heavily supported information derived from the literature review, while providing personal examples and unique insights. Information in the following sections was gleaned from interview discussions and provides supplemental detail within each barrier and facilitator category.

3.5.2. "Blindness" to Human Error and the Impact of Local Perspective

The Director of the Maintenance Human Factors group at a major airline (personal communication, October 29, 2014) described the Iceberg of Ignorance as a model that can be used to understand the discrepancy in knowledge of issues affecting front line workers and other levels of an organizational hierarchy. The model is represented in Fig. 3.1.

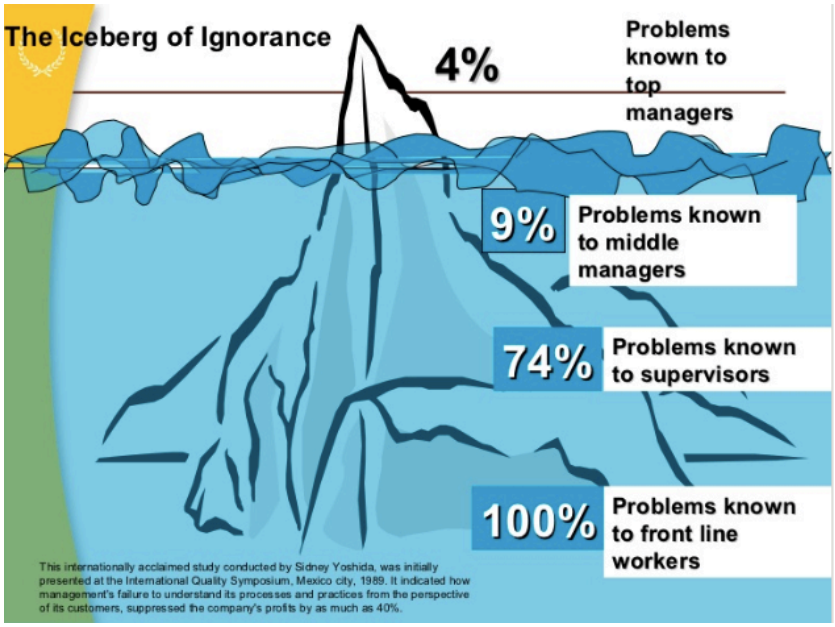

Fig. 3.1 Iceberg of Ignorance (Frndak, 2012)

This model clearly represents the potential effect of local perspective, directly resulting from lack of reporting incidents and near misses, and from insufficient communication among levels of hierarchy.

A former TWU mechanic (personal communication, December 18, 2014) argued that lack of reporting is often the result of certain aspects of human nature. Through his experience working with mechanics, he observed that people are generally unwilling to verbally admit mistakes, that they have an aversion to documenting such mistakes, and that they tend to deflect blame. In a Just Culture, mechanics are taught that what they may perceive as personal faults are actually more akin to tendencies they share with their peers, many of whom are affected by similar pressures and organizational deficiencies. Additionally, this former mechanic claimed that the most effective way to appeal to the "blindness" of executive leadership is to provide evidence of the potential financial benefit of the system prior to implementation using an accurate, persuasive cost-benefit analysis. Demonstrating the potential effect of such systems on morale and employee satisfaction should be of equal importance, but often the fiscal justification is a more effective motivation for executive decision-makers.

An EHS Union Leader at GE Aviation (personal communication, November 17, 2014) noted that many mechanics are afraid of being labeled "whiners" or "fakers", and feel embarrassed to report issues. Mechanics often blame their own incompetence for causing an error and argue that it was an isolated mistake, one that cannot be easily replicated. He described this flawed outlook as part of the "union mindset."

This conversation sparked the emergence of two relatively, but not entirely, distinct views of voluntary error reporting and its value: the "corporate mindset" and the "union mindset." Mechanics and technicians are typically associated with the union perspective, middle management and executive leadership are described as having a corporate point of view, and supervisors are often divided between the two positions. With respect to the value of voluntary reporting, both the corporate and union mindsets share the view that perfection in any human endeavor is by definition unattainable, and that focusing attention on potential hazards is only necessary if a clear and present danger exists. There are subtle differences in motivation behind these two outlooks that share a skepticism regarding error prevention.

The union mindset focuses on the unpredictability of hazards. Those who adhere to this mindset believe that it is impossible to develop and execute a remedial action plan for every possible error scenario, as the number of scenarios is theoretically infinite and consistently unpredictable. In reality, data collection allows for the recognition of patterns that describe error events and vastly improve the ability to detect and mitigate hazards. The union mindset can be interpreted as justifying/tolerating errors due to a perceived inability to gather sufficient data to predict and/or prevent all potential errors. It will become evident later in this report that the union focus on external hazards also tends to deemphasize the role of human error and emphasize random and seemingly uncontrollable environmental factors.

Those who adhere to the corporate mindset believe that perfection is not worth striving for because hazards, and therefore errors, cannot often be eliminated at a reasonable cost, only mitigated. Ascribing to the laws of diminishing returns and acceptable risk, the corporate mindset accepts a certain level of error as an inevitable aspect of human endeavor. Increasing training and/or removing underperforming employees are strategies often preferred to more costly solutions that require a thorough investigation of underlying system deficiencies. The corporate mindset views the pursuit of perfection as a potentially untenable cost of doing business that can only be managed and limited. The corporate mindset can be interpreted as justifying/tolerating errors because the perceived cost of error elimination is too great and cannot be justified.

3.5.3. Organizational Commitment to Safety Culture

Several interviewees' responses supported the notion that, in addition to financial issues, management and executive leadership image concerns may also trump the importance of safety. A manager at the Volpe Center involved with the implementation of the C^3RS program (personal communication, November 5, 2014) explained that union workers are subject to strict rules to prevent error, especially personal injury. Management is concerned with minimizing payments of damages, and executive leadership may fear more detrimental consequences, such as negative media attention. This conservative approach seems to be a common trait among experienced leaders; however, even new leadership may be hesitant to make significant controversial changes, particularly those that could result in increased reported errors, thereby threatening their emerging reputations.

A former TWU mechanic and ASAP review board member (personal communication, December 18, 2014) added that leadership may be concerned that voluntary reporting imposes a drain on the bottom line. Management may argue that voluntary reporting allows certain less motivated or less competent employees to avoid disciplinary action and/or removal. This is a legitimate concern, and there should be safeguards, including performance evaluations, in place to support all employees and to help identify anyone attempting to take advantage of the system.

Workers are quick to notice when executives and managers view error reporting as too costly or unimportant. A Quality Leader for On-wing Support at GE Aviation (personal communication, November 3, 2014) claimed that maintenance mechanics might not feel pressure from management to report at all. In some situations, management and workers may both feel that they benefit from this practice of non-disclosure. Although supervisors are familiar with the conditions and stresses affecting mechanics, management often fails to relate. A second Quality Leader (personal communication, November 3, 2014) explained that many mechanics only use voluntary reporting when issues cannot be resolved at a local level, such as with supervisor intervention. Reporting may be seen as a last resort due to either personal inconvenience or the perception that feedback will not be prompt or effective. Frustration with the current situation often outweighs a mechanic's motivation to help the organization to better understand these events.

The former Director of the Maintenance Human Factors group at a major airline (personal communication, October 27, 2014) argued that management and leadership must be convinced that voluntary reports are the only true method for obtaining useful information about near misses that could prevent serious accidents. If sufficient numbers of reports are not initially forthcoming, management should hold focus groups with the user population to test attitudes and understanding of the system. Supervisors have the most influence in actively promoting voluntary reporting. They have a closer working relationship with mechanics and a greater ability to build trust. Also, their performance expectations are less lofty than those of management, so there may be less personal risk involved with promoting improvements that affect production capabilities (Global Manager of Safety and Health Excellence Programs, personal communication, November 12, 2014).

A Transportation Safety of Flight and Compliance Coordinator (personal communication, November 4, 2014) argued that as a voluntary reporting system begins to provide valuable feedback, communication becomes of utmost importance. Bulletins should be disseminated that highlight the event, convey what was learned, and describe what solutions have been suggested and/or implemented. Communication of all accidents, incidents, and near misses, along with their outcomes (including those resulting in punishment) is important to further delineate the line between acceptable and unacceptable behaviors. This quality of communication improves trust and results in greater employee respect for the organization's leadership. Furthermore, in-person meetings between

leadership and management to discuss recent corrective action implementation as a result of voluntary reports validates the importance of the system and provides an additional means of broadcasting its success.

3.5.4. User Trust in Voluntary Reporting Systems and in Management

Each interviewee discussed the impact of trust among levels of hierarchy on the success of voluntary reporting systems, and several cited trust as the most influential determinant. Support for this assumption aligns well with the evidence presented in Section 2.4.5. A former TWU mechanic (personal communication, December 18, 2014) stated that lack of trust in voluntary reporting systems leads to the rise of urban legends about people losing licenses as a result of filing reports. He also claimed that retaliation is a reality. If workers are following management instruction to complete an unsafe task, which is later detailed in a voluntary report, the manager will also be questioned about the event. If only one or two mechanics are involved, the reporter's identity may not be kept confidential, and the manager may seek retribution against the reporter. The same principle applies to an observed unsafe act or an event involving multiple employees. As part of any investigation, all individuals mentioned in a report will be contacted. All interviewees agree that the purpose of voluntary reporting should not be to create an environment of distrust among peers or between subordinates and management. Those involved should be encouraged to be honest, to file a report or contribute to a group report, and to openly explain their motivations and thought processes both leading up to and during the event.

3.5.5. Voluntary Reporting System Training Techniques

A former TWU mechanic (personal communication, December 18, 2014) described the typical voluntary reporting training environment as severely lacking in trainee buy-in and involvement. Both management and the user population are resistant to training because they feel that the actual organizational culture is far different from what the training implies. He has overheard management comments such as, "Yeah, it will be business as usual next week." Training is often ineffective in proving that management initiatives can be worthwhile in guiding meaningful change. A GE Aviation Quality Leader (personal communication, November 3, 2014) added that it only takes one middle manager spreading a negative attitude toward voluntary reporting training to hinder the progress of the entire group.

Several interviewees claimed that online reporting interfaces are poorly designed and/or complex. In their experience, user training did not provide a visual representation of the online form, including identification of which fields required a response as opposed to those that were highly encouraged. Training often lacks clear examples of types of events to report. Or, the company may request (through training) the reporting of events that are different than those identified in the policy. Discovery of this type of discrepancy causes distrust and a lack of participation. Furthermore, follow-up training is non-existent (former TWU Mechanic, personal communication, December 18, 2014). A final concern was that event review teams lack proper training in root cause analysis and interview techniques. Their follow-up interviews are vital to the success of the

reporting system, and require a review team skilled in these areas to determine the full array of detailed causal factors that need attention (Global Manager of Safety and Health Excellence Programs, personal communication, November 12, 2014).

A Vice President of EHS Global Operations at GE Aviation (personal communication, December 22, 2014) added that hazard recognition training may be just as important as voluntary reporting system training. Experienced workers are so accustomed to highly practiced, repetitive tasks that they may be unaware of obvious hazards. This can result in a lack of reporting or gaps in error reports. She recommended an exercise in which workers travel in groups to unfamiliar areas of a plant or worksite to identify hazards. This activity not only provides workers with a fresh perspective, but it improves the likelihood of hazard recognition across the organization. She also argued that informal means of reporting, such as walkthroughs and conversations with plant managers, would motivate more employees to report concerns. Personal discussions are a far more powerful tool than online report submission. An informal conversation provides a more comfortable setting in which to ask important questions about work practices, motivation, and pressures. It also encourages employees to voice their opinions about how work processes could be improved to minimize routine violations and enhance both productivity and safety.

3.5.6. Personnel Changes that Influence Voluntary Reporting

Speaking with current and former members of a union organization was an important and insightful element of the interview phase. These individuals have a

unique perspective regarding the effects of personnel changes on reporting. A former TWU mechanic (personal communication, December 18, 2014) explained the importance of keeping a member of the mechanics' union on a review team. He described a personal experience in which the loss of a union member negatively affected the dynamic of the team and the team's relationship with the user population, thus hurting participation. He explained that without the protection of a union, management might go so far as to threaten employees with time off without pay if they file a report, or to offer employees a reduced or negligible punishment if they refrain from filing a report. Personnel changes, as well as differing management tactics, can elicit fear of this type of retaliation, even when such tactics are prohibited by official policy.

3.5.7. Voluntary Reporting System Policy and Procedure Definition

The former Director of the Maintenance Human Factors group at a major airline (personal communication, October 27, 2014) explained that many users are unsure about whether their name or other identifying information will be tied to the report and who will have access this information at each stage of the process. The flow of information should be outlined, in visual form, so that users are assured of the confidentiality of the system. Including representatives of user groups in the design of the system will increase user understanding of system policies and procedures. Users either fail to seek out these detailed system policies or have trouble understanding the complicated legal language in which they are written. Many perceive this language as purposefully vague, reflecting a company's lack of commitment to carrying out the policy as written. Without

closely inspecting the policy, employees may fixate on a particular point that dissuades them from reporting, rather than trying to understand the message in the context of the entire document. Others may misinterpret the policy to mean total exemption from punishment, regardless of the severity or illegality of their actions (former TWU Mechanic, personal communication, December 18, 2014).

The specific algorithm used to determine the acceptability of the report should be communicated to all users to clarify the organization's commitment to a uniform investigative approach. Over time, users will spread the message of organizational fairness in policy adherence, which should complement communication from management. It is equally important to prove to leadership that a voluntary reporting system is not a "secret society" eliminating all accountability for poor behavior and performance, but a well-defined tool to elicit and collect valuable, and otherwise concealed information. Both leadership and the user population should be involved in the establishment of clearly defined policies and procedures, including the algorithm used to determine acceptance criteria (Transportation Safety of Flight and Compliance Coordinator, personal communication, November 4, 2014).

3.5.8. Voluntary Error Reports and Interviews

The Director of the Maintenance Human Factors group at a major airline (personal communication, October 29, 2014) recalled that some companies require a report quota to prove to leadership that the system is working well. This methodology can result in the generation of less meaningful reports, as well as the

reporting of issues falling outside the scope of the system. Forced reporting hurts trust, especially when employees fear lay-offs if quotas are not met.

Several interviewees offered suggestions for improving the quality of error reports. The former Director of the Maintenance Human Factors group at a major airline (personal communication, October 27, 2014) stressed the importance of multiple channels for reporting, and a director at the Air Force Safety Center (personal communication, October 30, 2014) mentioned the need for both formal and informal reporting methods that can either be immediate or delayed. Fewer restrictions on reporting methods will encourage a larger group of participants to step out of their comfort zone and contribute valuable information. A former TWU mechanic (personal communication, December 18, 2014) suggested that interviewing other mechanics would help review teams to develop a more accurate benchmark for how all mechanics should react in a particular situation.

3.5.9. Analysis of Error Reports and Development of Corrective Actions

Given metric pressures and the often-skeptical nature of management, several sources recommended that corrective actions be developed without the input of management. Managers often weigh cost and time restraints more heavily than safety and may be resistant to implementing a recommended solution (Global Quality Leader for On-Wing Support, personal communication, November 3, 2014). If a team is hired to analyze error reports and suggest corrective actions, the organization and its managers should trust the judgment of this group. The organization can then assess the validity of the group's

recommendations by tracking the results of their solutions based on safety improvements and cost savings (Transportation Safety of Flight and Compliance Coordinator, personal communication, November 4, 2014).

A former TWU mechanic (personal communication, December 18, 2014) stated that the cost-benefit analyses conducted to prove the necessity of robust solutions are often poor. In addition, any such analysis should include a meaningful argument about the potential impact to safety. As many of the error event reports account for routine violations, the team developing corrective actions should seek ways to more clearly define everyday rules and change policies that are not being followed effectively. When one rule is questioned, the validity of all organizational policies may be doubted. Corrective actions should be focused on improving the clarity of policies and procedures and matching the rigidity of rules to the actual risks involved. This will provide greater incentive to follow rules, rather than taking shortcuts (EHS Union Leader, personal communication, November 17, 2014).

4. Questionnaire Development and Implementation

4.1. Questionnaire Purpose

To further investigate the barriers to and the facilitators of voluntary reporting as defined by the literature review and knowledge elicitation phases, it was necessary to explore and compare perceptions of reporting practices of system users (such as mechanics/technicians) and the managers who are responsible for supporting the system and disseminating clear policies. As this

study focused on employees in the aviation industry, questionnaires were distributed to mechanics and managers at numerous airlines that use a common voluntary reporting system, but have unique policies and methods of operation that can affect safety culture and reporting practices. Participants were asked to anonymously report individual characteristics and to judge whether a series of common errors and violations would be reported at their organization. If not, participants were asked to choose from a list of reasons for reporting hesitation.

The questionnaire would provide a means for understanding the potential influence of personal characteristics on one's perception of reporting practices as well as a measure of the level of agreement (or lack thereof) between reporting system-related perceptions held by mechanics and managers. Because 9 of the 11 presented errors/violations should be perceived as warranting an error report based on ASAP policy, the questionnaire data would assess adherence to reporting system policies across the industry. It would also provide valuable insights into how each group perceives and prioritizes reasons for not reporting, perceptions that are influenced by the previously defined barriers.

4.2. Questionnaire Development

4.2.1 Drafting the Questionnaire

A questionnaire was developed for potential users of a common voluntary reporting system and their managers to assess both groups' perceptions of reporting practices with regard to an array of errors and violations. This technique was adapted from the work of Clark (1998) in the railroad industry, but

the study was modified to focus on aircraft engine maintenance errors and violations.

Initial questions were designed to elicit personal information (age, gender, job title, years of experience) to determine how these factors might correlate with respondents' personal experiences with or opinions about voluntary reporting systems and their use. Familiarity with voluntary reporting was then assessed by requesting the number of reports personally submitted (by mechanics) or the number of reports personally observed leading to corrective actions (by management). The next set of questions presented 11 workplace scenarios derived from a combination of inadvertent human errors, deliberate routine violations, blatant disregard for safety, and/or illegal actions.

Participants were asked to choose which scenarios would be reported based on the specific reporting practices at their organization. For mechanics, this scenario-based approach assumes that there are individual, measurable differences in how employees understand, interpret, follow, and value their voluntary reporting system's policies and procedures. For management (executives, middle management, and supervisors), this approach reflects the assumption that there are individual, measurable differences in how organizations teach, deploy, value, monitor, and reward participation in their voluntary reporting system.

All participants were given the choice of answering "yes", "possibly", or "no" for each scenario. Answering "yes" was deemed a "correct" response to 9 of the 11 scenarios, as these are events that meet acceptance criteria for the ASAP

system used in commercial aviation. The remaining 2 scenarios would likely not be accepted under ASAP and, therefore, would not guarantee immunity from punishment. Answering "possibly" or "no" prompted participants to select from a list of reasons why mechanics might be deterred from submitting an error report. Going forward, this list will be referred to as "reasons for reporting hesitation." The structure of these questionnaires provided a direct comparison of opinions and perceptions about error reporting between the two groups most influential to the quality and utility of voluntary error reporting systems in the airline industry.

The list of errors/violations was developed by first considering a list of general maintenance error categories used by the Human Factors group at GE Aviation to characterize and study error. More detailed scenarios were generated based on studies the group conducted to test some of the most common issues within each of the general categories. A consideration in drafting the scenarios was ensuring variation in both the severity of errors/violations and the level of deliberateness of each act. The list of maintenance errors/violations was reviewed by a former TWU mechanic and ASAP review board member and a Transportation Safety of Flight and Compliance Coordinator who was instrumental in the development of the ASAP system at a major airline. This evaluation ensured that the chosen maintenance errors were common enough to cover a broad range of issues experienced by a large group of mechanics, but specific enough to prompt thoughtful consideration of whether or not they fell into the realm of reportable events. The following is the list of maintenance errors and violations that were presented to questionnaire participants:

A. Skipping a step in a procedure that is often skipped
B. Leaving a tool inside the engine
C. Observing someone breaking a rule that is a blatant disregard for safety
D. Failing to apply the exact final torque to a bolt using a proper torque wrench, but instead estimating it using a regular wrench
E. Forgetting to complete the final step in a procedure
F. Installing the wrong part
G. Skipping a required final inspection and/or sign off
H. Handing off a job without the proper paperwork
I. Arriving at work under the influence of alcohol or a controlled substance
J. Walking away from a work area without finishing a job or handing it off to someone else
K. Failing to properly secure an access panel or cowling

Scenarios "C" and "I" would likely not be accepted into a voluntary reporting system that ensures immunity from punitive action. The first is described as "blatant disregard for safety" and the second is an illegal act, two criteria that preclude report acceptance. (Note that this "numbering", A-K, will be used in the analysis and discussion to refer to each error scenario.)

Reasons for reporting hesitation were crafted based on information gleaned during the literature review and knowledge elicitation phases. Many responses were based on phrases mentioned during interviews by professionals who work closely with mechanics and/or reporting system review teams. The use of each reason reflects the existence of one or more of the previously defined

barriers. The former TWU mechanic/ASAP review board member and Transportation Safety of Flight and Compliance Coordinator also reviewed this list of reasons for reporting hesitation to verify their relevance to a mechanic's work environment, potential relationship with superiors, and general mindset.

The following is the list of reasons for reporting hesitation from which all participants were asked to choose after indicating "no" or "possibly" to an error/violation scenario.

1. It's too much work to go through the reporting process
2. That's just how the job is always done - it works fine every day
3. This type of incident wasn't serious enough to cause an issue down the road
4. Admitting to this incident might result in disciplinary action
5. It would make more sense to go straight to a supervisor or manager
6. The explanation of the event might lead to questions about others involved
7. Nothing will get done about this type of incident - management won't care or think it's important
8. I don't think lasting change will result from reporting this

The questionnaire was reviewed for ease of comprehension and to ensure that questions were not overly invasive. Several suggestions were incorporated into the final draft. The full questionnaire can be found in Appendix B.

4.2.2. Questionnaire Participants

Completed questionnaire responses were collected from 30 mechanics/ technicians and 27 managers at numerous airlines that use the ASAP system. Participants varied in age, gender, years of experience, and familiarity with voluntary reporting. This broad demographic provided an accurate snapshot of both user and management populations with varied experiences and, therefore, exposure to a wide range of barriers. Representation from numerous airlines further contributed to the variety of exposures. A detailed profile of each sample can be found in Section 5.3.

4.3. Hypotheses to be Tested

Eight null hypotheses were developed to test and compare voluntary reporting perceptions of a group of airline mechanics and managers that utilize a common non-punitive reporting system. These hypotheses are as follows:

1. There is no statistically significant difference between mechanics' and managers' patterns of acceptance criteria for error reports (assessed for aggregated data and for each individual error/violation).
2. There is no statistical correlation between mechanics' and managers' rank ordering of acceptable error/violation report scenarios.
3. There is no statistically significant difference between the pattern of reasons for reporting hesitation identified by mechanics and managers (assessed for total reason use and individual reason use).

4. There is no statistical correlation between mechanics' and managers' rank ordering of reasons for reporting hesitation.
5. (A) There is no statistically significant difference in the way in which mechanics of varying age identify criteria for acceptable voluntary error reports.

   (B) There is no statistically significant difference in the way in which managers of varying age identify criteria for acceptable voluntary error reports.
6. (A) There is no statistically significant difference in the way in which mechanics of varying years working at an organization identify criteria for acceptable voluntary error reports.

   (B) There is no statistically significant difference in the way in which managers of varying years working at an organization identify criteria for acceptable voluntary error reports.
7. (A) There is no statistically significant difference in the way in which mechanics of varying years working in aviation identify criteria for acceptable voluntary error reports.

   (B) There is no statistically significant difference in the way in which managers of varying years working in aviation identify criteria for acceptable voluntary error reports.
8. (A) There is no statistically significant difference in the way in which mechanics of varying experience using voluntary reporting systems identify criteria for acceptable voluntary error reports.

(B) There is no statistically significant difference in the way in which managers of varying experience using voluntary reporting systems identify criteria for acceptable voluntary error reports.

These eight hypotheses will be tested within the context of several general analysis concepts. The following are specific analysis goals that will be accomplished by (1) investigating the raw data and making general observations and (2) testing each previously defined hypothesis.

1. Determine how mechanics and managers who use a common voluntary reporting system perceive and identify reportable errors and violations (*hypotheses 1 and 2*).
2. Compare the perceptions of mechanics and management with regard to perceived use of reasons for reporting hesitation (*hypotheses 3 and 4*), and relate perceived importance of these reasons to the impact of their associated barriers.
3. Determine how individual characteristics influence error reporting perceptions (*hypotheses 5-8*) and reasons for reporting hesitation.
4. Assess the level of agreement of reporting practice perceptions within the individual mechanic and management samples.

4.4. Questionnaire Implementation

4.4.1. Questionnaire Distribution Process

Questionnaire participants were sought out with the help of various Field Service Engineers at GE Aviation who work closely with the major airlines to

which GE supplies commercial jet engines. Additionally, several interviewees, including a customer contact at an air framer and two individuals associated with the ASAP system, spread the word about this effort, which inspired volunteers to participate. Five major airlines were originally targeted. An initial goal of the study was to compare responses from each airline, which would have provided a clearer measure of the impact of corporate culture and unique policies/methods of operation. However, questionnaires reached employees from other airlines, and individual airline samples were not large enough to permit meaningful comparisons. As both the mechanic and management samples were derived from multiple airlines (introducing unknown variation), it was important that all participants used a common voluntary reporting system. The ASAP system is used by 96% of commercial airlines in the NAS, likely including the unknown airlines represented in the data set.

Each airline contact who disseminated questionnaires was given a prompt introducing the primary investigator, describing the effort, and ensuring complete anonymity and non-disclosure of airline names. Participants were assured that input was completely anonymous and voluntary, and they were instructed to participate only if they felt comfortable. Links to the online mechanic and manager questionnaires were included in the email, as well as the contact information of the primary investigator. The prompt can be found in Appendix B.

4.4.2. Data Collection Timeline

Data collection began in January of 2015 and continued through early March of 2015. A majority of participants completed their questionnaires within 48 hours of receiving a link. Based on the rapid response rate, an extended collection period to await additional responses was deemed unnecessary.

5. Questionnaire Analysis Methods

5.1. Goals of Analysis

The goal of the analysis was to determine the relative magnitude of each barrier to voluntary reporting affecting the perceptions and opinions of the user population (mechanics/technicians) and those who manage them (managers/supervisors). This goal could be accomplished by assessing the perceptions and practices of the two groups individually, but a more powerful investigation would also determine key inconsistencies between the two groups' perceptions of the relative importance of the identified barriers (as measured by the barrier totals derived from the "reasons" tallies).

Both personal characteristics and unique experiences as a result of position within an organization can affect perceptions of reporting practices and susceptibility to the previously defined barriers. The way in which the two sample groups perceive reporting participation is, in part, a direct reflection of their corporate cultures, which define and promote the use of these systems.

5.2. Overview of Analysis

This section provides an overview of the general assessments that were made to compare mechanic and management response data and the more specific associations that were tested according to the hypotheses presented in Section 4.3. Responses to each error/violation scenario ("yes", "possibly", "no", "unsure how/what to report") were evaluated, along with the rank order of scenarios based on percentage of "yes" responses. The internal agreement of each sample with regard to the reportability of each scenario was also assessed, followed by the influence of personal characteristics on reporting perceptions. Use of reasons for reporting hesitation was compared between the two samples, including the rank order of perceived impact and the influence of personal characteristics on this perception. An overview of the eight hypotheses used to test the statistical significance of the associations discussed in this section was presented. Finally, the relationship between reasons for reporting hesitation and barrier existence was discussed.

The first portion of the analysis focused on the sample groups' summarized responses garnered from completed questionnaires. The number of "yes", "no", "possibly", and "unsure how/what to report" (mechanics only) responses were tallied for each of the error/violation scenarios presented to participants. These tallies were used to compare response patterns within each separate sample group, and between the two groups. Next, the errors/violations were ranked based on percentage of "yes" responses for each sample, where n_1 = 30 mechanics and n_2 = 27 managers. The percentage "yes" delta was calculated

for each error/violation to determine which event scenarios divided the two sample groups in terms of reportability.

Perceived adherence to established reporting policies and guidelines was then assessed by applying a grading scale to the error/violation scenarios. The questionnaire was phrased so that participants were asked to choose whether a list of 11 errors and violations "*would* be reported" at their organization. Nine of the errors/violations would likely be accepted into a non-punitive reporting system, but the barriers uncovered in this study prove that many acceptable events are not reported. Within many organizational cultures in the aviation industry today, "yes", "no", and "possibly" could each represent an accurate response for any of the scenarios. For the purpose of understanding both the influence of individual perception and the imposed cultural impact, however, each participant's "score" was based on the number of "yes" responses chosen from the 9 acceptable event scenarios. These scores provided a comparison of mechanics' and managers' perceptions of reporting practices using each respective group's means, standard deviations, and top and bottom scoring tiers.

Each error/violation scenario was then evaluated based on the internal agreement of each sample group as to whether or not the 9 acceptable scenarios would be reported. The metric used for this portion of the analysis will be referred to as the "confidence factor." It is defined as the difference between the number of "yes" responses and the sum of "no", "possibly", and "unsure how/what to report" (where applicable) responses recorded for each event scenario. A high confidence factor symbolizes significant agreement between

members of the sample group about whether a given error/violation would or would not be reported, and a low confidence factor represents conflicting reporting opinions. Finally, the effect of personal characteristics was assessed. Age, years with a participant's current organization, years working in the aviation industry, and number of voluntary reports personally submitted (for mechanics) or number of voluntary reports personally observed leading to corrective actions (for management) were investigated for their influence on perception of reporting practices.

Justification for non-reporting was the next subject of evaluation. The eight previously-established reasons for reporting hesitation were ranked based on frequency of use by both sample groups separately, and using the aggregated data set, yielding a measure of the relative influence of each reason. The delta between mechanic and management mention of each reason was calculated to determine discrepancies in perceived relevance of each reason. Similar to the previous assessment of the reportability of events, the effect of personal characteristics on perceived justification of non-reporting was examined.

After capturing and comparing each sample group's opinions based on various criteria, a more detailed statistical assessment was conducted to determine where significant differences exist in: (1) perceptions of reporting practices and (2) reasons cited for reporting hesitation, both within each sample and between the two groups. The chi square method was used to test hypotheses 1 and 3, comparing mechanics' and managers' perceptions of reporting and reasons for reporting hesitation, respectively. Spearman's rank-order correlation was used to

test hypothesis 2, comparing the way in which the two sample groups ranked errors/violations based on perceived reportability, and to test hypothesis 4, comparing ranks of reasons for reporting hesitation. Hypotheses 5-8 were tested using chi-square, comparing perceptions of reportable events based on personal characteristics. All hypotheses can be referenced in Section 4.3.

Once significant associations in the data were determined, the relative impact of each barrier to voluntary reporting could be assessed. Frequency of mention of reasons for reporting hesitation was used to determine the relative magnitude of each previously defined barrier. Each reason for reporting hesitation is the potential result of one or more barriers. The magnitude of each barrier was calculated based on mechanic and management responses. Unique barrier evaluation and recommendations for barrier mitigation were based on the exposure of certain statistically significant differences in Section 6.3 and additional observations related to characteristics in Section 6.2.3.

5.3. Profile of Participant Sample Groups

A group of 30 aircraft mechanics and a group of 27 managers (to whom aircraft mechanics report) responded to the online questionnaires. Mechanics ranged in age from under 30 to over 60, and managers ranged in age from 30 to over 60. Both groups included participants who have worked at their current organization from under five years to over 20 years. Experience working in the aviation industry ranged from under 10 years to over 30 years for mechanics and

from 11-20 years to over 30 years for managers. The two groups are quantified based on these characteristics in Table 5.1, Table 5.2, and Table 5.3.

Table 5.1.

Questionnaire Participant Profile by Age

Age	Mechanics	Managers	Total
Under 30	1	0	1
30-40	5	2	7
41-50	7	8	15
51-60	12	11	23
61+	5	6	11
Total	**30**	**27**	**57**

Table 5.2.

Questionnaire Participant Profile by Years at Current Organization

Years at Current Organization	Mechanics	Managers	Total
0-5	3	3	6
6-10	8	7	15
11-20	5	13	18
21+	14	4	18
Total	**30**	**27**	**57**

Table 5.3.

Questionnaire Participant Profile by Years in Aviation

Years in Aviation	Mechanics	Managers	Total
0-10	4	0	4
11-20	3	6	9
21-30	10	11	21
31+	13	10	23
Total	**30**	**27**	**57**

Experience with voluntary reporting was an important consideration when analyzing participants' questionnaire responses. Level of experience was assessed using three measures: (1) a five point Likert scale of familiarity which

was self-reported by mechanics and management (Table 5.4), (2) mechanics' indication of the number of voluntary reports personally submitted in the past (Table 5.5), and (3) managers' indication of the number of report-driven corrective actions observed (Table 5.6).

Table 5.4.

Questionnaire Participant Profile by Familiarity with Voluntary Reporting

Familiarity with Voluntary Reporting	Mechanics	Managers	Total
Very Familiar	23	20	43
Somewhat Familiar	6	6	12
Neutral	0	1	1
Somewhat Unfamiliar	0	0	0
Very Unfamiliar	1	0	1
Total	**30**	**27**	**57**

Table 5.5.

Mechanic Participants' History of Voluntary Report Submission

		Number of Voluntary Reports Submitted			
Age	**Years in Aviation**	**0-2**	**3-5**	**6-10**	**11+**
Under 30 (1)	0-10	1			
30-40 (5)	0-10	2		1	
	11-20	2			
41-50 (7)	11-20		1		
	21-30			2	2
	31+		2		
51-60 (12)	21-30	1	2		2
	31+	2		1	4
61+ (5)	21-30	1			
	31+	2	1		1
Total		**11**	**6**	**4**	**9**

Table 5.6.

Management Participants' Observations of Corrective Actions

		Number of Voluntary Reports Seen Lead to Corrective Action			
Age	**Years in Aviation**	**0-5**	**6-10**	**11-20**	**21+**
30-40 (2)	11-20				2
41-50 (8)	11-20			1	1
	21-30	1	1		3
	31+				1
51-60 (11)	11-20	2			
	21-30			1	4
	31+	2			2
61+ (6)	21-30				1
	31+	1	1		3
Total		**6**	**2**	**2**	**17**

Of the 57 total participants in the study, only 7 were female (3 mechanics and 4 managers). Due to the lack of female data points, the influence of gender was not tested.

5.4. Discussion of Statistical Analysis Methods

5.4.1. Chi-Square Test of Independence

The chi-square test of independence was used several times in the study to evaluate samples from a population of airline employees that utilize a common, non-punitive voluntary reporting system. The chi-square method can be used to determine if there is a significant association between two categorical variables. A chi-square test was used to evaluate hypotheses 1, 3, and 5-8. Hypothesis 1 tested the association between job title (mechanic or manager) and perception of what is and what is not a reportable error/violation. Hypothesis 3 tested the

association between job title and perception of reasons cited for reporting hesitation. Hypotheses 5-8 tested the association between personal characteristics (age, years with an organization, years working in the aviation industry, and experience with voluntary reporting) and perception of reporting practices for mechanics and managers, individually.

Chi-square was appropriate for the previously mentioned tests of significance because each involved the comparison of two or more groups of categorical data. Each population was greater than 10 times the sample tested and the expected frequency for each subgroup tested (e.g., the expected number of "yes" responses for mechanics) was at least 5.

The chi-square method works by comparing observed data for each point of intersection between the two tested categories. An expected value is calculated to correspond with each of these entries based on the sum of the observed responses for each sub-category and the total responses. A "test statistic", or chi-square, is calculated using the following equation.

$$X^2 = \Sigma \left[(\text{Observed} - \text{Expected})^2 / \text{Expected}\right]$$

This test statistic is compared to a critical value determined by (1) the degrees of freedom of the experiment and by (2) the desired level of significance (α), defined as the probability of rejecting the null hypothesis when the null hypothesis is true (committing a type I error). If the test statistic is greater than the critical value, there is statistical significance to the dissimilarities in the data. For the purposes of this study, the significance level (α) used was 0.05.

5.4.2. Spearman's Rank-Order Correlation

Spearman's rank-order correlation is used to test the strength of association between two variables based on the respective rankings of their categorical data. This test may be used when the assumptions of the Pearson product-moment correlation are inapplicable. The Pearson test requires continuous data, but Spearman's correlation can be used to test ordinal, interval or ratio variables. The test is conducted by first ranking the data in each set. Any matching values are assigned a "tied" rank (e.g., matching values that would otherwise be ranked 6 and 7 would both be ranked 6.5, and 6 and 7 would not be used). The correlation coefficient, "ρ", is calculated using the formula:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

where "d_i" is the difference in paired ranks and "n" is the size of the sample. If tied ranks exist, the following formula is used:

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}$$

where "i" is a paired score. The correlation coefficient, ρ, can range from -1 to 1. A value of 1 signifies a perfect positive association between the ranks of the two data sets, 0 indicates that there is no association between the ranks, and -1 denotes a perfect negative association between the ranks.

Spearman's rank-order correlation was used to test hypothesis 2, to determine if an association exists between job title (mechanic or manager) and the ranked orders of errors/violations based on perceived reportability. It was also used to test hypothesis 4, which evaluated the association between job title (mechanic or manager) and the ranked order of reasons for reporting hesitation based on perceived use.

5.4.3. Sample Size Justification

A total of 57 completed questionnaires were collected, 30 from mechanics and 27 from managers. The chi-square test of independence is useful when each expected value is calculated to be at least 5. When comparing "yes" and "no"/ "possibly" responses for the set of 9 acceptable errors and violations, there were a total of 270 mechanic and 243 manager responses. When repeating this method for the two unacceptable violations, there were a total of 60 manager and 54 mechanic responses. These values resulted in expected values for each subcategory to be well above 5. Although lower, expected values remained greater than 5 when comparing perceptions of reporting practices for individual errors/violations.

When perceptions of reasons for reporting hesitation were compared using the chi-square method, mechanics recorded a total of 193 reasons and managers recorded a total of 247 reasons. Unlike the previous set of tests, these totals were unpredictable, as participants were able to select one or more reasons per event.

Whether comparing mechanic and management use of all 8 reasons or isolating each reason individually, all expected values were well above 5.

These sample sizes were not only appropriate for the use of chi-square, but their similarity validates the use of other methods of analysis. Raw numbers (such as the frequency of "yes" responses or reasons for reporting hesitation) were divided by each sample size, generating an average frequency per response for each sample. This approach maintains the integrity of the data because the sample sizes were so similar to begin with. Combined data (either raw frequencies or average frequencies per response) were only slightly skewed in favor of mechanic influence due to the small difference in sample sizes.

6. Results of Questionnaire Analysis

6.1. Classification of Reportable Errors and Violations

6.1.1. Summary of Data Collected

After sharing information about personal characteristics (described in Section 5.3), participants were asked to indicate whether a list of errors/violations would be reported at their organization. It was assumed that there would be consistency across each sample due to the fact that each organization uses the same voluntary reporting system. However, some variation was expected as a result of unique organizational characteristics, such as company policies, the message/values promoted by leadership, the ability of management to communicate effectively with subordinates, and the usefulness of training sessions. Table 6.1 provides an overview of aircraft mechanic responses when

asked whether a list of common errors and violations would be reported at their organization. Table 6.2 summarizes the frequency of responses to the nine error/violation scenarios that would be accepted into the ASAP system. These frequencies are represented graphically as percentages in Fig. 6.1.

Table 6.1.

Mechanics' Perceptions of Reporting Errors/Violations

CODE	Error/Violation	Yes	Possibly	No	Unsure How/ What to Report	Total Responses
A	Skipping a step in a procedure that is often skipped	12	12	5	1	30
B	Leaving a tool inside the engine	19	9	1	1	30
*C	Observing someone breaking a rule that is a blatant disregard for safety	15	14	1	0	30
D	Failing to apply the exact final torque to a bolt using a proper torque wrench, but instead estimating it using a regular wrench	11	9	9	1	30
E	Forgetting to complete the final step in a procedure	21	8	0	1	30
F	Installing the wrong part	26	4	0	0	30
G	Skipping a required final inspection and/or sign off	24	5	0	1	30
H	Handing off a job without the proper paperwork	11	11	6	2	30
*I	Arriving at work under the influence of alcohol or a controlled substance	15	6	8	1	30
J	Walking away from a work area without finishing a job or handing it off to someone else	11	5	11	3	30
K	Failing to properly secure an access panel or cowling	24	5	0	1	30
	TOTAL	**189**	**88**	**41**	**12**	**330**

**Report would not likely be accepted in a voluntary reporting system similar to ASAP*

Table 6.2.

Mechanics' Perceptions of Reporting "Reportable" Errors/Violations

"Yes"	"No"	"Possibly"	"Unsure How/ What to Report"
159	32	68	11

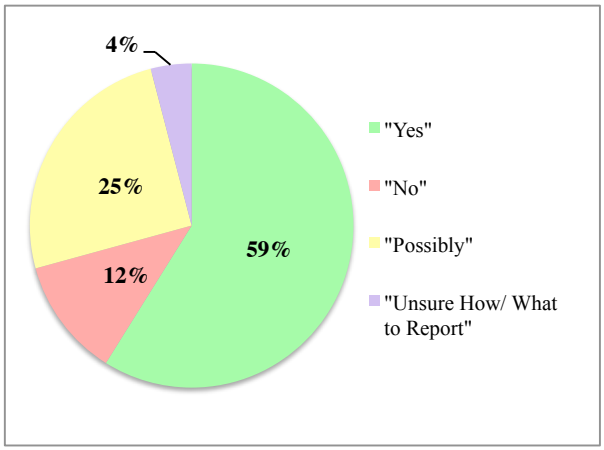

Fig. 6.1. Mechanics' Perceptions of Reporting "Reportable" Errors/Violations

Similarly, data from aircraft manager responses to the same list of errors and violations is presented in Table 6.3. Table 6.4 summarizes the frequency of responses to the nine error/violation scenarios that would be accepted into the ASAP system. These frequencies are represented graphically as percentages in Fig. 6.2.

Table 6.3.

Managers' Perceptions of Reporting Errors/Violations

CODE	Error/Violation	Yes	Possibly	No	Total Responses
A	Skipping a step in a procedure that is often skipped	8	11	8	27
B	Leaving a tool inside the engine	21	5	1	27
*C	Observing someone breaking a rule that is a blatant disregard for safety	12	13	2	27
D	Failing to apply the exact final torque to a bolt using a proper torque wrench, but instead estimating it using a regular wrench	13	10	4	27
E	Forgetting to complete the final step in a procedure	16	9	2	27
F	Installing the wrong part	24	2	1	27
G	Skipping a required final inspection and/or sign off	16	11	0	27
H	Handing off a job without the proper paperwork	11	12	4	27
*I	Arriving at work under the influence of alcohol or a controlled substance	16	7	4	27
J	Walking away from a work area without finishing a job or handing it off to someone else	9	16	2	27
K	Failing to properly secure an access panel or cowling	22	4	1	27
	TOTAL	**168**	**100**	**29**	**297**

**Report would not likely be accepted in a voluntary reporting system similar to ASAP*

Table 6.4.

Managers' Perceptions of Reporting "Reportable" Errors/Violations

"Yes"	"No"	"Possibly"
140	23	80

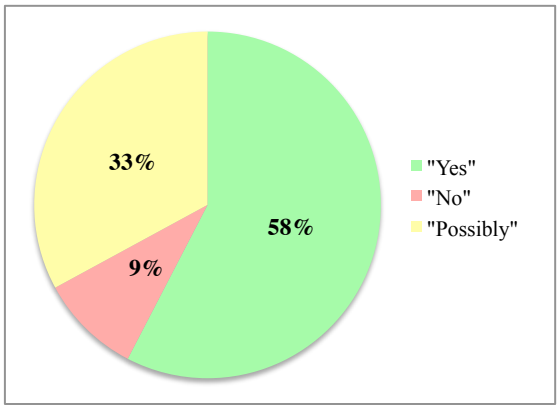

Fig. 6.2. Managers' Perceptions of Reporting "Reportable" Errors/Violations

At a glance, the results are very similar. For the nine errors and violations that would be accepted in the ASAP system, responses indicate that mechanics and managers believe that only 59% and 58% of the events, respectively, would be reported. According to ASAP system policies, 100% of these events should be reported. Managers were slightly more hesitant than mechanics, citing that 33% of the errors/violations were "possibly" reportable, compared to 25% for mechanics. This percentage may be lower for mechanics partly because of the additional option to indicate that they (and/or their peers) may be unsure of how or what to report.

Although questionnaires distributed to both mechanics and management were phrased to request whether a list of errors/violations *would* be reported at participants' organizations, it was impossible (and impractical) to eliminate the

influence of personal opinion and one's own reporting practices from mechanic responses. The "unsure how/what to report" response introduced a more personalized option which contradicted the neutrality of the original question, but it was important to allow for confusion to be expressed. Lack of knowledge regarding the use of the system and insecurity describing an error or violation in an event report were clear indications of insufficient training and learned helplessness. For future comparisons between mechanics and management, as well as compilation of total tallies, the "unsure how/what to report" responses will be combined with "possibly" responses.

Table 6.5 contains the combined mechanic and management data set for perceived reporting practices. Table 6.6 summarizes the frequency of responses to the nine error/violation scenarios that would be accepted into the ASAP system. These frequencies are represented graphically as percentages in Fig. 6.3.

Table 6.5.

Overall Perceptions of Reporting Errors/Violations

CODE	Error/Violation	Yes	Possibly + Unsure	No	Total Responses
A	Skipping a step in a procedure that is often skipped	20	24	13	57
B	Leaving a tool inside the engine	40	15	2	57
*C	Observing someone breaking a rule that is a blatant disregard for safety	27	27	3	57
D	Failing to apply the exact final torque to a bolt using a proper torque wrench, but instead estimating it using a regular wrench	24	20	13	57
E	Forgetting to complete the final step in a procedure	37	18	2	57
F	Installing the wrong part	50	6	1	57
G	Skipping a required final inspection and/or sign off	40	17	0	57
H	Handing off a job without the proper paperwork	22	25	10	57
*I	Arriving at work under the influence of alcohol or a controlled substance	31	14	12	57
J	Walking away from a work area without finishing a job or handing it off to someone else	20	24	13	57
K	Failing to properly secure an access panel or cowling	46	10	1	57
	TOTAL	**357**	**200**	**70**	**627**

**Report would not likely be accepted in a voluntary reporting system similar to ASAP*

Table 6.6.

Overall Perceptions of Reporting "Reportable" Errors/Violations

Total "Yes"	Total "No"	Total "Possibly"/ "Unsure"
299	55	159

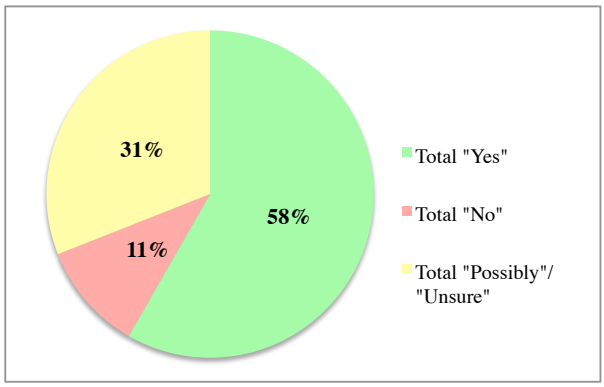

Fig. 6.3. Overall Perceptions of Reporting "Reportable" Errors/Violations

The results demonstrate that although these nine errors/violations would be accepted as ASAP reports, there are barriers influencing actual reporting practices and/or the way that participation is perceived. The substantial portion of "possibly" and "no" responses (42% combined) suggests that voluntary reporting system policies are either unclear, not communicated effectively, or simply not trusted. Finally, scenarios C and I, which would likely not be accepted by ASAP, were identified as more reportable than expected. The high reportability of scenario C, involving the implication of a colleague, was especially surprising.

6.1.2. Comparison of Perceptions of Reportable Events

In order to better understand the culture in which these systems operate, it was useful to rank errors and violations presented to participants based on the percentage of "yes" responses received by each scenario. Table 6.7 and Table 6.8

show the ranked order of the 11 errors/violations, according to mechanics and managers, respectively. Both the frequency of "yes" responses and the percentage of "yes" responses (per number of participants in each group) are shown in these tables.

Table 6.7.

Reportability Rankings of Errors/Violations from Mechanic Responses

CODE	Error/Violation	Number of "Yes" Responses	Percentage of Responses
F	Installing the wrong part	26	86.67
G	Skipping a required final inspection and/or sign off	24	80.00
K	Failing to properly secure an access panel or cowling	24	80.00
E	Forgetting to complete the final step in a procedure	21	70.00
B	Leaving a tool inside the engine	19	63.33
*C	Observing someone breaking a rule that is a blatant disregard for safety	15	50.00
*I	Arriving at work under the influence of alcohol or a controlled substance	15	50.00
A	Skipping a step in a procedure that is often skipped	12	40.00
D	Failing to apply the exact final torque to a bolt using a proper torque wrench, but instead estimating it using a regular wrench	11	36.67
H	Handing off a job without the proper paperwork	11	36.67
J	Walking away from a work area without finishing a job or handing it off to someone else	11	36.67

**Report would not likely be accepted in a voluntary reporting system similar to ASAP*

Table 6.8.

Reportability Rankings of Errors/Violations from Manager Responses

CODE	Error/Violation	Number of "Yes" Responses	Percentage of Responses
F	Installing the wrong part	24	88.89
K	Failing to properly secure an access panel or cowling	22	81.48
B	Leaving a tool inside the engine	21	77.78
E	Forgetting to complete the final step in a procedure	16	59.26
G	Skipping a required final inspection and/or sign off	16	59.26
*I	Arriving at work under the influence of alcohol or a controlled substance	16	59.26
D	Failing to apply the exact final torque to a bolt using a proper torque wrench, but instead estimating it using a regular wrench	13	48.15
*C	Observing someone breaking a rule that is a blatant disregard for safety	12	44.44
H	Handing off a job without the proper paperwork	11	40.74
J	Walking away from a work area without finishing a job or handing it off to someone else	9	33.33
A	Skipping a step in a procedure that is often skipped	8	29.63

**Report would not likely be accepted in a voluntary reporting system similar to ASAP*

According to both mechanics and management, scenario F ("Installing the wrong part") was deemed the most likely to be reported, followed by scenario K ("Failing to properly secure an access panel or cowling"), which received the same percentage of responses as scenario G ("Skipping a required inspection and/or sign off") for mechanics. In addition to scenario F and scenario K, scenario B ("Leaving a tool inside the engine"), scenario E ("Forgetting to complete the final step in a procedure"), and scenario G are all represented in the top five reportable events according to both mechanics and management. The commonality of these five scenarios to the top of both data sets can be explained by the nature of the issues. Scenarios B, E, F, and K are honest mistakes (with the potential for immediate outcomes), and scenario G is a common routine violation. Four scenarios were indicated by both groups to be the least reportable: A

("Skipping a step in a procedure that is often skipped"), D ("Failing to apply the exact final torque to a bolt using a proper torque wrench…"), H ("Handing off a job without the proper paperwork"), and J ("Walking away from a work area without finishing a job or handing it off to someone"). These are deliberate violations that may represent a lack of time or resources needed for mechanics to meet their goals. Reporting these types of violations (even if the resulting error/hazard was "caught") is important to understanding organizational deficiencies that contribute to human error.

An interesting finding was the placement of the likely unacceptable violations. These two scenarios, C ("Observing someone breaking a rule that is a blatant disregard for safety") and I ("Arriving at work under the influence of alcohol or a controlled substance") do not meet ASAP acceptance criteria. Although employees are free to file voluntary reports for these issues, those involved would not be guaranteed immunity from disciplinary action. With regard to any event involving another person (such as scenario C), those mentioned in a report would be contacted and required to submit their own report. If employees witness an error or violation, even one that clearly meets ASAP criteria, they should speak directly with the person(s) involved and encourage him or her to file a report. This approach minimizes both the threat of a tarnished peer relationship and the fear of/distrust in the system.

Despite the fact that filing a report for scenarios C and I would likely not guarantee immunity from disciplinary action, 15 mechanics (50%) and 12 managers (44%) indicated that scenario C would be reported at their organization.

15 mechanics (50%) and 16 managers (59%) indicated that scenario I would be reported. These two scenarios were expected to have the lowest rate of "yes" responses for both groups, yet both fell toward the middle of the data. These responses suggest that either voluntary reporting system policies are not being well communicated to employees, or that certain rules are not diligently enforced, allowing some users to take advantage of the system. It may also indicate that there is no other obvious means of reporting such a violation, and employees assume it to be safer than the risk of getting caught. Fig. 6.4 details percentage of "yes" responses indicated by mechanics, management, and the combined sample.

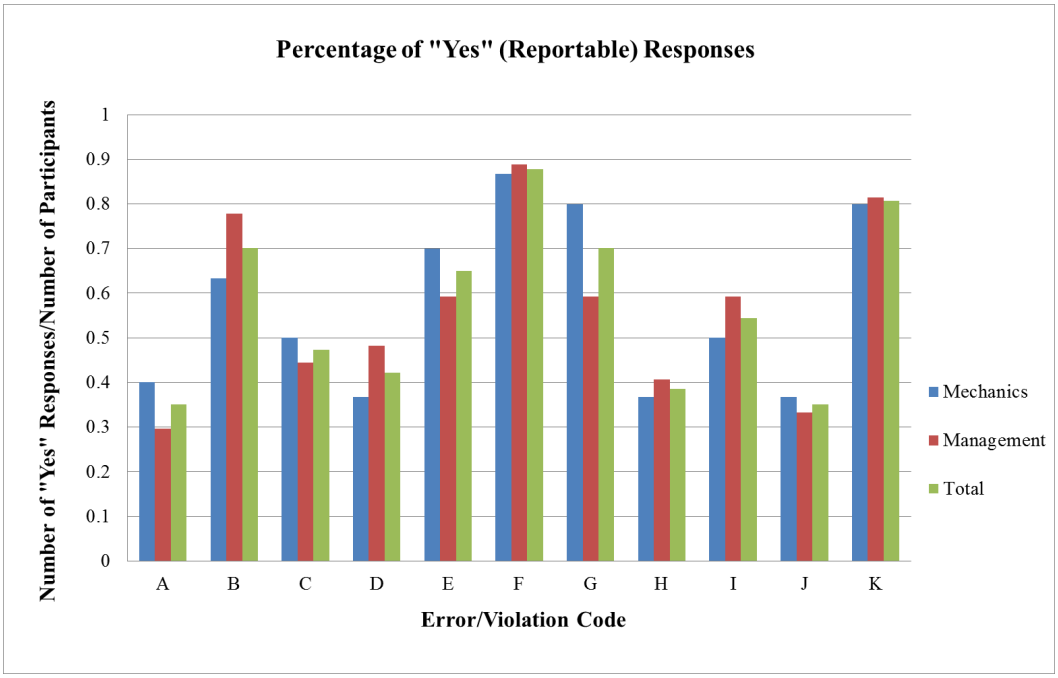

Fig. 6.4. Percentage of "Yes" Responses

A detailed comparison of error/violation ranking based on the percentage of "yes" responses can be found in Section 6.3.2. Spearman's rank-order correlation was

used to determine if discrepancies in the rank-order of the two samples are statistically significant.

Discrepancies were found between mechanic and management perceptions of reportable errors/violations. These inconsistencies were broadly investigated by comparing the delta between mechanic and management "yes" response rates for each error/violation. These findings are detailed in Fig. 6.5.

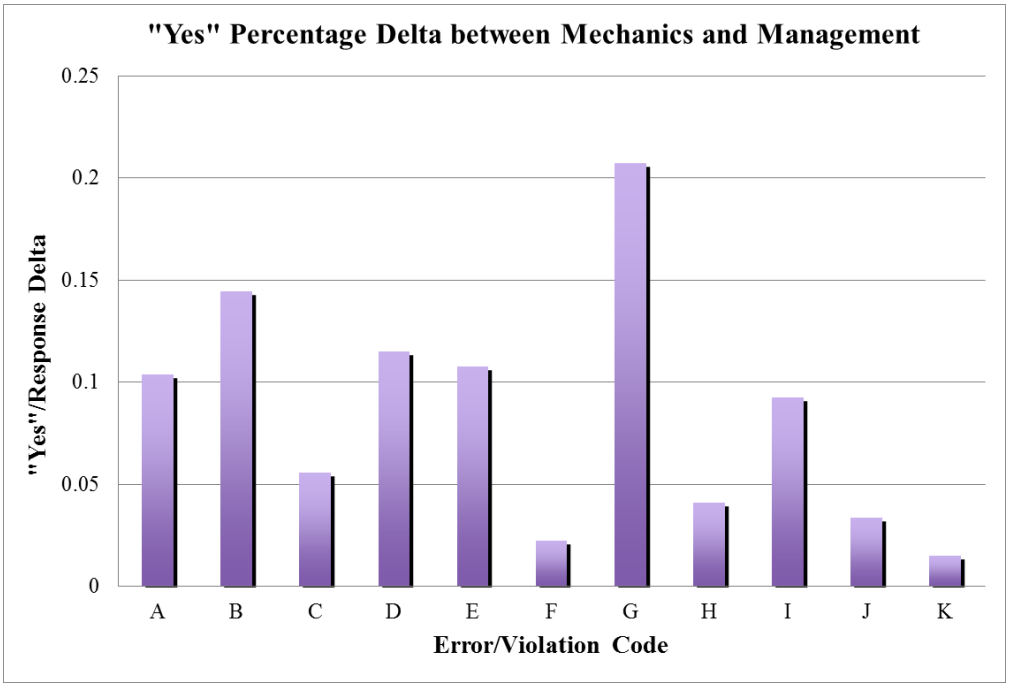

Fig. 6.5. "Yes" Percentage Delta between Mechanics and Management

Scenario G ("Skipping a required final inspection and/or sign off") produced the greatest divide between the two groups. Mechanics indicated this scenario to be highly reportable, while management seemed to have a contradictory perception. This scenario would certainly be considered a routine violation, but also represents several gray areas. Different organizations may have unique policies

regarding final inspection/sign-off, and/or different organizational levels may have their own interpretation of the stringency of such policies.

A similar cause for discrepancy may have applied to scenario A ("Skipping a step in a procedure that is often skipped"). As in scenario G, this also represents a routine violation related to deliberately ignoring a required step in a process, and once again mechanics perceived this scenario to be more reportable than managers did. The data seem to suggest that mechanics are aware that diverging from a procedural sequence is an issue important enough to warrant a report. However, there appears to be a disconnect with regard to managers' perceptions of mechanics' work environments due to insufficient flow of information from mechanics through supervisors up to managers.

Interestingly, the opposite phenomenon (managers perceiving greater reportability than mechanics) can be observed with errors related to hardware. Scenario B ("Leaving a tool inside the engine") and scenario D ("Failing to apply the exact final torque to a bolt using a proper torque wrench") were perceived as more reportable by managers than mechanics. Discussion of reasons for reporting hesitation in Section 6.2 will examine whether mechanics seem to be influenced more by fear of retribution, by complacency with current practice, by lack of awareness of future consequences, or by some combination of these factors. A more detailed comparison of perceptions of reasons for reporting hesitation was conducted using the chi-square test for independence. Results are presented and discussed in Section 6.3.3.

6.1.3. Perception of Adherence to Reporting Policies/Guidelines

As previously mentioned, 9 of the 11 presented errors and violations would be accepted into the ASAP system. A "score" was computed for each participant based on the number of "yes" responses given out of the 9 errors/violations that could be considered reportable. Scores do not only reflect the individual's perception of reporting practices at his or her organization. These scores also represent the effectiveness with which each organization teaches and encourages voluntary reporting, uses voluntary reporting data to develop and implement corrective actions, and communicates the success of the system. The average of these scores represents the industry's performance in accomplishing these goals. Table 6.9 summarizes each data set of calculated scores.

Table 6.9.
Reporting Practices based on Perceptions

	Mean (%)	Standard Deviation	% Below 50%	% Above 75%	% Above 90%
Mechanics	58.89	27.55	36.67	36.67	10.00
Managers	57.61	30.67	44.44	40.74	14.81
Total	**58.28**	**28.81**	**40.56**	**38.70**	**12.41**

Assuming that 100% represents the categorization of all 9 events as reportable, the mean scores for each sample group, though similar, are relatively low. Although a greater percentage of managers scored above 75% and above 90%, a larger percentage of managers also scored below 50%, indicating greater variation in management perceptions of reporting practices, and a potentially broader range of management familiarity and/or concern with voluntary reporting. These results indicate that almost half of voluntary reporting system users are possibly

reporting less than half of the events that would be accepted into a voluntary reporting system. Only 12% of all respondents displayed judgments in close alignment with ASAP guidelines. Tables 6.10, 6.11, and 6.12 describe the groups representing scores below 50%, above 75%, and above 90%, respectively.

Table 6.10.

Scores Below 50% based on Personal Characteristics

	Score below 50%		
	Average Age	**Average Years in Aviation**	**Average Reports Submitted/Corrective Actions Observed**
Mechanics	51-60	21-30	3-5
Managers	51-60	21-30	11-20

Table 6.11.

Scores Above 75% based on Personal Characteristics

	Score above 75%		
	Average Age	**Average Years in Aviation**	**Average Reports Submitted/Corrective Actions Observed**
Mechanics	51-60	21-30	6-10
Managers	51-60	11-20	20+

Table 6.12.

Scores Above 90% based on Personal Characteristics

	Score above 90%		
	Average Age	**Average Years in Aviation**	**Average Reports Submitted/Corrective Actions Observed**
Mechanics	41-50	21-30	6-10
Managers	51-60	21-30	11-20

In terms of age, the largest percentage of questionnaire participants were between 51 and 60, so it can be expected that this group would contribute heavily to all three scoring tiers. It should be noted that the average age of mechanics scoring above 90% is 41-50 with considerable experience (21-30 years) in aviation. With regard to history of involvement with voluntary reporting, higher scores correlated with increased voluntary report submission (mechanics) and more report-driven corrective actions observed (managers). This may be a reflection of improved trust in the system due to familiarity with its non-punitive nature, a better understanding of system policies, and a heightened awareness of system capabilities and guidelines attributable to experience and confidence gained over time.

6.1.4. Confidence Factor

A "confidence factor" was developed to assess agreement within each sample group regarding which error/violation scenarios warrant a report. This factor is defined as the difference between the number of "yes" responses and the sum of "possibly" and "no" responses. Such a metric provides a means of

measuring the confidence with which each sample collectively perceived an error/violation as reportable. Tables 6.13 and 6.14 show the ranked confidence factors for each error/violation for mechanics and managers, respectively.

Table 6.13
Mechanics' Confidence Factor

CODE	Confidence Factor
F	22
G	18
K	18
E	12
B	8
D	8
H	8
J	8
A	6
C	0
I	0

Table 6.14
Managers' Confidence Factor

CODE	Confidence Factor
F	21
K	17
B	15
A	11
J	9
G	5
E	5
I	5
H	5
C	3
D	1

Table 6.15
Confidence Factor Delta

CODE	Confidence Delta
G	13
B	7
E	7
D	7
A	5
I	5
H	3
C	3
F	1
K	1
J	1

These tables show that some of the same errors/violations that were deemed highly reportable were also done so "confidently", particularly by mechanics. Other events, particularly scenario C ("Observing someone breaking a rule that is a blatant disregard for safety") and scenario I ("Arriving at work under the influence of alcohol or a controlled substance") for mechanics and scenario C and scenario D ("Failing to apply the exact final torque to a bolt using a proper torque wrench") for managers, reflected very little agreement within their respective group perceptions. Interestingly, scenario C and scenario I are the two violations, which would not likely be accepted by ASAP.

Although the confidence factors of some errors/violations show agreement between the two samples, others are clearly more divergent. Table 6.15 describes

the delta between mechanic and management confidence factors for each error/ violation. The delta for scenario G ("Skipping a required final inspection and/or sign off") is most prominent. Reviewing the original data, 24 mechanics indicated that this routine violation would be reported, 5 responded with "possibly", and 1 responded with "I'm unsure how/what to report". Alternatively, only 16 managers indicated that this scenario would be reported and 11 responded with "possibly." This discrepancy indicates that mechanics understand the importance of reporting this violation and feel comfortable doing so, while managers believe that mechanics either underestimate the severity of the incident or fear retribution. Manager and mechanic outlook regarding reporting hesitation will be addressed in Section 6.2. Fig. 6.6 displays the confidence factor for each error/violation based on mechanic and management responses and their deltas.

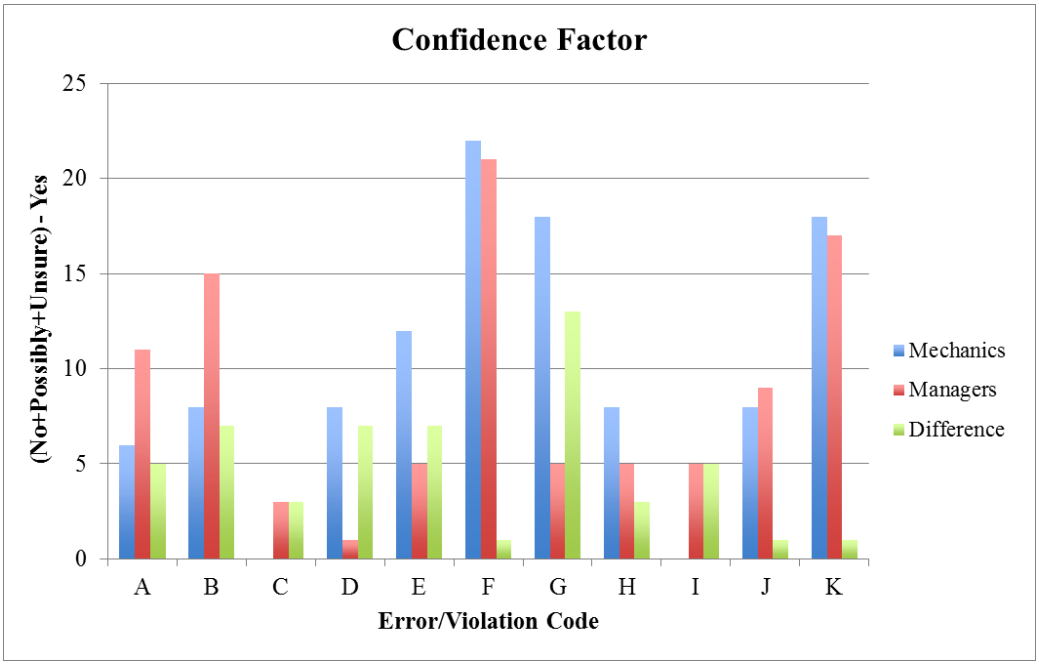

Fig. 6.6. Confidence Factor for Errors/Violations

6.1.5. Effect of Personal Characteristics on Reporting Perceptions

A final evaluation of mechanic and management perceptions of reporting practices involved the isolation and investigation of personal characteristics. This allowed for the evaluation of each sample separately by comparing trait subgroups. Fig. 6.7 shows the influence of age on mechanics' perceptions of reporting practices.

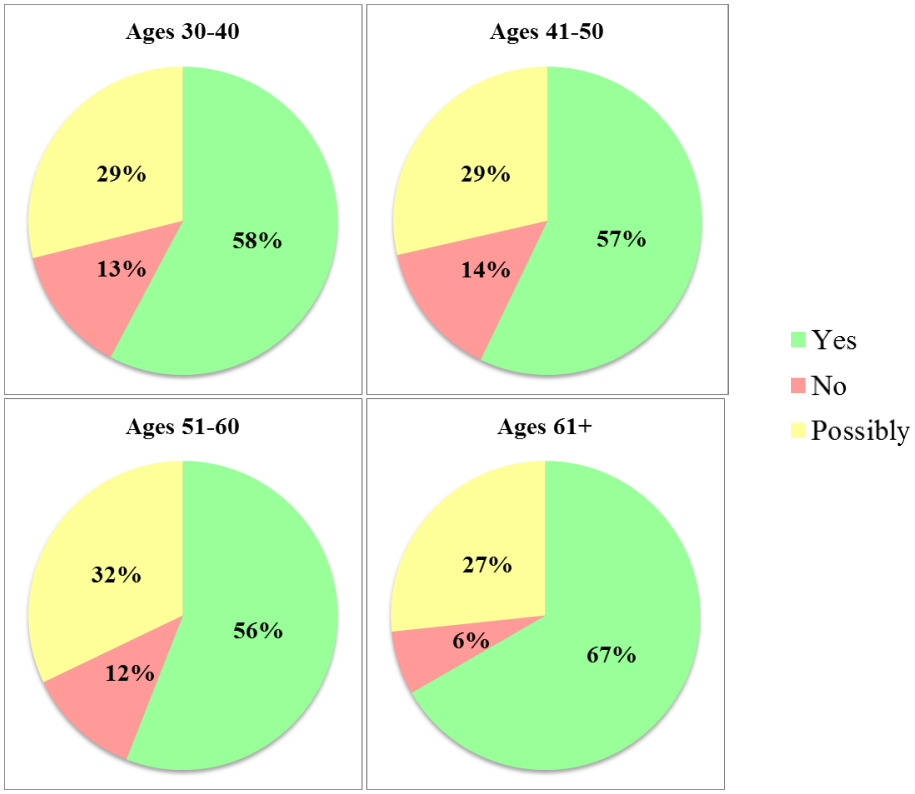

Fig. 6.7. Mechanic Perceptions of Reporting based on Age

There does not appear to be substantial variation in the perceptions of 30 to 60 year-old mechanics. However, mechanics over the age of 60 seem to perceive a higher degree of reporting than the other three groups. Not only is the percentage of "yes" responses considerably higher, the use of "no" was less than half as likely (on average) in this group than the others.

Unlike the mechanic sample, management perceptions of reporting practices seems to vary significantly by age, but without any discernable pattern. Fig. 6.8 shows the influence of age on management's perception of reporting practices.

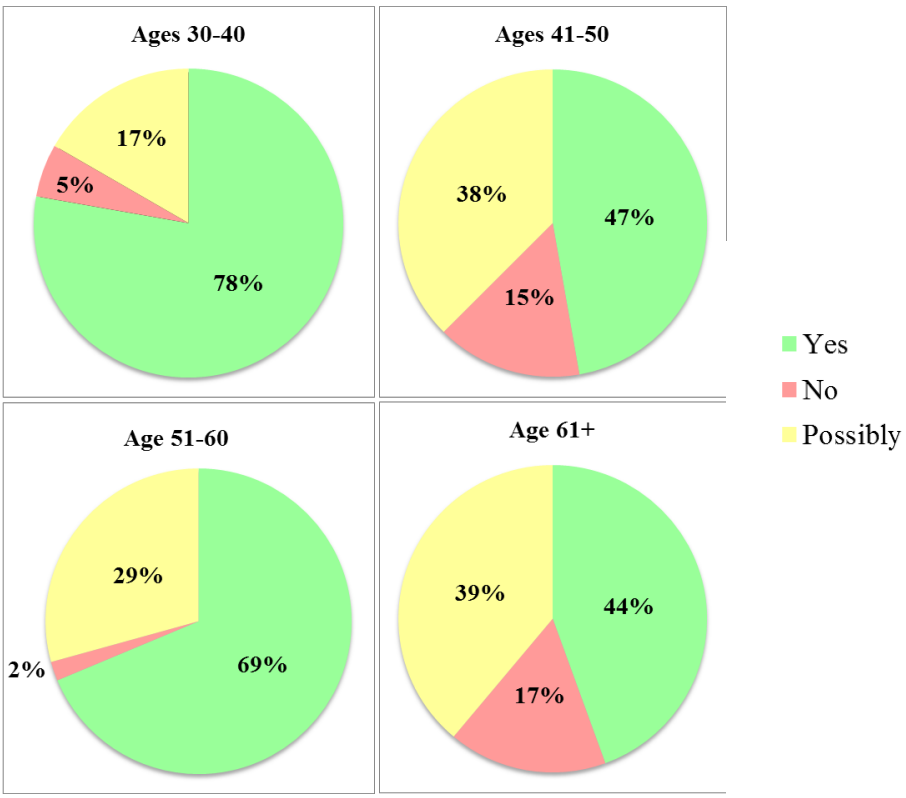

Fig. 6.8. Management Perceptions of Reporting based on Age

One key observation is that younger managers identified a substantial number of reportable events, but the 51-60 year-old population was not far behind. 41-50 year-old managers seemed to have similar perceptions to managers over the age of 60. This variation likely supports a lack of uniformity among managers with regard to their understanding, involvement, or acceptance of voluntary reporting systems. It exposes a need for stronger, mandatory training and improved communication between leadership and middle managers. Chi-square tests of

independence were used to formally evaluate the association between age and reporting perceptions. Results are discussed in Section 6.3.5.

The influence of number of years at an organization was also assessed. Fig. 6.9 shows mechanics' perceptions of reporting based on years with an organization.

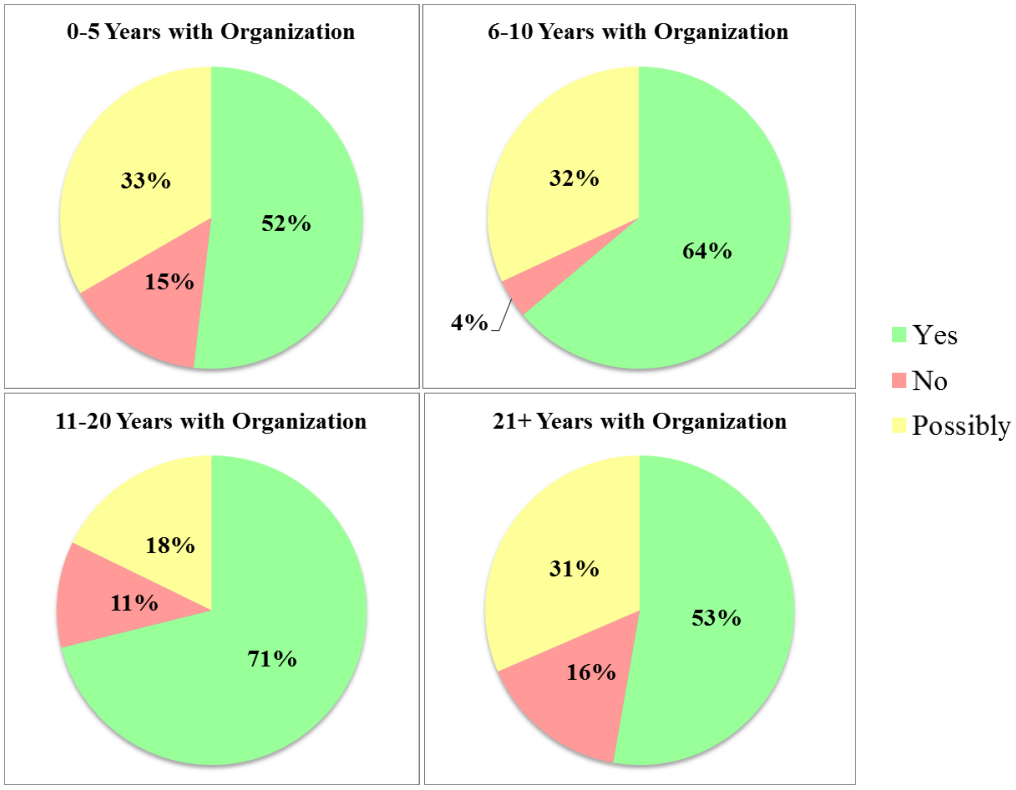

Fig. 6.9. Mechanic Perceptions of Reporting based on Years with Organization

It appears that those who are new to an organization and those who have been with an organization for a substantial amount of time perceived a lesser degree of reporting in their environment. The tallies from these two groups were nearly identical. Those who are "mid-career" seemed more aware of active reporting. Fig. 6.10 presents management's perception of reporting based on years with an organization.

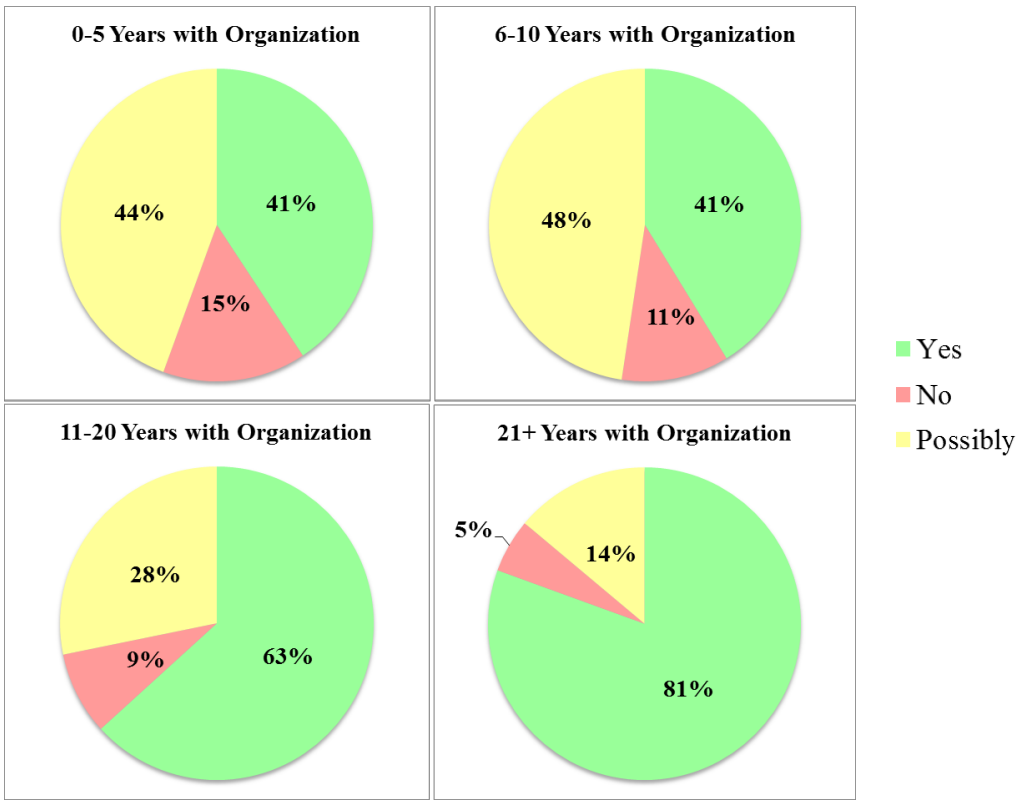

Fig. 6.10. Management Perceptions of Reporting based on Years with Organization

This figure shows a far more discernable pattern of reporting perceptions as employees gain experience in the workplace. Perceptions of reportable events increased, while identification of non-reportable events (based on "no" responses) decreased with gained experienced. This might indicate that with managerial experience at an airline comes improved understanding of mechanics' environment, daily tasks, and the often-subtle errors/violations of which many managers are unaware. This may reflect a greater level of communication with subordinates as well as strong managerial support for and involvement with voluntary reporting systems. Additionally, seniority at an organization lends itself to involvement with new, innovative endeavors. More experienced managers

may be summoned to become champions of voluntary reporting due to their understanding of the organization and their influence and credibility with its employees. It appears that mechanics' involvement in voluntary reporting may peak during the middle of their career, while managers' involvement is more prevalent later in their career. Chi-square tests of independence were used to formally evaluate the association between years at an organization and reporting perceptions. Results are discussed in Section 6.3.6.

The influence of years working in the aviation industry on reporting perceptions was also evaluated. Fig. 6.11 shows mechanics' perceptions of reporting practices based on years in aviation.

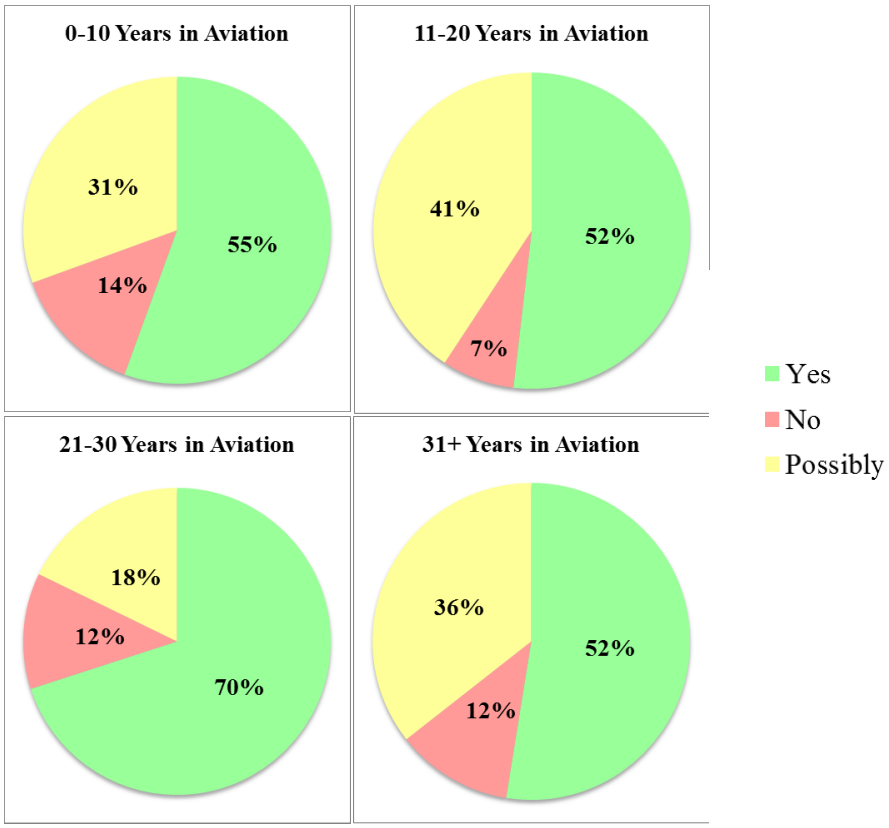

Fig. 6.11. Mechanic Perceptions of Reporting based on Years in Aviation

There is little variance between the 0-10, 11-20, and 31+ years subgroups, but those who have worked in aviation for 21-30 years seem to observe far more active participation in reporting. The significance of this is not abundantly clear, as both older (experienced, but possibly skeptical) and younger (less experienced, but possibly more open to reporting) employees identified a smaller percentage of reportable scenarios than those of the 21-30 year group. Fig. 6.12 assesses management's perception of voluntary reporting practices based on years working in the aviation industry. Note that there were no respondents in the 0-10 year subgroup.

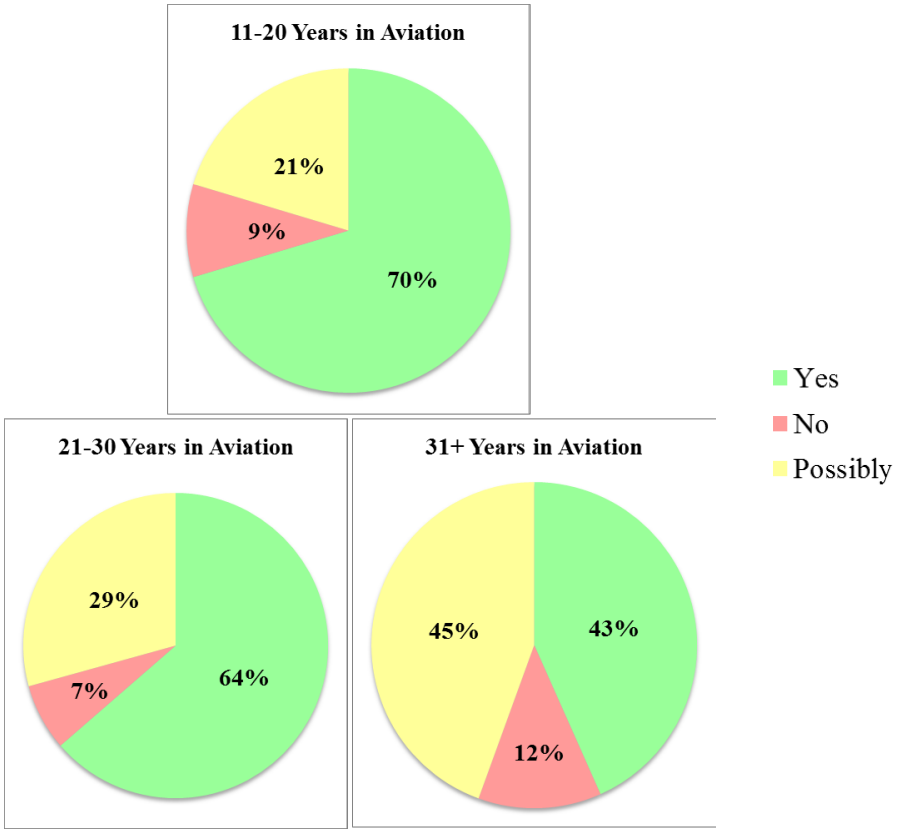

Fig. 6.12. Management Perceptions of Reporting based on Years in Aviation

Interestingly, the effect of years in aviation on observed voluntary reporting follows an opposite pattern to that of years with an organization. Identification of reportable events is inversely related to experience in aviation. The greatest number of reportable events was identified by those newest to the industry, and this tally decreased with experience. This finding differentiates the effect on perceived reporting practices of (1) years with an organization and (2) years in the aviation industry. Those newer to the industry may be less jaded by the idea of violations being "common practice", and they may see safety concerns in a fresh new light. They also may be more familiar with and involved in voluntary reporting systems than older employees. However, the influence of seniority and building a professional reputation may hinder newer managers' involvement with voluntary reporting, as evident in Fig. 6.10. Chi-square tests of independence were used to formally evaluate the association between years in aviation and reporting perceptions. Results are discussed in Section 6.3.7.

The final personal characteristic assessed for its association with voluntary reporting perceptions was experience with voluntary reporting systems. This was evaluated based on the number of reports personally submitted in the past (for mechanics) and the number reports personally observed resulting in corrective actions (for managers). Fig 6.13 shows mechanics' perceptions of voluntary reporting based on reporting experience.

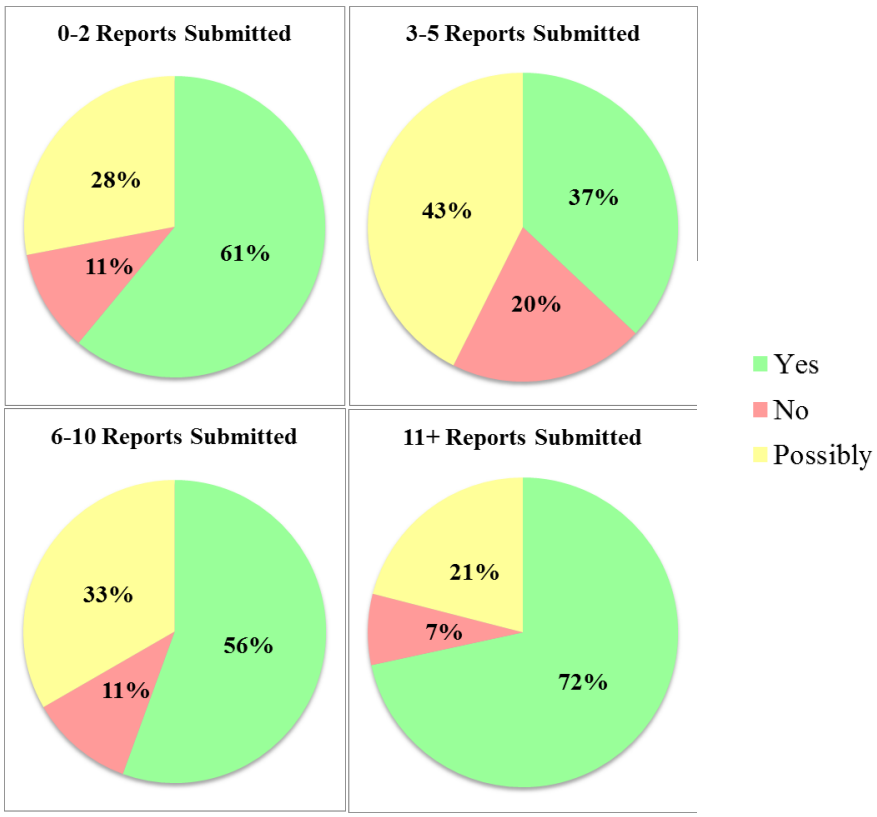

Fig 6.13. Mechanic Perceptions of Reporting based on Reporting Experience

Though not a great deal of insight can be gained from the first three groups (0-2, 3-5, 6-10), it is clear that those with the most voluntary reporting experience are more aware of its use and likely to encourage its use. As previously mentioned, mechanics undoubtedly drew upon personal experience when indicating the reportability of each error/violation, rather than simply commenting on observed reporting practices. Fig. 6.13 shows that experience with reporting builds trust in the system, making users more likely to report a broad range of errors and violations, varying in severity and deliberateness. Fig. 6.14 represents management's perceptions of reporting practices based on the number of report-driven corrective actions observed.

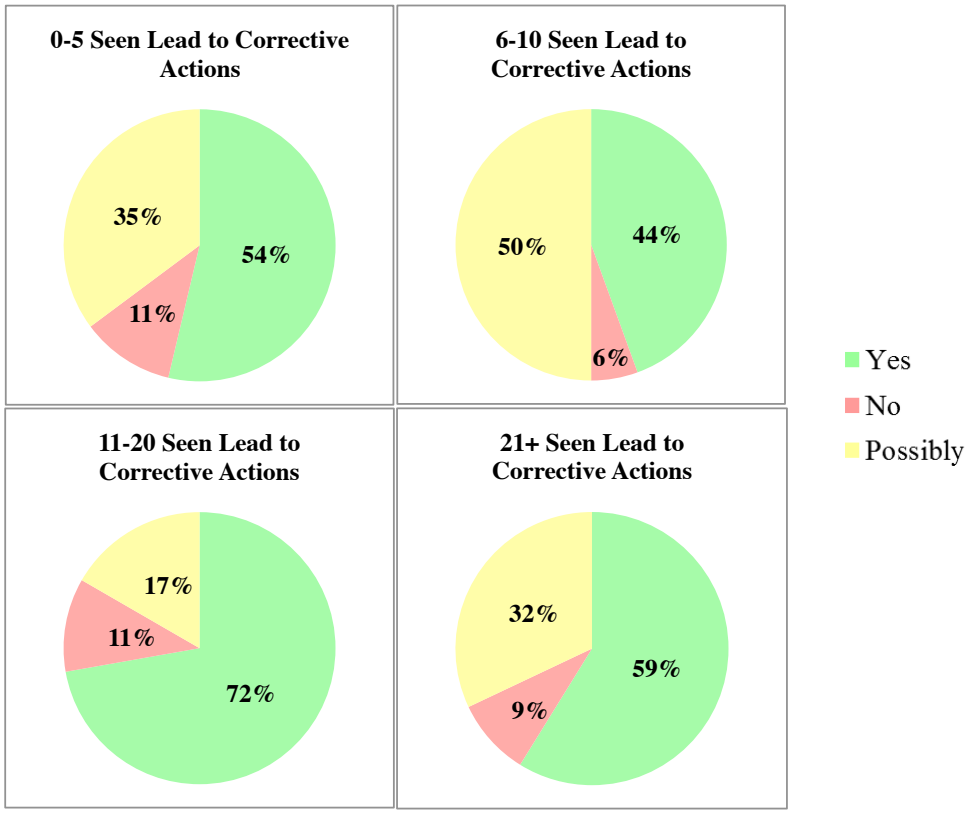

Fig. 6.14. Management Perceptions of Reporting based on Corrective Actions Observed

Although there is no clear observable pattern to be gleaned from this figure, the greatest percentage of "yes" responses are found in the two groups that have observed the most corrective actions. It is somewhat surprising that managers who have witnessed the most corrective actions are not reporting the highest perceived use of the system. It is possible that certain managers are so intimately familiar with the system and its benefits that they are also more cognizant of missed reporting opportunities. Chi-square tests of independence were used to formally evaluate the association between experience with voluntary reporting systems and reporting perceptions. Results are discussed in Section 6.3.8.

6.2. Justification for Non-Reporting

6.2.1. Summary of Data Collected

When questionnaire participants indicated that an error/violation would either possibly be or likely not be reported at their organization, they were presented with a list of reasons for reporting hesitation that were introduced in Section 4.2.1. These reasons, derived from the literature review and personal interviews, were worded to encompass organizational deficiencies, inadequate understanding of risk, and both fear of and indifference to the system. Each of the reasons represents the existence of one or more of the previously defined barriers, so by evaluating the frequency of use of each reason, the relative impact of each barrier can be determined. Sections 6.2.2 and 6.2.3 compare mechanic and management perceived use of reasons for reporting hesitation and assess the influence of personal characteristics on these perceptions. From these evaluations, the unique impact of each barrier on mechanics, management, and trait-specific groups was determined. These results are summarized in Section 6.4.

6.2.2. Comparison of Perceptions of Justification for Non-Reporting

To determine potential differences in the impact of barriers to voluntary reporting between mechanics and management, it was necessary to compare the use of reasons for reporting hesitation by the two samples. Tables 6.16 and 6.17 show these reasons ranked based on mechanic and manager use, respectively.

Table 6.16.

Reasons for Reporting Hesitation Ranked by Mechanics' Perceptions

Code	Reason for Reporting Hesitation	Mechanics	
		Mentions	Mentions/ Response
4	Admitting to this incident might result in disciplinary action	46	1.53
2	That's just how the job is always done - it works fine every day	27	0.90
7	Nothing will get done about this type of incident - management won't care or think it's important	24	0.80
3	This type of incident wasn't serious enough to cause an issue down the road	21	0.70
1	It's too much work to go through the reporting process	20	0.67
8	I don't think lasting change will result from reporting this	18	0.60
5	It would make more sense to go straight to a supervisor or manager	17	0.57
6	The explanation of the event might lead to questions about others involved	14	0.47

Table 6.17.

Reasons for Reporting Hesitation Ranked by Managers' Perceptions

Code	Reason for Reporting Hesitation	Management	
		Mentions	Mentions/ Response
4	Admitting to this incident might result in disciplinary action	52	1.93
2	That's just how the job is always done - it works fine every day	41	1.52
5	It would make more sense to go straight to a supervisor or manager	39	1.44
6	The explanation of the event might lead to questions about others involved	33	1.22
3	This type of incident wasn't serious enough to cause an issue down the road	29	1.07
1	It's too much work to go through the reporting process	22	0.81
7	Nothing will get done about this type of incident - management won't care or think it's important	19	0.70
8	I don't think lasting change will result from reporting this	12	0.44

Reason 4 ("Admitting to this type of incident might result in disciplinary action") was cited most frequently by both groups, implying that trust in the system and/or in management is recognized to be a significant barrier to reporting participation. Reason 2 ("That's just how the job is always done – it works fine every day") was the second most commonly cited reason by both groups. This indicates that some mechanics are unaware of their own fallibility and that of their peers, and/or that some mechanics are indifferent to the potential safety risks that result from

shortcuts and rule breaking. Some employees evidently share the mindset that violations are a part of the job and are necessary to meet performance goals. Some employees may be unaware of the potential consequences of these violations because they have never observed a major incident resulting from such risk. Near-miss events are often not considered influential enough to report or to warrant the alteration of a routine that has become common practice.

Fig. 6.15 provides an overview of reasons mentioned per response by mechanics and management, and it details total mentions per response.

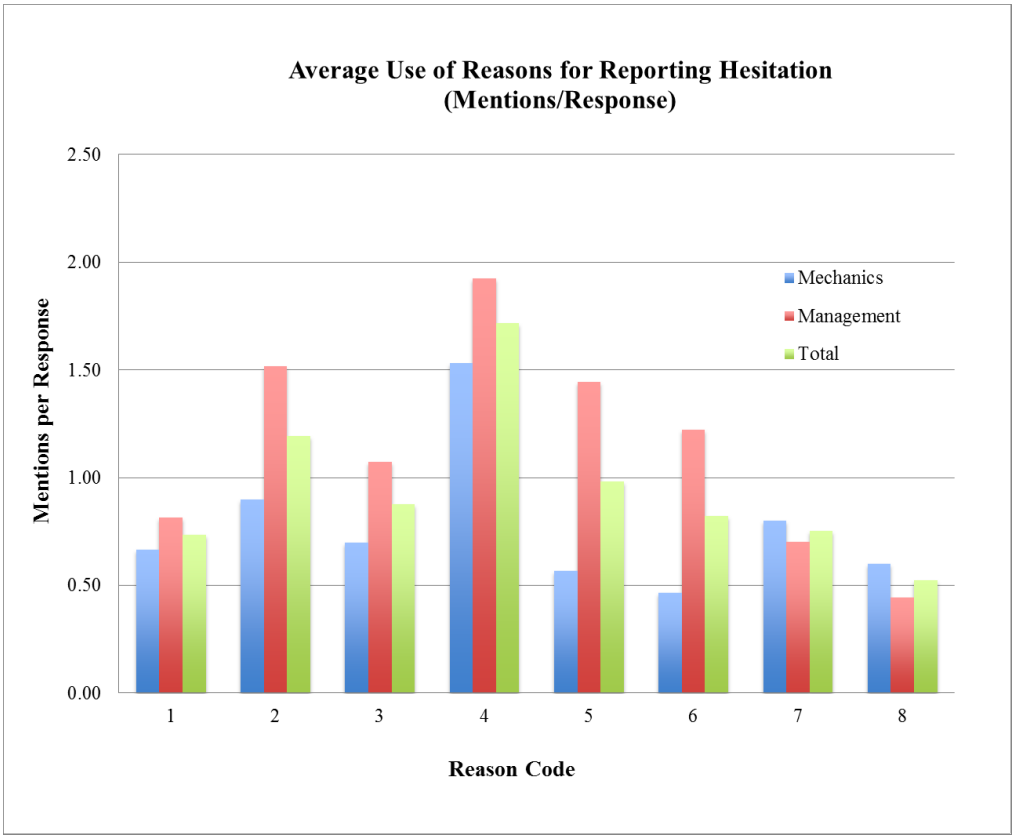

Fig. 6.15. Use of Reasons for Reporting Hesitation

The questionnaire stated that more than one reason could be selected for each error/violation, but Fig. 6.15 shows that managers cited far more reasons per

response than mechanics. Managers used an average of 9.15 reasons per response, in comparison to 6.43 reasons per response used by mechanics.

Based on the mentions per response data, the differences in mechanic and management use of each reason for reporting hesitation were compared. Fig. 6.16 presents the delta between mechanic and management use of each reason for reporting hesitation.

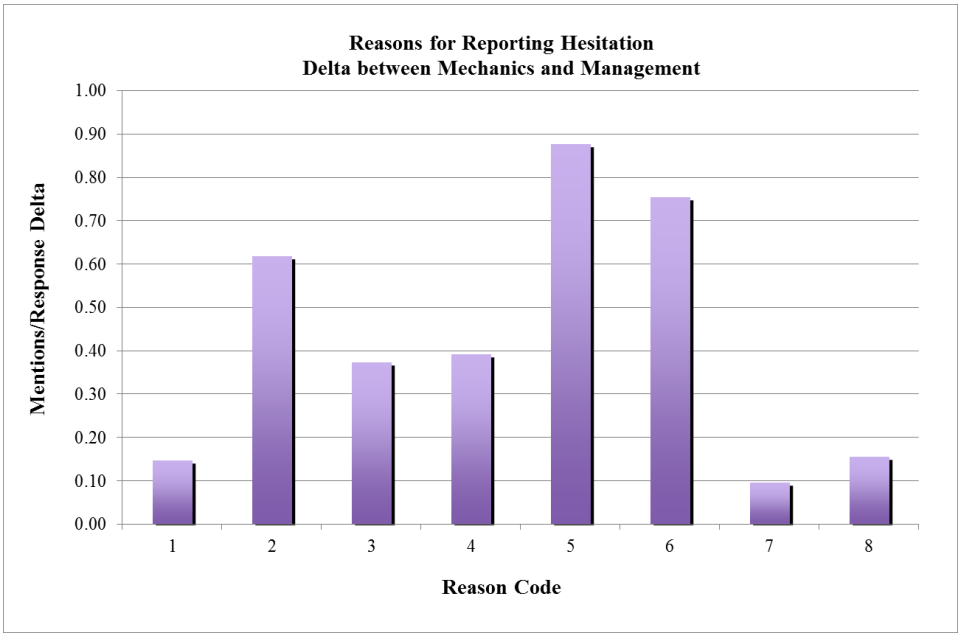

Fig. 6.16. Delta of Reasons for Reporting Hesitation

Reason 5 ("It would make more sense to go straight to a supervisor or manager") displayed the greatest disparity between the groups. Managers, who are often balancing pressure from leadership with the needs of their subordinates, implied that mechanics were likely to bypass the reporting process in favor of direct intervention from a superior. Mechanics, however, cited this reason far less frequently, indicating a disparity in the way that the two groups view management involvement in the voluntary reporting process. In reality, the use of reason 5 for

any error/violation other than scenario C or scenario I (those that would not be accepted) indicates a lack of understanding of system policies. The 9 remaining errors/violations should be reported to maximize the benefit of the system. Reporting these issues would still allow managers to stay apprised of workers' concerns, but with the added protection of anonymity. Using the reporting system also lessens managers' workload, as they are not tasked with both solving the issue at hand and implementing recommended solutions, only the latter.

Reason 6 was the second most differently scored among sample groups, reflecting a stronger management belief that mechanics are concerned with protecting their peers. A chi-square test was used to evaluate the association between each sample's perception of reason use. Results will be discussed in Section 6.3.3.

6.2.3. Effect of Personal Characteristics on Perception of Justification for Non-Reporting

In this section, the personal characteristics that were examined in Section 6.1.5 with regard to perceptions of reportable events were evaluated for their association with citation of reasons for reporting hesitation. This allowed for the determination of which barriers to voluntary reporting influence certain trait-specific groups. Fig. 6.17 – Fig. 6.20 portray perceived use of reasons for reporting hesitation by mechanics and managers of varying age.

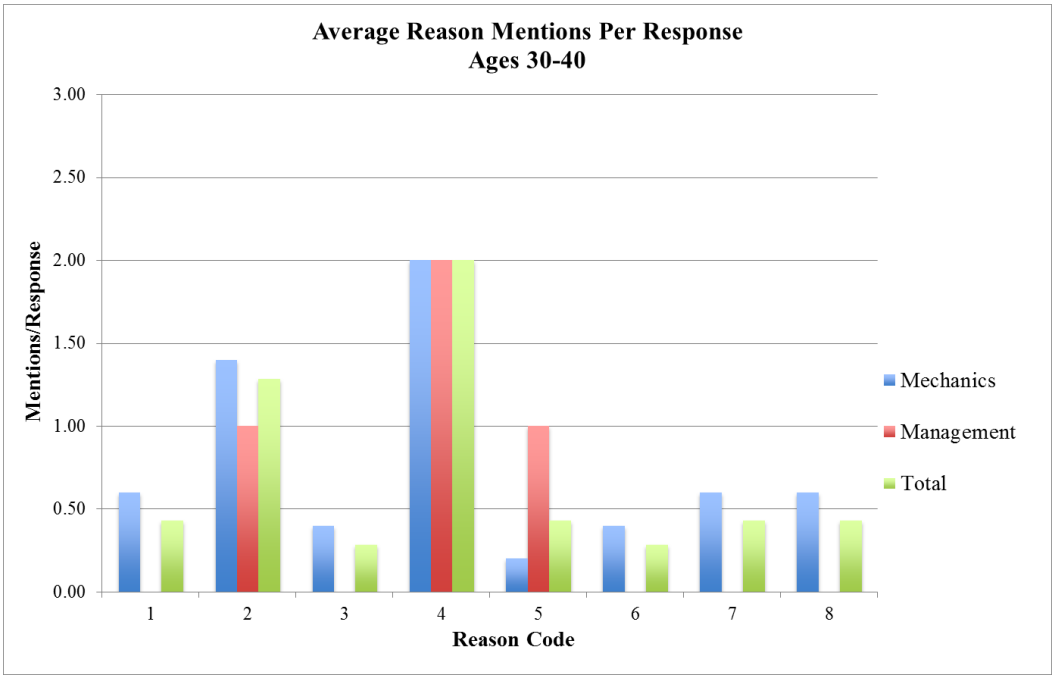

Fig. 6.17. Use of Reasons for Reporting Hesitation: Ages 30-40

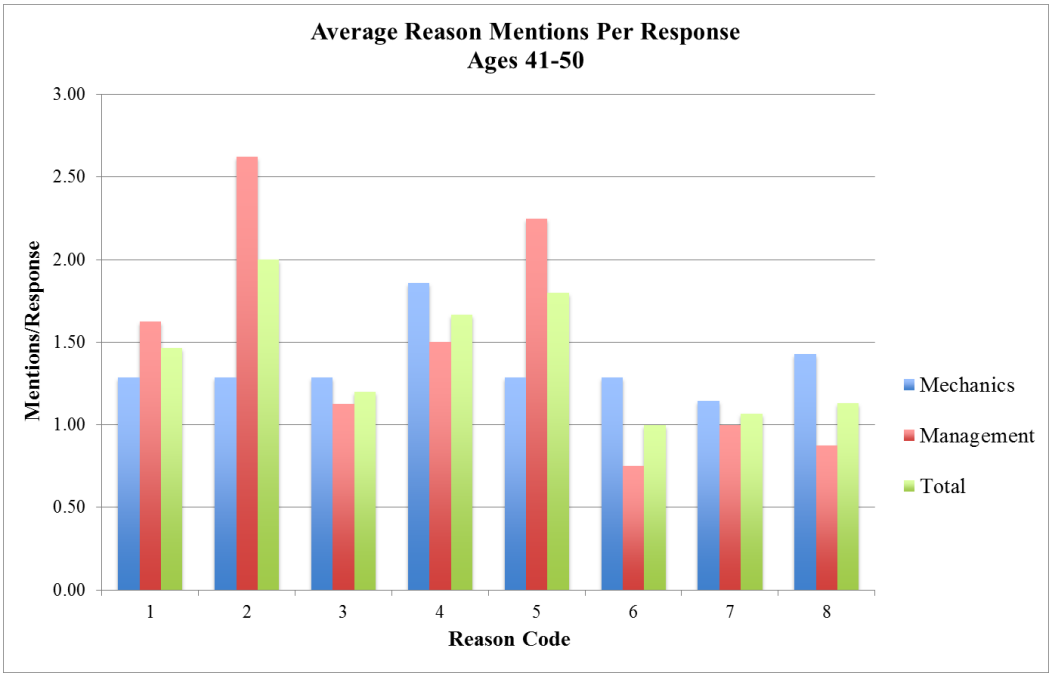

Fig. 6.18. Use of Reasons for Reporting Hesitation: Ages 41-50

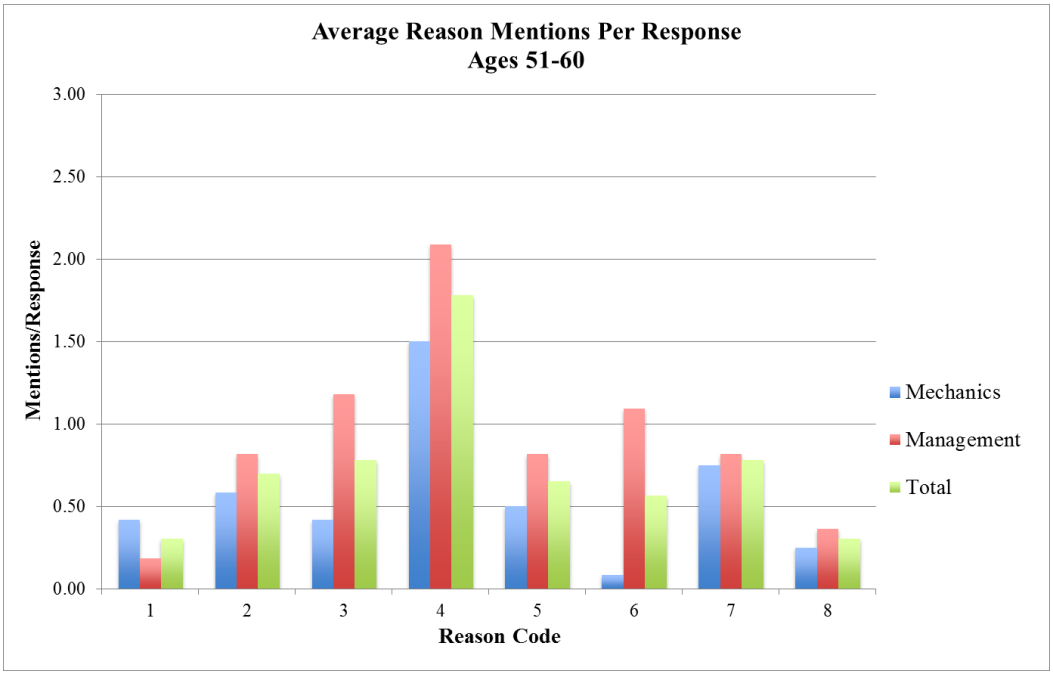

Fig. 6.19. Use of Reasons for Reporting Hesitation: Ages 51-60

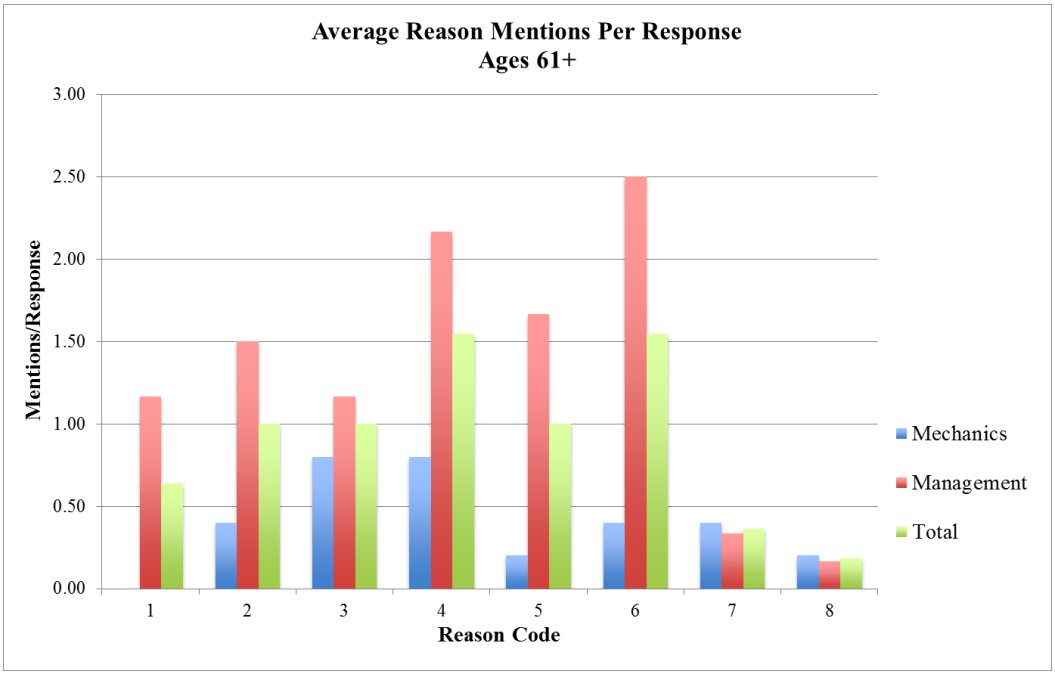

Fig. 6.20. Use of Reasons for Reporting Hesitation: Ages 61+

Overall, 30-40 year olds averaged fewer reasons for reporting hesitation per response than older groups, although their support for the most commonly used

reason, “Admitting to this incident might result in disciplinary action” (reason 4), was apparent. It is important to note that there were only two managers represented in this group, which influenced the presence of management data in Fig 6.17. Reasons for reporting hesitation were used most abundantly by the 41-50 year-old group (Fig. 6.18), and mechanics accounted for a slightly greater presence. This differs from the 51-60 year-old group (Fig. 6.19) and the over 60 year-old group (Fig. 6.20), for which management perceptions of reasons for reporting hesitation were far more abundant. Notably, for employees over the age of 60, the differences in the perceived uses of reason 5 (“It would make more sense to go straight to a supervisor or manager”) and reason 6 (“The explanation of the event might lead to questions about others involved”) are substantial.

Fig. 6.21-6.24 portray perceived use of reasons for reporting hesitation according to mechanics and management by years with their current organization.

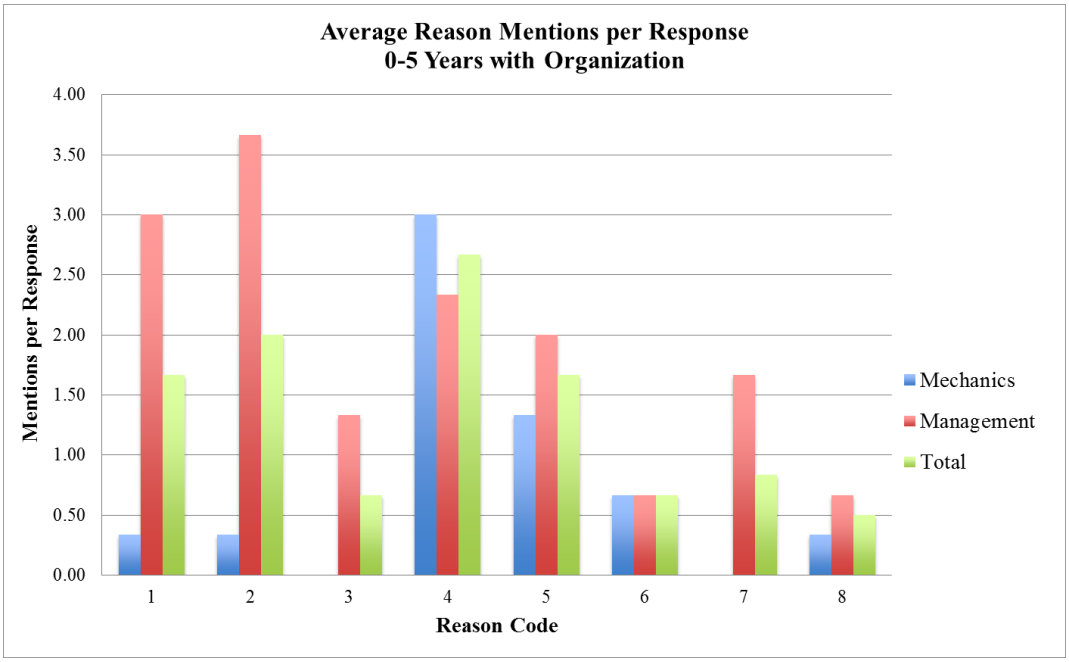

Fig 6.21. Use of Reasons for Reporting Hesitation: 0-5 Years with Organization

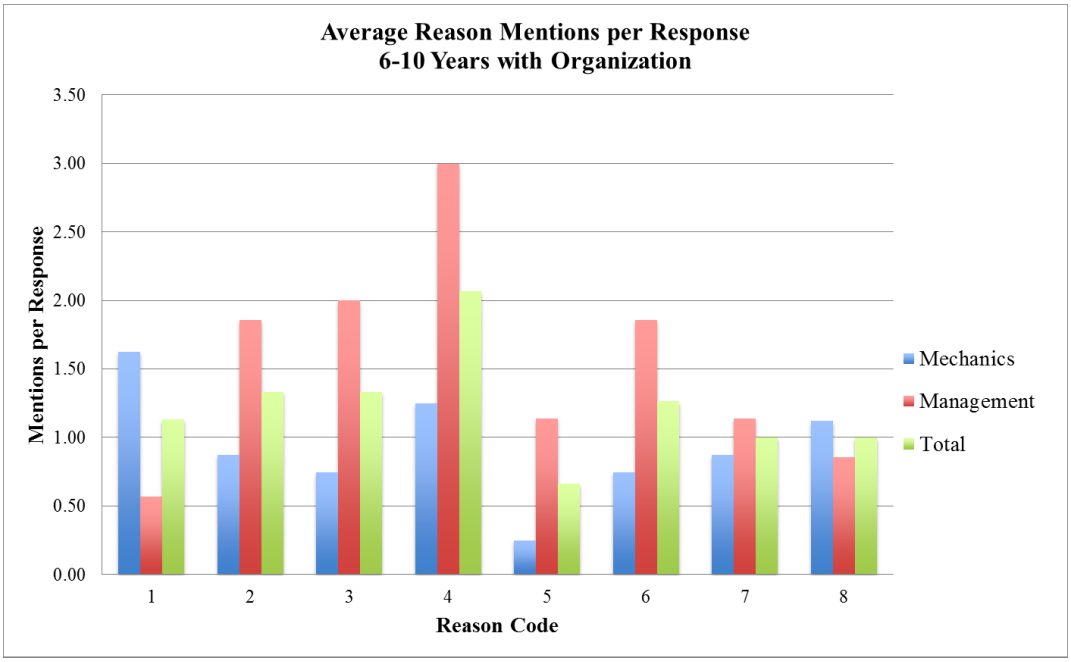

Fig 6.22. Use of Reasons for Reporting Hesitation: 6-10 Years with Organization

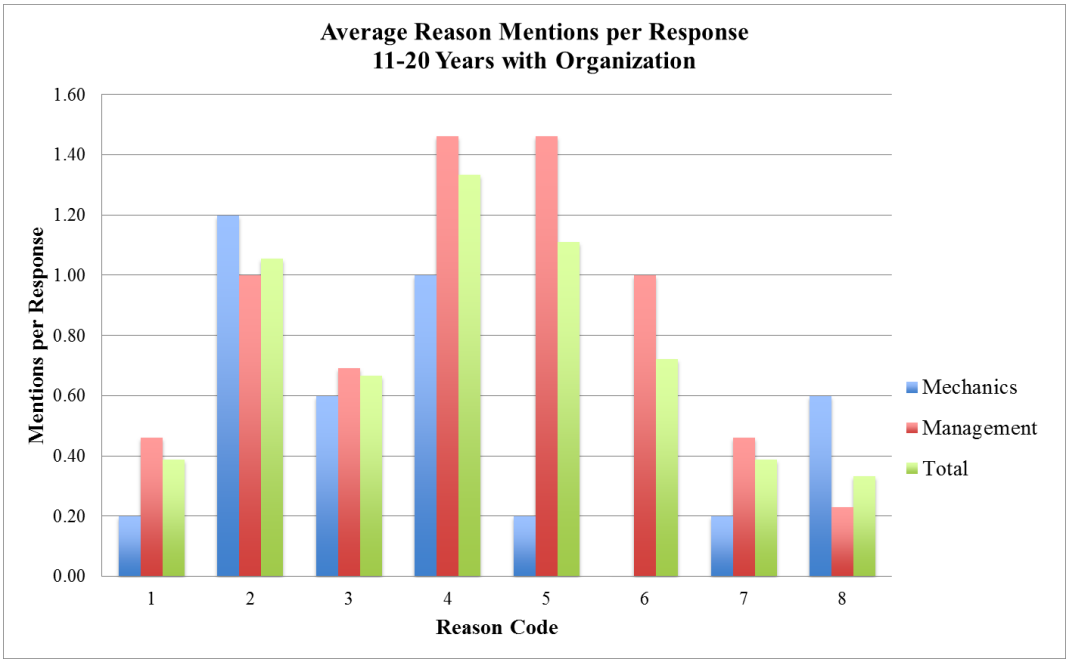

Fig 6.23. Use of Reasons for Reporting Hesitation: 11-20 Years with Organization

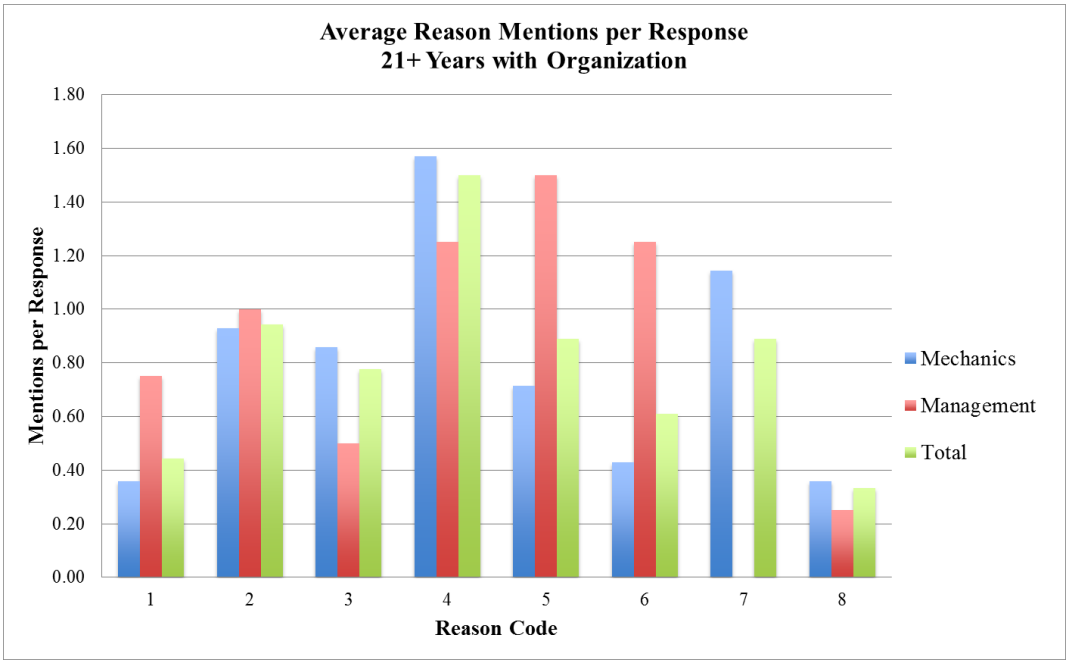

Fig 6.24. Use of Reasons for Reporting Hesitation: 21+ Years with Organization

Overall, reason citation was higher for individuals who have worked for their current organization for a longer period of time (at least 11 years). Management seemed to observe more reasons for reporting hesitation across the four subgroups, and several disparities in response patterns exist. For newcomers to an organization (Fig. 6.21), management cited reason 1 ("It's too much work to go through the reporting process") and reason 2 ("That's just how the job is always done – it works fine every day") far more often than mechanics. This may be due to the inevitable hearsay that defines new employees' perceptions of work practices before they develop their own opinions of mechanics' performance based on experience. Similarly, more experienced managers who have worked at their organization for at least 11 years (Fig. 6.23 and Fig. 6.24), cite the use of reason 5 ("It would make more sense to go straight to a supervisor or manager") and reason 6 ("The explanation of the event might lead to questions about others

involved") at a far greater rate than mechanics, suggesting that older managers either question mechanics' knowledge of or commitment to voluntary reporting system policies, or lack this knowledge themselves. Mechanics' use of reasons for reporting hesitation does stand out markedly in one area. More experienced mechanics frequently cited reason 7 ("Nothing will get done about this type of incident – management won't care or think it's important"), yet managers with the same level of experience never used this reason.

The final comparison was based on number of years working in the aviation industry. Fig. 6.25 – Fig. 6.27 portray perceived use of reasons for reporting hesitation by mechanics and management of varying years of experience in aviation. Note that a comparison of responses from those working in the aviation industry for 0-10 years was not included because no management data was collected for this timeframe.

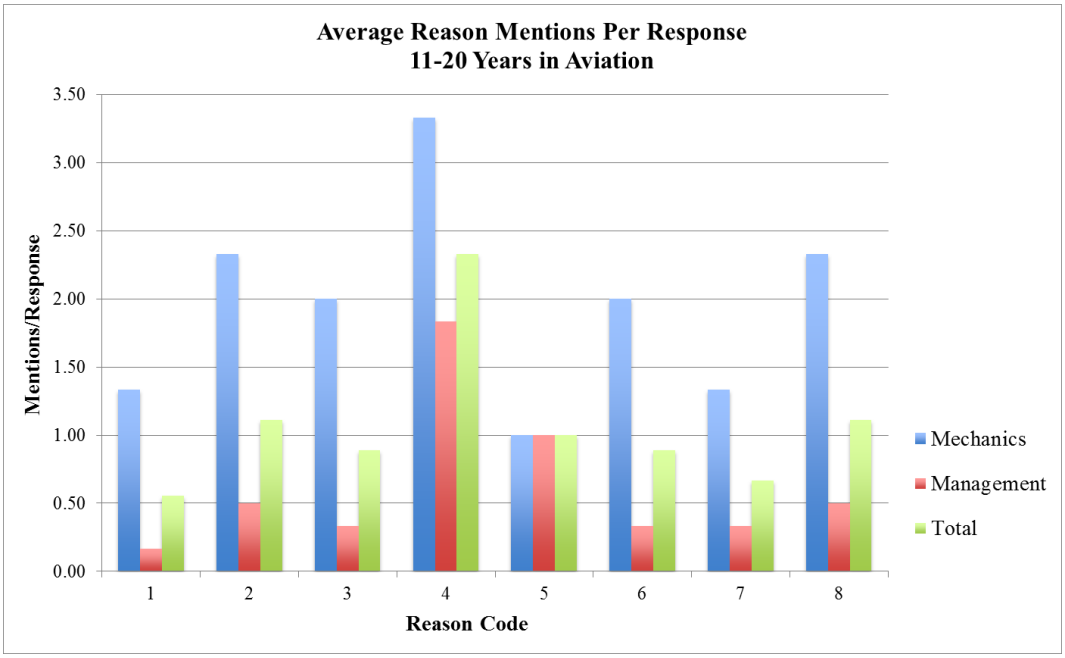

Fig. 6.25. Use of Reasons for Reporting Hesitation: 11-20 Years in Aviation

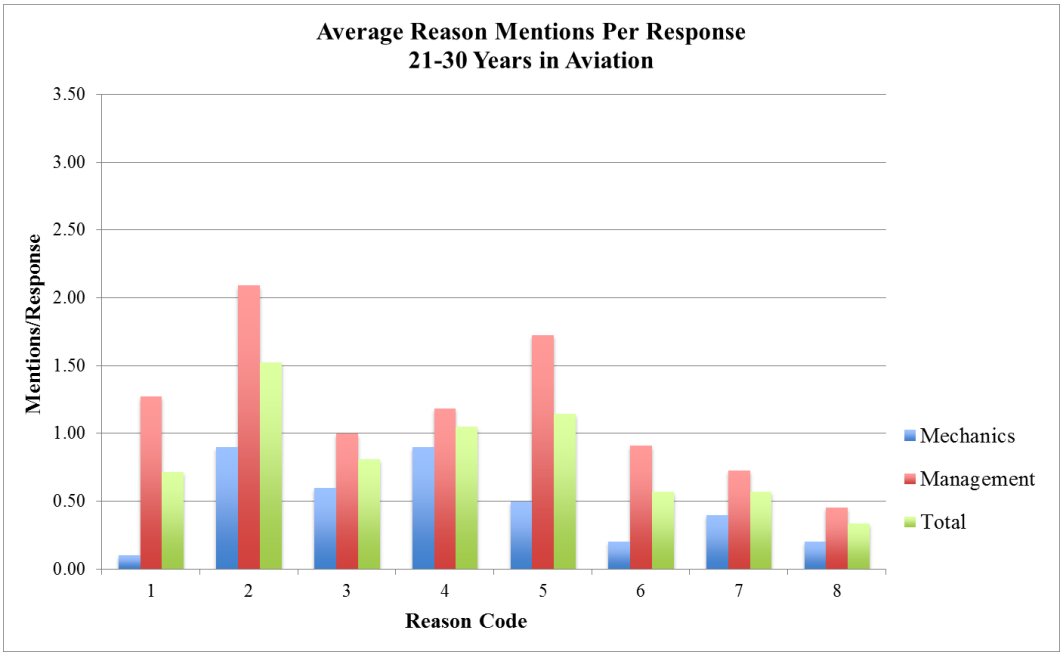

Fig. 6.26. Use of Reasons for Reporting Hesitation: 21-30 Years in Aviation

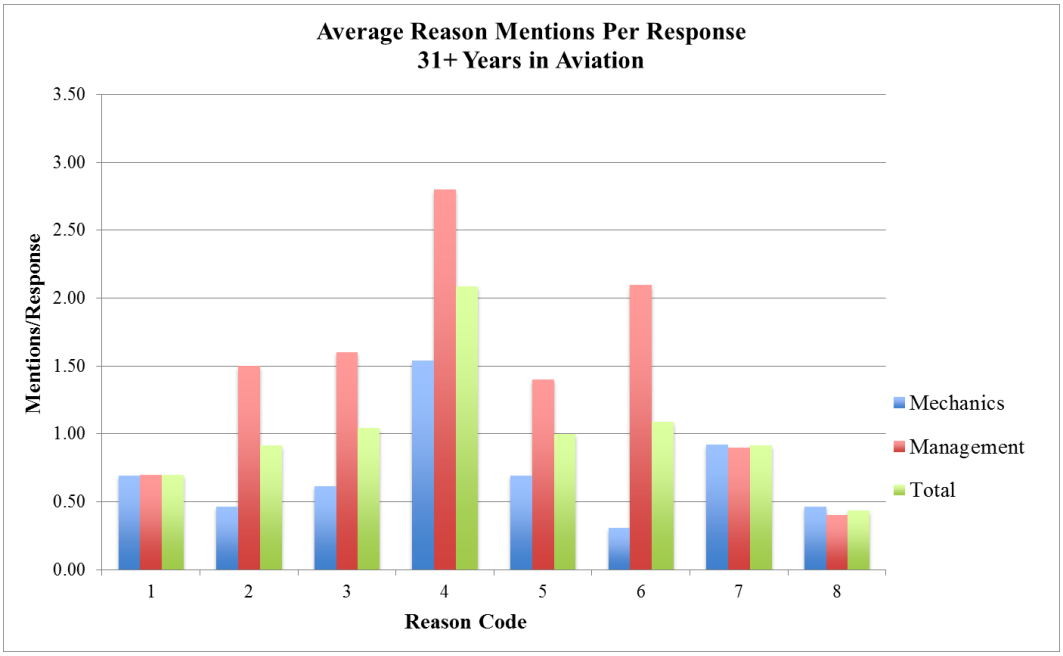

Fig. 6.27. Use of Reasons for Reporting Hesitation: 31+ Years in Aviation

Although managers have been more predominant in citing perceived reasons for reporting hesitation, examining the results by years in aviation exposed a unique outcome. Mechanics with 11-20 years in aviation recorded reasons for reporting

hesitation more abundantly than managers. In fact, use of reasons for reporting hesitation by managers in this group was less than most subgroups considered in this section. This supports the idea that newer managers with less experience in aviation may be less engaged with voluntary reporting, less confident about their voluntary reporting knowledge, and/or less critical of mechanics' reporting practices.

Two additional characteristics that describe experience with voluntary reporting were assessed to understand their association with perception of reasons for reporting hesitation. Mechanics' experience was evaluated based on the number of voluntary reports they have personally submitted in the past, and management's experience was tested by comparing the number of voluntary report-driven corrective actions observed. Although the two samples could not be directly compared using this data, internal conclusions were drawn within each group. Fig 6.28 describes mechanics' use of reasons for reporting hesitation based on their history using voluntary reporting systems.

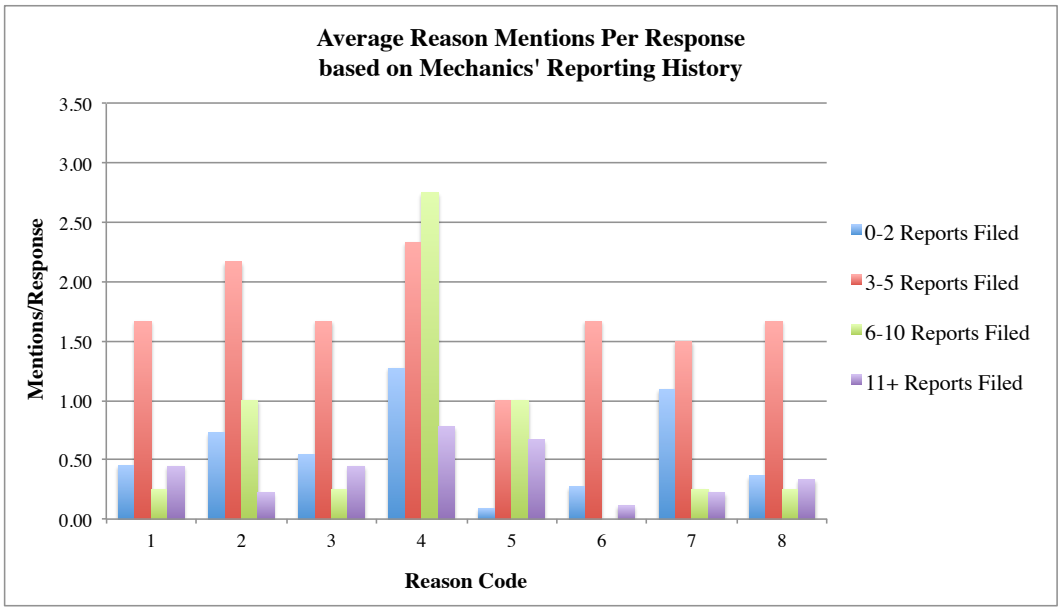

Fig 6.28. Use of Reasons for Reporting Hesitation based on Mechanics' Reporting History

Overall, those with some, but limited experience (3-5 reports filed) showed the greatest perceived use of reasons for reporting hesitation. The use of reason 4 ("Admitting to this incident might result in disciplinary action") shows an interesting pattern. Users with some, but limited, experience using a voluntary reporting system (3-10 previous report submissions) appear to either perceive the use of or personally use this reason profusely. However, after 10 reports have been filed, the use of this reason experiences a significant drop off, likely indicating that users gain trust in the system and those who are responsible for upholding its policies. Additionally, less experienced users (0-5 reports previously submitted) cited reason 7 ("Nothing will get done about this type of incident – management won't care or think it's important") far more frequently than more experienced users, indicating that increased knowledge of and involvement with voluntary reporting systems also improves confidence in the

development of corrective actions and management's commitment to their implementation.

Fig. 6.29 shows the assessment of management's use of each reason for reporting hesitation based on the number of implemented corrective actions they have observed as a result of voluntary error reports.

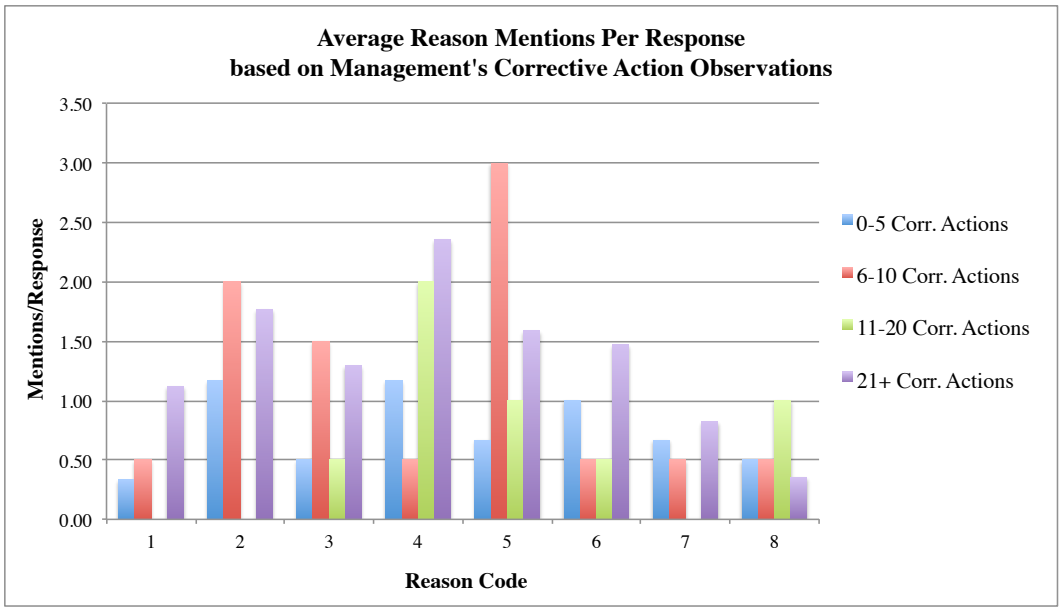

Fig 6.29. Use of Reasons for Reporting Hesitation based on Management's Corrective Action Observations

Unlike mechanics, experience with voluntary reporting systems (11-21+ corrective actions observed) increased managers' use of reason 4 ("Admitting to this incident might result in disciplinary action"). Mechanics and managers seem to disagree on whether trust in these systems is gained or lost through continued use. In addition to reason 4, highly experienced managers (21+ corrective actions observed) generally perceived elevated reason use. This suggests that intimate

familiarity with the system and its benefits may also result in a greater skepticism regarding proper system use due to perceived user dissatisfaction and fear.

6.3. Statistical Interpretation of Results

6.3.1 Results of Hypothesis 1: Mechanic and Management Classification of Reportable Events

With respect to null hypothesis 1, the association between job title (mechanic or manager) and perception of reportable errors/violations was tested using the chi-square test of independence. Table 6.18 shows the frequency of observed and expected responses for each sample. This data was used to calculate the chi-square test statistic to determine if there were statistically significant differences between the reporting perceptions of mechanics and managers.

Table 6.18.
Reporting Perception Responses for Chi-Square Test

Response	Mechanics		Management		
	Obs	Exp	Obs	Exp	TOTAL
Yes	189	187.89	168	169.11	357
Possibly/Unsure/No	141	142.11	129	127.89	270
TOTAL	330		297		627

Comparing the two categories of responses between mechanics and managers (degrees of freedom = 1), it was determined that there is no statistically significant difference (chi-square = 0.032, p = 0.86) between perceptions of reportable events. On average, mechanics and managers cited a similar percentage of errors/violations as reportable. Each individual error/violation was also assessed,

but none showed statistically significant differences between mechanic and management perceptions of reporting. Null hypothesis 1 should not be rejected.

6.3.2. Results of Hypothesis 2: Rank-Order Correlation of Reportable Events

With respect to null hypothesis 2, the correlation between mechanics' and managers' rank ordering of acceptable error/violation scenarios was tested. Table 6.19 summarizes these rankings for both mechanics and managers, which were used to test the association using a Spearman's rank-order correlation.

Table 6.19.
Rank-Order of Reportable Errors/Violations

	Mechanics		Managers	
CODE	% Yes Responses	Rank	% Yes Responses	Rank
A	0.40	6	0.30	9
B	0.63	5	0.78	3
D	0.37	8	0.48	6
E	0.70	4	0.59	4.5
F	0.87	1	0.89	1
G	0.80	2.5	0.59	4.5
H	0.37	8	0.41	7
J	0.37	8	0.33	8
K	0.80	2.5	0.81	2

Based on Spearman's test, a strong correlation ($\rho = 0.808$, $p = 0.008$) was identified between the way in which mechanics and managers classified reportable events. Null hypothesis 2 should not be rejected. This association shows that although reporting participation does not necessarily follow recommended practices and system policies, mechanics and managers generally agree on the reporting practices they observe.

6.3.3. Results of Hypothesis 3: Mechanic and Management Justification for Non-Reporting

With respect to null hypothesis 3, the association between job title (mechanic or manager) and perceived justification for non-reporting was tested. Table 6.20 shows the frequency of observed and expected reason use for mechanics and management. These responses were used to calculate a chi-square test statistic to determine if there were statistically significant differences between mechanic and management perceptions of reasons for reporting hesitation.

Table 6.20.
Reasons for Reporting Hesitation Responses for Chi-Square Test

Reason	**Mechanics**		**Management**		
Number	Obs	Exp	Obs	Exp	**TOTAL**
Reason 1	20	18.10	22	23.90	42
Reason 2	27	29.30	41	38.70	68
Reason 3	21	21.54	29	28.46	50
Reason 4	46	42.23	52	55.77	98
Reason 5	17	24.13	39	31.87	56
Reason 6	14	20.25	33	26.75	47
Reason 7	24	18.53	19	24.47	43
Reason 8	18	12.93	12	17.07	30
TOTAL	187		247		434

Using an aggregated data set of eight potential reason responses compared between the two samples (degrees of freedom = 7), differences in perceived reason use were determined to be statistically significant (chi-square = 14.72, p = 0.04). Evaluating each reason individually, a statistically significant difference (chi-square = 4.25, p = 0.039) was found in the use of reason 5 (“It would make more sense to go straight to a supervisor or manager”). Differences in the use of reason 6 (“The explanation of the event might lead to questions about others

involved") and reason 8 ("I don't think lasting change will result from reporting this") likely contributed to the overall significance, as the test statistics for these two reasons were just below the critical value ($p = 0.051$ and $p = 0.052$, respectively). Null hypothesis 3 should not be rejected for the aggregated reason data set and for the specific use of reason 5. These results will be used to support differences in barrier impact between mechanics and management in Section 6.4.

6.3.4. Results of Hypothesis 4: Rank-Order Correlation of Justification for Non-Reporting

With respect to null hypothesis 4, the correlation between mechanics' and managers' rank ordering of reasons for reporting hesitation was assessed. Table 6.21 summarizes these rankings for mechanics and managers, which were used to test the association using the Spearman's rank-order correlation.

Table 6.21.
Rank-Order of Reasons for Reporting Hesitation

	Mechanics		Managers	
Reason #	**Reasons/ Response**	**Rank**	**Reasons/ Response**	**Rank**
1	0.67	5	0.81	6
2	0.90	2	1.52	2
3	0.70	4	1.07	5
4	1.53	1	1.93	1
5	0.57	7	1.44	3
6	0.47	8	1.22	4
7	0.80	3	0.70	7
8	0.60	6	0.44	8

Spearman's test showed that there was not a statistically significant correlation ($\rho = 0.36$, $p = 0.38$) between the rankings determined by responses from these two

groups. Null hypothesis 4 should be rejected. This supports the results of hypothesis 3, that there are significant differences in the use of certain reasons for reporting hesitation between mechanics and managers.

6.3.5. Results of Hypothesis 5: Perception of Reportable Events based on Age

With respect to null hypothesis 5, the association between age and perceived reporting practices was tested. Table 6.22 and Table 6.23 show the frequency of observed and expected responses for mechanics and management, respectively, based on age group. These responses were used to calculate a chi-square test statistic for each sample to determine if there were statistically significant differences in reporting perceptions based on age.

Table 6.22.

Mechanic Responses by Age for Chi-Square Test

Age	**Yes**		**No/Poss/Unsure**		
	Obs	Exp	Obs	Exp	**Total**
Under 30	6	5.3	3	3.7	9
30-40	26	26.5	19	18.5	45
41-50	36	37.1	27	25.9	63
51-60	61	63.6	47	44.4	108
61+	30	26.5	15	18.5	45
TOTAL	159		111		270

Table 6.23.

Management Responses by Age for Chi-Square Test

Age	Yes		No/Poss/Unsure		
	Obs	Exp	Obs	Exp	**Total**
30-40	14	10.37	4	7.63	18
41-50	34	41.48	38	30.52	72
51-60	68	57.04	31	41.96	99
61+	24	31.11	30	22.89	54
TOTAL	140		103		243

*There were no management responses by employees under the age of 30

Comparing the two categories of responses from mechanics of five age groups (degrees of freedom = 4) and managers of four age groups (degrees of freedom = 3), it was determined that (1) there is no statistically significant difference (chi-square = 1.71, p = 0.79) in mechanics' perceptions of reportable errors/violations based on age and (2) there is a statistically significant difference (chi-square = 14.99, p = 0.0018) in managers' perceptions of reportable errors/violations based on age. Null hypothesis 5 should be rejected for the sample of managers. Variation in age was proven to influence management perception of reporting practices. The 30-40 and 51-60 year-old populations noted a far greater percentage of reportable events than the 41-50 and over 60 groups.

6.3.6. Results of Hypothesis 6: Perception of Reportable Events based on Years with an Organization

With respect to null hypothesis 6, the association between years of experience at an organization and perceived reporting practices was examined. Table 6.24 and Table 6.25 show the frequency of observed and expected

responses for mechanics and management, respectively, based on years working at an organization. These responses were used to calculate a chi-square test statistic for each sample to determine if there were statistically significant differences in reporting perceptions based on years with an organization.

Table 6.24.

Mechanic Responses by Years with an Organization for Chi-Square Test

Years at Org.	**Yes**		**No/Poss/Unsure**		
	Obs	Exp	Obs	Exp	**Total**
0 to 5	14	15.9	13	11.1	27
6 to 10	46	42.4	26	29.6	72
11 to 20	32	26.5	13	18.5	45
20+	67	74.2	59	51.8	126
TOTAL	159		111		270

Table 6.25.

Management Responses by Years with an Organization for Chi-Square Test

Years at Org.	**Yes**		**No/Poss/Unsure**		
	Obs	Exp	Obs	Exp	**Total**
0 to 5	11	15.56	16	11.44	27
6 to 10	26	36.30	37	26.70	63
11 to 20	74	67.41	43	49.59	117
20+	29	20.74	7	15.26	36
TOTAL	140		103		243

Comparing the two categories of responses from mechanics and managers of four tiers of experience at an organization (degrees of freedom = 3), it was determined that (1) there is no statistically significant difference (chi-square = 5.77, $p = 0.12$) in mechanics' perceptions of reportable errors/violations based on years of service at their organization and (2) there is a statistically significant difference (chi-square = 19.32, $p = 0.0002$) in managers' perceptions of reportable errors/violations based on years of service at their organization. Null hypothesis 6

should be rejected for the sample of managers. Variation in years working at an organization was proven to influence management perceptions of reporting practices. Employees with more experience at an organization indicated a greater percentage of error/violation scenarios to be reportable.

6.3.7. Results of Hypothesis 7: Perception of Reportable Events based on Years in Aviation

With respect to null hypothesis 7, the association between years working in the aviation industry and perceived reporting practices was tested. Table 6.26 and Table 6.27 show the frequency of observed and expected responses for mechanics and management, respectively, based on years working in the aviation industry. These responses were used to calculate a chi-square test statistic for each sample to determine if there were statistically significant differences in reporting perceptions based on years in aviation.

Table 6.26.

Mechanic Responses by Years in Aviation for Chi-Square Test

Years in AVI	**Yes**		**No/Poss/Unsure**		
	Obs	Exp	Obs	Exp	**Total**
0-10	20	21.2	16	14.8	36
11 to 20	14	15.9	13	11.1	27
21-30	63	53	27	37	90
31+	62	68.9	55	48.1	117
TOTAL	159		111		270

Table 6.27.

Management Responses by Years in Aviation for Chi-Square Test

Years in AVI	Yes		No/Poss/Unsure		
	Obs	Exp	Obs	Exp	**Total**
11 to 20	38	31.11	16	22.89	54
21-30	63	57.04	36	41.96	99
31+	39	51.85	51	38.15	90
TOTAL	140		103		243

*There were no management responses by employees with 0-10 years in aviation

Comparing the two categories of responses from mechanics of four tiers of experience working in aviation (degrees of freedom = 3) and managers of three tiers of experience working in aviation (degrees of freedom = 2), it was determined that (1) there is no statistically significant difference (chi-square = 6.99, p = 0.072) in mechanics' perceptions of reportable events based on years in aviation and (2) there is a statistically significant difference (chi-square = 12.58, p = 0.002) in managers' perceptions of reportable events based on years in aviation. Null hypothesis 7 should be rejected for the sample of managers. Variation in years working in aviation was proven to influence management perceptions of reporting practices. Managers with less experience in aviation indicated a greater percentage of error/violation scenarios to be reportable.

6.3.8. Results of Hypothesis 8: Perception of Reportable Events based on Experience with Voluntary Reporting

With respect to null hypothesis 8, the association between experience with voluntary reporting systems and perceived reporting practices was tested. For mechanics, level of experience was denoted by the number of voluntary reports

personally submitted, and managers' level of experience was represented by the number of report-driven corrective actions observed. Table 6.28 shows the frequency of observed and expected responses for mechanics based on voluntary reports submitted, and Table 6.29 shows the frequency of observed and expected responses for management based on number of report-driven corrective actions observed. These responses were used to calculate a chi-square test statistic for each sample to determine if there were statistically significant differences in reporting perceptions based experience with voluntary reporting.

Table 6.28.

Mechanic Responses by Submitted Reports for Chi-Square Test

Reports Submitted	**Yes**		**No/Poss/Unsure**		
	Obs	Exp	Obs	Exp	**Total**
0-2	61	58.3	38	40.7	99
3-5	20	31.8	34	22.2	54
6-10	20	21.2	16	14.8	36
10+	58	47.7	23	33.3	81
TOTAL	159		111		270

Table 6.29.

Management Responses by Observed Corrective Actions for Chi-Square Test

Corr. Actions Observed	**Yes**		**No/Poss/Unsure**		
	Obs	Exp	Obs	Exp	**Total**
0-5	29	31.11	25	22.89	54
6-10	8	10.37	10	7.63	18
11-20	13	10.37	5	7.63	18
20+	90	88.15	63	64.85	153
TOTAL	140		103		243

Comparing the two categories of responses from mechanics and managers of four tiers of experience (degrees of freedom = 3), it was determined that (1) there is a statistically significant difference (chi-square = 16.53, p = 0.0009) in mechanics' perceptions of reportable errors/violations based on number of

voluntary reports personally submitted and (2) there is not a statistically significant difference (chi-square = 3.28, p = 0.072) in managers' perceptions of reportable errors/violations based on observed report-driven corrective actions. Null hypothesis 8 should be rejected for the sample of mechanics. Variation in history using a voluntary reporting system was proven to influence mechanics' perceptions of reporting practices. Mechanics with the most experience using a voluntary reporting system indicated the greatest percentage of errors/violations to be reportable.

6.4. Relation of Justification for Non-Reporting to Barrier Prevalence

As previously mentioned, each reason for reporting hesitation presented in the questionnaire is related to one or more potential barriers to voluntary reporting. This section will determine the relative impact of each barrier according to mechanic, manager, and subgroup questionnaire responses. Table 6.30 relates day-to-day operational reasons for reporting hesitation to the theoretical and cultural barriers that are likely influencing the decision not to report.

Table 6.30.

Barrier Association to Reasons for Reporting Hesitation

Barriers	Related Reasons for Reporting Hesitation
"Blindness"/ Local Perspective	2. That's just how the job is always done – it works fine every day. 3. This type of incident wasn't serious enough to cause an issue down the road.
Org. Commitment to Safety Culture	1. It's too much work to go through the reporting process. 2. That's just how the job is always done – it works fine every day. 3. This type of incident wasn't serious enough to cause an issue down the road. 4. Admitting to this type of incident might result in disciplinary action. 7. Nothing will get done about this type of incident – management won't care or think it's important. 8. I don't think lasting change will result from reporting this.
Trust in the System and in Management	4. Admitting to this type of incident might result in disciplinary action. 5. It would make more sense to go straight to a supervisor or manager. 6. The explanation of the event might lead to questions about others involved.
Training Techniques	1. It's too much work to go through the reporting process. 5. It would make more sense to go straight to a supervisor or manager. * I'm unsure how/what to report.
Policy and Procedure Definition	4. Admitting to this type of incident might result in disciplinary action. 5. It would make more sense to go straight to a supervisor or manager.
Error Reports/ Interviews	1. It's too much work to go through the reporting process. 6. The explanation of the event might lead to questions about others involved.
Analysis/ Development of Corrective Actions	7. Nothing will get done about this type of incident – management won't care or think it's important. 8. I don't think lasting change will result from reporting this.

*Although not one of the 8 designated reasons, the use of this response can be attributed to training deficiencies.

Rejection of null hypothesis 3 proved that perceived reasons for reporting hesitation by mechanics and managers were statistically different. Based on the

frequency of reason mentions, a "score" was calculated for each barrier. Because it is impossible to predict which barrier(s) may be influencing the mindset of a system user in any given circumstance, the number of potential barriers associated with each reason was taken into account. When scoring each barrier based on the frequency of use of each associated reason, these frequencies were adjusted based on the total number of potential barriers related to each reason. For example, the score for "Blindness to Human Error and Impact of Local Perspective" for mechanics was calculated using the following steps:

1. Determine which reasons were affected by this barrier and the frequency of use of each reason from the mechanic data set.

   Reason 2 = 27, Reason 3 = 21

2. Determine the total number of barriers potentially associated with the reasons determined in step 1.

   Reason 2 = 2 barriers, Reason 3 = 2 barriers

3. Divide the frequency of each reason (from step 1) by the total number of potential barriers to each reason (from step 2) to obtain the relative influence of "Blindness/Local Perspective" on each associated reason.

   Reason 2 = 27/2 = 13.5, Reason 3 = 21/2 = 10.5

4. Sum the influence of "Blindness/Local Perspective" on each associated reason to obtain a total score.

   13.5 + 10.5 = ***24***

Tables 6.31 and 6.32 display barrier impact scores according to mechanics' and managers' perceptions of reporting practices, respectively. Note that the barrier "Personnel Changes" was not tested, as it was found to be least impactful during the information gathering phases and was most difficult to assess given the structure of the questionnaire.

Table 6.31.

Barrier Impact based on Mechanics' Perceptions of Reporting

Barrier	Score
Commitment to Safety Culture	67
Trust in the System/Mgmt	26
Policy and Procedure Definition	26
Blindness/Local Perspective	24
Training Techniques	24
Analysis/Corrective Actions	21
Error Reports/Interviews	11

Table 6.32.

Barrier Impact based on Managers' Perceptions of Reporting

Barrier	Score
Commitment to Safety Culture	75
Trust in the System/Mgmt	41
Policy and Procedure Definition	41
Blindness/Local Perspective	35
Training Techniques	20
Error Reports/Interviews	18
Analysis/Corrective Actions	16

Although the use of reasons for reporting hesitation by mechanics and management were deemed to be statistically dissimilar, the impact of the barriers to voluntary reporting are ordered similarly by both groups. "Organizational Commitment to Safety culture" is a broad term that can influence many, if not all,

of the other barriers and, therefore, was not surprisingly determined to be the most impactful reporting barrier based on the reasons for reporting hesitation indicated by both groups. Similarly, the importance of trust aligns well with information gleaned from the literature review and from interviews with industry professionals. "Policy and Procedure Definition", "Blindness to Human Error and the Impact of Local Perspective" and "Voluntary Reporting Training Techniques" were also ranked similarly based on each sample's responses, suggesting that the relative impact of each barrier was accurately determined based on the analysis of questionnaire responses.

There was one area of misalignment in rankings between the two data sets. The last two categories, "Error Reports/Interviews" and "Analysis/Development of Corrective Actions" are in reverse order between the two samples. Mechanics' responses imply that they are more concerned with the analysis of error reports and the resulting corrective action implementation (management's responsibility) and less aware of their own misperceptions about the appropriate quantity and quality of reports that voluntary reporting systems should generate. Conversely, management perceptions of reporting are related more to the quality of error reports and the interview process (the responsibility of mechanics and the review team) than to their own shortcomings related to corrective action implementation and feedback.

Overall, management's identified reasons for reporting hesitation outnumbered those cited by mechanics, perhaps indicating management's general awareness of the barriers that influence voluntary reporting. Forty-one to fifty

year-old employees, those with significant experience at their organization (11-21+ years), and those who have observed 21+ report-driven corrective actions all showed elevated numbers of reasons for reporting hesitation and, therefore, an awareness of barriers to voluntary reporting participation. These groups represent mid to late career employees with experience at their company and with voluntary reporting systems. Mechanics with the most experience submitting voluntary reports cited the fewest number of reasons, suggesting that barriers may be less impactful to those who are more familiar and comfortable with the system.

There were several additional findings related to groups with specific characteristics that may influence barrier prevalence. Thirty to forty year olds cited the fewest reasons for reporting hesitation of any age group, possibly implying that this younger cohort of employees is less aware of the range of issues that inhibit proper event recording or otherwise prevent these systems from working properly. New employees should be quickly trained in the benefits of voluntary reporting and the need to promote its use.

Managers over the age of 60 and those with 11-21+ years working for their organization cited the use of hesitation reasons 5 and 6 far more than mechanics of the same age group. Reasons 5 and 6 relate to trust and policy and procedure definition, respectively, implying that veteran managers may benefit from additional education regarding the theory and practice of voluntary reporting as well as additional hands-on training in system use. This training might enhance their ability to effectively and credibly communicate with their

subordinates and, therefore, build the trust needed to promote buy-in to a system that could be viewed as self-incriminating.

Managers who are new to an organization cited hesitation reasons 1 and 2 far more than mechanics of the same level of experience. Both reasons 1 and 2 are heavily related to safety culture and, more specifically, to cultural influences that undermine the importance of voluntary reporting in general. Interestingly, it could be inferred that new managers are influenced by hearsay and believe that mechanics are unwilling to use voluntary reporting systems while, in reality, new mechanics are actually more open to participating. New managers, in addition to learning "how to be managers" should place particular emphasis on working to establish strong relationships and clear communication channels with subordinates so that they can become intimately familiar with mechanics' work practices and reporting habits.

Experienced mechanics (21+ years at an organization) cited reason 7 ("Nothing will get done about this type of incident – management won't care or think it's important") frequently, while managers of this same experience level never cited it once. This seems to represent one area in which experienced mechanics and managers interpret the safety culture of their organization quite differently. Older mechanics may lack faith in management's ability and/or willingness to implement effective corrective actions from voluntary error report recommendations, while experienced managers do not seem to share this concern. This may be a legitimate result of mechanics' past experiences and/or may reflect a lack of guideline acceptance or understanding by experienced managers. While

the culture may be changing around them, veteran mechanics may need additional, more effective communication from their managers and reassurance that managers are committed to their role in corrective action implementation.

When comparing mechanics' responses within the sample, those who submitted fewer voluntary reports also used reason 7 ("Nothing will get done about this type of incident – management won't care or think it's important") more frequently than those with more experience using such systems. This implies that through continued system use and the trust and familiarity that engender, mechanics may re-evaluate their perceptions of an organization's commitment to safety culture and the effectiveness of the process by which reports are analyzed and corrective actions are developed/implemented.

Comparing managers' experiences with voluntary reporting systems, those who have observed the implementation of a greater number of voluntary report-driven corrective actions tended to cite reason 4 ("Admitting to this incident might result in disciplinary action") as a cause of hesitation more than those with less experience using voluntary reporting systems. This implies that experience observing and/or taking part in influential report-driven improvements heightens awareness of the trust issues that can hinder participation in these systems. Managers who have seen and experienced the most benefit should be more involved in promoting system policies, especially those that affect user anonymity and immunity from punitive action.

7. Discussion of Results

7.1. Summary of Results

Through the literature review and knowledge elicitation, eight barriers to the effective implementation and continued use of voluntary reporting systems were identified. The initial research and interviews provided specific examples of barrier influence within the context of the aviation industry. Table 7.1 summarizes the barriers to voluntary reporting that were uncovered and investigated in this study.

Table 7.1.
Summary of Barriers to Voluntary Reporting

Barrier	Examples Identified through Research and Interviews
"Blindness"/ Local Perspective	• Unwillingness to admit mistakes/false assumption of infallibility • Lack of awareness of how actions can lead to safety concerns • Image of reporting: inconvenient, embarrassing, unimportant • Metric pressures and "image" may outweigh safety
Commitment to Safety Culture	• Leadership fear of tarnishing safety record or suffering financial losses • Lack of leadership visibility to broadcast importance of safety and reporting • Allowing routine violations to become standard practice and not investigating why they occur • Belief that management will not care enough to make lasting changes • No "Just Culture" of openness and shared responsibility
Trust in the System and in Mgmt	• Fear that managers will punish for errors, regardless of policy • Management fear that workers will take advantage of system • Fear of implicating colleagues and hurting relationships • Fear of retaliation
Training Techniques	• Lack of clear instruction on how to use the system • No clearly defined scope of types of events to report (or lack of adequate examples) • Focus on critical issues only, not minor ones • Managers not trained adequately on providing meaningful feedback • General resistance to training (both users and management complain that it does not portray true culture) • No follow-up training

Personnel Changes	• Changes in understanding of and commitment to system • Changes in level of corrective action implementation • Changes in the way the system is run • Lack of succession planning to groom new champions
Policy and Procedure Definition	• Long document of complicated legal language is not as effective as a face-to-face promise • Organization may not follow policy perfectly • Organization must clearly communicate system policies, especially the line between report acceptance and punitive action
Error Reports/ Interviews	• Inadequate recollection of event or withholding of details • Lack of time, writing ability, motivation • Insufficient methods for reporting and complicated interfaces • Interviewer(s) lack(s) knowledge of the event and/or focuses more on the outcome than the person's behaviors and decision-making process
Analysis/ Development of Corrective Actions	• Focus on local, rather than systemic solutions • Inadequate knowledge of work environment/task – need SMEs • Management pushback regarding implementation of corrective actions • Cost benefit analysis not conducted or poorly conducted • Implemented corrective actions not effectively disseminated

This information inspired the development of a questionnaire to test aircraft mechanic and management perceptions of reportable events and reasons for non-reporting. The results of the questionnaire analysis demonstrate that underreporting is the result of various reasons for reporting hesitation. These reasons support the existence of the previously defined barriers (with the exception of "Personnel Changes", which was not tested). When asked to indicate if a list of common aircraft maintenance errors and violations would be voluntarily reported at their organization, mechanics and managers responded in a comparable manner. Both groups identified a similar pattern of acceptable error/violation scenarios as appropriate for report filing (hypothesis 1).

Responses to the nine errors/violations would likely be accepted into the ASAP voluntary reporting system (used by each respondent's organization), guaranteeing immunity from punitive action, mechanics and managers responded

that only 59% and 58%, respectively, would be reported. Despite the similarity of these percentages, there was significant variation within each sample, with percentages ranging from 0 to 100 for both groups. This large, within-group variation reflects misperceptions of reporting practices by certain mechanics and managers. Misperceptions of reporting practices may also further propagate an existing misunderstanding of the type and severity of errors that warrant reports, resulting in report submissions for only a portion of acceptable events. Thus, these scores support the existence of barriers that not only influence reporting system perceptions, but also system participation. Those with more experience either using voluntary reporting systems or observing report-driven corrective actions indicated a greater percentage of errors/violations to be reportable.

In addition to a similar percentage of errors/violations deemed reportable by mechanics and managers, the ranked order of errors/violations based on percentage of "yes" responses (or reportability) was also very similar (hypothesis 2). Scenarios representing honest mistakes were perceived as more reportable than deliberate violations. However, the two unlikely acceptable violations were seen as more reportable than predicted, indicating either a lack of understanding of specific reporting system guidelines and policies or inappropriate use of the system generally. Mechanics and managers seemed to disagree most on the likelihood of employees reporting a violation of inspection/sign off requirements. Mechanics indicated this violation to be highly reportable (with substantial within-group agreement), while managers were more uncertain (with substantial within-group disagreement). Alternatively, errors/violations related to engine

hardware or tools were perceived as more reportable by managers than mechanics.

Evaluating the perceptions of mechanics and managers separately based on personal characteristics determined that statistical associations exist between (1) management's observations of report-driven corrective actions and personal/professional characteristics (hypotheses 5-7) and (2) mechanics' history of submitting voluntary reports and perceptions of reportable events (hypothesis 8). Although it was expected that age, years working for an organization, and years working in aviation would be related (and possibly yield overlapping results), contradictory associations were exposed between these factors and reporting perceptions. A positive correlation was identified between management experience at an organization and percentage of errors/violations deemed to be reportable, while a negative correlation was found to exist between management years in aviation and percentage of errors/violations deemed to be reportable. Additionally, there was no significant correlation between age and reporting perceptions.

It was determined that a statistically significant difference exists between the way in which mechanics and managers perceive the reasons for reporting hesitation that may deter potential system users from participating (hypothesis 3). This was supported by the finding that no association exists between the rank order of mechanics' and management's citing of reasons for reporting hesitation (hypothesis 4). The reason for reporting hesitation most commonly cited by both groups was "Admitting to this incident might result in disciplinary action",

demonstrating a lack of trust in the system and management (barrier 3: User Trust in Voluntary Reporting Systems and in Management). The second most cited reason was "That's just how the job is always done – it works fine every day", which reflects misperception about safety risk (barrier 1: "Blindness" to Human Error and Local Perspective) and a culture that supports routine violations (barrier 2: Organizational Commitment to Safety Culture). Mechanics and managers disagreed most on the use of the justification that "It would make more sense to go straight to a supervisor or manager", demonstrating insufficient understanding of the system (barrier 4: Voluntary Reporting System Training Techniques) and a lack of clear system policies (barrier 6: Voluntary Reporting System Policy and Procedure Definition).

The association between the identification of reasons for reporting hesitation and personal characteristics was also assessed. Discrepancies between subgroups of each trait (age, years with an organization, years working in aviation, and experience with voluntary reporting systems) exposed differences in barrier impact in the final stage of the analysis. The impact of each barrier was assessed according to mechanics' and managers' responses, and observations were made regarding specific subgroups within each sample.

The rank order of the barriers, based on perceived impact, was similar for both groups, but with key differences related to the unique perspectives and experiences of each group within an organization. "Organizational Commitment to Safety Culture" was found to be the most significant barrier to proper event recording according to both mechanics and managers. Safety culture is defined as

the values and integrity of leadership that shape an organization. Safety culture, therefore, affects the potential impact of each of the other barriers. "User Trust in Voluntary Reporting Systems and in Management" and "Voluntary Reporting System Policy and Procedure Definition" were both found to be, equally, the second most impactful. "Blindness to Human Error and the Impact of Local Perspective" and "Voluntary Reporting Training Techniques" were ranked 4th and 5th, respectfully, by both samples.

These findings imply that users of voluntary reporting systems must be able to trust in the promise of non-punitive responses to error reporting, which can only be achieved by a clear understanding of the difference between acceptable events and those that would not meet system criteria. Mechanics perceived "Analysis of Error Reports and Development of Corrective Actions" to be slightly more impactful barriers than managers did, while managers perceived "Voluntary Error Reports and Interviews" to be slightly higher priority barriers than mechanics did. These discrepancies may be a reflection of differences in responsibilities and bias toward their respective groups.

7.2. Comparison of Results to Literature

Mechanics' and managers' identification of the barriers to voluntary reporting aligned well with information gleaned from the literature review. Specifically, the results support a study conducted by Clarke (1998), which investigated barriers to incident reporting by train conductors of three British railroads. This study specifically focused on the influence of mechanics'

perceptions of managers' reactions to reports. Clarke hypothesized that managers' attitudes would be the most significant factor defining the reporting practices of train conductors. Similar to the present study, Clarke developed a questionnaire presenting 12 potential incidents that a conductor might encounter. Participants were asked to indicate the likelihood that they would submit a report for each of the 12 incidents. For every "possibly" or "no" response, participants were asked to select from a list of six reasons for their hesitation.

Clarke's study found reasons related to management attitudes to be the most obstructive to conductors' voluntary reporting participation. The top three reasons cited by mechanics in the present study (reasons 4, 2, and 7) can all be related to management interactions, communication and influence. Clarke's study did not offer participants the opportunity to choose a reason for reporting hesitation related to punitive action, which was the most commonly cited reason found in the present study (reason 4). However, the most commonly cited reason in Clarke's study was "Just part of a day's work." This aligns with the second most cited reason in the present study, "That's just how the job is always done – it works fine every day" (reason 2). The third most popular reason in Clarke's study was "Nothing would get done about it", aligning with the third-ranked reason in the present study, "Nothing will get done about this type of incident – management won't care or think it's important" (reason 7). Similar to the present study, Clarke found that conductors were more likely to report incidents that could pose an immediate hazard.

In addition to alignment with Clarke's conclusions, the results of this study also support research findings from Union Pacific Railroad's San Antonio Service Unit (SASU). A safety process known as Changing At-Risk Behavior (CAB), part of the FRA Human Factors Program's Clear Signal for Action (CSA) risk-reduction method, was implemented at SASU. The CAB risk-reduction method focuses on three elements: (1) "Behavior-based safety", (2) "Continuous improvement", and (3) "Safety leadership development." Behavior-based safety is an ongoing exercise in which trained peers observe each other in their work environment and provide confidential safety-related feedback. Continuous improvement is defined by the collection of safety-related data to develop and implement necessary corrective actions related to safety hazards. Safety leadership development involves improved management training to increase communication and commitment to safety.

Throughout the first three years of implementation (2005-2008) voluntary surveys were submitted to assess the progress of the CAB risk-reduction effort. Assessment of these surveys found significant improvement of perceived labor-management relations, and the quantitative measure of improvement was equal for both workers and managers (Coplen et al., 2009A). Additionally, Human Factors derailment rates decreased by an impressive 69% from 2006 to 2008 as a result of CAB implementation (Coplen, Ranney, & Zuschlag, 2009B).

The three elements of the CAB process that influenced these improvements relate very closely to the barriers defined in the present study. "Behavior-based safety" is an effort to improve safety culture and combat cultural

blindness by helping workers to understand the potential implications of at-risk behavior that are often ignored. Involving peer review techniques eliminates some of the negative effects of the "tribal" or "macho" mindset that cause embarrassment and fear of retribution related to reporting. "Continuous improvement" stresses the importance of data collection in the development and implementation of robust corrective actions, an important concept for both mechanics and managers. Mechanics must be responsible for providing useful data in the form of clear, detailed reports and informative interviews, and managers must realize the importance of voluntary reporting as an invaluable tool for collecting critical and otherwise unavailable data. "Safety leadership development" is crucial for building trust between mechanics and managers and for inspiring managers to more proactively demonstrate their commitment to supporting a voluntary reporting system, upholding its policies, and implementing recommended corrective actions.

7.3. Recommendations

7.3.1. Applying Facilitators

The literature review and interviews with industry professionals assisted in the development of facilitators that counteract each barrier to effective voluntary reporting practices. Table 7.2 summarizes these facilitator recommendations.

Table 7.2.

Summary of Voluntary Reporting Facilitator Recommendations

Barrier	Recommended Facilitators
"Blindness" to Human Error/Local Perspective	• Provide evidence of the safety and financial benefits of non-punitive voluntary reporting to leadership • Aim to form a partnership among organizational levels which balances responsibility, promotes the understanding of unique circumstances/pressures/concerns, and strives for a unified goal • Create strong, integrated middle management teams responsible for communicating to both superiors and subordinates (made up of those perceived as most fair and consistent) • Encourage individualism in labor groups (break from the idea of infallibility and find common goals between mechanics/management)
Org. Commitment to Safety Culture	• Work toward achieving both a systematic safety culture and Just Culture that encourage the reporting of all types of potential issues • Encourage supervisors to interact more with labor workers to understand the pressures that influence routine violations • Implement peer review programs that encourage open dialogue about errors, near misses, and other hazardous situations • Provide incentives for active reporting • Promote system use through bulletins/posters/emails, especially documenting lessons learned and implemented corrective actions • Implement safeguards to prevent "slackers" from taking advantage of the system and prove to leadership that this is not a concern • Improve communication of all accidents, incidents, and near misses
Trust in the System and in Mgmt	• Clearly define the type of system (open, confidential, or anonymous), including who (if anyone) will have access to identifying information • Improve communication by managers to mechanics regarding punishable vs. non punishable violations and the system's policy of protection from punitive action • Encourage an employee to submit a report if an unsafe act is observed, rather than doing so himself/herself • Encourage system users to communicate positive experiences with system use, especially those related to confidentiality
Voluntary Reporting Training Techniques	• Show examples/screen shots of any interface used to submit a voluntary report • Include many examples of errors/violations that should be reported, including everyday actions that mechanics may not realize could be linked to safety issues • Teach the reporting process as part of management training, as well as stress the importance of encouraging reporting, implementing recommended corrective actions, and providing feedback to employees • Include hazard recognition training – workers travel in groups to unfamiliar areas of a plant or worksite to provide a fresh perspective • Provide an informal means of reporting through training session discussions • Utilize in-class modeling, report writing, and group reviews of reports

Personnel Changes	• Establish a system of succession planning so that new champions of voluntary reporting can step into leadership roles as employees retire or change roles • Include a union member on the event report review team
Voluntary Reporting System Policy and Procedure Definition	• Include representatives from user groups in the design of the system • Clearly communicate the delineation between acceptable and unacceptable behaviors, and reinforce the system's promise of non-punitive action for accepted reports • Outline the flow of information (where the report goes, who sees it, what information is attached at each stage) in visual form for users • Use (and communicate the use of) an algorithm that focuses on the behavior and decision-making process of individuals, rather than error outcome, to determine if reports meet acceptance criteria
Voluntary Error Reports/ Interviews	• Provide multiple user-friendly channels for report submission (written, verbal, computer-based, and handheld device application-based) • Limit the complexity of reporting interfaces • Determine best combination of structured data entry and open text fields that works best for the organization • Use follow-up interviews to either gain clarifying information based on reports and/or to provide information necessary to retroactively generate accurate structured responses • Involve subject matter experts and other labor workers in the development of interview questions • Train interviewers on the concept of "hindsight bias" and "fixation" to ensure fair, comprehensive interviews • Allow and encourage users to submit supplemental information (documents/visuals/maps)
Analysis of Error Reports/ Development of Corrective Actions	• Involve members of the organization who understand the task and environment in which the error was committed • Look for ways to improve or modify rules/procedures that are not followed well • Assure that the group developing corrective actions is a cross functional team including members of Engineering, Finance, Safety, etc. that explores systematic, not just local, fixes • Develop and disseminate a strong cost-benefit analysis utilizing cost data from all departments involved in the cross functional team • Track the effectiveness of the system based on lessons learned, number of tangible interventions, and/or the magnitude of risk/harm reduction • Celebrate system successes, improved metrics • Acknowledge and reward system users

In addition to providing recommendations to address each barrier, the questionnaire analysis exposed valuable information regarding the prevalence of each barrier to mechanics, managers and trait-specific groups. Mechanic and manager data exposed the top three perceived barriers to be safety culture, trust,

and policy and procedure definition. In many ways, these three barriers overlap. For example, improved training in voluntary reporting practices can improve safety culture, trust in the system, and understanding of policies and procedures. In reality, the operation of a truly effective voluntary reporting system requires the understanding that barriers to reporting participation may have distinct elements, but are closely related. Reducing the impact of each barrier is integral to the success of the system.

7.3.2. Engaging Less Experienced Managers

Based on the questionnaire analysis, newer managers cited reason 1 ("It's too much work to go through the reporting process") and reason 2 ("That's just how the job is always done – it works fine every day") more often than they cited any other reason. There was also a significant discrepancy between their use of reasons 1 and 2 and the use of these reasons by mechanics of the same experience level. These findings suggest that younger, less experienced managers may have initial, incorrect perceptions of mechanics' work habits and should be collaborating with with mechanics to better understand reporting practices and concerns. It may also be beneficial to pair newer managers with more experienced managers who are well versed in voluntary reporting to discuss error reports and recommendations for corrective actions. Thus newer managers will have the opportunity to observe veteran peers and, therefore, to better understand reporting practices and concerns. All managers should take the opportunity to visit the work areas of their subordinates to observe day-to-day operations and to

identify areas for improvement that would require management intervention (time limitations, resource allocation, staffing, etc.).

7.3.3. Improving Communication between Experienced Employees

Employees with more experience at an organization, and specifically managers who have witnessed a significant number of report-driven corrective actions, are most aware of barriers to voluntary reporting. Experienced managers (over the age of 60 and with at least 11 years of experience) used reason 5 ("It would make more sense to go straight to a supervisor or manager") and reason 6 ("The explanation of the event might lead to questions about others involved") far more than experienced mechanics. Alternatively, mechanics with over 20 years of experience cited reason 7 ("Nothing will get done about this type of incident – management won't care or think it's important") far more than managers of the same group.

Both of these findings attest to a discrepancy in perceptions of system use between experienced mechanics and managers. This indicates the importance of recurring training on the use of voluntary reporting systems for both mechanics and managers, not only to reinforce the importance of adhering to proper reporting practices, providing meaningful feedback to reporters, and utilizing recommended corrective action development, but also to elicit buy-in from older employees who may be unaware of the positive changes being made with regard to safety culture. It would also be beneficial to have a peer review process where mechanics and managers meet to share their experiences and concerns. Mechanics

could discuss their reservations regarding the use of voluntary reporting (along with any other concerns), to implement meaningful change while managers who are familiar with the system could provide success stories and lessons learned.

7.3.4. Employing Experienced Voluntary Reporting System Users and Overseers

Finally, with regard to experience using voluntary reporting, mechanics with little experience submitting reports cited hesitation reason 7 ("Nothing will get done about this type of incident – management won't care or think it's important") far more frequently than those with a considerable history of reporting, indicating that experience brings trust that management is using recommendations from this system to influence change. Managers with more voluntary reporting system experience were most likely to site reason 4 ("Admitting to this incident might result in disciplinary action"), indicating a heightened awareness of trust issues.

It would be beneficial for both groups of experienced voluntary reporting system users and overseers to meet and develop ways to spark communication between management and users, and among the user population. It might be beneficial to invite supervisors to oversee discussions by groups of users and communicate concerns to managers. Despite efforts made by management to be more visible, verbal communication among users can be the most effective way of instilling trust and promoting a belief in management commitment to the system. A reporting-based "suggestion and/or question box" or a "help desk" call-in center might be beneficial to new, inexperienced users. It would also be useful to

develop a mentoring program in which experienced system users/overseers would be available to answer questions about system use, policies, and benefits (either confidentially or anonymously).

7.3.5. Improving the Reporting of Routine Violations

The results of the questionnaire analysis show that routine violations are seen to be less reportable than honest mistakes. Scenarios A ("Skipping a step in a procedure that is often skipped"), D ("Failing to apply the exact final torque to a bolt using a proper torque wrench…"), H ("Handing off a job without the proper paperwork"), and J ("Walking away from a work area without finishing a job or handing it off to someone") all represent routine violations and were seen to be the least reportable by both mechanics and managers in this study. Depending on an employee's specific group and/or supervisor, these scenarios may be seen as non-reportable due to fear of disciplinary action, the common nature of the scenario, and/or the assumption that such practices will never change. It is important that these mindsets are challenged through voluntary reporting system implementation.

Improving the voluntary reporting of routine violations could be accomplished by describing such scenarios in a separate portion of training sessions so that their relevance to voluntary reporting is clear. An upstream solution for the elimination of these violations is the use of checklists detailing critical steps in a procedure that would require the signature of a co-signer (such as a supervisor). If routine violations are perceived to be a significant issue, it

may be useful to organize an ongoing focus group of mechanics to discuss the motivations behind routine violations. A group of peers may feel more comfortable discussing these issues together, as opposed to risking the embarrassment and threat of disciplinary action that many perceive to be associated with filing error reports.

7.4. Study Limitations

The study was originally intended to compare the perceptions of voluntary reporting practices held by mechanics and managers at five major airlines. Such a study would have minimized variations in participant responses resulting from unique corporate environments and varied policies governing the use and management of voluntary reporting systems. Comparing employees from the same organization would potentially limit the influence of external factors, allowing for a more accurate assessment of barrier impact within each company. Mechanic and management samples within the five aforementioned airlines were not of sufficient size to evaluate separately. This inability to compare organizations also limited the possibility of investigating if/how unique company policies can take precedence over the commonality of the reporting system itself, resulting in disparities of reporting participation and perceptions. Although sufficient for the chi-square analyses conducted, larger sample sizes would have been preferable given the vast discrepancies in overall responses. Although the average percentage of "yes", "no", and "possibly" responses were similar between mechanics and management, the high coefficient of variation of "scores" indicated a wide range of responses within each group.

Although it was necessary to directly compare mechanic and management questionnaire responses to determine significant discrepancies, it was impossible to phrase questions both uniformly and in a way that elicited the direct opinions of each group. Half of questionnaire participants were voluntary reporting system users and half were observers of this process. Personal reporting opinions were likely inherent in mechanic responses, while management responses were based on their observations of reporting practices. Though respondents were asked to indicate if the presented errors/violations *would* be reported at their organization, responses likely stemmed from a variety of personal interpretations of the question, as reflected in the high standard deviations for the two groups.

Mechanics may have responded based on (1) how they would report, (2) how they perceive those around them to report, or (3) how employees should report. The majority of mechanics' responses were likely rooted in (1), which would provide an accurate portrayal of reporting practices. Managers' responses likely aligned with (2). Mechanics have an inherently more accurate understanding of the events leading up to an error, while managers are naturally one level removed from the situation. Therefore, the scope of the study was limited to by the accuracy of managers' perceptions of actual reporting practices. It may have also been beneficial to elicit the personal opinions of management regarding whether or not a list of errors/violations *should* be reported. This would have provided a portrayal of management attitudes regarding human error, the benefit of voluntary reporting systems (or lack thereof), and understanding of their personal role in system use.

Finally, the impact of each barrier was estimated based on an inferred association between each reason for reporting hesitation and the influence of a particular barrier. Participants were not asked to comment on the existence of the previously defined barriers; rather their selections of reasons for reporting hesitation were translated into the relative magnitude of each barrier. Although this method resulted in similar rank ordering of barriers between both samples, barrier magnitudes, and therefore rankings, were not derived based on direct participant responses and could therefore not be compared using a statistical assessment.

7.5. Future Research

This study could be enhanced by several interesting opportunities for future research. Additional data collection targeting specific airlines over a longer period of time would allow for the assessment of mechanic-management agreement within organizations, as well as the comparison of airlines with unique organizational practices. As previously mentioned, it would also be beneficial to directly assess management attitudes toward voluntary reporting, rather than focusing solely on their observations of system use.

In the current study, experience using voluntary reporting systems was assessed somewhat differently for each sample. Mechanics indicated a quantity of personally submitted voluntary reports, and managers specified the number of report-driven corrective actions they had observed. A direct comparison of this data could not be made. Going forward, it would be useful to compare observed

corrective actions between mechanics and management in addition to questioning mechanics' personal reporting history. This would not only demonstrate the effects of publicizing report-driven corrective actions to the organization, but would expose existing gaps in the understanding of corrective action implementation between the two levels of hierarchy.

This study assessed the relative impact of barriers to success in voluntary reporting using a somewhat indirect technique. Rather than directly questioning participants about their awareness of each barrier that might hinder reporting participation, the relevance of each barrier was assessed based on perceptions of actual reporting practices. Although this method worked successfully and provided valuable insight into airline reporting practices, it also required some assumptions, specifically regarding the linkage between various day-to-day reasons for reporting hesitation and the underlying barriers they reflect. In the future, it would be valuable to request opinions directly related to barrier prevalence in addition to investigating reporting practices. This would expose the perceptions and biases of each group (mechanics and managers), as well as their possible blindness to the influences of underlying barriers.

Future implications of this work may also involve the development and testing of a training tool and/or process for both mechanics and managers designed to address the barriers to voluntary reporting. This tool/process could be used to instruct employees at several airlines and the resulting impact on voluntary reporting participation could be assessed. A unified training program for mechanics and managers would use interactive activities to expose existing

barriers, promote collaborative discussions and activities to understand each perspective, and provide a platform for mutually determining meaningful solutions to benefit both groups. In addition to an improved training tool, it might be interesting to test the influence of an online/call-in "help desk" that would allow system users to anonymously submit questions about system use and policies.

8. Summary and Conclusions

Each phase of information gathering increased support for the existence of reasons for reporting hesitation and their associated barriers to voluntary reporting. The questionnaire data further clarified the relevance of these barriers in an industry where the use of voluntary reporting is growing rapidly. The concept of transforming the culture of an organization to support open dialogue about human error has been discussed in literature for a number of years, but discussions with industry professionals indicate that such a transformation is still an elusive goal that will require significant effort. An increasing number of studies are being conducted to evaluate deficiencies in safety culture, especially in high-risk industries where regulatory agencies are stressing the use of voluntary reporting systems to fulfill safety management system requirements.

The barriers to voluntary reporting were first uncovered in a literature review and were later supported and further illuminated during interviews. The analysis of questionnaire responses provided a comparison between the two groups most involved in the use and success of voluntary reporting system

operation in aviation – airline mechanics and their management. It was determined that the two groups perceive general reporting practices similarly, but recognize justification for non-reporting by potential system users somewhat differently. Age, years with an organization, and years working in aviation affected managers' perceptions of reporting practices, while experience submitting voluntary reports influenced mechanics' views. Responses from both groups indicate the influence of each of the eight barriers, ranked in a similar order of importance. Safety culture, trust, and policy and procedure definition were determined to be the most disruptive barriers to successful voluntary reporting for both groups. Recommendations were provided to overcome each of the eight barriers, with additional suggestions related to subgroups with common traits.

It is important to continue the discussion about the inevitability of human error and the ongoing shift to a Just Culture of shared responsibility. The use of tools that seek to uncover latent organizational conditions that contribute to error may still be a new and potentially uncomfortable concept for some, but the value of these tools is undeniable, and their benefits extend to reducing the potential for fatal accidents. In high-risk industries such as aviation, rail, and medicine, there is often little (or no) room for error. Rather than blaming the individual for an outcome that could have been prevented, it is important to understand the upstream factors that can align to place an individual in a potentially hazardous situation. A Just Culture focuses on the role of the organization and the industry in encouraging an open dialogue about error and implementing stronger

safeguards against potential hazards. Voluntary reporting systems are vital to this effort, and their success will continue to grow as we seek to eliminate factors that inhibit participation and actively promote robust corrective action implementation.

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10. Appendix A: Interview Material

10.1. Introductory Message

Hi (name),

I'm Katherine Darveau. I'm in the Edison Engineering Development Program at GE Aviation and I'm working on my Masters in Human Factors at Tufts University. It was recommended to me by [GE Aviation employee] that I reach out to you to see if you would be willing to be interviewed for my thesis. Here is a bit of background on the scope of the project:

While working in the Human Factors group here at GE, I thought a lot about ways to strengthen safety management systems by better understanding the underlying causes of human error. I began investigating voluntary reporting and found that it can be an effective tool for error data collection and analysis. The purpose of my thesis is to identify barriers and facilitators to the implementation and successful use of voluntary reporting systems in order to define best practices. Aside from researching existing open reporting systems and techniques, I am exploring human error, macro ergonomics, corporate culture, and methods for achieving buy-in at various organizational levels.

Interview questions will focus on your current position/responsibilities and background, your understanding of and opinions of voluntary reporting, and any experiences you'd be willing to share where you've dealt with human error (either committed by you or another person). Finally, any insight that you can provide on potential obstacles or best practices for achieving buy-in and effecting lasting change would be of great value.

Would you be willing to speak with me for one hour sometime in the next few weeks? Any information you provide can be sanitized or credited as you desire. I appreciate you taking the time to consider helping me with my thesis, and I look forward to speaking with you!

Thanks for your help!

Katherine

10.2. Interview Discussion Questions

1. What is your current role and what are your responsibilities? (Or, if retired, most recent role and responsibilities)
2. Can you describe your professional background that lead to your current role?
3. What is your level of familiarity with voluntary/open reporting systems?

   Very familiar – somewhat familiar – neutral – somewhat unfamiliar – very unfamiliar
4. If person is familiar, ask them to elaborate on their experience to find out if they've ever used one or been part of one's implementation.
   - If so: What elements do you find useful/what difficulties do such systems pose as a method of error data collection?
   - If not: Can you think of how one might be used to make improvements to your group's work?
5. If person is unfamiliar, explain what they are, then ask - Do you think that these systems could be useful in reducing human error? Why or why not?
6. Are you familiar with the opinions of others within your organization toward open reporting?
   - For example, are there/have there been individuals championing an effort to implement such a system? Is/was there negative pushback?

(Now let's talk a little bit about human error.)

7. Would you be willing to share an example of when human error, either committed by you or another person, had a significant impact?
   - Do you think it could have been prevented? How?
   - Are you aware of any underlying causes that could have contributed to the error, or do you feel that it was it solely the responsibility of the person who committed it?
   - Do you think that others could have made the same mistake?
   - Do you think that an open reporting system could have helped to prevent this error or prevent it from occurring in the future?
8. *(If question 7 didn't reach the last part)* How do you think open reporting could help reduce error?

9. What aspects, if any, of open reporting with regard to error reduction concern you? (Such as having errors exposed/out in the open, methods for reporting errors, quality of the data obtained, etc.) How would you address these concerns if you were implementing a system?

10. Do you think that the implementation of an open reporting system would require a shift in organizational culture? What changes would have to be put in place in order for this to work?

11. What measures could be put in place to develop buy-in and effectively shift away from a culture of blame toward that of understanding and focus on corrective action?

12. What level(s) of the organization would give the most pushback and why?

    Those directly using the system (such as maintenance workers), their supervisors, middle management (such as a subsection or section manager), upper management (such as the VP of a division or higher)

For those directly involved in the development of an open reporting system:

1. What was the issue that prompted conversations about an open reporting system?

2. How did you determine that an open reporting system could be an effective solution?

3. What obstacles did you face and how did you address them?

4. How did you develop buy-in?

5. Did you find that a shift in culture was necessary?

6. Do you have any best practices that you could share?

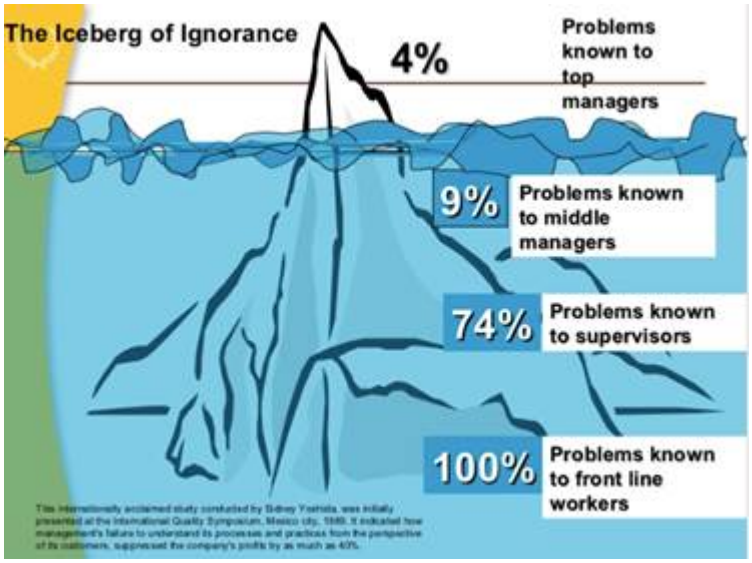
7. What is the number one responsibility each level (senior leadership, middle management, front line) to the successful implementation of an open reporting system?

11. Appendix B: Questionnaire Material

11.1. Introductory Message

Subject Line: Please take **5 minutes** to complete this survey

Body: Take a look at this visual below and if you can spare **5 minutes** of your time, help us as an industry to better understand how voluntary reporting can begin to address this problem.



Hi, my name is Katherine and I'm engineer at GE Aviation and a candidate for a Master's degree in Human Factors at Tufts University. I'm working on a thesis that explores differences in opinions and perceived use of voluntary reporting practices at several major airlines that utilize a similar system. Reponses to the following surveys will help provide valuable information on best practices for successful voluntary reporting that maximizes its benefit to an organization and its employees. Please choose the survey below that fits your job title.

Mechanic/Technician survey link:

https://tufts.qualtrics.com/SE/?SID=SV_6x6T69RkMwDJvA9

Manager survey link:

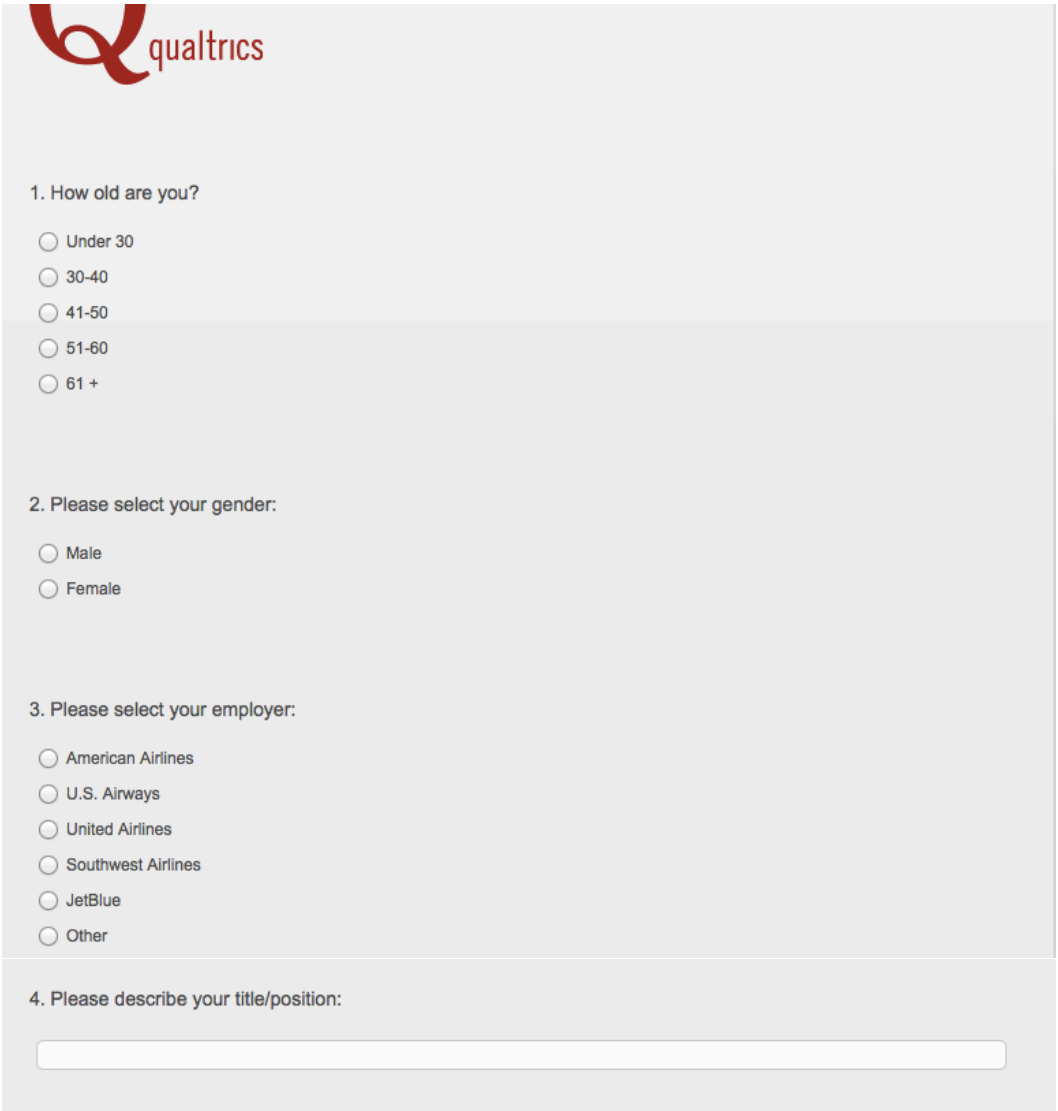
https://tufts.qualtrics.com/SE/?SID=SV_5i5oyQqRSqruyy1

This survey is voluntary and can be stopped at any time without consequence. Participants only need to answer questions that they feel comfortable answering and Katherine (the creator of the survey), GE Aviation,

and Tufts University will have no knowledge of the name or identity of any person who submits a response to this survey. It is completely anonymous and airline names will never be disclosed. The survey should take **less than 5 minutes**.

Please contact me if you have any questions:
katherine.darveau@ge.com
W: ###-###-####
C: ###-###-####

11.2. Questionnaire Distributed to Mechanics



5. How many years have you been with your current company?

- ◯ 0-5
- ◯ 6-10
- ◯ 11-20
- ◯ More than 20

6. How many years have you worked in the aviation industry?

- ◯ 0-10
- ◯ 11-20
- ◯ 21-30
- ◯ More than 30

7. What is your level of familiarity with the ASAP reporting system, or voluntary reporting in general?

- ◯ Very familiar
- ◯ Somewhat familiar
- ◯ Neutral
- ◯ Somewhat unfamiliar
- ◯ Very unfamiliar

8. How many ASAP or other types of voluntary reports have you submitted?

- ◯ 0-2
- ◯ 3-5
- ◯ 6-10
- ◯ More than 10

>>

9. Based on the voluntary reporting practices established at your organization as part of the corporate belief system, would the following events be reported? Choose either "Yes", "No", "Possibly" or "I'm unsure how or what to report"

	Yes	Possibly	No	I'm unsure how or what to report
9a. Skipping a step in a procedure that is commonly skipped	◯	◯	◯	◯

	Yes	Possibly	No	I'm unsure how or what to report
9b. Leaving a tool inside the engine	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9c. Observing someone breaking a rule that is a blatant disregard for safety	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9d. Failing to use a torque wrench to apply the exact required final torque (estimating it using a regular wrench)	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9e. Forgetting to complete the final step in a procedure	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9f. Installing the wrong part	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9g. Skipping a required final inspection and/or sign off	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9h. Handing off a job without the proper paperwork	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9i. Arriving at work under the influence of alcohol or a controlled substance	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9j. Walking away from a work area without finishing a job or handing it off to someone else	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9k. Failing to properly secure an access panel or cowling	○	○	○	○

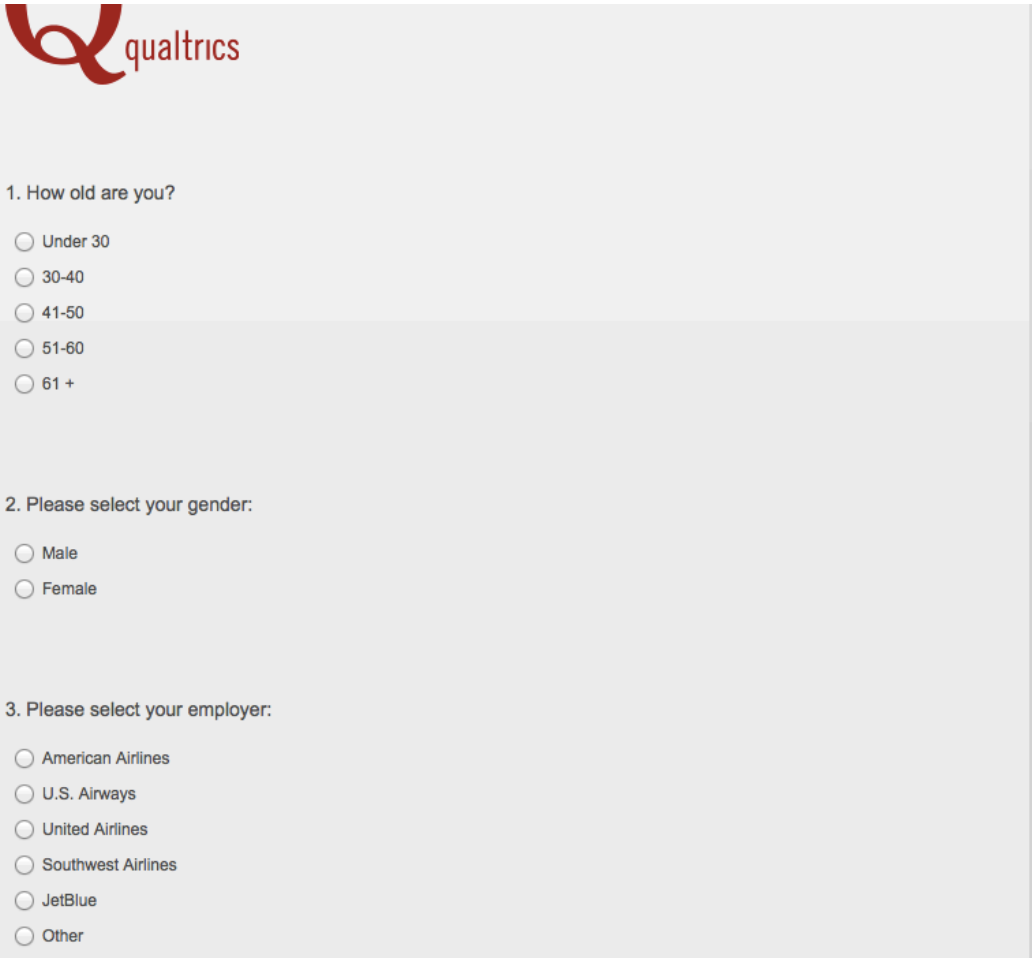
Upon selecting “possibly” or “no” for 9a through 9k, the following screen would appear:

Please provide a reason why you might hesitate to report this error (select all that apply):

- [ ] It's too much work to go through the reporting process
- [ ] That's how the job is always done - it works fine every day
- [ ] This type of incident wasn't serious enough to cause an issue down the road
- [ ] Admitting to this incident might result in disciplinary action
- [ ] It would make more sense to go straight to a supervisor or manager
- [ ] The explanation of the event might lead to questions about others involved
- [ ] Nothing will get done about this type of incident - management won't care or think it's important
- [ ] I don't think lasting change will result from reporting this

10. Please provide comments about the voluntary reporting system at your organization (what works well, what could be improved, personal experiences with the system, etc.)

11.3. Questionnaire Distributed to Managers



4. Please describe your title/position:

5. How many years have you been with your current company?

- ◯ 0-5
- ◯ 6-10
- ◯ 11-20
- ◯ More than 20

6. How many years have you worked in the aviation industry?

- ◯ 0-10
- ◯ 11-20
- ◯ 21-30
- ◯ More than 30

7. What is your level of familiarity with the ASAP reporting system, or voluntary reporting in general?

- ◯ Very familiar
- ◯ Somewhat familiar
- ◯ Neutral
- ◯ Somewhat unfamiliar
- ◯ Very unfamiliar

8. How many ASAP or other types of voluntary reports have you seen lead to corrective actions?

- ◯ 0-5
- ◯ 6-10
- ◯ 11-20
- ◯ More than 20

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9. Based on the voluntary reporting practices established at your organization as part of the corporate belief system, would the following events be reported? Choose either "Yes", "No", "Possibly" or "I'm unsure how or what to report"

	Yes	Possibly	No	I'm unsure how or what to report
9a. Skipping a step in a procedure that is commonly skipped	◯	◯	◯	◯

	Yes	Possibly	No	I'm unsure how or what to report
9b. Leaving a tool inside the engine	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9c. Observing someone breaking a rule that is a blatant disregard for safety	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9d. Failing to use a torque wrench to apply the exact required final torque (estimating it using a regular wrench)	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9e. Forgetting to complete the final step in a procedure	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9f. Installing the wrong part	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9g. Skipping a required final inspection and/or sign off	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9h. Handing off a job without the proper paperwork	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9i. Arriving at work under the influence of alcohol or a controlled substance	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9j. Walking away from a work area without finishing a job or handing it off to someone else	○	○	○	○

	Yes	Possibly	No	I'm unsure how or what to report
9k. Failing to properly secure an access panel or cowling	○	○	○	○

Upon selecting “possibly” or “no” for 9a through 9k, the following screen would appear:

Please provide a reason why you might hesitate to report this error (select all that apply):

- [ ] It's too much work to go through the reporting process
- [ ] That's how the job is always done - it works fine every day
- [ ] This type of incident wasn't serious enough to cause an issue down the road
- [ ] Admitting to this incident might result in disciplinary action
- [ ] It would make more sense to go straight to a supervisor or manager
- [ ] The explanation of the event might lead to questions about others involved
- [ ] Nothing will get done about this type of incident - management won't care or think it's important
- [ ] I don't think lasting change will result from reporting this

10. Please provide comments about the voluntary reporting system at your organization (what works well, what could be improved, personal experiences with the system, etc.)