11-21-2008

How Organizational Arrangements Affect High Reliability in Public Research Universities: Perceptions of environmental Health and Safety Directors

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HOW ORGANIZATIONAL ARRANGEMENTS AFFECT HIGH RELIABILITY IN PUBLIC RESEARCH UNIVERSITIES: PERCEPTIONS OF ENVIRONMENTAL HEALTH AND SAFETY DIRECTORS

by

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A dissertation submitted in partial fulfillment of the
requirements for the degree of

DOCTOR OF PHILOSOPHY
in
PUBLIC ADMINISTRATION AND POLICY

Portland State University

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DISSERTATION APPROVAL

The abstract and dissertation of Rita Finn Sumner for the Doctor of Philosophy in Public Administration and Policy were presented November 21, 2008, and accepted by the dissertation committee and the doctoral program.

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ABSTRACT

An abstract of the dissertation of Rita Finn Sumner for the Doctor of Philosophy in Public Administration and Policy presented November 21, 2008.

Title: How Organizational Arrangements Affect High Reliability in Public Research Universities: Perceptions of Environmental Health and Safety Directors

The American research university is composed of two related but relatively independent structures. The academic core composed of faculty guilds, has the primary responsibility for academic content and quality. The administrative shell is responsible for mobilizing and distributing resources that support the work of the guilds and it protects guilds from harmful external forces. Part of the complex relationship between the academic core and the administrative shell is enabling the creation of internal quality through arranging institutional conditions to prepare resources to better manage risk. The need for research universities to develop infrastructures regarding environmental health and safety (EHS) to inform decision-making in regard to managing resource risk has been reported.

High Reliability Organization (HRO) theory has emerged out of the study of complex, tightly coupled, high-risk organizations that operate under difficult conditions with very low rates of accidents. There are five organizational characteristics consistently observed across the high-risk sectors studied. This descriptive research extends the application of HRO theory to public research

universities in order to determine organizational arrangements that affect university performance based on the five HRO characteristics.

Data collection instruments included 1) a web-based survey sent to 165 EHS directors at U.S. public research universities, and 2) a Website Review Protocol to collect institutional website information from a subset of survey respondents. The dimensions of data collected included organizational relationships, safety governance, HRO capacity, and safety message framing.

The research was guided by five sub-problem tasks. The final task included the analysis of select nominal scale variables from the findings of previous sub-problem tasks and other survey data using Ragin's (2006) Qualitative Comparative Analysis software to determine the presence or absence of each variable under conditions of either presence or absence of high reliability.

The findings suggest that the presence of certain organizational arrangements can be linked to either high or low HRO performance in universities. Conclusions are drawn that the application of HRO theory to universities demonstrates utility for examining these complex institutions and assessing various social structures and social actions as predictors of high reliability.

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CHAPTER I. INTRODUCTION

Introduction to the Problem

The American research university prototype, as described by Lombardi (2001), is composed of two related but relatively independent structures. The academic core, composed of faculty "guilds," has the primary responsibility for academic content and quality. The administrative shell is responsible for mobilizing and distributing resources that support the work of the guilds; it protects the guilds from harmful external forces. According to Lombardi et al. (2001), the "primary focus of a research university is on the creation of internal quality" (p.7). Part of the complex relationship between the academic core and the administrative shell is enabling the creation of internal quality through arranging institutional conditions to prepare resources to better manage risk and crisis (Lauwerys, 2002; Weick & Sutcliffe, 2001; Mitroff, Diamond, & Alpaslan, 2006). According to a report published by RAND Corporation (Goldman & Williams, 2000) research universities must commit a significant investment to the development of an infrastructure for environmental health and safety that informs organizational decision-making to better manage risk and crisis (Veltri, 1990).

Universities have reported negative consequences linked to gaps in managing risk-related decision-making within the scope of the environmental health and safety function. Some specific incidents include a scientist's painful death from a chemical exposure (Byard et al., 1998); an Environmental Protection Agency (EPA) fine in excess of $1 million dollars (United States Environmental Protection Agency, 2000);

student fatalities and injuries in a dormitory fire (Smothers, 2006); and a laboratory-acquired high mortality disease (Barry, 2005). Each of these incidents was not just an isolated event but is symptomatic of deeper systemic flaws within each institution (Dekker, 2002).

Over time public universities have evolved a diversity of strategies, structures, and social dynamics in developing decision-making processes influenced by policy, politics, risk, and contexts with varying degrees of success. The safety function has become a recognized organizational feature with the role of managing many aspects of organizational risk and maintaining and enhancing regulatory compliance and professional best practices. The safety function has garnered the role of designing and shaping the development of environmental health and safety policy within an organization. This process includes interpretation of external information, the synthesis of information adapted to the university, and the negotiation of information through social systems (Hill & Hupe, 2003).

One research trajectory that has examined organizations successful in managing risk under challenging conditions has focused on organizational reliability. Organizational reliability has emerged out of research on high reliability organizations (HROs). The progenitors of HRO theory, Todd LaPort (1996), Karlene Roberts (1990), and Gene Rochlin (1996), examined organizations across high-risk sectors including air traffic control, electric utility grid management and U.S. Navy aircraft carriers (Clarke & Short, 1993). The observations and careful study of these large-scale systems, including infrastructure and social processes, were selected because

they were able to operate under very trying conditions and yet experience very few accidents even though they encountered a large number of unexpected events.

The observations of HROs have led to the development and aggregation of common characteristics as found in these high-risk and high-performing entities. The application of HRO theory and characteristics has expanded over time to encompass other technical and industrial activities in order both to reduce the incidence of error or failure and to improve organizational reliability or effectiveness (Creed, Stout, & Roberts, 1993). The testing of the usefulness of HRO theory in a broader range of settings and in less reliable organizations has been advocated by several HRO researchers (Barrett, Novak, Venette, & Shumate, 2006; Mannarelli, Roberts, & Bea, 1996).

Public universities have been described as complex, loosely coupled systems[1] (Weick, 1976; Orton & Weick, 1990). These structural features present challenges when responding to external policy and performance requirements, addressing vulnerabilities, and reacting to unanticipated events that engage the subsystem of safety-related decision processes or the safety subsystem[2]. The role of the safety function, a part of the safety subsystem, is to influence decision-making and operating action capabilities through a well-designed process. However, the attempt to influence decision-making through a particular process understates the complexity of the action. The challenge on a deeper level is in understanding the existing social context of a

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[1] Coupling refers to the interdependency of elements that vary in number and strength, e.g., tight and loose coupling. A system is used to refer to the university composed of loosely coupled elements or subsystems.

[2] Safety subsystem refers to the minimum infrastructure composed of the Environmental Health and Safety (EHS) function; safety governance structures; and safety networks.

university in which action by the safety function must take place (Weick, 1976; Weick & Sutcliffe, 2001).

James Short and Lee Clarke (1992) generated interest in understanding the organizational and institutional context of risk because hazards and risks are conceptualized, identified, measured and managed within those entities (Roberts, 2003). Short and Clarke (1992) have focused on risk-related decisions, which, as they have stated, are "often embedded in organizational and institutional self-interest, messy inter- and intra-organizational relationships, economically and politically motivated rationalization, personal experience, and rule of thumb considerations that defy the neat, technically sophisticated, and ideologically neutral portrayal of risk analysis as solely a scientific enterprise (p.8)." The authors' passage suggests the need to disentangle decision-making processes regarding risk within the organizational complexity of the structural and social context. Further, it provides the impetus to understand the safety-related infrastructure embedded within the complex social dynamics of universities from the perspective of an individual purportedly holding a critical lens for examining the larger institutional system.

Statement of the Problem

The problem that is the focus of this research concerns the unexamined organizational arrangements in public research universities that affect high reliability capacity. High reliability capacity is positioned as a master construct intended to aid in understanding risk-related decision processes regarding safety, health, and environmental aspects. Also considered is the effect on reliability of the Carnegie

classification system for public research universities that has constructed groupings based on level of research activity. The classifications in descending order of total research dollars include Very High Research (VHR), High Research (HR), and Research (R) (Carnegie Foundation, 2007).

Limitations of the Study

Subsequent to its intellectual genesis, high reliability organization theory has been extended beyond the initial high-risk organizational systems to other organizational types, generally, to enhance error-free decision-making through the development of an interactive management dynamic and enlarging self-awareness of vulnerabilities (Rochlin, 1993). These extensions have included: commercial aviation (Foushee & Lauber, 1993), maritime operations (Roberts & Moore, 1993), financial institutions and commercial banks (Libuser, 1994), health care services (Resar, 2006), patient safety in health care (Henriksen & Dayton, 2006), faculty trust and school mindfulness in middle school settings (Hoy, Gage III, & Tarter, 2006), USDA Plant Protection and Quarantine border inspection teams (Venette, 2003), and a Midwest fire department (Barrett, Novak, Venette, & Shumate, 2006). However, the infrastructure and processes that develop in response to risk and adversities in universities has not been explicated. Nor has the research literature on universities as organizations, as yet, encouraged the high reliability organization theory as a potential research trajectory. The current research project will extend the application of HRO theory to universities.

Universities offer complex, dynamic environments within which risk-mitigating decision-making takes place to varying degrees across each institution. The literature examining safety within universities is sparse. One dissertation examining the implementation of an Environmental Management System in a university was discovered (Lee, 2003). One thesis examining congruency and integration of a safety management system in a university undergoing organizational change was reviewed (Sumner, 1997). However, specific research regarding the interaction of the safety subsystem within the larger institutional system was not discovered.

The recent research examining organizational response to managing risk and creating a safe work environment has cut across a variety of institutional sectors including offshore oil and gas industry (Mearns, et al., 1999), airport ground handling (Diaz & Cabrera, 1997), British Rail system (Clarke, 1999), nuclear power (Lee, 1998) manufacturing (Zohar, 1980), and Australian manufacturing and mining (Griffin & Neal, 2000) among others. Following the Chernobyl disaster, much of the research effort has targeted increased understanding of safety culture and safety climate within organizations. These studies have illuminated and highlighted the needed shift in the use of leading indicators rather than the traditional lagging indicators of safety, such as accidents as "they offer insight into the state of safety without the need for retrospective analyses of negative safety outcomes" (Yule, 2003; p.2). Basic assumptions of the culture/climate literature, as explicated by Zohar and Luria (2003), suggest that top managers at the organizational level create policies and procedures that are subsequently implemented by unit managers. The research emphasis has not directly touched on the critical role of the safety function or the development of the

infrastructure of a safety subsystem or safety management system (Cooper, 2000). Scheirer (1981) has been critical of attempts to evaluate the outcomes of programs when the facets, infrastructure, and processes are presumptive. This research will attempt to explicate these assumptions in public universities.

To move beyond the identified limitations, this research will examine the organizational context of universities to explore structures and processes that may affect safety decision-making across social subsystems. The primary lens for data collection will be the acquisition of observations from the university director of the safety function. Counter-balancing the single-respondent perspective will be a review of university websites of a sub-set of institutions to gather and analyze projected, written information regarding risk and safety management. The analyses of these data sources will be punctuated with the aggregation of similar characteristics discovered into a series of university system archetypes. This evidence-based research will explore the uncharted nexus of safety infrastructure relationships with the larger organizational system and the interface with the organizational alignment of universities to characteristics representing high reliability organizations. The findings are expected to provide a launching platform for future research through the explication of context within universities, i.e., social systems, social structures, and safety infrastructure in terms of reliability-enhancing criteria.

Purpose Statement

The purpose of this research project is to provide both insight and illumination of ideas for a variety of target audiences, and contribute to the research literature

across several disciplines. Directors of the safety functions in education and especially universities will find this helpful in understanding the organizational context in which they practice as well as ideas for self-analysis of the safety function within their unique institution. Higher education administrators may find the study worthwhile in terms of seeing the value of investment in the health and safety infrastructure both as part of a larger risk and crisis management portfolio for their institutions (Mitroff et al., 2006) as well as the capacity-building skill of resource-sustaining decision-making (Veltri, 1990). Students of organizational theory may discover interesting facets of deconstructing public institutions of higher education. HRO theorists may discover opportunity for critique.

In regard to the literature, high reliability organization theory is the primary model or framework to pursue the research problem that has emerged for this project. In addition, the use of an analytical framework embracing a cross-discipline synthesis is expected to provide insightful vistas to those interested in organizational context and their subsystems. Several researchers favor an interdisciplinary approach, i.e., crossing traditional disciplinary boundaries in order to fully explore the multiple dimensions present in research (Shrivastava, 1994; Veltri, 1994; Hill & Hupe, 2003). Further, Scott (2004; p.14) describes a scholarly movement in social psychology "toward integration and intellectual inclusiveness." Rather than viewing organizations or systems through alternate lenses, the value of "treating them as complementary—each being necessary to a more adequate understanding of the complex organizational realm" is encouraged. The attempt to understand patterns within complex organizational environments has been described in terms of needing "kaleidoscopic

sensitivity" (Weick, 1998; p.75) to render clearly the multiple patterns that may have the potential for adversity. Therefore, this research project will embrace and extend a broad literature landscape to address the problem breaking with tradition. The substantive areas of public administration, occupational safety, social psychology, program implementation, HRO theory, disaster and crisis studies, and organizational theory and change offer a unique opportunity for the development of a synthetic framework for this research.

Over the last decade, there has been an increased interest in trying to understand the relationship between management practices and other organizational factors in regard to the decisions relative to occupational/environmental health and safety (DeJoy et al., 2004). Several approaches have been pursued. Safety climate is discussed in the organizational psychology literature--the study of attitudes and perceptions of employees regarding the importance of safety in their organization (Zohar, 1980; Dedobbeleer & Beland, 1991; and DeJoy et al., 2004); and safety culture--the study of the deeper and less readily accessible core values and assumptions of the organization regarding safety (Mearns & Flin, 1999). From the safety and crisis management literature executive accountability and administration of the safety function have emerged including important models for safety directors in communicating the justification for supporting the investment in safety to business executives (Veltri, 1991). The literature on high reliability organizations and the somewhat antithethetical normal accident theory provide an organization backdrop and complementary systems safety theory in the study of organizational response to crisis and organizational phenomena associated with causes of failure (LaPorte, 1996;

Perrow, 1999; Shrivastava, 1995). These disciplinary areas provide complementary guiding elements within contemporary safety theory. However, because of the emerging prominence of HRO theory as an analytical tool for examining complex organizations and their capacity to effectively deal with unexpected events, a reliability frame is expected to provide a promising perspective especially in pursuing a novel and untested application in university systems in regard to risk-related decision making.

The implementation and public administration literature provide a rich evolution of perspectives for inclusion. Organizational, political, and social context within which a policy is implemented profoundly affects its chances for success (Berman, 1980). The complexity of implementation and organizational crisis beg the use of context and multi-level perspectives in the analysis (Scheirer, 1981; Hill & Hupe, 2003). Both vertical and horizontal dimensions have been attended to in implementation research and assist in the examination of context (Hill & Hupe, 2003). Scheirer (1981) captures these dimensions as she advocates for viewing the implementing organization as an integrated social system with multiple levels and interactive processes all of which need to be incorporated for complete process understanding. Grabowski and Roberts (1996) echo this research sentiment as they endeavor to identify interfaces and interactions in organizational systems to study human and organizational error. To understand decision-making in higher education, knowledge of formal and informal governance structures, relationships, and processes are critical.

Methodology

The central constructs of this investigation include the use of high reliability organization theory to understand the risk decision-making capacity of universities and systems theory to launch a framework for exploring the safety subsystem within a larger university system.

The research question for this project may be stated as:

What are the organizational arrangements that affect high reliability in U.S. public research universities as perceived by the EHS directors?

To address the problem for this project there are 5 sub-problem tasks to solve. The sub-problem tasks may be stated as follows:

1. Determine the degree of high reliability organization capacity present in public research universities.
2. Determine the degree of coupling capacity present in public research universities.
3. Determine the degree of safety governance capacity present in public research universities.
4. Examine the content and construction of information on university websites relevant to the management of risk.
5. Characterize organizational arrangements of public research universities in terms of HRO capacity.

The focus of this study is on organizational arrangements and actions present in public universities that both affect the operationalization of safety policy and prepare decision-makers to effectively mitigate risk and control crises. Two broad

conceptual examination strategies as reported in Hill and Hupe (2003) include vertical and intra-organizational relationships. The study of vertical links, also referred to as vertical public administration, suggests that there is merit to examining the context or layers of an organization or system to understand how it operates. Public universities are generally embedded in university systems or boards placing an additional level of formal hierarchy above each executive level. The administrative arrangement and oversight between systems and individual universities varies from state to state. Regional accrediting agencies and other external regulatory agencies (such as, OSHA, EPA, and others) add both voluntary and mandatory compliance directives for which university executives are accountable.

Intra-organizational dynamics within and between the various social entities add to the complexity of the university environment. This arrangement may complicate communication and the introduction of change or innovation, such as the creation of an ad hoc governance body to address an emerging health and safety issue. Consequently, the burden has been on universities (and/or university systems) to develop organizational strategies and structures to accommodate the added weight from the environment and internalize safety as an operational imperative in consideration of internal social and political conditions (Rochlin, 1993).

The study methodology to answer the question needs to possess the capacity to examine both the vertical and horizontal aspects of organizational conditions and processes in universities in terms of high reliability and the interface with the subsystem of safety. In addition, the *n* or number of cases needs to be large enough so

that trends as well as common and unique arrangements can be identified for further study. These are some of the challenges identified at the outset of this project.

Contents of the Dissertation

The dissertation consists of five chapters. Chapter I provided an introduction to the problem, research question, and evidence of deficiencies in the literature arguing the importance of the current research project. Chapter II reviews and weaves the literature across a broad spectrum of both theoretical and pragmatic space including systems theory, safety theory, high reliability organization theory, and the organization of public higher education to demonstrate the importance of the research question. It also shares the characterization of operational definitions used in this research. Chapter III describes the limitation of standard unitary methodologies and builds a case for using mixed method in this study. Further, Chapter III focuses upon the development of the mixed methods approach to examine the core constructs and their dynamics across 165 public universities. Chapter IV reports and interprets the findings from data from the two sources, survey and website review. In addition, Chapter IV derives a series of university archetypes using Qualitative Comparative Analysis software (Ragin, 2006). Chapter V discusses the significance, implications, and assumptions of the findings. Further, Chapter V recommends future research to continue the path to greater breadth and depth of understanding of the complexities of the social context of universities in terms of reliability criteria and the management of risk.

CHAPTER II. REVIEW OF THE LITERATURE

Introduction

Chapter II further explicates the sub-problem tasks as introduced in Chapter I. The chapter begins with a discussion of high reliability organization theory. Next, universities as complex organizations are elaborated. Third, an overview of safety theory is discussed. This includes both historical information and more current theoretical debates. Finally, the research question articulated in Chapter I is parsed into its elemental sub-questions that will drive the construction of the methods section in Chapter III.

High Reliability Organizations

A pressing concern for colleges and universities is anticipating unexpected events and preparing a resilient infrastructure if an accident or catastrophe does occur (Mitroff, et al., 2006). As noted in Chapter I, universities have faced serious, resource draining failures. These ongoing and unexpected challenges will continue into the future as suggested by Perrow (1999; p.356) in his manuscript describing normal accidents. Universities will continue to perform as global leaders in research and teaching activities embracing high-risk technologies and enlarging operational supporting subsystems with their own inherent risks. Maintaining a consistent forward path to success in setting and achieving goals is challenging for each institutional subsystem affected by adversities as well as the university as a whole. As introduced

in Chapter I, several researchers advocate for extending the application of High Reliability Organization theory to new

sets of organization types (Barrett, Novak, Venette, & Shumate, 2006; Mannarelli, Roberts, & Bea, 1996). This research intends to meet that challenge by extending the application of HRO theory to the examination of public research universities.

Weick and Sutcliffe (2001) have synthesized a template of characteristics reflecting research findings on a variety of both technologically and socially complex systems that have been successful in reducing adversities. Weick and Sutcliffe (2001) characterize their hallmark model as collectively contributing to organizational mindfulness (p.3). The authors describe organizational mindfulness as

> "... striving to maintain an underlying style of mental functioning that is distinguished by continuous updating and deepening of increasingly plausible interpretations of what the context is, what problems define it, and what remedies it contains. The key differences between HROs and other organizations is managing the unexpected often occurs in the earliest stages, when the unexpected may give off only weak signals of trouble...Mindfulness preserves the capability to see significant meaning of weak signals and give strong responses to weak signals."

There are five characteristics that describe these high performing and mindful organizations (Weick & Sutcliffe, 2001). First, organizations exhibiting vigilance in both searching for any lapse, error or potential adverse event as well as responding with immediacy to correct or change a process, as needed are said to be preoccupied with failure. Second, organizations that maintain the integrity of their own complexity in self-examination with an eye toward nuanced and diverse explanations exhibit a trait described as reluctance to simplify. Third, the continuous system-wide self-examination for loopholes and weaknesses to detect deficiencies during normal

operating times as well as critical and timely self-reflection following an event demonstrates the HRO characteristic of sensitivity to operations. Fourth, organizations that are well prepared for the unplanned and unknowable event have developed capabilities to detect, contain, and bounce back from those errors are described as committed to resilience. Finally, high reliability organizations cultivate diversity of resources to aid in detecting and reporting weakness or errors and empowering individuals with specialized knowledge to intervene. This characteristic is referred to as deference to expertise.

Complex Public Organizations and High Reliability

Public universities present unique organization contexts. The organizational contexts include: 1) the relationship complexity between the academic core and administrative shell; 2) the tension between formal (top down) and informal (horizontal) governance structures; 3) very complex structures and social processes; 4) overall, very loose coupling; and 5) a safety subsystem and infrastructure designed to facilitate the management of risk. To understand the complex social processes of organizations, many researchers advocate for the examination of organizations as systems (Grabowski & Roberts, 1996; Scheirer, 1990; Scott, 1998). This sentiment is expressed by HRO researchers Grabowski and Roberts (1996; p.2) in "Human and Organizational Error in Large Scale Systems" in which the authors develop supporting arguments for their thesis that "we cannot fully understand the complex social processes that underlie either the reliable or unreliable operations of complex social and technical systems without examining such systems in their totality." Further,

Mannarelli, Roberts, and Bea (1996) advocate for extending research on organizational reliability to "less extreme organizations" (p.84) with unique and complex environments, such as universities.

Deconstructing the Complexity of Organizational Landscapes

Social theorists have set forth two ways of looking at human action in organizations, i.e., social system and social action (Conrad & Haynes, 2001). Social system focuses on structural configurations and is concerned with maintaining order while social action focuses on subjective experience and creative action. The social system perspective contains discussions of systems theory, coupling, and networks. The social action or actionist cluster includes culture, problem framing (Conrad & Haynes, 2001) as well as power (Mechanic, 1962; Salancik & Pfeffer, 1977). Several bridging or integrative constructs have evolved regarding the structure—action dialectic, however, theoretical depth to explore these is beyond the scope of this project[1]. The social system and social action clusters will provide a framework from which to examine the subsystem of environmental health and safety information movement within a unique public institutional system set.

General Systems and Open Systems Theory—Social System Cluster

To move towards the study of complex processes and complex environments in the management of risk in public universities, a discussion of general systems

[1] See Conrad and Haynes (2001) for a discussion on structuration; unobtrusive control and identification; and critical theory.

theory and the open systems classification is elucidated. A system is a set of interrelated elements where the whole is more than the sum total of the parts of the system. The two basic parts of a system are elements and interrelationships. A subsystem is any identifiable component of a larger system that is made up of its own interrelated elements (Scott, 1998). Perrow (1999) further divides systems into "four levels of increasing aggregation: units, parts, subsystems, and system" (p.70). In the organization set under study, the university is a system composed of departments, functions and various other subsystems such as financial, human resources, maintenance, purchasing, and academic guilds including components directly relevant to this research, such as ehs[2] and governance.

Many universities are embedded in larger systems of higher education. For the purpose of this research, these are termed supra-systems (Scott, 1998). Supra-systems may even be extended to broader contextual phenomena, such as the financial investment in higher education resources decided by state legislatures and the public's perception of accountability in higher education. The system arrangement creates linkages across system levels and confounds the attempt to erect clear boundaries (Scott, 1998; p.89). Therefore, understanding a system, its subsystems, parts, and units as well as the larger context (supra-system) is considered critical in examining system reliability as described in Weick and Sutcliffe (2001).

Scott (1998) characterizes open systems theory as a sub-set of classification within general systems theory. In open systems theory, a system is capable of self-

[2] Lower case ehs is used to differentiate between the sub-system and the functional entity; the functional entity is referred to as EHS or safety function--a part of a safety subsystem.

maintenance on the basis of a throughput of resources, information, etc. from the environment and necessary for system vitality (Scott, 1998). Entropy, a term borrowed from the 2nd Law of Thermodynamics, is energy that cannot be turned into work, thus, these systems evolve into chaos. According to Scott (1998) the opposite of entropy is negative entropy or negentropy. These systems evolve toward an increase of order and complexity. Systems able to maintain a negentropic state have continuous throughput of information from the environment. A somewhat divergent view is expressed by Berniker and Wolf (1999) who argue that while living systems may feed on negentropy or order, organizations feed on information. The authors view information as a parallel concept to energy. The authors state that:

> "[n]egentropy or order and entropy are understood as physical phenomena that can be measured and observed in the universe. Information exists in symbolic media and represents mental phenomena. Information is the discovery and appreciation of order and pattern in the universe. The informational counterpart to entropy is noise which can be understood as ambiguity and equivocality in information. Noise may be a product of information itself or a result of the channels through which information is communicated."

They further argue that organizations can become too complex to remain effective in their attempt to respond to increasing complexity. A further challenge to Scott's (1998) open systems theory is from Orton and Weick (1990) who argue for a dialectic approach using both open and closed systems to study the concept of coupling discussed later in Chapter II.

For this research, the subsystem of safety (and its parts) within the university--a system--is examined using open systems theory. The safety function, a part of a subsystem of the university, provides the main organizational interface with the external environment selecting and synthetically arranging the incoming information

received to improve the order and, subsequently, the complexity of the subsystem of safety and risk management. Berniker and Wolf (1999) argue that to improve order the transfer of knowledge must be at a level sustained and undiluted above the surrounding organizational noise. The ideal arrangement of conditions is to enable filtering organizational noise to better facilitate information diffusion and sensemaking in universities regarding the management of risk and development of high reliability (Weick, 2001).

An important feature of open systems thinking is that of equifinality (Scott, 1998; Bertalannfy, 1968). The concept implies that there are more ways than one of producing a given outcome. Stated another way, it implies the availability of multiple paths to either a production or organizational goal and the availability of slack resources[3] (Berniker & Wolf, 1999; Scott, 1998). The general principle is that there does not have to be a single method for achieving an objective (Katz & Kahn, 1966). This principle is congruent with other unique institutional factors in universities such as subsystems of governance, culture, and others. This research assumes that there is no one menu of factors for developing characteristics of high reliability, but rather unique organizational arrangements within each system that provide facets of both facilitation and barriers to the process (Scott, 1998). However, there may be factors that are present associated with more successful characteristic development. These are all facets to be explicated through the present project. However, as Perrow (1999)

[3] Slack resources are unused resources during normal operation producing ease in a system. However, as demand increases additional resources are needed and slack is reduced placing increased strain on the system (Scott, 1998).

points out, in tightly coupled systems the concept of unifinality (p.94) with little slack and a single means to an end must be considered as potentially problematic.

Safety Subsystems in University Systems

As previously stated, for the purpose of this project the safety subsystem in universities includes the safety function, safety governance entities, and safety network(s) embedded in a larger university system along with its state level supra-system, if applicable.

The organization of safety-related programs in university environments reflects a variety of arrangements. Some universities have maintained an aggregated safety function while others have disaggregated safety-related programs. Some combining functions include risk management, human resources, business operations, and facilities. Some university EHS directors report directly to the second level of administration while others may be positioned three or more levels below the president (or chancellor).

Shrivastava (1994) observed that crisis preparation as well as response requires a cross-functional effort. The coordination and integration of this effort presents particularly challenging circumstances in loosely coupled organizations such as universities (Weick, 1976). With the emergence of sustainability initiatives and ISO standards in universities and industry, one current trend includes the inclusion of occupational health and safety into a larger environmental management system (Lee, 2003; Labodová, 2004) or embedded in sustainable development (Shrivastava, 1994). Because of the diversity of possibilities, it is incumbent on the agent of the safety

function to understand the technical, political, and cultural landscape of the parent organization in order to navigate the organizational topography (Mechanic, 1962; Tichy & Ulrich, 1984).

The safety function serves as the environmental sensing unit to locate external policy, guidelines, and best practices; synthesize, frame and contextualize information; and, subsequently, navigate, coordinate and negotiate information within a university system to enable improved decision-making to manage risk to institutional resources and contribute to organizational reliability. The following are common (but not exhaustive) external information sources used by the safety function.

The External Landscape of Universities Relevant to Safety Subsystems

Occupational Safety and Health Administration - OSHA

The harmful effects of an unhealthy workplace environment were known as early as the time of Hippocrates. In 1713 Bernardino Ramazzini, referred to as "the father of occupational safety and health," carefully documented the perils of unhealthful workplaces (Rothstein, 1983; p.1). In the United States, the first Congressional reports on industrial accidents and illnesses were prepared and submitted in 1837. At the federal level progress was slow in developing preventive legislation. The ensuing labor movement provided some impetus. Individual states took on the early efforts of relieving the hardship of industrial accidents from individual workers and their families (Rothstein, 1983).

Finally, on December 29, 1970, President Richard M. Nixon signed the Occupational Safety and Health Act. The Occupational Health and Safety

Administration (OSHA) mission as stated in section 2(b) of the OSH Act is "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources" (Rothstein, 1983; p.5). In addition, the stated role of the new agency for accomplishing its mission is by setting and enforcing standards, and providing training, outreach, and education. More recently, under political pressure, OSHA has shifted emphasis to establishing partnerships and encouraging continual improvement in workplace safety and health (United States Department of Labor OSHA, 2006).

Section 18 of the Occupational Safety and Health Act of 1970 encourages individual states to develop and operate their own job safety and health programs. OSHA approves and monitors state plans and provides up to 50% of an approved plan's operating costs. There are currently 22 states and jurisdictions operating complete state plans (covering both the private sector and state and local government employees) and four that cover public employees only. State plans must adopt workplace rules that are at least as strict as the federal rules. Federal OSHA allows state OSHA agencies to promulgate additional rules based on particular hazards in their individual jurisdictions (United States Department of Labor OSHA, n.d.).

The OSH Act established two separate functional areas within one agency. The two functional areas are compliance and consulting. The compliance arm operates in an enforcement mode including the activities of inspection, responding to employee complaints, citing violations and imposing and collecting monetary fines. Research suggests that the traditional command and control regulatory stance acts as a general inducement for the industrial and service establishment of in-house occupational

health and safety programs (Pedersen, 1996). OSHA consulting activities include provision of health and safety advice upon request and at no cost to an organization. Under the OSH Act, if the consulting group discovers a violation they are bound to a non-disclosure rule to the compliance side.

The shift in OSHA has been toward more flexibility and industry self-regulation and away from strict command and control coercive practices by shifting the budgetary emphasis into consulting, outreach training, and industry partnership programs, such as the Voluntary Protection Program (VPP) and the Safety and Health Achievement Recognition Program (SHARP). These partnership programs provide incentives for comprehensive health and safety program development organization-wide. The drive toward this shift occurred during the Clinton Administration under the 1995 "Reinvention of Government" initiative (Pedersen, 1996). One tension dynamic that the self-regulation theory generates is the need for maximum flexibility of regulatory response to industry behavior, i.e., a shift toward greater discretion for street-level bureaucrats. However, a discussion of this concept is beyond the scope of this paper (Pedersen, 1996). The relevant concept for this discussion is the enlarging opportunity for external partnering with a regulatory agency.

Universities, in general, are large, complex organizations whose operations cut across a large variety of types of work environments, including research/teaching laboratories and classrooms, construction, industrial and academic mechanical shops, maintenance, health care facilities, and office environments. Consequently, management strategies need to include an appropriate risk management schema that embrace a diversity of regulatory requirements and best practices.

Federal OSHA safety committee rules apply only to federal agencies. States with OSHA counterparts have been given authority for promulgating rules for general safety committees within their jurisdictions. In general, safety committees are part of an overall strategy to encourage labor and management problem-solving regarding hazards in the workplace. The creation of this representative body, in theory, influences the decision-making capacity of an organization and, thus, is expected to become a part of the overall governance structure or subsystem. Relevant to the study of safety committees, O'Toole (1999) concluded that safety outcomes (injury data) were better in manufacturing firms supporting voluntary safety committees rather than mandatory ones. Actions and level of success of these governance structures in universities is an area ripe for exploration.

Environmental Protection Agency – EPA

The mission of the Environmental Protection Agency (EPA) is to protect human health and the environment (United States Environmental Protection Agency, n.d.). The agency was formed in 1970 as a reorganization effort under the Nixon administration, in response to growing public demand for cleaner water, air, and land. The reorganization provided the aggregation of parts of several other agencies (Lewis, 1985). Compliance rules in universities include a diversity of environmental requirements. The cradle to grave management of hazardous chemicals affects materials purchased, used, and generated as waste from academic and research laboratories, and academic and maintenance shop operations as well as construction debris containing asbestos and lead paint. The Clean Air Act requires universities to

apply for discharge permits by reporting the air discharge burden from point sources such as laboratory chemical fume hoods, products of combustion from mechanical boilers used for building heat, and products of combustion from incineration facilities, such as would be used for morgue, general, and biological waste streams. Storm water discharge permitting requires the assessment of quality and volume of water run off from paved areas of institution-owned surface area.

Nuclear Regulatory Commission - NRC

The Nuclear Regulatory Commission (NRC) covers three main areas of regulatory interest to universities: nuclear materials, nuclear waste products, and reactors (United States Nuclear Regulatory Commission [U.S. NRC], n.d.-a). In most universities the management and oversight of nuclear materials and nuclear waste products originates from research located in the sciences or from medical origins if a medical facility is co-located with a university. Some universities have research and testing nuclear reactors, as well, adding to the complexity of regulatory oversight, such as Oregon State University, Washington State University, Texas A&M, University of Florida, and University of Wisconsin (U.S. NRC, n.d.-b). Each university must apply for a radioactivity materials license for their facility with strict compliance oversight from governing agencies. The university licensing agreement requires the strict and comprehensive management of radioactive materials from purchase to safe handling to waste disposal, the creation of an oversight committee (or governance structure--a part of the safety subsystem) and a written policy. In addition, the use of other types of equipment, such as x-ray equipment for diagnosis, treatment or research, is licensed.

The licensing agreement provides a regulatory lever whereby the NRC or the state-equivalent agency can revoke the license for items of non-compliance (U.S. NRC, n.d.-c). This act could interrupt the purchase and use of radioactive materials, halt research and/or services, and generate adverse publicity

Accrediting Agencies

Accrediting agencies provide external curricular oversight and approval at both the institutional and departmental/programmatic level. These accrediting bodies fall into one of three categories, regional, national, or specialized and professional accrediting organizations. Each organization is recognized by the Council for Higher Education Accreditation (CHEA), the U.S. Department of Education (USDE), or both (Eaton, 2006). In addition, the Public Health Service has oversight over universities engaged in the use of vertebrate animals in research and teaching. The non-profit agency Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC) is a private, nonprofit organization that promotes the humane treatment of animals in science through voluntary accreditation and assessment programs (AAALAC). There is a mandatory occupational health component for staff, researchers, and students involved in the care of facility animals (Association for Assessment and Accreditation of Laboratory Animal Care International, n.d.-a).

In regard to specialized accrediting bodies, explicit language relevant to health and safety can be found in accreditation handbooks. For example, in the National Association of Schools of Theater (NAST) 2007-2008 Handbook (NAST

Accreditation Handbook (National Association of Schools of Theater [NAST], 2007-2008; p.53) under Article VIII it states, "[i]t is the obligation of the institution that all students in theater programs be fully appraised of health and safety hazards and procedures inherent in the use of materials and equipment appropriate to specific disciplines and be instructed in their proper handling and operation. The institution shall have a plan by which it addresses health and safety on a continuing basis." Further evidence instructs institutions to develop "three essential competencies, experiences, and opportunities..." including "a knowledge of federal and local health and safety codes and practices" for students in the Bachelor of Fine Arts in Design/Technology programs (NAST, 2007-2008; p.94). An additional example is the ABET (Accreditation Board for Engineering and Technology) Criteria for Accrediting Engineering Programs for the 2008-2009 Accreditation Cycle. In the "Criteria for Accrediting Engineering Programs" document, the term safety is referenced once in regard to student performance outcomes and three times within program criteria as curriculum learning components (Accreditation Board for Engineering Technology, 2007).

Grantors

Three prominent federal granting agencies include the National Institutes of Health (NIH), Department of Defense (DOD), and Centers for Disease Control and Prevention (CDC). These agencies may have implicit expectations or assumptions regarding active and effective health, safety and environmental performance. However, there appears to be variation among agencies as to explicit requirements for

successful grant applications. NIH places priority on safety of human subjects, animal care, and environmental effects of the proposed project in their application document (National Institutes of Health Office of Extramural Research [NIH OER], 2008). In addition, NIH also has a 1995 guidance document for grantees "Health and Safety Guidelines for Grantees and Contractors: NIH Guide, Volume 24, Number 33, September 22, 1995" specifically addressing occupational health and safety accountability for grants (NIH OER, 1995).

As stated earlier, a requirement for compliance under the Public Health Service is that an institution using vertebrate animals in research or teaching must have an operational occupational health and safety program for animal care staff and students (National Research Council, 1997). DOD frames their grant requirements to include health and safety program management, principal investigator accountability acceptance for occupational health and safety, and safety function agent affirmation that all regulatory requirements are met for the institution. In addition, DOD requires an annual reassurance that all regulatory requirements are actively implemented (United States Department of Defense, n.d.). The receipt of federal funding also places the institution in the vulnerable position for an evaluative site visit by either the grantor or the General Accountability Office (United States Government Accountability Office, 1991).

Institutional Compliance and Public Accountability

The Association of College and University Auditors (ACUA) is an association of almost 500 colleges and universities, committed to increasing knowledge on

internal auditing, regulatory compliance and risk management in higher education (Association of Collage and University Auditors [ACUA], n.d.). The referenced website explains that economic, regulatory, and ethical concerns are quickly changing the business world in which institutions of higher education operate. Although not mandatory, the interpretation of the spirit of the Sarbanes-Oxley Act of 2002 is being incorporated in the governance processes of many institutions of higher education and the requirement for a strong, independent internal auditing activity is one of several areas being considered by senior administrators and trustees (ACUA, 2004; Council for Higher Education Accreditation, 1995). One example can be found at Stanford University. The university has developed a matrix structure composed of 21 compliance areas including Fire and Building Safety and Environmental Health and Safety. The auditing function has created a code of ethics that includes a statement of accountability, reporting framework and whistleblower protection (Stanford University Internal Audit and Institutional Compliance Program, n.d.). The University of Texas System instituted an institutional compliance program organized from the state system of higher education level (University of Texas System-Wide Compliance Program, n.d.).

Professional Guidance Models

NACUBO

EHS-oriented professional, consensus-based, and other organizations provide guidance on management and administrative standards of practice and recommendations for program administrators. NACUBO (National Association of

College and University Business Officers) and Price-Waterhouse Coopers collaborated on a higher education project to develop a strategy for managing risk. The co-produced white paper entitled "Developing a strategy to manage enterprise risk in higher education" (Cassidy et al., 2003) provides guidance for self-evaluation and articulates points on a continuum for the self-assessment. At one end of the continuum, implying a weaker system of risk management, it is labeled "focus primarily on managing the hazards of crises and being in compliance with laws and regulations." At the mid-point, it is labeled "focus on controlling uncertainties as well as on crisis management and compliance." The end point implies a well-developed system of risk management and is labeled "views risk as opportunity to enhance stakeholder value in addition to crisis management, compliance, and controlling uncertainty." The paper provides an institution self-examination survey to identify placement on the continuum (Cassidy et al., 2003).

ANSI

The American National Standards Institute (ANSI) has created the ANSI Z10-2005 national standard "Occupational Health and Safety Management Systems". The standard is a voluntary consensus standard developed to provide greater standardization of management leadership and employee participation, planning, implementation, evaluation and corrective action and management review relevant to the safety context (Manuele, 2006). While not explicitly mandatory under OSHA, non-compliance with the ANSI Z10-2005 may be citable under the "General Duty

Clause" which states that all employees have a right to a safe work environment (Rothstein, 1983).

CSR and ISO

Following the rise in environmental legislation in the 1980's, the growth of environmental management systems (EMS) gained prominence. In the 1990's the shift toward corporate environmentalism gained momentum following the 1992 Earth Summit in Rio de Janeiro, Brazil. At that time a chorus of voices grew advocating for voluntary sustainable development, inciting a mindset regarding the current limitation of governmental regulations to enforce sustainable practices, and extending the idea as an expectation of civil society. The corporate social responsibility (CSR) concept emerged from the business sector and has become commonplace since 2000. The International Standard, ISO 14001 was released in 1996 as a formal set of environmental management system principles, guidelines and measurement criteria (Lee, 2003).

There has been some debate regarding the inclusion of occupational health and safety with environmental aspects of the ISO standards; however, many corporations have voluntarily combined the two facets (Lee, 2003). Shrivastava (1995) argues that not only is corporate social responsibility an ethical matter, it is a matter of long-term survival; it facilitates "a broader repertoire of actions for preventing and coping with...crisis" (p.225).

Many corporate and business entities have moved toward adopting external and global management systems, and many of these firms enter into various

agreements and granting partnerships with universities. This leaves the question of the need for an institutional shift toward a commitment to CSR and ISO in terms of meeting global criteria unanswered.

Synthesis of the External Landscape

Over the last 30 years the complexity of higher education systems has increased dramatically. Regulatory policies with environmental and safety and health responsibilities affecting universities have originated from several federal agencies. The major agencies include the Occupational Safety and Health Administration (OSHA) within the Department of Labor; Environmental Protection Agency (EPA), an Executive Branch Agency; and the Nuclear Regulatory Commission (NRC), an Executive Branch Agency. In addition, universities engaging in research in the sciences and engineering are subject to complying with requirements imposed by several federal granting agencies including Centers for Disease Control and Prevention, Department of Defense, National Institutes of Health, among others. In addition, a plethora of information sources impinging on health and safety performance include professional benchmarking, research, white papers, and accrediting and public accounting bodies.

The rules promulgated by the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), and OSHA represent only a small part of the decision-making process for which the safety function supports enablement. The theme of this research is to examine organizational arrangements that enable the management of risk and build high reliability. Thus, extending Grabowski and

Roberts' (1996) comments to universities, regulators, as external agents to an organization, do not have "comprehensive responsibility to assure that each of the system elements works efficiently and effectively" (p.4). Compliance that encourages reliance on external mandates alone leaves organizations vulnerable to "disconnects and errors" and lacking in "systematic performance monitoring programs..." (p.4). This statement implies that there are limitations to confining the safety infrastructure in universities to command and control and compliance strategies, and enhances the argument that the high performance management of risk is a process of social navigation and negotiation.

Governance Subsystems in University Systems

The term governance refers to the way in which collective effects are produced in a social system (Hill & Hupe, 2003). The governance paradigm presents a shift to a more horizontal mode of governance in the form of network management (p.110-111). The application has entered the organizational sphere from an extension of the emergence of central government attention to relations of dependency, values extension, and the argument for rehabilitation of the hierarchical model of governing.

The concept of governance has been applied to a variety of systems including universities. The institutional governance structure of universities has been characterized as the inclusion of departments, programs, divisions or schools, campus-wide committees, administration, and boards of trustees in interdependent roles. If the institution is part of a state system, an additional level of complexity is added to an already complex structure (Johnston, 2003). Governance implies the existence of a

"political process involving the achievement of consensus or obtaining consent or acquiescence necessary to carry out a program, in an arena where many different interests are in play" (Johnston, 2003; p.58). In her critical review of the literature in university leadership and governance, Stéphanie Mignot-Gérard (2003) describes the study of the system of governance in universities as composed of the identity of the various leaders, the relationships of cooperation or competition between them and their respective leadership styles, and the nature of the relationships that are established between these leaders and the various representative bodies, councils, and committees.

Birnbaum (2003) bifurcates institutional governance into the "claims of two different, but equally valid, systems for organizational control and influence. One system, based on legal authority, is the basis for the role of trustees and administration; the other system, based on professional authority, justifies the role of the faculty. The importance of legal authority was recognized with the founding of the first colleges. The acceptance of the role of professional authority is a more recent phenomenon that has evolved over time" (p.2). The balance between systems and their decision-making roles is termed shared governance. Morrill (2003) describes decision-making in the university as composed of "two overlapping worlds...the organization and the academic" (p.2). The term has also been extended to other relevant governance structures (Johnson, 2003). The American Association of University Professors' 1967 *Statement on Government of Colleges and Universities* (American Association of University Professors, n.d.) formalizes shared governance as central to the distinctive nature of American higher education. Morrill (2003) refers to collaborative

governance as an opportunity for faculty, administration, and higher education board to work together with a focus on strategic leadership. In addition, Kezar and Eckel (2004) advocate for scholarship using open systems theory in the study of governance within universities.

Both Johnson (2003) and Mignot-Gérard (2003) paint a broad descriptive landscape of the study of the subsystem of governance in universities. Their inclusive descriptions provide an aperture of opportunity to pursue a finer grain texture in the previous discussions of higher education governance configurations and processes. Birnbaum's (2003) bifurcation implies context whereby the safety function and the developing safety subsystem seek the legal legitimacy from the formal hierarchy and, simultaneously, the legitimacy from the professional informal authority. Examining the addition of safety governance structures and processes to the university shared governance model will broaden understanding of the fit of these additional entities in systems of higher education. Applying HRO theory to universities and simultaneously exploring dimensions of safety governance will serve to increase depth of understanding.

Coupling—Social System Cluster

To further explicate the complexity of systems, the term coupling provides a useful heuristic to facilitate a way of making sense of organizations (Weick, 1976; Berman, 1980). Coupling has been described as operational links within an organizational structure. Further, Orton and Weick (1990; p.204) articulate loose coupling as a dynamic process by stating that the term "suggests that any location in

an organization (top, middle, or bottom) contains interdependent elements that vary in the number and strength of their interdependencies." Orton and Weick (1990) speak to the study of coupling in terms of a dialectic perspective. The authors argue that the study of loose coupling is the study of paradox enlisting the researcher to examine connection and autonomy simultaneously. The loosely coupled system under study, the university, is said to project a dialectic image of both distinctiveness and responsiveness. Further, the authors argue that a uni-dimensional approach (examining either loose coupling or tight coupling) is overly simplistic and limiting in studying complex systems and understanding organizational puzzles.

In terms of the current study, the phenomenon can be evidenced on multiple levels. One example in regard to the safety policy implementation process, can be described that the safety function, an autonomous element of the university system, serves as the main sensing unit to external environmental health and safety regulatory policy, best practices, and other guidance models. In turn, in order to move toward a negentropic state, the safety function facilitates action within a loosely coupled university as directed tactics and their extensions are needed to bridge the operating expanse characterized by a high degree of loose coupling (Orton and Weick, 1990). The bridging demonstrates a tightening of coupling which is intended to initiate a response by targeted autonomous elements within the same system.

In their review of the literature, Orton and Weick (1990) characterize the literature on loose coupling into five voices: causation, typology, direct effects, compensations, and organizational outcomes. Causation and typology provide an explanatory space for understanding the complexity of loosely coupled universities

and the subsequent challenge of the coupling dynamic elemental to the strategies and tactics of the environmental health and safety function. The voice of causation suggests the recurring themes of 1) an unclear means-end connection; 2) fragmented external environment; and 3) fragmented internal environment. The voice of typology emphasizes the use of descriptive clarity in explicating loose coupling. The authors relate the most frequently recurring types of loose coupling, such as between hierarchical level and among subunits.

The voice of direct effects advocates the use of loose coupling as a management strategy. The direct effects include modularity, requisite variety and discretion. The discretion strategy is parsed into behavioral (capacity for autonomous action) and cognitive (freedom to perceive or construct an idiosyncratic meaning). The voice of compensations is an attempt to "search for non-obvious sources of order that administrators can use to influence dispersed organizations" (p.211). Examples of compensations for loose coupling include enhanced leadership, focused effort, and shared values. The voice of organizational outcomes has been employed as a strategy to try to "predict and measure the effects that loose coupling has on the performance of organizations " (p.213). Five organizational outcomes explicated by Orton and Weick (1990) include persistence, buffering, adaptability, satisfaction, and effectiveness. The voices as summarized by Orton and Weick (1990) may provide a framework for understanding the coupling relevant to the safety subsystem as a dialectic phenomenon in a university system.

The concept of coupled systems as sets of elements across time, used in regard to system discussions, will be explicated in at least two relevant contexts: (1)

universities as complex systems, and (2) human and organizational error adverse systems (reliable systems) nested within the university system. Weick (1976) characterizes educational organizations as loosely coupled systems. However, Grabowski and Roberts (1996) argue that complex systems, generally, contain a mix of subsystems, parts or units with varying degrees of coupling, so a single classification of a university as loosely coupled may be misleading. Orton and Weick (1990) support the dynamic image of loosely coupled systems.

The coupling heuristic can be applied in a variety of ways in universities. In a university system the administration (or formal governance system) is not the main source of expertise and decision-making with its traditional dissemination through a hierarchy of management and non-management subsystems. Rather, administration (formal governance) and faculty (informal governance) tend to have different roles, independent authority, low levels of standardization and different agendas. Under certain circumstances the coupling can be described as loose. However, viewed as a dialectic phenomenon, degree of coupling looseness between the two main decision-making (governance) subsystems changes conditionally. Conditions of loose coupling between the main governance structures present challenges for legitimating the role, authority, and decision-making capacity of the EHS function, the ehs governance structures and processes, and safety network development.

Further discussion of universities as complex systems can be found in "Retrenchment and Adaptability in the University". In this analysis, Rubin (1979) explores the aspects of universities that increase their ability to adapt when resources

decline. The author relies on the key concepts of adaptability[4] and loose structure. The author deconstructs coupling in terms of horizontal units, vertical units and between the organization and its environment. As oriented by Rubin (1979), system coupling for the current project can be appreciated across multiple levels or layers (vertical coupling), such as, coupling between a state system of higher education (previously referred to as supra-systems) and individual universities (referred to as systems); coupling between the university system executives and elements of the safety sub-system; and coupling between managers/supervisors/faculty and line employees/GRA/GTA/students regarding health and safety. Further, vertical coupling can be examined among any of the following: governance subsystem(s), college, school, department, group, and individual. Horizontally across universities, coupling is described as loose, that is among and between departments, academic and operational functions, including the safety function as a part of a safety subsystem, and departments and governance subsystems including safety governance elements. The loose vertical and horizontal coupling presents challenges for facilitating the development and continuous throughput of information above the general organizational noise of an ehs subsystem.

[4] Rubin (1979; p.213) defines adaptability as "the capacity of the organization to change in order to continue to achieve organizational goals when changes in the environment threaten accomplishment of those goals." The four tasks included in adaptability include, 1) identify change from the environment; 2) stage for long term responses while buffering short term pressures; 3) compress or expand structure to facilitate achievement of goals; and 4) evaluate and adjust course of action.

Within the context of a university, coupling of high reliability systems[5] (LaPorte, 1996) or human and organizational error adverse systems (Grabowski & Roberts, 1996) to the existing formal and informal subsystems as well as vertical and horizontal elements provide unexplored relationships ripe for examination. For example, as required by OSHA at the federal level, some state-level OSHA agencies and the NRC, the formation of governance bodies for representing each agency's scope of rules is a part of the larger risk management subsystem. Many universities have developed unique safety governance structures on a continuum from minimalist with a strict compliance role to very elaborate risk management schemata. This is examined in this research in regard to coupling with other decision-making structures and processes. In addition, other coupling dynamics are examined, such as EHS (the function) coupling with supra-system and system policy actors from both a vertical and horizontal perspective.

As stated in Chapter I, the safety function and the safety subsystem are embedded in a larger university with varying degrees of coupling, access, and support. The safety function in its role to discover, compile, synthesize, frame, and negotiate enhanced safety decision making into the institution, may encounter system constraints that present challenges. The transfer of knowledge is important because as university actors understand the risks they face to varying degrees, they can act meaningfully only when they are knowledgeable about the rules and resources that exist in a particular situation (Conrad & Haynes, 2001). This places the burden on the

[5] The High Reliability Organization (HRO) Project was initiated "to explore the conditions that are associated with large-scale operating systems already performing at an extraordinary level of safety and productive capacity in the face of very demanding circumstances" (LaPorte, 1996; p.60).

assertiveness of the safety function in its role to synthesize policy content and best practices, produce message clarity and timeliness, solicit expert input from affected stakeholders, and facilitate the development of an adequate system structure and appropriate social action to ensure an institution-wide interactive communication network and subsequently, unambiguous interpretation and action (learning) within the university as a system. As described earlier, this action is movement toward negentropy or transfer of information at a level above the surrounding organizational noise. This is also described by Orton and Weick (1990) as a strategy to manage within the context of loose coupling using the "voice of compensation" (p.211).

Historically, higher education has been slow to respond to external forces such as the regulatory landscape. The open systems model describes universities as loosely coupled. The loose coupling allows for adaptation by individual units isolated from the system (university) as a whole. Further, the subunits have the flexibility to respond to changes without creating disequilibrium in other parts of the organization. This localized adaptation can also be seen as the development of independent subcultures. Weick (1976) explains that the counterpoint to localized adaptation could forestall the spread of advantageous mutations from other parts of the system. In a university, this phenomenon suggests a sealing off capacity, including maintaining loose coupling with the safety subsystem. This reiterates the challenge of the safety function, safety governance and safety network in coupling intensity and encourages the examination of efforts to observe the coupling of the safety subsystem in terms of dialectic.

Networks—Social System Cluster

Another system perspective useful in examining the implementation of health, safety, and environmental policy is network theory. Klijn and Koppanjan (2000) trace the theoretical roots of the network concept in the study of policy from the bottom up approach as discussed in the work on implementation structures by Hjern & Porter (as cited in Hill & Hupe, 2003) and the interactive approach to policy (Lindblom, 1965). The authors argue that conflicting interests characterize policy processes and problem definitions are dynamic and unpredictable (Klijn & Koppanjan, 2000; p.138). The argument embraces the development of policy as a "complex interaction of processes between a large number of actors. These actors are mutually dependent so policy can only be realized on the basis of cooperation" (Klijn & Koppanjan, 2000; p.139). Speaking from the context of a university environment, Rubin (1979) argues that in regard to organizationally relevant horizontal linkages, "the greater the number of informal ties, the greater the likelihood and speed with which a change in one unit will effect a change in another unit" (p.213). This is echoed in Axelrod's (1997) social influence model based on computer simulations. Further, as Orton and Weick (1990) have characterized in their discussion of loose coupling, networks provide a compensation strategy in bridging loosely coupled systems as may be found in universities.

Hastings (1993) describes networking within organizations as presenting a "boundary busting"[6] (p.8) opportunity. These complex interaction processes require

[6] Boundary busting is defined as "...a systematic awareness and elimination of physical, personal, hierarchical, functional, cultural, psychological and practical boundaries and barriers to such

steering the collaborative and cooperative goals and interests. Adapting Klijn and Koppanjan's (2000) network management strategies that include process management and network constitution to the research at hand can provide a steering framework to enable understanding the implementation of environmental and health and safety policy within a very loosely coupled university with many internal boundaries. According to Klijn and Koppanjan (2000; p.140) "process management tends to the interaction between actors...seek[ing] to unite the various perceptions of actors and solve...problems..." Strategies reflecting the process management of health and safety actor interaction management may be described in the following scenario.

The selection and motivation of actors to participate in a laboratory safety committee (a governance structure within the subsystem of safety) in a university environment suggests the need for gaining both sustained and intermittent access to a diverse group of individuals to maximize reliability, framing issues to enable the convergence of perception, and managing emerging conflict (Klijn & Koppanjan, 2000; Susskind & Field, 1996). In addition, this describes changes to the coupling dynamic under certain conditions. Access and support need to be gained from multiple perspectives. For example, in a highly decentralized university, factors such as the ability to gain support from both formal and informal authority elements, acceptance of accountability, power/authority given to the EHS function, and other factors may play a vital role in completing creating order within a safety infrastructure. In a loosely coupled university system, action can be taken to manipulate the degree of

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cooperation and communication is a continuing process that is necessary to perpetuate the ability of the [organization] to stay flexible and adaptive" (p.8).

coupling or increase tightness between the safety function and multi-departmental stakeholders.

Klijn and Koppanjan (2000) suggest that the issue of cooperation is central to developing networks to move policy (or any change) into an organization. To examine success or failures in the network approach to policy, Klijn and Koppanjan (2000) advocate for the measurement of the degree to which cooperation has been achieved. Only when actors are able to bring their perceptions together and formulate common goals and interests will networks for policy lead to satisfactory outcomes since process management is essential to stimulate learning processes (Klijn & Koppanjan, 2000; p.143). As introduced earlier, the main decision-making governance structures in universities are the formal hierarchy and the informal faculty senate. Soliciting support to increase legitimacy[7] from each of these structures by designing an appropriate frame may be essential to gain support and legitimize stakeholder participation.

Network constitution assumes "institutional characteristics of a network also influence strategies and co-operation opportunities of actors..." (Klijn & Koppenjan, 2000; p.141). Shifting context and extending Gościkowski (2001) who advocates for a university model re-orienting from "disciplinary departmentalization" (p.449) to a "flexible multiple system of interrelated work groups" to address problem situations implies a fluid network embracing multiple "angles of view" that are problem-centered. Introducing new actors into a network can change positions of power and regularities of interaction. Dynamics such as introducing new actors, rule changes, or

[7] "Legitimation concerns the problem of explaining or justifying the social order in such a way as to make institutional arrangements subjectively plausible—the problem of motivating actors to enact actions by locating them with a comprehensible, meaningful world" (Scott, 1991; p.169).

network changes can create shifts in positions of power and interaction patterns. Further, greater influence may be achieved when stakeholders with higher levels of system influence are actively engaged. For example, general safety committee composition, where present, varies from university to university as far as investment and representation by upper level administration and faculty. The effect of composition and other factors has not been addressed in regard to governance-type structures.

The safety function as well as the system of safety is knowledge and technology transfer intense. Hastings (1993), in his discussion of networks, distinguishes between hard and soft dimensions of the transfer process. The author discusses the complementary core networking processes of hard networks defined as technology driven connections that depend on human-computer information transfer and relationship-building and soft networking defined as people driven connections that emphasize person-to-person information transfer and interpersonal relationship-building. The confluence of these dimensions provides a model of a dynamic operating continuum incorporating the relationship-creating network with the electronic information-creating and information-diffusing network as bi-directional operations. The investment, support and operationalization of these connections may influence the success of the information signal regarding safety.

Culture—Social Action Cluster

The study of culture has been described as a varied and rich concept and, consequently, there has been a lack of consensus in constructing its definition in

organizations (Smircich, 1983). Within the organizational literature Smircich (1983) has developed a series of themes in organization and management research. Smircich (1983) distinguishes the use of culture as a variable and as a root metaphor. Culture as a variable uses a systems theory framework and recognizes organizations as "culture-producing phenomena" (p.344). It is concerned with "articulating patterns of contingent relationships among collections of variables that appear to figure in organizational survival" (p.344). Practitioners operating in this framework have emphasized the enhancement of adaptive mechanisms within organizations by structuring interventions to target cultural subsystems and the values and norms in use (French & Bell, 1990). As summarized by Smircich (1983), the assumption in this line of thinking is that culture is malleable and open to reconfiguration. Others would argue that once established, culture is difficult to change (Yule, 2003).

Culture as a root metaphor "promotes a view of organizations as expressive forms, manifestations of human consciousness. Organizations are understood and analyzed not mainly in economic or material terms, but in terms of their expressive, ideational, and symbolic aspects" (Smircich, 1983; p.347-348). Smircich (1983) describes three thematic areas of metaphors including (1) organizational cognition that suggests that organizations operate as systems of knowledge, i.e., within a "network of subjective meaning that members share varying degrees, and appear to function in a rule-like manner" (p.342); (2) organizational symbolism that suggests patterns of symbolic discourse "facilitate shared meanings and shared realities" (p.342); and (3) unconscious processes and organization that suggest that "organizational forms and practices are manifestations of unconscious processes" (p.342). Development of the

shared meanings is a function of the use of language. The development of frames creates mental maps that contribute to a world-view and decision-making capacity in regard to safety (Grabowski & Roberts, 1996).

Pidgeon (1997) defines safety culture as "the set of assumptions, and their associated practices, which permit beliefs about danger and safety to be constructed" (p.6). The influence of culture in the decision-making process within organizations has been examined across disciplines. Relevant research and theory can be found in both the university governance and the health and safety literature. Kezar and Eckel (2004) critique the solo use of systems and structure in the pursuit of understanding governance in higher education. The authors argue, "human, social cognition, and cultural theories should be used in combination with systems and structures to create a richer understanding of governance" (p.395).

Culture has been a recently embraced research phenomenon in regard to the success of occupational health and safety in organizations. The rapid development of new technologies and the evolving complexities and tight coupling between the technology and human organizational subsystems changed the nature of work across industries (Wiegmann, et al., 2004). With the increasing number of catastrophic events over time in high-risk industries, subsequent investigations and analyses have led to conclusions implicating root causes such as culture. The study of culture in organizations with respect to safety emerged during the accident investigation following the nuclear accident at Chernobyl in 1986 (Pidgeon, 1997; Wiegmann et al., 2004).

Grabowski and Roberts (1996) have developed a set of determinants of error adverse large-scale systems. The determinants include: structure, decision-making, communication, culture, and human-computer interface. In regard to culture, the authors argue that systems requiring a constant investment in health and safety are directly related to the need for a strong culture. Further, the development of a culture embracing safety and reliability requires that value be placed on the active development and use of policies, procedures, and reward systems that enhance safety, i.e., infrastructure.

Problem Framing—Social Action Cluster

Smircich's (1983) sweeping thematic composition regarding culture provides an opportunity to extend into another facet of the actionist cluster—problem framing. As suggested by Katz and Kahn (1966) "the reception of inputs into a system is selective...Systems can only react to those information signals to which they are attuned" (p.293). The authors explain that coding mechanisms determine the acceptance or rejection of information. Other identifiers for coding mechanisms include mental mapping (Grabowski & Roberts, 1996) and framing (Rochefort & Cobb, 1994). Safety framing begins with defining the problem. Problem definition is an important precursor to the implementation of health and safety policy in universities. As Rochefort and Cobb (1994) argue "the study of problem definition offers a systematic way to unveil [the] interrelationships...of the influence of actions and words as the embodiments of the ideas, arguments, convictions, demands and perceived realities that direct..." institutional decision-making (p.27). The rhetoric

surrounding health and safety within the organization can influence the process, outcomes, and development of decision- making capacity in the management of risk (Rochefort & Cobb, 1994).

As stated in Chapter I and supported in the NACUBO/Price-Waterhouse Coopers white paper (Cassidy et al., 2003) the philosophical continuum can range from fear of external regulatory enforcement or adverse publicity for an institution to an internal emphasis on creatively integrating representative programs, enabling a learning culture, or acknowledging the positive business aspect. Another statement of framing is the balance between assistance/facilitation, and coercion in policy design is affected by the institutional perception (Rochefort & Cobb, 1994). In response, the implementation process across the organization would reflect the creation of mental mapping through language where the organizational environment would ascribe to a continuum. At one end of the continuum, adversarial encounters with a reliance on sanctioning mechanisms would reside. At the other end of the continuum, an emphasis on capacity building that enables decision-making by organizational members to minimize risk to institutional resources and contributes to institutional sustainability goals would exist.

The literature of problem definition highlights the complexity of social reality and how it may be cast in different lights (Rochefort & Cobb, 1994). Rochefort and Cobb (1994) describe the continuum of building a causal argument in defining a problem as extending from micro individual behavior to macro social forces. The search for causes or blame of accidents aligns along a similar scale, i.e., focusing intervention/attention at the individual level, the proximal cause (frequently analyzed

as unsafe acts/unsafe conditions), to more distal analyses that include management/organizational systems including external factors. An open systems (Scott, 1998) perspective invites the consideration of the proximal event as embedded in a larger distal and encompassing system.

Weick (1976) in "Educational Organizations as Loosely Coupled Systems" suggests that there are rather barren structures for sensemaking to take place in universities. He advances the philosophy that in the midst of ambiguity there may be "increased pressure to construct or negotiate some kind of social reality" (p.13). For the safety function, this suggests that a concurrent task is to leverage problem framing to influence mental mapping and, subsequently, decision making on multiple organizational levels, e.g., executive administration, operational and academic managers, supervisors, line staff and GRAs and GTAs. In addition, the extension of the image creation of safety might provide academic advantage of curricular integration of ehs concepts to the student level of the university. Weick (1987) provides a hint of an ideal strategy by describing achievement of a high reliability system to include simultaneous centralization and decentralization. Culture is the essential construct in bridging the seemingly independent phenomena (Weick, 1987). Thus, this suggests an interrelationship between culture and framing.

Anthony Veltri (1990) has promoted an enlarging example of problem framing. Veltri (1990) argues that to be successful with enlisting executive support for investing in the safety function, the safety agent must have command in the use of business and financial models. The models advance the use of common executive terminology in demonstrating the business advantages of a comprehensive health and

safety program. Schein (1992) argues that organizations are differentiated into various subcultures by the use of unique language within each subculture. By adapting an executive subculture language, it provides a bridging system or path into the executive subculture. Extending the bridging theory across the university system to understand and adapt the language of other subcultures, e.g., academic disciplines, student, maintenance, and others, may provide improved opportunity for creating mental maps in regard to ehs decision-making within each subculture. The approach, as Veltri (1990) has elucidated, has also been reported in the governance literature as establishing justification or legitimacy of the safety function in terms of the "bottom line" benefit. Other legitimacy contexts include moral justification and professional judgment (Scott, 1998).

Power—Social Action Cluster

Perrow (1999) identifies power as an under-acknowledged culprit, exceeding culture, leading to failure in high-risk systems. Coupled with power is interest group theory, as Perrow (1999) suggests, which imposes the view that a "variety of groups within or without the organization will tend to use it for their own ends and these may or may not be consistent with the official goals or the public interest" (p.369). In "Organizational Decision Making as a Political Process: The Case of a University Budget", Pfeffer and Salancik (1974) examine the effect of subunit power on resource allocation decisions. The authors define power as the "ability to influence outcomes, changing what might have been in the absence of the use of power" (p.148). The authors demonstrate that academic units with the higher degree of power were able to

obtain more resources (increased proportion of general funds) independent of the change in workload. In consideration of a safety function responsible for critical infrastructure elements for managing institutional risk, the formal power afforded to the safety function by executives from either the institutional or system level may be assessed by criteria to provide some insight regarding organizational positioning and resource allocation. In addition, both Perrow's (1999) and Pfeffer and Salancik's (1974) view of power may be extended to examination of safety governance structures.

Lukes (1974) provides an insightful and relevant treatise in "Power: A Radical View." In the treatise, Lukes reports on bias in decision-making in terms of the domination of defenders of the status quo. The defenders "are so secure and pervasive to their position that they are unaware of any potential challenges to their position and, thus, of any alternative to the existing political process, whose bias they work to maintain...the bias of a system...is sustained...by socially structured and culturally patterned behavior of groups, and practices of institutions which may indeed be manifest by inaction" (p.21-22). Lukes (1974) offers a context for examining levers of change possible as may be initiated or facilitated from the middle of an organization.

Safety Theory

Analysis of Adverse Events

As previously stated the emergence of human error is often cited as the probable cause of accidents (Reason, 1990). For many organizational systems it has been estimated that seventy to ninety percent of all accidents can be traced to human

error. Post-event examination of these accidents has typically, and shortsightedly, included only the conditions and processes either at the immediate interface of the failure or within one or more subsystems not extending to the system performance as a whole (Grabowski & Roberts, 1996). This backward-mapping observation is congruent with Scheirer's (1981) argument that in order to understand implementation (or other change) processes in social systems, multi-level phenomena and their interrelationships must be understood.

Reason (1990) bifurcates the breakdown in complex systems into active[8] and latent[9] failures to stress the need for the examination of entire system in which the event occurred. Elmore (1979) developed backward mapping as an analytic strategy to examine implementation. The backward mapping strategy may provide a borrowed framework for examining safety subsystem failures. The steps in the backward mapping process include,

> "...a statement of the specific behavior at the lowest level of the implementation process that generates a need for a policy...the statement of an objective...expressed as a set of operational operations...then effects, or outcomes, that will result from these operations...the analysis backs up through the structure...asking two questions: What is the ability of this unit to affect the behavior that is the target of the policy? And what resources does this unit require in order to have the effect?" (p. 604).

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[8] Reason (1990; p.476) defines active failures as "...those errors and violations having immediate adverse effect."

[9] Reason (1990; p.476) defines latent failures as "...decisions or actions, the damaging consequences of which may lie dormant for a long time, only becoming evident when they combine with local triggering factors...active failures...to breach the system's defenses. Their defining feature is that they were present within the system well before the onset of a recognizable accident sequence. They are most likely to be spawned by those whose activities are removed in both time and space from the direct human-machine interface: designers, high-level decision makers, regulators, managers and maintenance staff."

While the backward mapping model, along with other analytical tools such as system safety frameworks, offers a retrospective analysis of a system or subsystem failure, the process of productive organizational learning in social systems is vulnerable to hijacking by political forces (Sagan, 1993) or trapped in a loop of production to satisfy regulators (Ale, 2005).

Complex Systems and System Failures

There has been vigorous debate between the two dominant schools on the origins of accidents and system reliability (Sagan, 1993; Perrow, 1999). Others advocate for theoretical co-existence and complementarity of the theories (Rochlin, 1996; LaPort & Rochlin, 1994). Jarman (2001) has proposed reframing the debate to move beyond the dichotomized positions to a four-part heuristic tool of analysis.

The dichotomized debate includes Normal Accident Theory (NAT) and HRO theory. Normal Accident Theory (NAT) advocates espouse that accidents are inevitable in complex, tightly coupled technological systems. HRO theory advocates propose that organizations facing complexity and tight coupling have developed organizational strategies to achieve outstanding safety records (Roberts & Moore, 1993). HROs centralize the design of decision premises in order to allow decentralized decision-making (Weick, 1987).

The underpinning research for NAT and HRO has been an emphasis on complex organizational systems with a high degree of catastrophic potential, e.g., nuclear power, airline industry, marine systems, and chemical manufacturing. However, as Mannarelli, Roberts, and Bea (1996) have proposed, the increasing public

sensitivity reported in the media regarding health, legal, and environmental concerns has mobilized the idea of expansion of the application of findings from earlier research to "less extreme organizations" (p.84). This research will pursue their speculation by utilizing aspects of both NAT and HRO theory, research, and findings applied to universities their systems and subsystems toward a more complementary effort.

Safety as a profession emerged as an organizational response to emerging high-risk technologies and associated accidents and injuries (Shrivastava, 1994). The study of accidents and crises has illuminated various causal factors. Weigmann et al. (2004) outline the four stages in the evolutionary development in accident causation theories. The first stage, the technical period, was marked by rapid developments in new mechanical systems where design, construction and reliability of the new systems were identified as factors in accidents. The second stage, the period of human error, identified accident fault as operator error rather than catastrophic mechanical system failure. The third stage, the socio-technical period, is where accident investigators placed blame for error on the interaction of human and technical factors. Finally, the fourth stage has been termed the organizational culture period where the contextual factors of an organization in which accident events were embedded became suspect elements in searching for causal factors. Reason (1990) describes the third stage actors (the front-line operators at ground zero of an adverse event) as the providers of information to illuminate the fourth phase through "local triggering conditions necessary to manifest systemic weaknesses created by fallible decisions made earlier in the organization and managerial spheres" (p. 475). Reason distinguishes third and

fourth stage theories as active and latent human failures as part of his theory on human system error.

Weick (1987) has explained the susceptibility to accidents of complex organizations as resulting from "unforeseen consequences of misunderstood interventions" (p. 112). Weick argues that humans themselves are not sufficiently complex to sense and anticipate the problems generated by complex organizational systems. He advocates for "requisite variety" (p. 112) in human form in order to better match the system or organizational complexity. Another facet of Weick's argument moves toward the need for collective diversity to improve requisite variety and reliability of an organizational system.

The policy and implementation literature can provide guidance on deconstructing intra-organizational social systems and organizational arrangements that facilitate or enable change. The safety literature has evolved through a relatively short history…the "human factors" paradigm assumes that safety problems could be "engineered out." The focus was on the nexus of the individual worker and the immediate work environment. The limitations described by both sets of authors--Kezar and Eckel (2004) and Huber and Daft (1987)--the age of structuralism embraced the assumption that altering structure could improve effectiveness. Similarly the strength of evidence has grown that the context of the social system in which human factors are embedded plays a significant and evolving role for consideration in approaching issues holistically.

Operational Definitions

Attention to operational definitions was guided by Scheirer and Rezmovic, (1983) who state,

> "[a]n operational definition connects the empirical observations to the underlying logic of the construct being measured, and thus clarifies the conceptualization of key concepts. In the absence of an operational definition a gap remains between the level of theory and the level of observation. Then the researcher lacks the necessary prescriptions for what to observe in order to measure the construct of interest."

Therefore, several operational definitions for this research have been developed and made explicit to facilitate clarity regarding the multi-component elements and processes planned within this research. Table 2.1 at the end of this chapter provides a listing of operational definitions and their propositions for this project. The set of operational definitions includes vertical relationships, horizontal relationships, safety governance and organizational reliability. These represent the main constructs for this research project.

Sub-Problem Tasks for this Project

To examine the research question in detail, developing a set of sub-problem tasks provided a framework within which to pursue the proposed research question. This section parses the complexity and multi-dimensionality of the research question by providing supporting evidence for each of five sub-problem tasks as follows:

Sub-Problem Task 1: Determine the degree of high reliability organization capacity present in public research universities.

High reliability capacity is used as the dependent variable in this project. The research question sets the stage to examine organizational arrangements as related to high reliability capacity in universities. Universities exhibiting characteristics rich in high reliability dimensions are expected to be higher performing in terms of vertical and horizontal coupling and safety governance capacity. Several researchers have pursued this avenue of research and have pursued the development of an index or scale for measurement (Barrett, et al., 2006; Hoy, et al., 2006; Venette, 2003). A set of survey items was adapted from other research for use in universities in order to develop an index to measure degree of HRO capacity.

Sub-Problem Task 2: Determine the degree of relationship/coupling capacity present in public research universities.

The system of higher education, as described previously, includes the university embedded in a larger state system of higher education (supra-system). The subsystem of safety including the safety function, its associated elements and processes are embedded in a university system with its elements and processes. In high reliability organizations LaPorte (1996; p.60) argues that "there [should] be clear institutional interest in high reliability performance. This can be seen in strong super-ordinate institutional elements of the parent organization."... Scheirer's (1981) integrated social system model, as derived from Katz and Kahn's (1966) open systems model, uses evaluation from a multi-level perspective. The multi-level perspective

includes the processes and interrelationships at the macro level – the organization as a whole and interchange between the organization and its environment; the intermediate level – the organizational sub-units and the processes which regulate daily operations; and the micro level – behaviors, motivations and cognitions. Therefore, understanding the conditions and processes of the vertical dimension will be considered critical to pursuing the research question.

Horizontal connections are more informal interrelationships. These can be described as essential to manifold processes in a university. Horizontal systems include emergent networks to address specific safety issues and co-production[10], and safety knowledge interchange networks[11] as contrived by Hastings (1993) who bifurcates them into hard (computer) and soft (social) types. The motivation and sustainability of these networks may be affected by a variety of organizational factors is explicated in this project. Both vertical and horizontal dimensions are examined through the development of a series of survey statements to collect data regarding each safety director's level of satisfaction with support and communication from various groups unique to higher education.

Sub-Problem Task 3: Determine the degree of safety governance capacity present in public research universities.

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[10] The concept of co-production refers to the joint contribution of environmental and health and safety policy implementation by partners in a system (Hanf, as cited in Hill & Hupe, 2003). An example is the development of a safety coordinator concept as part of the sub-system of safety in universities whereby each department has on either an assigned or voluntary basis an individual who to some degree coordinates the implementation of ehs policy and provides active communication to the safety function.

[11] Knowledge interchange network is a re-framing of Hastings (1993) dual type of classification of hard and soft networks.

Since governance structures and processes vary from institution to institution as described by Kezar and Eckel (2004), it may be speculated that the membership, role, voice, and coupling of the safety committee(s) will vary by institution. The examination of assimilation of safety governance across subsystems and guilds remains largely un-addressed in the literature. A major factor affecting efficiency is the composition and role of governance bodies (Kezar & Eckel, 2004). In addition, providing inadequate institutional support has been related to less efficiency. The authors define efficiency as the timeliness in decision-making. A low rate of responsiveness in addressing critical systems errors increases institutional risk (LaPorte, 1996; Weick, 1987).

Governance capacity is examined through the development of a series of statements of agreement directed at universities with general safety committees. The statements reflect the institutional role, influence, and coupling of the safety committee within the context of the unique university environment.

Sub-Problem Task 4: Examine the content and construction of information on university websites relevant to the management of risk.

The language used to frame messages about health and safety to the institutional community provides insights into the intentions of the message composer(s) and provides opportunity to speculate about interpretation by the university website visitor. Further, examination of university websites provides an opportunity to augment, corroborate, or dispute survey data. It also allows data triangulation with the addition of this data source. To confine search time and guide

research effort a Website Review Protocol (Mikkelsen et al., 2005) was developed to collect parallel data regarding vertical and horizontal coupling, safety governance, and high reliability observations along with message framing.

Sub-Problem Task 5: Characterize organizational arrangements of public research universities in terms of HRO capacity.

The intention of this research project is to group universities based on the presence or absence of a set of organizational characteristics. The arrangement characteristics were examined from the perspective of an HRO index score. Ragin (2006) has developed a software package called Fuzzy Set Qualitative Comparative Analysis (fs/QCA) that was used to perform the groupings.

Conclusion

This chapter has laid the groundwork in pursuit of answering the research question and solving the sub-problem tasks. Chapter III will develop a methods framework in order to pursue exploring and explaining the five proposed sub-problem tasks as a collective strategy for addressing the research question.

Table 2.1 Operational Definitions and their Propositions

Concept of Interest	Operational Definition	Proposition
Vertical Relationships (IV)	Vertical relationships refer to the parsing of the complexity of an organizational system, its suprasystem, subsystems, parts, and units by examining social system (systems theory, network, and coupling) and social action (culture, power, and framing) clusters through hierarchy (Scheirer, 1981; Conrad & Haynes, 2001; Hill & Hupe, 2003; Perrow, 1999).	The coupling of vertical system components in a public university system relates to the level of organizational reliability.
Horizontal Relationships (IV)	Horizontal relationships refer to the parsing of the complexity of an organizational system into social system (systems theory, network, and coupling) and social action (culture, power, and framing) clusters through lateral connections (Scheirer, 1981; Conrad & Haynes, 2001).	The coupling of horizontal system components in a public university system relates to the level of organizational reliability.
Safety Governance (IV)	The term governance refers to the way in which collective effects are produced in a social system (Hill & Hupe, 2003). It suggests the use of authority in providing systemic steering and direction (Wamsley, 1990 in Hill & Hupe, 2003). Adapting Rhodes (1997) in Hill and Hupe (2003), it refers to self-organizing, intra-organizational networks.	The coupling of safety governance subsystems within universities relates to the level of organizational reliability.
Organizational Reliability (DV)	Organizational reliability refers to the extension and adaptation of operational dynamics/characteristics found in "...operating systems performing at an extraordinary level of safety and productive capacity in the face of very demanding circumstances..." (LaPorte, 1996; p.60).	The organizational arrangements in public universities relate to the level of organizational reliability.

CHAPTER III. METHODS

Introduction

The overarching approach in this descriptive research project to moving from research problem to the development of archetypes or clusters of universities with shared patterns or configurations was a case-comparative strategy. The advantages of cross-case analysis include both greater generalizability and deeper understanding and explanation of phenomena in multiple settings than single case research (Miles & Huberman, 1994). The approach utilized mixed methods (both quantitative and qualitative) in data collection along with an analysis allowing both case-oriented and variable-oriented strategies. The cooperative use of mixed strategies both avoids the fragmentation of variable-oriented approaches and maintains the narrative complexity of case oriented approaches (Ragin, 2000).

The descriptive research project was useful to both generalize the findings to university systems and their safety sub-systems, and to develop a detailed view of the application and meaning of the phenomenon of high reliability in higher education organizations as a risk management strategy. Advocacy and support for the use of mixed methods in a single project can be found across the several major disciplinary areas complementing this research project including implementation of public policy (Elmore, 1979; Hill & Hupe, 2003; Scheirer, 1981), high reliability organizations (Mannarelli, Roberts, & Bea, 1996), management and organizational research (Currall & Towler, 2003), and safety culture (Wiegmann et al., 2004).

In this chapter the research problem, sub-problem tasks, data collection methods, methods for analysis, and data description are presented. The two data collection methods are discussed individually while maintaining focus on the combined contributions to the overall project.

Overview of the Research Design

The design for the methods used was modeled from Tashakkori and Teddlie's (2003) "Sequential Mixed Method Design" (p. 688). The design incorporated both quantitative and qualitative strategies. Figure 3.1 (at the end of this chapter) presents the model to guide the flow for the research project. At the apex of the model the research question is posed. The top box on the left of the two-column section of the diagram illustrates the main quantitative method of data collection for the survey research. In addition, there were a limited number of open-ended questions to facilitate elaboration of responses.

Following the return of completed surveys, the website review data collection commenced and was based on useable, returned surveys, i.e., survey responses were used to inform selection of the website search phase (see box at top of right hand two-column section in Figure 3.1). Much of the early data analysis of the survey data was done separately using SPSS. However, as website data was collected it was constantly compared to survey data.

A series of indices was created from both the survey and web review. Subsequently, tables were constructed to examine, compare and amalgamate the data. Further, independent variables (supra-system coupling level, system coupling level,

safety staffing ratio, and level of executive support) were selected to use in the Qualitative Comparative Analysis (QCA) software developed by Ragin et al. (2006) to examine the relationship of these variables with the dependent variable--the degree of HRO capacity for each institution (see Table 3.1 below). Finally, a series of equations was derived to characterize and group the various organizational arrangements using the QCA software (Ragin et al., 2006).

Table 3.1 Variables and Measurements Used in Qualitative Comparative Analysis

Variable	Type	Measurement
HRO Level	Dependent	Level of Agreement—5-point Likert scale
Supra-System Coupling Level	Independent	Level of Satisfaction—5-point Likert scale
System Coupling Level	Independent	Level of Satisfaction—5-point Likert scale
Safety Function Staffing Level	Independent	Staffing per university FTE population
Executive Support Level	Independent	Executive support identified as a facilitator

Justification for the Research Design

The mixed methods approach involved the collection and analysis of both quantitative and qualitative data in a single study. The assumption for this research is that collecting diverse types of data best provided an understanding of the research problem. The predominantly quantitative phase employed a survey composed with mainly closed-ended questions with some added open-ended questions. The addition of open-ended questions allowed respondents to express themselves in their own words and allowed the researcher to explore greater breadth of respondent perspectives in regard to their particular organizational environment. Subsequently, a

qualitative website review and data analysis strategy was used to augment and corroborate the survey data. The combination of methods was designed to offset the weaknesses inherent within one method with the strength of the other method. The use of the two methods combined in a single study has been termed "complementarity" by Morgan (2001).

Advantages and Limitations of Each Data Collection Method

The use of a census survey for data collection provides both advantages and limitations. A survey design provides a quantitative "description of trends, attitudes, or opinions for a population by studying a sample of that population" (Creswell, 2003). The purpose is to generalize from a sample to a population so that inferences can be made about aspects of system-wide structures and processes in regard to safety sub-system relationships and the effect on reliability in the context of public universities (Sapsford, 1999). However, in this project the sample was the entire population of universities based on certain selection criteria. The main advantages in the use of surveys are economy of design and rapid turnaround in data collection (Creswell, 2003).

In addition, surveys provide a robust method for measuring attitudes, comparing perspectives, and eliciting other content from research participants. They can be administered to groups and offer such benefits as the following: anonymity of respondents is protected; moderately high measurement validity can be assured for well-constructed and well-tested surveys; low non-response rate can be expected for closed-ended questionnaires; and ease of data analysis is facilitated through closed-

ended items according to Johnson and Turner (2003; p.306). Electronic rather than mailed surveys provide for further streamlining of the cost by eliminating mailing expense and an even more expedited return time due to elimination of transportation of hard copy documents (Dillman, 2007). The limitations of surveys include the need for validation; brevity; potential for missing data; possible reactive effects; non-response to select items; low response rate for mailed surveys; vague answers to open-ended items; differences in open-ended responses possibly reflecting verbal ability, obscuring the issues of interest; and time-consuming data analysis for open-ended items (Johnson & Turner, 2003; p.306).

The secondary data search of public university websites provides both advantages and limitations. The addition of this stratified, purposive, mainly qualitative method to the survey will quell Webb et al.'s (2000; p.1) criticism of both the "overindulgence upon a single fallible method" and his further criticism that the use of interviews and questionnaires "intrude as a foreign element into a social setting...elicit atypical roles and responses, and are limited to those who are accessible and will cooperate..." The advantages of website searches include opportunity to obtain language, words, and framing used by both primary and secondary sampling units; can be accessed at a time and place convenient to the researcher; represents data created with previous time investment; and provides a time efficient method of data collection, i.e., no transcription (Webb et al., 2000).

Additionally, secondary data sources can provide insight into what people think and what they do; can be collected for time periods occurring in the past; are useful for corroboration; are grounded in the local setting; and can be useful for

exploration (Johnson & Turner, 2003; p.317). The limitations to this method of data collection include the enormous variety in structure of websites so accessibility will vary among websites and intuitive navigating will be necessary. Other limitations include the potential for a lag time between actual changes and a website reflecting the change(s); the potential for projecting a more ideal representation than is currently operating; and, potential low interpretive validity (Johnson & Turner, 2003; p.317).

Strategy for the Survey Research Component

The cross-sectional survey was sent electronically to the director of the safety function within each institutional system. These individuals were assumed to have specific responsibility for management of the main safety function within each selected public institution. It was assumed that these individuals are particularly knowledgeable about the history, strategy, structure, operation and perceived role of the safety function and safety governance structures within their respective universities as well as possessing general knowledge of unique cultural artifacts, barriers and facilitators regarding the management of risk within their particular institution.

Schutt (1999) distinguishes between the terms elements and sampling units. Since this research project was designed to understand the conditions and processes affecting organizational reliability from the perspective of the safety function director, understanding characteristics of a university system was imperative as argued in Chapter II. Therefore, the elements under study have been termed universities. The entity for collecting information about the elements, the director of the EHS function,

has been called the sampling unit. The previous description also has been called two-stage sampling. Using stage terminology, the elements, i.e., the universities, are the primary sampling units. The secondary sampling units, the directors of the safety function, provide information about the safety sub-system nested within a larger institutional system of a university and its broader context.

The surveys were sent electronically using *WebSurveyor*, a software package for creating, distributing, and compiling survey data. The surveys were self-administered by the respondents at the selected institutions. Email addresses were compiled from each university website and an electronic list was created to facilitate distribution. The advantage of electronic distribution is lower cost and faster response time than traditional mailed surveys, as well as eliminating time for data entry and potential error, and facilitating data analysis (Gelmon, Foucek, & Waterbury, 2005). To develop a deeper understanding of each safety sub-system nested within a university system context, open-ended, interpretive questions within the electronic survey were strategically embedded.

There were several special recommendations for construction of online surveys considered for this project (Dillman, 2007). These included the following:

1) Minimize the number of screens respondents must click through.
2) Minimize the amount of scrolling respondents must do to answer a question.
3) Do not try to fit all questions on a single screen.
4) Use graphics and images to increase the attractiveness of online surveys.
5) Allow respondents to partially complete a survey, stop, and finish it at a later time.

Selection of Universities

The National Center for Education Statistics (NCES), located within the U.S. Department of Education (USDE) and the Institute of Education Sciences (IES), is the primary entity for collecting and analyzing data related to education (United States Department of Education [USDE], n.d.-a). The Integrated Postsecondary Education Data System (IPEDS) is the core postsecondary education[1] data collection program for NCES. The data collection framework used for IPEDS is the Carnegie Classification System (Carnegie Foundation, 2007) created by the Carnegie Foundation Commission on Higher Education (Douglass, 2005)[2]. The classification system was conceived in 1970 for use by its own researchers. It was published in 1973 and subsequently updated in 1976, 1987, 1994, 2000, and 2005 for use by external researchers. The classification framework provides a comprehensive, nuanced, and evolving tool for grouping post-secondary institutions. Through the iterations of change over time, the Carnegie Commission has attempted to respond to critics and add flexibility and depth to the commonly relied upon research tool composed of frequently updated institution-generated datasets.

IPEDS is a single, comprehensive system designed to encompass all institutions and educational organizations whose primary purpose is to provide

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[1] The National Center for Education Statistics defines postsecondary education as "the provision of a formal instructional program whose curriculum is designed primarily for students who are beyond the compulsory age for high school. This includes programs whose purpose is academic, vocational, and continuing professional education, and excludes avocational and adult basic education programs" (http://nces.ed.gov/ipeds/AboutIPEDS.asp).

[2] See November 2005 online document "The Carnegie Commission and Council on Higher Education: A Retrospective" by John Aubrey Douglass, Senior Researcher at the Center for Higher Education Studies, UC Berkeley for an historical perspective. http://cshe.berkeley.edu/publications/docs/ROP.Douglass.Carnegie.14.05.pdf.

postsecondary education. The IPEDS system is built around a series of surveys to collect institution-level data in a variety of areas. Organizations that provide instructional programs as defined by IPEDS are considered institutions within the IPEDS universe. The universe of postsecondary education institutions is divided into three categories based on highest degree awarded or the length of the longest program: 1) Baccalaureate or higher degree or certificate granting institutions; 2) 2-year award institutions (i.e., institutions must have at least a 2-year program but less than a 4-year program; and 3) less-than 2-year institutions.

The IPEDS database provides a "Dataset Cutting Tool" (DCT) as a search engine for selecting institutions based on an array of criteria to create a customized dataset (USDE, n.d.-b). The current selection criteria that researchers can use include: state or other jurisdiction; geographic region; type of institution; degree-granting status; highest degree offered; institutional category; Carnegie Classification 2005: Basic; Carnegie Classification 2000; degree of urbanization; institution size category; and miscellaneous.

The 2005 IPEDS database was used for selecting institutions for this research. The research focused on the analysis of complex organizational structures and processes. Four year or above institutions ("type of institution" criteria in IPEDS), classified as doctoral-granting with research-centered missions, were expected to possess a heightened level of risk because of the greater general size as well as operational and curricular complexity. In 2005, the Carnegie classification system was most recently revised. Traditionally, institutions were grouped by degrees offered.

They were re-characterized by academic area, student academic level, and academic setting and now appear multiple times based on the more nuanced categories.

An example of change in the most recent revision relevant to this project is the characterization of doctoral level institutions. In the Carnegie Classification 2000, doctoral institutions were characterized as either doctoral/research-extensive (awarding 50 or more doctoral degrees per year across at least 15 disciplines) or doctoral/research-intensive (awarding at least 10 doctoral degrees per year across 3 or more disciplines, or at least 20 doctoral degrees per year overall). In the Carnegie Classification 2005, the doctoral degree categories were recast to characterize the level of institutional research, i.e., research universities-very high research activity, research universities-high research activities, and doctoral/research universities. The IPEDS search engine allows the researcher to compile data sets using selection criteria, Carnegie Classification 2000 or 2005. Each provides the same list of institutions in groupings of either two or three, respectively. In addition, the two separate search engine options provide groupings of primary sampling units that offer variety for comparison and analysis.

Using the IPEDS search engine 2000 criteria and selecting public, four year and above institutions, 102 research-extensive and 64 research-intensive universities were identified. However, one research-intensive university was located in the Commonwealth of Puerto Rico, a culturally distinct archipelago under U.S. sovereignty. Since this university was not within the 50 United States, it was excluded from the research population. Therefore, 63 doctoral/research intensive institutions were selected. Combining the two categories yields a study population of 165. Using

IPEDS 2005 criteria, and selecting public, four year and above, and very high research activity yields a field of 63 institutions; high research activity yields 75 institutions; and the doctoral/research selection adds 27 institutions. The total is equivalent to the 2000 criteria minus the institution located in Puerto Rico.

Lombardi et al. (2005) has created a comprehensive ranking system for U.S. research universities published in a report. The report provided a comparison group for the analyzed data of the IPEDS selected cases. The aggregate data collected from the top 25 American public research universities identified by Lombardi et al. (2005) were used to compare some of the data.

Pre-Testing the Survey

Since the survey questions were developed specifically for this research, it was imperative to pre-test the questionnaire. The survey was piloted using a cohort of public higher education safety directors within the states of Oregon and Washington. Where a university was part of the study population, an alternative individual within the safety function was invited to complete and comment on the pre-test to avoid contaminating the response pool. The pilot test served to establish the content validity of the instrument, improve clarity of questions, enhance the format and sequencing of questions, refine the scales, and identify any other potential problems with the survey design in a fixable timeframe (Creswell, 2003). Comments from the pilot cohort were incorporated into the final instrument revisions (Creswell, 2003).

An announcement of the upcoming pilot survey was sent June 14, 2007 to individuals via email to either a safety director at each institution or to a surrogate if

the safety director was part of the survey population. On July 14, 2007 the survey was sent to the seven selected respondents. Ideally, the administration of the pilot should be identical in process to that of the actual research design, using *WebSurveyor,* to ensure that respondents to the pilot experience the survey identically to that of the actual survey population. However, because of lagging operational knowledge of the mail function of *WebSurveyor,* the pilot survey was distributed to seven informants using individual university email accounts. Five of the seven respondents replied to the invitation by completing the *WebSurveyor* survey for a 71% response rate.

All of the five respondents (100%) reported their age as 40 years or greater. Three of the five (60%) placed themselves in the 50-54 year age group. Three of the five (60%) were female. Three of the five respondents (60%) identified themselves as Caucasian/white. All respondents (100%) reported having at least a Bachelor's degree. One individual (20%) reported having a Masters degree. Three (60%) had some post-Baccalaureate credits. Two respondents (40%) had been in their current position three years or less. One individual reported 10 or more years in their current position. All five reported time in the EHS career field as seven or more years in total. In sum, the pilot respondent group, while small, provided some degree of diversity in regard to their demographics, experience and background as a representative of the larger survey population.

The last question in the pilot survey provided an open-ended opportunity, with researcher prompts, for pilot respondents to comment on any dimension of the survey, e.g., clarity of statement describing purpose of survey, clarity of questions, word

clarity, and missing response options. In addition, two survey experts[3] reviewed the survey and provided constructive feedback on construction and substantive content. Edits to the pilot survey were made in *WebSurveyor* prior to distribution to the survey population.

Survey Distribution

As described previously in Chapter III, EHS Directors at 165 public research institutions were selected as respondents for the web-based survey. Using specific search criteria as previously discussed, the IPEDS database provided a survey population of 165 doctoral level, public research universities. Each of the 165 institutional websites was visited in order to identify the individual currently serving in the role of EHS director (or equivalent) and to collect each email address as well as link to each institutional website and EHS website for later data collection using the Website Review Protocol. There was a high degree of variation among university websites because of differentiation in regard to organizational structure, institutional web design preference, operational transparency, and the organization and development of the safety function. (This will be discussed under " Limitations" later in this chapter.) One university from the IPEDS population was eliminated since an exhaustive institutional web search was unsuccessful in locating an institutional safety function manager along with several unproductive telephone calls in an attempt to locate an individual responsible for the safety function.

[3] Dr. Sherril Gelmon (Portland State University, College of Urban and Public Affairs), Dr. Anthony Veltri, (Oregon State University, College of Health and Human Performance).

Therefore, a letter to notify respondents of the upcoming survey was sent to 164 individual email accounts from September 10 through September 13, 2007 (Appendix C). At the time of the notification of the upcoming invitation to take part in the survey, the researcher was in the process of learning the Mailing Lists function of *WebSurveyor*. Therefore, individual email accounts were used to distribute the notification letter. The revised and final survey was sent October 1, 2007 using the *WebSurveyor* software package and the Mailing Lists function to distribute and track the surveys (Appendix D). On October 15 the first reminder letter was distributed through *WebSurveyor* (Appendix G). On October 30 a second and final reminder was sent (Appendix H). Both of the reminder letters were sent using the Mailing List function. The survey was closed on November 16, 2007.

Maximizing the Response Rate

Several strategies were used to increase response rates. A pre-notification e-mail was sent to each potential survey respondent two weeks prior to electronically distributing the survey (Appendix C). This was intended to increase the likelihood of response because of the anticipation of the survey as well as to possibly spark curiosity among respondents who may look for the survey arrival. The pre-notification also served as a confirmation that the correct institutional respondent was contacted to take part in the survey. A response was requested in the event the contact was in error and a correct contact person was requested. A reminder-e-mail was sent to all respondents at both two weeks (Appendix G) and four weeks (Appendix H) after the initial survey was electronically distributed. As described above, the use of electronic

survey software should also increase response rates, as compared to time lags and mechanical issues involved in completing and mailing a paper survey.

Website Data Collection

Following the receipt of completed surveys, nineteen universities (primary sampling units) were purposively selected based on certain selection criteria to ensure representation from pre-determined groupings. Priority was given to respondents who replied within three weeks of the initial survey distribution. The representative groupings or criteria for selection included geography and Carnegie classification. However, flexibility was maintained during the selection process in case seemingly rich groupings emerged. A semi-structured website search using the established protocol (Appendix F) was used following a preliminary analysis of the returned survey. The protocol was adapted from an existing web review protocol as developed by Mikkelsen, Gelmon, Seifer, and Kauper-Brown (2005).

The website protocol was developed to gather standard information from website pages relevant to each university including, but not limited to, supra-system level pages and university system pages (e.g. safety function, safety committees, university executives, Human Resources, and Risk Management pages). Because of the expected discovery of unique aspects of each university environment, flexibility was maintained to pursue rich leads during website data gathering. Relevant documents archived and available were reviewed. In addition, unique features, characteristics, use of language, and processes either anticipated or not were noted for possible inclusion in the analyses and findings.

The design of the protocol provided a systematic website review process parsing data collection along four dimensions. Dimension 1 provided a framework with twelve sub-dimensions for examining vertical relationships. This included reviewing the state system of higher education website, when applicable, to search for evidence of health and safety-related language directed at individual institutions; reviewing institutional executive websites for evidence of health and safety-related language; and reviewing the EHS website to capture the language used to frame safety strategies and describe available evidence of supporting statements from the institutional hierarchy. Dimension 2 provided a framework for examining horizontal relationships parsed into thirteen sub-dimensions including evidence of safety coordinator structure and processes as well as information transfer strategies from the EHS webpage. Dimension 3 detailed eight sub-dimensions contributing to knowledge regarding institutional safety governance. Elements regarding a search for the presence of explicit role statements for safety governance bodies, evidence of a relationship among governance bodies, evidence of a relationship between faculty governance and safety governance, evidence of a relationship between executives and safety governance, and evidence of transparency and open communication regarding safety governance activities were included. Dimension 4 was composed of six sub-dimensions to collect data regarding organizational reliability using Weick and Sutcliffe's (2001) five dimensions of high reliability as a basic framework. The sub-dimensions included error reporting, empowerment and skill building for hazard identification, organizational learning process, slack resources, safety subsystem transparency, and knowledge transfer to reduce effect of unanticipated events.

As university supra-system and system websites were reviewed, data and interpretive elements were manually recorded on each of the website protocol forms.

Data Management

As the completed surveys were received, the responses were assigned unique identification numbers to facilitate any additional data cleaning and flag cases of particular interest. It was necessary for the researcher to retain knowledge of the data source so that the subsequent web site review could be performed on selected cases. Responses from the *WebSurveyor* survey were downloaded and imported into SPSS. Initial descriptive frequency distributions were run to facilitate data cleaning and provide a general profile of the respondents, followed by a series of cross-tabulations to examine the data for inconsistent relationships, unexpected averages or large numbers of missing values (Dillman, 2007).

Responses to open-ended questions were reviewed within the context of the closed-ended responses for each respective survey. Written notes were recorded for each case number to track and identify emergent themes. Attention was given to understanding the background context of the comments added within each survey as part of the interpretive process of analyzing qualitative data. Data management followed simultaneous involvement in data gathering and analyses. Text notes were written as either new ideas emerging from the data or as contributions to understanding the core concepts within the framing of this research as developed in Chapter II.

In regard to the subsequent purposive website review, the surveys were used to select the 19 cases based on the previously mentioned criteria. As stated previously, the constructed "Website Review Protocol" guided data collection. As each protocol was completed, the researcher reviewed it and recorded written notes both interpretive from the data or notations representing unique features discovered during website review that surpass the lines of inquiry in the semi-structured protocol. Constant comparisons of the website findings with the self-administered surveys was ongoing in search of emergent themes (Strauss, 1987). Attention was given to developing a clear system for keeping track of data to permit easy, flexible, and reliable use of data. These actions constituted the basis for a "systematic, coherent process of data collection, storage and retrieval...aimed at ensuring (a) high-quality accessible data; (b) documentation of just what analyses have been carried out; and (c) retention of data and associated analyses after the study is complete" (Huberman & Miles, 1994; p.428).

Validity and Reliability of Data Sources

The use of a mixed methods design in a research project should include evidence of forethought and discussion of the steps for checking the validity of both the quantitative and qualitative phases of the study (Tashakkori & Teddlie, 2003). Scheirer and Rezmovic (1983) have been critical of the lack of establishment of validity and reliability in measurement of implementation studies. Validity means that the measurement of a variable does indeed measure that particular variable. Reliability

suggests that the data collection or research is repeatable. The following addressed these threats and treatments for this study from each methodological perspective.

Reliability analysis using SPSS can be used to determine whether a set of survey questions and item statements for a reliability scale. This means that the items measure a single concept with reasonably high intercorralations. A Cronbach's alpha greater than approximately 0.70 allowed the conclusion that the index is reliable.

In regard to qualitative data analysis, construct validity is used to test for the establishment of correct operational measures for the concepts being studied (Yin, 2003). Triangulation, a tactic for improving construct validity, refers to the combining of methods, data sources, and other factors to examine what is under study. In this research, both data triangulation and methods triangulation were used (Patton, 1987). In this research project, data triangulation included collecting data from multiple sources, e.g., self-administered survey and website review data – such as accessible documents, general information, and framing language used; triangulation was intended to corroborate the same facts or phenomena as well as add depth of understanding to the research. Methods triangulation included the use of both quantitative and qualitative data collection.

Reliability refers to the demonstration that operations of a study—such as the data collection procedures—can be repeated with the same results. The development and use of a "Website Review Protocol" (Appendix F) provided a consistent research data collection guide to improve repeatability.

Limitations and Assumptions

Despite all of these efforts, there were still some remaining limitations to the research design, and some assumptions that must be acknowledged as they may affect the generalizability of findings. Reliance on a single informant to provide complete data on a complex institution was a limitation. However, since the selected survey respondent was the recognized facilitator of safety subsystem functioning within that institution, the director of the safety function was anticipated to be the respondent who would provide the most thorough responses within the data collection framework.

Use of the entire population of the IPEDS public research universities was a limitation. Therefore, findings and conclusions may have limited applicability to private and other smaller four-year, professional and community-based institutions. The population included only United States universities within the 50 states, in order to maintain some consistency across the population. Generalizations cannot be made to United States territories, possessions, or other extension facilities including military outside of the 50 states, or to other global institutions.

The number of higher education facilities per state, in general, is widely variable reflecting history, population base, and multiple other factors. Subsequently, the use of the selection criteria for primary sampling units—universities—varies, as well. Therefore, there will be an uneven distribution of selected universities per state. Alternative strategies, such as selecting land-grant institutions, were considered but were rejected in favor of the defined population selection strategy in order to draw upon the most relevant set of selection criteria for the research topic.

This research project placed a high degree of dependence on the use of Internet technology. It was assumed that all respondents had at least one email account within the parent institution and were knowledgeable in its use. Along the same lines, it was assumed that each purposively selected institution had a developed, searchable website. In addition, it was assumed that each safety function had a developed website within the framework of the institutional site. Preliminary scanning of selected institutions within the survey population showed that all have websites, and it has been widely recognized that higher education institutions are increasingly relying upon websites as a primary communication and information dissemination vehicle (Duderstadt et al., 2002).

Instrument Construction and Data Analyses

The two data collection tools were constructed using a combination of the intended plan to capture the complexity of social elements within universities, their safety subsystems, and extractions from models, scales, hypotheses, and indicators from other relevant research. The survey was constructed to collect data regarding respondent demographics, safety function characteristics, university characteristics, details regarding safety committees, various safety function relationship characteristics, and characteristics regarding high reliability. The Website Review Protocol was designed to collect data from the each selected institutional website that parallels many dimensions of the survey.

As stated in Chapter I, there were five sub-problem tasks to solve. To solve Sub-Problem Task 1, 20 survey items were compiled to collect perceptions of

university safety directors regarding HRO characteristics. A 5-point Likert scale was used ranging from very satisfied = 5 to very dissatisfied = 1. As discussed in Chapter II, there are five performance characteristics found in high reliability organizations (Weick & Sutcliffe, 2001). Four items for each characteristic were adapted for this project from previous research.

In one relevant study, an "HRO Perception Scale" as developed by Barrett, Novak, Venette, and Shumate (2006) was used with 85 fire department respondents. Scale items were partitioned into two subscales and the hypothesized relationships were factor analyzed for fit. The research was an extension and testing of Venette's (2003) scale developed and applied to USDA Plant Protection and Quarantine border inspection teams. The overall scale reliability was 0.83 (N=85) for the 2006 study.

In a second study, Hoy, Gage III, and Tarter (2006) applied the "mindfulness" construct to schools and the inextricably related construct of faculty trust as demonstrated in the study (Weick & Sutcliffe, 2001). A survey with a 20-item mindfulness measure (M-Scale) using a 6-point Likert scale from strongly disagree (1) to strongly agree (6) was distributed to faculty of 75 middle schools. Through factor analysis two significantly correlated factors (subscales) were discovered.

Both of the preceding studies relied on the work of Weick and Sutcliffe (2001) and their development of five characteristics of mindfulness (p. 3). These characteristics formed the basis of the scales developed and tested in each study. The index for the current project was created using 20 items on a 5-point Likert scale. The purpose of the study was to apply the construct of organizational reliability to 165 public universities and explore organizational arrangements affecting reliability. The

research was intending to capture the perspective of the safety function director as the informant of safety sub-system structures, processes, and relationships within a larger institutional context.

The 20 items were tested for reliability using Cronbach's alpha. Three items with low item-total correlation (less than .3) were dropped. The final number of statements included 17 items (Cronbach's alpha = .916). The data for each of the HRO items were summed to create an index. The scores ranged from a low of 27 to a high of 81. A frequency distribution figure is provided in the Chapter IV findings (Figure 4.1). A cut-point of 63 was determined using SPSS and the scores were dichotomized. Universities exhibiting high HRO capacity scored ≥ 63 and low HRO capacity universities scored < 63.

To solve Sub-Problem Task 2, safety function relationships were examined. Ten items were constructed to represent the level of satisfaction, scored on a 5-point Likert scale similar to the design for Sub-Problem Task 1, with relationships across the institution. However, an additional selection option of NA (not applicable) on the survey was added because not all states have the same state system oversight and not all universities have safety coordinator programs. The intention in item construction was to capture both vertical and horizontal components unique to universities and their relationship to the safety function. Scores represented level of satisfaction of the safety function director with institutional elements framed in terms of supportiveness, communication and/or general relationship.

As discussed in Chapter II, Scheirer's (1981) work informed the use of the examination of both vertical and horizontal organizational dimensions in order to use

an integrated social system perspective for analyzing organizational ripeness for introducing change. Further, Axelrod's (1997) social influence model suggested that boundaries between cultural zones dissolved when similarities were sought. This implies that actions of engagement that include satisfying communication and support by various organizational entities in universities as perceived by the safety function director, provide evidence of a well-coupled dynamic environment. In contrast, low satisfaction in communication and support suggest a low coupling dynamic.

Two indices were created from the set of 10 items. The first index, the Coupling Index, represented intra-institutional coupling with the safety function. Seven of the 10 items were used to create the index. The two items regarding the state system of higher education and the one item regarding safety coordinator programs were not used.

The seven items were tested for reliability using Cronbach's alpha. The overall alpha was 0.843. The data for each of the items were summed to create an index. The index of scores ranged from a low of 17 to a high of 39. A cut-point of 33, as determined using SPSS, was used to dichotomize the cases. Scores of ≤ 33 represented low satisfaction expressed by the respondent with intra-institutional relationships. Scores >33 represented a high level of satisfaction with intra-institutional relationships.

The second index, Supra-System Coupling Index, was created using the two relevant survey items. The two items were tested for reliability using Cronbach's alpha. The overall alpha was .820. The data for each of the items was summed to create an index. The index of scores ranged from a low of 2 to a high of 10. A cut-

point of 6 was determined with SPSS. Cases scoring ≤6 had a low satisfaction with relationship with state system of higher education. Cases with scores >6 reported a high level of satisfaction with state systems of higher education.

To solve Sub-Problem Task 3, a group of survey items was created to collect safety director observations of the operation of the general safety committee unique to universities, where present. A set of 13 items was compiled for the survey. The strategy was to examine the general safety governance body through its actions, relationships within a university context, and the institutional perceptions of it. This combination was used as a surrogate for committee effectiveness. Less than 70% of respondents reported the presence of a general safety committee. The 13 items were tested for reliability. Three items had inter-item correlations below .3 and were subsequently dropped. The overall alpha for the remaining 10 items was .898. A 5-point Likert scale was used to measure level of agreement (strongly agree = 5 to strongly disagree = 1) with the 10 statements. The data for each item were summed to develop an overall index and score for each case.

Scores ranged from a low of 11 to a high of 48. The cut point was determined to be 33.5. Cases with scores less than 33.5 had low committee effectiveness. Cases with scores greater than 33.5 had high committee effectiveness. Chi-square analysis was done to compare the dichotomized Governance Index scores with HRO Index scores.

To solve Sub-Problem Task 4, a Website Review Protocol (Appendix F) was developed based on the work of Mikkelsen, et al. (2005). The protocol was composed of dimensions parallel to the survey including the vertical dimension, the horizontal

dimension, the safety governance dimension, and the organizational reliability dimension. Each dimension was composed of several sub-dimensions to reflect the unique environment of universities. Each sub-dimension was constructed with a 4-point scoring system to determine degree of presence observed. In addition, a 3-point scoring scheme for framing was created across the sub-dimensions. A protocol was completed for each of 19 universities (a subset of respondent institutions).

Ultimately, sub-dimension scores were averaged. Each of the four dimension average scores was dichotomized. An average score of 1 or 2 was re-scored as low and a score of 3 or 4 was re-scored as high. Framing was removed from scoring within each sub-dimension and interpreted more broadly representing the message to the institution. The language projected by the safety function website (as a priority) was subsequently used to interpret the framing dimension aligned along one of three sub-dimensions. The sub-dimensions included 1) regulatory compliance only; 2) regulatory compliance and mitigation that acknowledged prevention; and 3) regulatory compliance, mitigation and value added also acknowledging the overall contribution to the success of the institution.

In addition, tables were created to examine cases based on HRO Index scores and to compare, augment, and corroborate survey data.

To solve Sub-Problem Task 5, dichotomized scores were compiled to create five independent variables and one dependent variable for use in Qualitative Comparative Analysis (QCA) software (Ragin, 2006). Independent variables included the Supra-System (or System) Index and Coupling Index. In addition, three other dichotomized indexes were created from the survey data including 1) safety staff FTE

to institutional FTE ratio, 2) safety function reporting level, and 3) executive support when reported as a facilitator. The dependent variable was the dichotomized HRO Index. More detail regarding these variables is provided in Chapter IV.

The QCA software, using Boolean algorithms, derived a series of equations of variable groupings present in the cases under study. More detail regarding QCA software and interpretations of the findings is provided in Chapter IV.

Data Integration

While quantitative treatment of the survey data marked the onset of data analysis, the subsequent treatment of all data collected proceeded using constant comparisons including between qualitative data sources and between qualitative and quantitative data. The constant comparison allowed a synthesis to emerge (Strauss, 1987). The synthesis facilitated a convergence of understanding of both the effect of various organizational factors upon reliability as devised at the outset and the revelation of new insights, theories and frameworks.

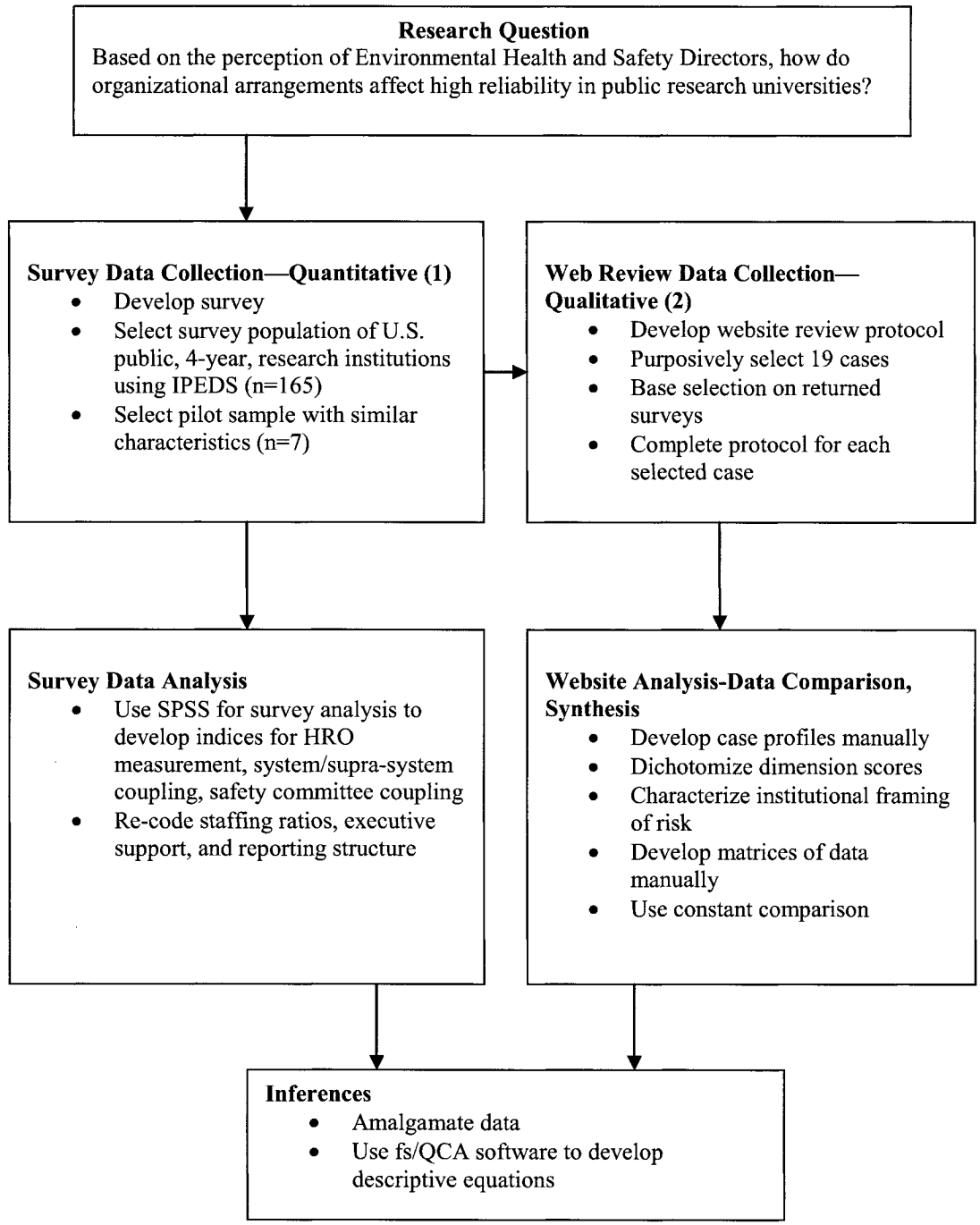
For this research qualitative and quantitative methods were combined to solve the specific sub-problem tasks. Erzberger and Kelle (2003) propose the use of a triangulation technique to enable the type of expected relationship between the results of the methods. The authors argue that results of combining qualitative and quantitative methods to answer a specific research question, in general, will enable one of three outcomes to arise: 1) convergence--results lead to the same conclusions or mutual verification of the data; 2) complementarity--data collection may relate to different objects or phenomena but may be complementary to each other, i.e., provide

supplementary data to formulate a more compete answer to the research question; and 3) divergence or contradiction—the findings from each of the data collection methods yields conflicting results. The research design planned demonstrated the applicable dimensions as described in Chapter IV.

Conclusion

This chapter outlined the research design and methods used for conducting the research for this project. The two data collection methods, survey and website review, were detailed and the analyses of the five sub-problem tasks were discussed. The described methodology has allowed for the examination and interpretation of data presented in Chapter IV.

Figure 3.1 Cross-Sectional Comparative Research Sequential Mixed Design



CHAPTER IV. FINDINGS AND DISCUSSION

Introduction

This chapter details findings for the study. Overviews of the respondent profiles, EHS department profiles, and institutional profiles are described. Results from the two data collection methods are reported in sequential order. An amalgamation of both case and survey data for the 19 purposively selected universities is reported. The chapter reports the findings for each of the three sub-problem tasks. Finally, cases are characterized and grouped based on similar organizational features. The data illuminates understanding in regard to both an exploratory application of HRO theory to public research universities and the complexity of relationships in universities in regard to the safety subsystem.

Survey Findings

Final Survey Respondent Demographic Profiles

Seventy-seven (77) surveys were returned. Two surveys were eliminated: one survey was returned without the unique identification number attached by the researcher prior to distribution and a second survey was eliminated because less than 50% of the questions were completed. Therefore, 75 usable surveys were returned for a 45.5% response rate.

In regard to geographic location of universities, more than one-half (n=50; 66.7%) of the 75 respondents reported that the institution was situated in an urban

setting. Seventeen (22.7%) reported placement in a suburban location, and eight (10.6%) identified their geography as rural.

Respondents from institutions across 38 states were represented. Table 4.1 below displays groupings of states aligned with the corresponding number of institutions responding to the survey.

Table 4.1 Number of Responding Institutions per State

Number of Institutions Responding	States
5	California, Michigan, North Carolina
4	Colorado
3	Indiana, Missouri, Oregon, Tennessee, Virginia
2	Georgia, Illinois, Louisiana, New York, and Texas
1	Alaska. Arkansas, Delaware, Hawaii, Idaho, Iowa, Kentucky, Maryland, Massachusetts, Montana, Mississippi, New Mexico, North Dakota, Pennsylvania, South Carolina, South Dakota, Utah, Vermont, Wisconsin

Within the most recent Carnegie classification system (Carnegie Foundation, 2007) doctoral level research institutions are divided into a set of three categories based on research activity, as discussed in Chapter III. Of the 75 respondents, 35 (46.6%) were classified as Doctoral Level/Very High Research Activity (VHR), 28 (37.3%) were classified as Doctoral Level/High Research Activity (HR), and 12 (16%) were classified as Doctoral Level Research (R). Seven respondents were from the Lombardi Top 25 (Lombardi et al., 2007) public research university (L25) ranked field, a subset of the Very High Research activity classification.

Of the 75 respondents, 62 (82.7%) were male and 13 (17.3%) were female. In regard to ethnicity, 66 (88%) reported their race as Caucasian/White, 6 (8.0%)

identified as Black/African American, 2 (2.7%) were of Asian descent, and 1 (1.3%) identified as belonging to the American Indian/Native Alaskan group.

Thirteen (17.3%) respondents reported that their academic terminal degree included a doctorate, 44 (58.7%) reported receiving a Masters degree, 11 (14.7%) respondents reported completing some post-baccalaureate academic credits, 6 (8%) reported receiving a Bachelors as their terminal degree, and 1 (1.3%) reported having some college or an associate degree.

Table 4.2 below displays the dimensions of respondent gender, ethnicity, and academic achievement. Seventy-seven percent (77%) of female respondents reported completing either a Masters or Doctorate degree while 74% of males reported acquiring either a Masters or Doctorate degree suggesting similar educational achievements across genders. Further, this suggests that graduate education is a desirable accomplishment for individuals holding the safety function director position in public research institutions.

Table 4.2 Gender, Ethnicity, and Terminal Degree

	Female				Male				
	Asian	**Black**	**Native**	**White**	**Asian**	**Black**	**Native**	**White**	**Total**
Less than Bachelors	--	--	--	--	--	--	--	N=1	N=1; 100%
Bachelors	--	--	--	--	--	N=1	--	N=5	N=6 100%
Post-Bachelors	--	--	--	N=2	N=1	--	--	N=8	N=11 100%
Masters	--	N=1	--	N=8	N=1	N=1	N=1	N=32	N=44 100%
Doctorate	--	--	--	N=2	--	N=3	--	N=8	N=13 100%
Total	--	N=1 100%	--	N=12 100%	N=2 100%	N=5 100%	N=1 100%	N=54 100%	N=75 100%

Seventy-three of 75 (97.3%) respondents completed the question regarding terminal degree. Forty percent of respondents (n=29) reported a terminal degree that emphasized some facet of environmental health and safety including public health. Twenty-one individuals reported having a Masters degree in this category as well as 3 Doctorates. The next largest respondent degree program reported was in the sciences (n=17). Within this group, respondents reported 5 Masters and 7 Doctorate degrees. Eleven respondents held engineering or industrial technology degrees with 5 Masters and 2 Doctorate degrees (see Table 4.3 below).

Table 4.3 Academic Major and Terminal Degree

	EHS/ Public Health	Science	Engineer/ Industrial Tech.	Social Science	Business Public Admin.	Edu.	Fine Arts	Total
Bachelors	N=2	N=2	N=2	N=0	N=0	N=0	N=0	N=6
Post-Bac-calaureate	N=3	N=3	N=2	N=3	N=0	N=0	N=0	N=11
Masters	N=21	N=5	N=5	N=2	N=7	N=2	N=1	N=43
Doctorate	N=3	N=7	N=2	N=0	N=0	N=1	N=0	N=13
Total	N=29 40%	N=17 23%	N=11 15%	N=5 7%	N=7 10%	N=3 4%	N=1 1%	N=73 100%

The highest percentage (n=17; 22.7%) of respondents was in the 50-54 year age category. The second highest percentage included two groups 55-59 and 60 or greater each with an n of 14 (18.7%). These age groups were followed by the 40-44 year (n=13; 17.3%) and 45-49 year (n=12; 16.0%). The age groups with the smallest number of respondents included 35-39 year (n=4; 5.3%) and 30-34 year (n=1; 1.3%).

Respondents were asked about time within their current positions as well as within the field of safety. The majority of respondents (n=39; 52%) reported employment in their current position for 10 or more years. Eight (10.7%) respondents

reported 7-9 years, 13 (17.3%) reported 4-6 years, 14 (18.7%) reported 1-3 years, and 1 (1.3%) reported less than 1 year in their current position. This suggests at least some degree of stability within safety leadership positions in universities. Ninety-three percent (93%; n=70) of respondents reported 10 or more years total in the EHS profession. Three respondents (4%) reported 7-9 years while 2 (2.7%) reported 1-3 years of experience in their current profession. The findings suggest that a majority of EHS directors in public research universities have a long-term commitment to that profession.

Fifty-two respondents (n=52; 69.3%) reported achieving at least one professional certification while 23 (30.7%) reported no current certifications. The most frequently reported certifications among the 52 certified respondents were Certified Industrial Hygienist (n=17; 32.7%); Certified Safety Professional (n=13; 25%); Certified Hazardous Material Manager (n=12; 23.1%); and Registered Sanitarian (n=7; 13.5%). Twenty-four other certifications that were not listed on the survey were reported. This was an expected finding because of the breadth of academic backgrounds, however there were no clear descriptive trends among these responses, so those additional findings are not reported here.

Ninety-two percent (n=69) of the 75 respondents reported membership in at least one professional organization. Forty-five percent (45%; n=34) of respondents reported affiliation with at least one other professional organization. One individual respondent reported that survey responses were selected based on all staff affiliations not just that of the individual respondent. This represented a challenge in interpreting the responses. The most frequently reported professional organizational affiliations

were CSHEMA[1] (n=64; 85%); AIHA[2] (n=23; 31%); and ASSE[3] (n=18; 24%). Many other professional affiliations not listed in the survey were reported in the open-ended survey question provided at the end of the option check off but are not reported here.

Table 4.4 below displays salary range according to gender. Among all respondents, more than one-half reported their salaries to be $80,000 or greater (n=48; 64%). Sixty-seven percent (67%) of males and 54% of female respondents were within this salary group. Ten respondents (n=10; 13.3%) reported their salaries in the $70,000-$79,999 range. Eight respondents (10.7%) reported a salary in the range of $60,000-$69,999. Five respondents reported salaries between $50,000-$59,999; 3 reported less than $49,999. While 67% of males and 54% of females reported a salary greater than $80K, it is difficult to draw conclusions because of the low number of female (n=13; 17.3%) respondents relative to males (n=62; 82.7%).

Table 4.4 Salary Range and Gender

	<$50K	**$50-59K**	**$60-69K**	**$70-79K**	**≥$80K**	**Total**
Male	N=2; 3%	N=5; 8%	N=5; 8%	N=8; 13%	N=41; 67%	N=61; 100%
Female	N=1; 8%	N=0	N=3; 23%	N=2; 15%	N=7; 54%	N=13; 100%
Total	N=3; 4%	N=5; 7%	N=8; 11%	N=10; 14%	N=48; 65%	N=74; 100%

Table 4.5 below displays salary ranges within each of the three Carnegie research classifications. As is evident in the table, number (and percentages) of reported salary ranges above $80K increase with increasing complexity and intensity

[1] CSHEMA--Campus Safety Health and Environmental Management Association
[2] AIHA--American Industrial Hygiene Association
[3] ASSE – American Society of Safety Engineers

of research level, i.e., 25% (n=3) of Research (R) level respondents report a >$80K salary; 48.2% (n=13) of High Research (HR) level university respondents reported a >$80K salary; and 91.4% (n=32) of Very High Research (VHR) level university respondents reported a >80K salary.

Table 4.5 Salary Range and Carnegie Classification

	<$50K	$50-59K	$60-69K	$70-79K	≥$80K	Total
Carnegie: Very High Research	N=0	N=0	N=1 2.9%	N=2 5.7%	N=32 91.4%	N=35 100%
Carnegie: High Research	N=1	N=4 14.8%	N=3 11.1%	N=6 22.2%	N=13 48.2%	N=27 100%
Carnegie: Research	N=2 16.7%	N=1 8.3%	N=4 33.3%	N=2 16.7%	N=3 25%	N=12 100%
Total	N=3	N=5	N=8	N=10	N=48	N=74

Table 4.6 displays salary range and Lombardi Top 25 institutions. Seven of the 75 respondents were from Lombardi ranked Top 25 Public Research Universities. The reported salary for all 100% of the Lombardi Top 25 ranked institutions was equal to or greater than $80,000. In contrast, 61% of respondents from institutions not ranked in the Lombardi Top 25 list reported salary equal to or greater than $80K.

Table 4.6 Salary Range and Lombardi Top 25 Ranking

	<50K	$50-59K	$60-69K	$70-79K	≥$80K	Total
Lombardi Top 25 ranked--Yes	N=0	N=0	N=0	N=0	N=7; 100%	N=7; 100%
Lombardi Top 25 ranked--No	N=3; 5%	N=5; 8%	N=8; 12%	N=10; 15%	N=41; 61%	N=67; 100%
Total	N=3	N=5	N=8	N=10	N=48	N=74

Safety Function Budget Trends

Table 4.7 below displays the data profile of all 75 respondents regarding budget trends examining both the current and next fiscal year. Thirty-two percent (n=24; 32%) of respondents reported that they received an increase in the current

fiscal year and will receive an increase in the next. Eleven (n=11; 15%) respondents reported an increase in the current fiscal year and no change for the next fiscal year. Eleven (n=11; 15%) respondents reported no change this fiscal year and the same for the next. Three (n=3; 4%) institutions received decreased budgets two years in succession. For the next fiscal year, 44% (n=33) of the survey population reported that their function would receive an increase, 33% (n=25) reported no change, and 9.3% (n=7) reported a planned decrease in budget. The findings indicate that of the respondents provided with adequate data from their institutions (n=65), slightly more than 50% (n=33) of those will receive a budget increase in the next fiscal year. In contrast, 10.8% expect a budget decrease.

Table 4.7 Safety Function Budget Trend

Budget Trend	Next FY-Increase	Next FY-Decrease	Next FY-No Change	Next FY-Unsure	Total
Current FY-Increase	N=24	N=0	N=11	N=2	N=37
Current FY-Decrease	N=3	N=3	N=2	N=0	N=8
Current FY-No Change	N=5	N=4	N=11	N=8	N=28
Current FY-Unsure	N=1	N=0	N=1	N=0	N=2
Total	N=33	N=7	N=25	N=10	N=75

Staffing and Budget Ratios

Respondents were asked to provide the full time equivalent (FTE) staffing numbers for the safety function, budget for current fiscal year, and FTE sum of faculty, staff and students for each individual institution. Calculations were performed on these data to create two separate series of ratios that were subsequently re-coded into variables. The two distinct series of ratios included 1) five EHS staff FTE to institutional FTE ratios in a series ranging from 1 safety FTE to $\leq$ 2,000 institutional FTE to 1 safety FTE to > 5,000 institutional FTE; and 2) three EHS budget dollars to

institutional FTE ratios in a series ranging from ≤$40 safety budget per institutional FTE to >$80 safety budget per institutional FTE.

Dividing the institutional population by the number of EHS staff created the staffing ratios. The series of five staffing ratios were re-coded[4] and corresponding variables were created in SPSS. Information regarding number of staff and campus population not provided by respondents was harvested from institutional websites, if available. A ratio of 1 to ≤2000 would indicate a denser number of safety staff per institutional population. In contrast, a ratio of 1 to >5000 would indicate a sparser number of safety staff per institutional population.

Table 4.8 below displays an abbreviation of the converted staffing ratios as found within the Carnegie classification system. Approximately three-quarters of respondents (74.3%) of Very High Research classified universities reported a high-density ratio of 1 to ≤2000. Between 35% and 36% of High Research and 8.3% of Research characterized <respondents would be classified as possessing a high-density ratio of 1 to ≤2,000. In regard to the Lombardi Top 25 universities, five of the seven respondent universities reported a ratio of 1 to ≤2000. The remaining two universities reported a ratio of 1 to ≤3,000. All seven are within the higher density end of the continuum.

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[4] The re-coding format for staffing ratio was as follows: 1 = less than or equal to 1 safety FTE to 2000 institutional population (1 = 1 to ≤2000); 2 = greater than 2000 but less than 1 safety FTE to 3000 institutional population (2 = 1 to >2000 and ≤3000); 3 = greater than 3000 but less than 1 safety FTE to 4000 institutional population (3 = 1 to >3000 and ≤4000); 4 = less than 1 safety FTE to 5000 institutional population (4 = 1 to >4000 and ≤5000); and 5 = 1 safety FTE to greater than 5000 institutional population (5 = 1 to >5000).

Table 4.8 EHS Staffing to Institutional Population Ratio Across Carnegie Classifications

N=75	Carnegie-VHR	Carnegie-HR	Carnegie-R
1 to ≤2000	N=26; 74.3%	N=10; 35.7%	N=1; 8.3%
1 to ≤3000	N=5; 14.3%	N=8; 28.6%	N=4; 33.3%
1 to ≤4000	N=1; 2.9%	N=3; 10.7%	N=0; 0
1 to ≤5000	N=2; 5.7%	N=4; 14.4%	N=1; 8.3%
1 to >5000	N=1; 2.9%	N=3; 10.7%	N=6; 50%
Total	N=35; 100%	N=28; 100%	N=12; 100%

Similarly, a budget ratio was calculated by dividing the total EHS budget by the institutional population. The resulting series of three ratios include a low EHS investment of less than $40 per institutional FTE; a moderate investment of between $40 and $80 per institutional FTE; and a high investment of greater than $80 per institutional FTE. The 69 of 75 cases without missing data were re-coded[5] in SPSS to reflect the calculated ratios.

Table 4.9 below displays the Carnegie classification of cases and their respective budget ratio groupings. Nearly 75% of respondents representing Very High Research institutions reported either high or moderate EHS function investment based on institutional population. Approximately 33% of respondents from High Research classified universities report either high or moderate investment while no Research classified institutions reported budget expenditures for the safety function within either the high or moderate category. Six of seven L25 university directors responded to the question. There were two (33.3%) Lombardi Top 25 institutions in each of the three budget ratio categories. Similar to the staffing ratio, the investment per FTE

[5] The recoding format for the budget ratio was as follows: 1 = less than $40 per institutional population (1= <$40/FTE); 2 = greater than or equal to $40 but less than or equal to $80 per institutional population (2 = ≥ $40 ≤ $80/FTE); and 3 = greater than $80 per institutional population (3 = > $80/FTE).

follows a similar trend, i.e., VHR institutions in general, spend more money on safety infrastructure compared to HR and R Carnegie classifications.

Table 4.9 EHS Budget to Institutional Population Ratio Across Carnegie Classifications

EHS$/FTE	Carnegie-VHR	Carnegie-HR	Carnegie-R
< $40	N=9; 26.5%	N=16; 66.7%	N=9; 81.8%
$40 to $80	N=17; 50%	N=4; 16.7%	N=2; 18.2%
> $80	N=8; 23.5%	N=4; 16.7%	N=0
Total	N=34; 100%	N=24; 100%	N=11; 100%

Facilitators and Barriers

Table 4.10 below displays the affirmative responses when the survey population was presented with a list of options and asked to characterize the listed factors in terms of each one serving as a "facilitator" or "barrier" to the success of EHS function within their larger organization. Executive support, EHS staffing level, and respect of faculty categories elicited the highest response rates overall. The nature of academia, EHS staffing levels, operating budget, and salaries for staff were identified as the main barriers with the highest number of responses. The respondents identified respect of the faculty, executive support, scope of authority, and ability to make change as the greatest facilitators of EHS success.

Table 4.10 Reported Facilitators and Barriers to Safety Function Success

	Facilitator	Barrier	Total Responses
Executive Support	40	23	63
EHS Staffing Level	15	46	61
Respect of the Faculty	44	9	53
Nature of Academia	4	47	51
Scope of Authority	31	18	49
Operating Budget	11	35	46
Ability to Make Change	21	21	42
Salaries for Staff	8	28	36
Other Resources	12	12	24

Forty-six of 75 respondents (61%) affirmed that an institutional entity (individual or group) served in the role of champion for the safety function within that particular institution. Of the 46 respondents affirming at least one champion, 38 (83%) characterized the explicit supporter as an institutional executive or administrator. One of the 46 (2%) respondents characterized the champion as a faculty leader. Three respondents (6.5%) characterized the champion as other management staff.

Safety Governance Profiles

General Safety Committees

Two-thirds of respondents (n=50; 66.7%) affirmed the presence of a general safety committee at their campus. Table 4.11 displays the presence of general safety committees across the Carnegie classified research institutions. It shows that more than 50% but less than 75% of respondents from each Carnegie classification reported the presence of a general safety committee.

Table 4.11 Presence of a General Safety Committee Across Carnegie Classifications

N=50	Present	Absent	Total
Carnegie VHR	N=25; 71.4%	N=10; 28.6%	N=35; 100%
Carnegie HR	N=17; 60.7%	N=11; 39.3%	N=28; 100%
Carnegie R	N=8; 66.7%	N=4; 33.3%	N=12; 100%

Other Safety-Related Committees

Respondents were asked about the presence of other specific safety-related governance bodies on their campuses. All 75 (100%) of the safety function managers responded. Table 4.12 below displays the number and percentage of committees

present across the 75 institutions. Animal Care, Radiation Safety, and Biological Safety were the most commonly reported. In contrast, committees representing Security, EHS Policy, and Laboratory Safety were the least reported across the 75 campuses.

Table 4.12 Specific Types of Safety Governance Bodies

Committee Type N=75	Present	Absent
Animal Care	N=72; 96%	N=3; 4%
Radiation Safety	N=71; 94.7%	N=4; 5.3%
Biological Safety	N=68; 90.7%	N=7; 9.3%
Emergency Management	N=48; 64%	N=27; 36%
Sustainability	N=39; 52%	N=36; 48%
Laboratory Safety	N=35; 46.7%	N=40; 53.3%
EHS Policy	N=21; 28%	N=54; 72%
Security	N=20; 26.7%	N=55; 73.3%
Laser Safety	N=18; 24%	N=57; 76%

Table 4.13 below presents affirmative responses regarding specific safety governance bodies within each of the Carnegie classifications. In general, institutions classified as Very High Research reported the highest within group percentages for the presence of topic-specific safety-related governance bodies. The percentages generally trend downward from VHR to HR to R. Numbers are reported within each Carnegie group.

Table 4.13 Safety Governance Type Across Carnegie Classifications

	Very High Research Present-Yes (n=35)	High Research Present-Yes (n=28)	Research Present-Yes (n=12)
Radiation Safety	N=35; 100%	N=25; 89.3%	N=11; 91.7%
Laser Safety	N=11; 31.4%	N=5; 17.9%	N=2; 11.1%
Laboratory Safety	N=20; 57.1%	N=10; 35.7%	N=7; 58.3%
Animal Care	N=35; 100%	N=28; 100%	N=9; 75%
Biological Safety	N=35; 100%	N=26; 92.9%	N=7; 58.3%
Security	N=12; 34.3%	N=6; 21.4%	N=2; 16.7%
Emergency Management	N=22; 62.9%	N=20; 71.4%	N=6; 50%
EHS Policy	N=13; 37.1%	N=6; 21.4%	N=2; 16.7%
Sustainability	N=24; 68.6%	N=12; 42.9%	N=3; 25.0%

Safety Committee Relationships

Respondents were asked to select one statement from a list of options provided regarding the relationship among safety-related committees. Table 4.14 displays the list of statement options that form a continuum from very independent to very formal interactions and oversight. The majority of respondents identified their safety governance sub-systems as operating toward the independent, autonomous end of the continuum distanced from a more formal systemic approach. Interestingly, but not unexpected, all five of the institutions reporting their safety governance structures and processes as having formal and regular interactions and an overarching policy committee were within the Very High Research classification.

Table 4.14 Continuum of Relationships Among Safety Governance Bodies

	Frequency	Percent
Each committee operates autonomously	N=17	22.7%
Some informal interactions among committees as needed	N=31	41.3%
Regular informal interactions	N=13	17.3%
Regular formal interactions	N=9	12.0%
Regular formal interactions and a macro policy committee	N=5	6.7%
Total	N=75	100%

Determine the Degree of HRO Capacity in Public Research Universities--Sub-Problem Task 1

A set of survey statements (including 45 a, b, e, f and 46 a through p) was constructed to gather the respondents' perceptions regarding their respective institutions. The twenty statements were adapted from the existing literature on high reliability organizations and revised to examine universities from the EHS director perspective. Each item was linked to one of the five HRO characteristics based on both the description of the characteristics in Weick and Sutcliffe (2001) and the review

of items developed and linked in previous studies (Venette, 2003; Barrett et al., 2006; Hoy et al., 2006). Two of the questions were reverse-phrased to reduce response bias. The responses for the reverse-phrased questions were reverse-coded prior to further analysis to ensure a positive covariance between reverse-phrased items and other items (Field, 2005). The panel of statements was constructed with 5 Likert-type response options ranging from strongly agree scored as 5 to strongly disagree scored as 1. Frequency data for the 20 HRO items are presented in Table 4.15 below.

The 20 items were tested for reliability using Cronbach's alpha. The overall alpha suggested high reliability at .920. The item managers including faculty are concerned about making high-risk errors had a corrected item-total correlation of less than .3 suggesting that consideration should be given to dropping the item. The item was dropped. In addition, the two items with reverse-phrasing based on HRO theory expected to follow standard operating procedures and errors are reported in simplistic terms were both negative regarding corrected item-total correlation with reverse-coding suggesting that the phrasing of the items may have lacked clarity. In examining the frequencies for all items, these two items, when reversed, trended in the opposite direction from the other items. These two items were also dropped. As a result, 17 of 20 items were retained from the original set. Cronbach's alpha for the 17 remaining items was strong at .916 suggesting high reliability among the remaining items. After dropping 3 items, the number of items used per characteristic was changed from four to less than four for three of the five HRO characteristics. Dropped items are displayed in italics in Table 4.15 below.

Table 4.15 HRO Characteristics and Corresponding Survey Items

HRO Characteristics	HRO Items Composing the Five Characteristics
Preoccupation with failure	1. Administrators are very concerned about making high-risk errors. *2. Managers including faculty are very concerned about making high-risk errors (dropped)* 3. University members feel comfortable reporting errors and adverse events 4. Analyzed errors are viewed as learning opportunities.
Reluctance to simplify	1.There is a supported and active safety network *2.Analysed errors and adverse events are reported in simplistic terms. (dropped)* 3. Mutual respect is evident when diverse opinions are expressed. 4. Recommendations by a safety committee are given careful consideration.
Sensitivity to operations	1.Employees at all levels are empowered to initiate and achieve safety improvements 2.Managers/Faculty have active access to training regarding role and accountability 3.Interdeparmental collaboration is encouraged to address shared safety issues. 4. Administrators consistently provide adequate resources to support safety activities.
Commitment to resilience	1.The creation of a new committee to address an emerging safety issue would be supported. 2.Administrators at this university regard safety as a core value. 3.Planning for emergencies engages individuals from across the university. 4. Skill and knowledge development for safety decision-making is a priority.
Deference to expertise	1.My opinions as safety director are taken into account in the daily operations. 2.My staff is recognized as safety experts. *3.All employees are expected to follow standard operating procedures without question. (Dropped)* 4. My department is a trusted resource.

The data for the 17 remaining items were summed across each case and used to develop an index, or overall composite score, to represent a perceived degree of reliability for each public institution as reported by the respondent representing that institution, the safety function director. Because there were 17 questions with a Likert-type scale ranging from 1 to 5, the range for the index was 17 to 85. A score of 17 would represent the perception that the university operates at a low degree of reliability based on high reliability organization characteristics. In contrast, a score of

85 would represent the perception that the decision-making context of the university closely aligns with high reliability organization characteristics. Indices have been used by Venette (2003) to analyze perceptions of HRO characteristics.

Table 4.16 displays the aggregated descriptive data reflecting the 17 high reliability organization characteristics arranged in order of descending mean value. The highest level of agreement (highest mean) was found in the following items: EHS is a trusted resource (item 1), EHS staff recognized as experts (item 2), and administrators have concern for making high-risk errors (item 3). In reference to the five characteristics of HROs as presented in Weick and Sutcliffe (2001; 2007), the results suggest that public research universities tend to exhibit positive responses within the dimensions of preoccupation with failure (item 3) and deference to expertise (items 1 and 2). University executives were perceived as placing a high degree of emphasis on reducing complacency and increasing vigilance to any threat to institutional resources. In addition, the perception of respondents suggests that the safety function was perceived as an enabling force in reducing risk.

Referring to Table 4.16 below, the lowest level of agreement was found in the following items: administrators consistently provide adequate resources to support safety development and implementation activities (item 17), the creation of a new committee to address an emerging safety issue would be supported (item 16), and knowledge development for individuals relevant to safety decision-making is a priority (item 15). In regard to HRO characteristics, the items with lower levels of agreement suggest that public research universities have less capacity in regard to dimensions within sensitivity to operations (items 17), and commitment to resilience

(item 15 and item 16). The lower score for item 17, safety function resource adequacy, suggests a potential disconnect between university administrators' view of "loopholes in the system defense, barriers and safeguards..." and the safety function directors' view (Weick & Sutcliffe, 2001; p.13). The diminished response scores for items 15 and 16 below, enhancement of safety decision-making and creation of an emergent committee, suggest a low level of commitment for investing in deep knowledge for rapid recovery from unanticipated events through "intelligent reaction and improvisation" (Weick & Sutcliffe, 2001; p. 67).

Table 4.16 Descriptive Statistics for HRO Section

N=73	Mean	Mode
1. My departmental staff are recognized as experts.	4.18	4
2. EHS is a trusted resource.	4.17	4
3. Administrators are concerned about making high-risk errors.	4.09	4
4. The activity of planning for emergencies actively engages individuals from across this university.	3.84	4
5. My opinions are taken into account in daily operations.	3.72	4
6. Mutual respect is evident when diverse opinions are expressed.	3.71	4
7. Managers (including faculty) have active access to specific training that informs them of their role and accountability for safety.	3.71	4
8. Interdepartmental collaboration is encouraged to address shared safety issues.	3.53	4
9. Administrators regard health and safety as a core value.	3.51	4
10. University members feel comfortable reporting errors.	3.44	4
11. Employees at all levels are empowered to initiate safety change.	3.44	4
12. Recommendations by a safety committee to the university are given careful consideration.	3.37	3
13. There is a supported and active safety network.	3.33	4
14. Analyzed errors are viewed as learning opportunities.	3.32	4
15. Skill development relevant to safety decision-making is a priority.	3.29	4
16. The creation of a new committee to address an emerging safety issue would be supported.	3.24	4
17. Administrators consistently provide adequate resources to safety.	3.19	4

Figure 4.1 below presents the frequency distribution of high reliability organization index scores based on 73 responses. Two cases contained missing data and were excluded from the table. The scores range from 27 at the low end of the

index to 81 at the high end of the index. The bar chart in Table 4.16 presents the frequency of scores (y-axis) with scores summed into groups (x-axis). The cut point for dividing the frequency distribution of the 73 valid cases (cases with no missing data) into 2 groups of cases was determined using SPSS v.15.0. The cut point was calculated to be 63. The dichotomized HRO Index can be described as 1) a high degree of HRO characteristics would have scores equal to or greater than 63; and 2) a low degree of high reliability characteristics would have scores less than 63. The variable was re-coded in SPSS to reflect the dichotomy.

Figure 4.1 Frequency Distribution of HRO Index Scores

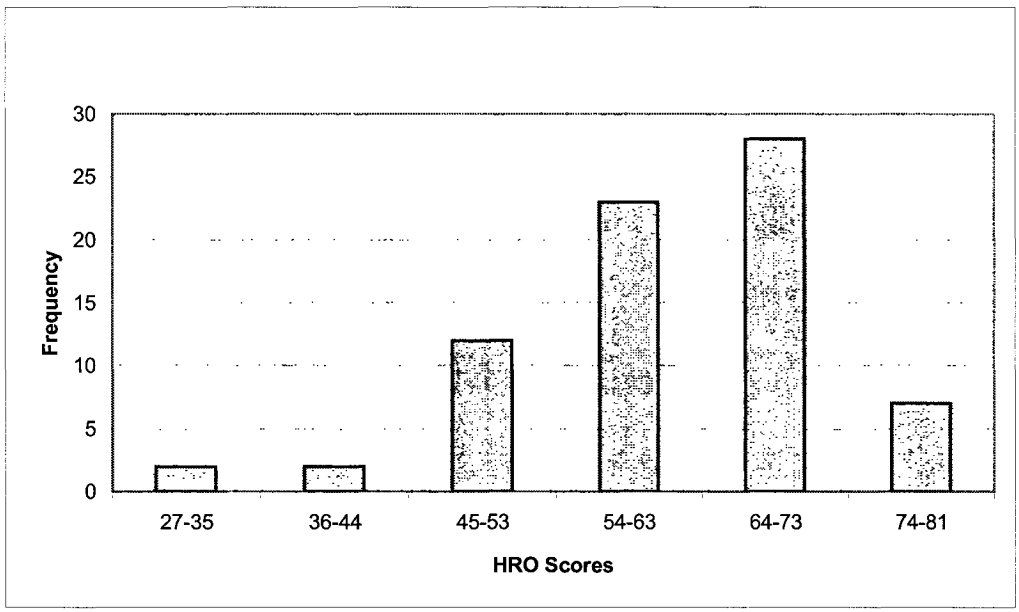


Table 4.17 below further explicates the findings using the dichotomized data of the HRO Index applied across the Carnegie classifications. As seen in the following table, slightly less than 50% of VHR institutions scored in the high category on the HRO Index (n=17; 48.6%). Slightly greater than 50% (n=14; 53.8%) of HR

institutions scored high on the HRO Index and 50% (n=6) of R institutions scored high. These findings suggest that the Carnegie classification in public research universities does not predict HRO capacity.

Table 4.17 Level of HRO Characteristics in Public Research Universities

	High Degree--HRO Index	Low Degree--HRO Index	Total
Carnegie VHR	N=17; 48.6%	N=18; 51.4%	N=35; 100%
Carnegie HR	N=14; 53.8%	N=12; 46.2%	N=26; 100%
Carnegie R	N=6; 50%	N=6; 50%	N=12; 100%
Total	N=37	N=36	N=73

In sum, approximately 50% of the institutions in each Carnegie classification were characterized as possessing a high degree of HRO capacity and 50% possessed a low degree of HRO capacity. This finding suggests that research classification does not determine the HRO capacity of a public research university. However, in regard to the seven Lombardi Top 25 institutions (a subset of Carnegie VHR classifications), five scored high on the HRO index while two institutions scored low. This suggests that a higher percentage of universities that are within the Lombardi Top 25 ranking tend to exhibit a higher degree of HRO capacity.

Summary Sub-Problem Task 1

In order to solve the sub-problem task, an HRO Index was developed from the specified group of survey items, tested for inter-item correlation and overall reliability, which resulted in three low reliability items being dropped, and summed for each university with no missing data (n=73). The index was developed and dichotomized into two categories: 1) high degree, and 2) low degree. Each respondent institution

was placed in one of the two categories based on HRO index score (high = ≥ 63 HRO Index score; low = < 63 HRO Index score). In addition to the evenly divided distribution of high and low degree of HRO capacity across Carnegie classifications (Table 4.17), the wide distribution of HRO Index frequencies corroborates the literature (Chapter II) regarding the diversity of unique organizational contexts found in universities.

Determine the Degree of Relationship/Coupling Present in Public Research Universities--Sub-Problem Task 2

Survey statements 44a through 44j were constructed to gain insights into safety function directors' level of satisfaction with facets of relationships among supra-system and system elements. The 10 statements were developed to examine a combination of both the vertical and horizontal elements of a university environment and the relationship of the safety function within that context. A 5-point Likert-type scale was used with responses ranging from 5 = very satisfied to 1 = very dissatisfied. A not applicable (NA) option was also provided.

Table 4.18 below presents the aggregate data representing safety function directors' level of satisfaction with horizontal and vertical relationships. The table is arranged in descending order of aggregated level of satisfaction (the sum percentages of very satisfied and somewhat satisfied). The items with the highest level of total satisfaction in descending order include support from direct supervisor (83.8%), collaboration with peers at other in state universities (79%), relationship with research groups (78.4%), communication with administrators (67.6%), and support from

administrators (63.5%). The combination of somewhat dissatisfied and very dissatisfied responses included support from the state system of higher education (32.5%), communication with faculty leaders (29.7%), support from university administrators (27%), and communication with administrators (24.3%) as items with the lowest level of satisfaction.

Table 4.18 Reported Level of Satisfaction with System and Supra-System Relationships

N=74	Very Satisfied	Somewhat Satisfied	Neutral	Somewhat Dis-satisfied	Very Dis-satisfied	NA
1. Support from direct supervisor	N=38 51.4%	N=24 32.4%	N=4 5.4%	N=5 6.8%	N=3 4.1%	N=0
2. Collaboration with other state universities	N=42 56%	N=17 23%	N=9 12.2%	N=4 5.4%	N=2 2.7%	N=0
3. Relationship with research groups	N=21 28.4%	N=37 50%	N=6 8.1%	N=8 10.8%	N=2 2.7%	N=0
4. Communication with administrators	N=29 39.2%	N=21 28.4%	N=6 8.1%	N=12 16.2%	N=6 8.1%	N=0
5. Support from university administrators	N=25 33.8%	N=22 29.7%	N=7 9.5%	N=14 18.9%	N=6 8.1%	N=0
6. Relationship with state system	N=9 12.2%	N=22 29.7%	N=22 29.7%	N=7 9.5%	N=7 9.5%	N=7 9.5%
7. Support from state system of higher education	N=5 6.8%	N=15 20.3%	N=23 31.1%	N=11 14.9%	N=13 17.6%	N=7 9.5%
8. Support from academic leaders	N=5 6.8%	N=23 31.1%	N=32 43.2%	N=5 6.8%	N=9 12.2%	N=0
9. Support of safety coordinator program	N=6 8.2%	N=21 28.8%	N=16 21.9%	N=12 16.4%	N=3 4.1%	N=15 20.5 %
10. Communication with faculty leaders	N=2 2.7%	N=22 29.7%	N=27 36.5%	N=12 16.2%	N=10 13.5%	N=1 1.4%

An index similar to the HRO Index was created to represent safety function relationships. One statement with limited applicability across the respondent population was not included: support for a safety coordinator program since 20.5% of respondents indicated the absence of this type of program. In addition, responses to the

two statements representing the safety function relationship with the state system of higher education (supra-system) were analyzed separately since 9.5% of respondents reside in states where this response was not applicable. The remaining seven items were summed across each case (excluding cases with missing data) to create a relationship or coupling index.

Because there were seven questions with a Likert-type scale ranging from 1 to 5, the range for the index was 7 to 35. A score of 7 would represent a low level of satisfaction with safety function relationships within the larger institutional context. In contrast, a score of 35 would represent a high level of satisfaction with intra-system relationships. As noted above, indices have been used by Venette (2003) to analyze perceptions of HRO characteristics. This index is used to gather data regarding characteristics on a unique organizational environment. The reliability was established using Cronbach's alpha. The reliability of the index was high (alpha = 0.843). Corrected item-total correlation statistics for all seven items were greater than 0.3 suggesting that all items correlated well. For Cronbach's Alpha if deleted, six items were less than the overall alpha. One item was slightly above the overall alpha (alpha if deleted = 0.852), however, the item was retained since the inter-item correlation statistic was adequate
(i.e., >.3).

Table 4.19 below contains the mean and mode of the responses for the aggregated data from 74 respondents for each of the seven items representing the level of safety function satisfaction with the state of intra-institutional relationships or

coupling with sub-groups unique to universities. The items are arranged in descending order based on the mean.

Table 4.19 suggests that there was a high level of satisfaction as reported by the safety function director with dimensions of organizational coupling with other in-state institutional peers and the next level upward for reporting in the formal structure. There is a more modest level of satisfaction and more diverse range of satisfaction within the respondent population regarding safety function coupling with the two institutional administrator items (items 4 and 5). The lowest level of satisfaction was reflected with the two dimensions representing coupling with Faculty Senate and other faculty leaders (items 6 and 7). Overall, this suggests the presence of institutional barriers in many universities to the development of social networks, especially with the academic core, to enable informed decision-making in regard to managing risk.

Table 4.19 Descriptive Statistics for Institutional Relationships

N=74	Mean	Mode
1. Opportunity to collaborate with EHS directors at other universities within state.	4.3	5
2. Level of support from your direct supervisor.	4.2	5
3. Level of engagement between EHS and research.	3.9	4
4. Frequency of communication with university administrators.	3.7	5
5. Level of support from university administrators.	3.6	5
6. Level of support from faculty senate and other academic leaders.	3.1	3
7. Frequency of communication with faculty senate and academic leaders.	2.9	3

Figure 4.2 below presents the frequency of the relationship index scores. The range of scores ran from a low of 17 to a high of 39. A cut point of 33, as determined using SPSS v. 15.0, was used to divide the responses into two groups to dichotomize the scores. Scores less than or equal to 33 ($\leq$33) were recoded to represent low

satisfaction with intra-institutional relationships and scores greater than 33 (>33) were recoded to represent high level of satisfaction with intra-institutional system relationships. The wide distribution of the frequencies representing level of coupling of the safety function with sub-groups in the larger institution again reflects the diversity of unique institutional social environments found in universities.

Figure 4.2 Frequency Distribution of Relationship/Coupling Index Scores--System

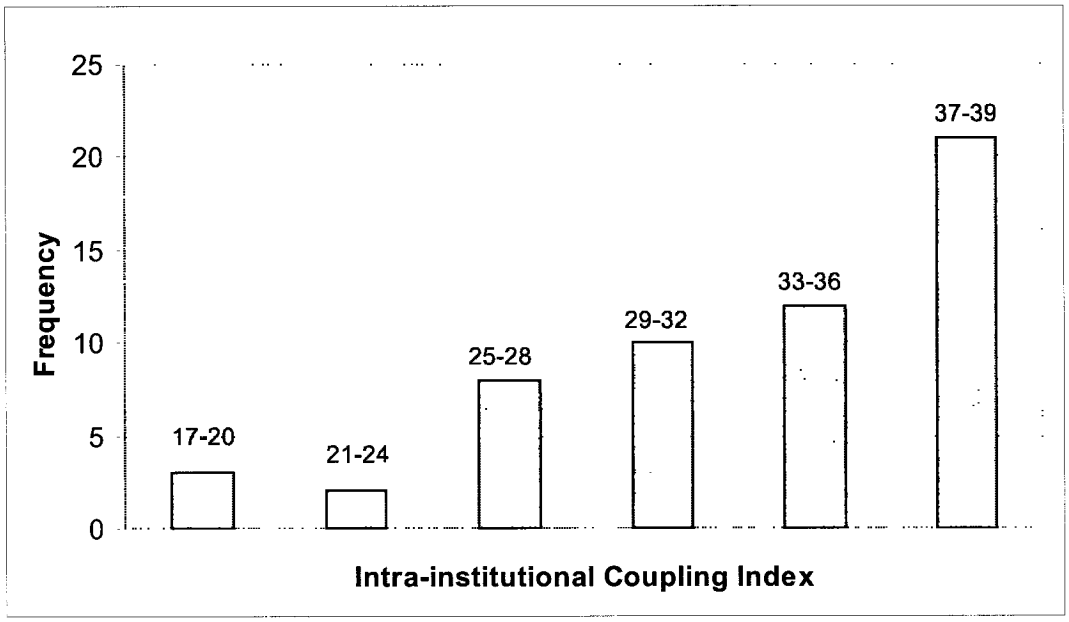


Table 4.20 below reports the level of coupling based on a dichotomized index of case sums for respondent institutions across the three Carnegie public research classifications. As demonstrated in the table, respondents in VHR classified universities were the only group that exceeded 50% of institutions scoring in the high level of coupling category (n=22; 64.7%). The HR and R scored 33.3% (n=9) and 41.7% (n=5) in the high coupling category, respectively. In regard to the Lombardi Top 25 institutions, all seven (100%) of the ranked institutions scored within the high

level of coupling category. In contrast to HRO capacity, coupling level does not appear to be consistent across Carnegie classifications.

Table 4.20 Level of Intra-Organizational Coupling in Public Universities

	High Degree—Coupling Index	Low Degree—Coupling Index	Total
Carnegie VHR	N=22; 64.7%	N=12; 35.3%	N=34; 100%
Carnegie HR	N=9; 33.3%	N=18; 66.7%	N=27; 100%
Carnegie R	N=5; 41.7%	N=7; 58.3%	N=12; 100%
Total	N=36	N=37	N=73

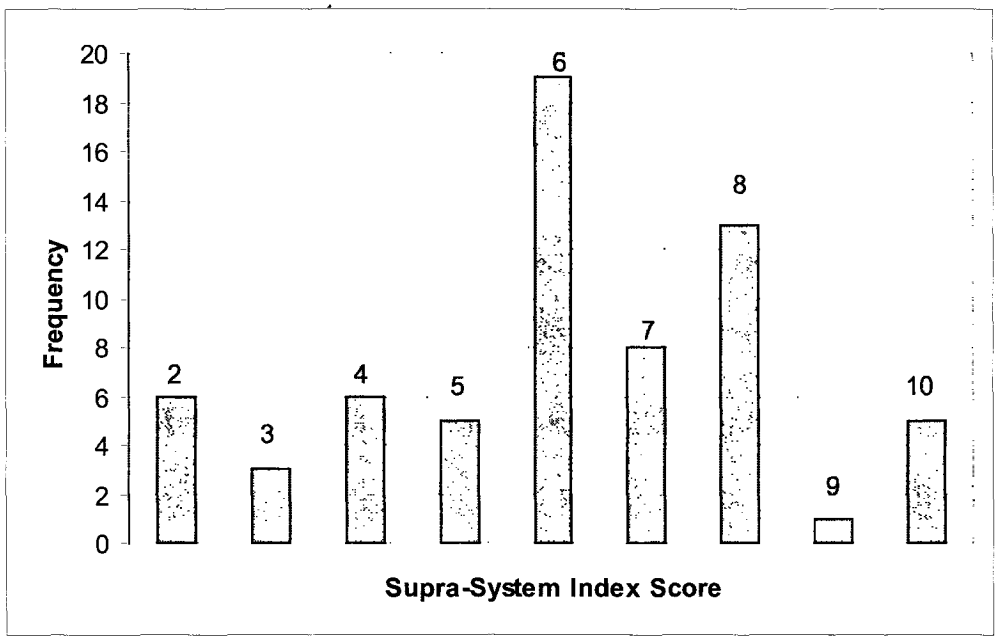
Public research universities may be embedded in a diversity of formal governance systems at the state level. Two system-relevant questions asking respondents to report their level of satisfaction with the following were extracted from the bank of questions regarding institutional relationships: 1) EHS relationship with the state system of higher education; and 2) state system of higher education support for EHS. The two items had a reliability of .820 suggesting high reliability.

Table 4.21 below presents level of satisfaction with supra-system relationships. There were 66 valid respondents who reported that their institutions were part of a larger system of higher education. Nine institutions reported not applicable for either one or both items including two cases with missing data and were, thus, excluded. As described in the previous section, the statement responses were structured using a 5-point Likert-type scale. The values of the responses ranged from 5 = very satisfied to 1 = very dissatisfied.

The scores were summed across the two items, 1) EHS relationship with state system of higher education; and 2) State system of higher education support for EHS. Scores ranged from 2 to 10. Cases with a response sum of 2 were very dissatisfied

with the supra-system relationship. In contrast, cases with a response sum of 10 were very satisfied with the supra-system relationship. Figure 4.3 displays the supra-system relationship/coupling index scores 2 through 10 on the x-axis. The y-axis displays the frequencies of the case scores within each range. For example, there were six cases with a score of 2 suggesting a low level of satisfaction with the supra-system relationship. In contrast, there were five cases with a score of 10 suggesting a high level of satisfaction with the supra-system relationship.

Figure 4.3 Frequency Distribution of Relationship/Coupling Index Scores—Supra-System



SPSS was used to determine the cut point of 6. Referring to the above table, case sums ≤ 6 reflect a low degree of satisfaction. In contrast, case sums > 6 reflect respondents reporting a high degree of satisfaction with supra-system relationships. The dichotomous variable was recoded in SPSS as 2 = cases ≤ 6 and 1 = cases >6.

Table 4.21 below presents the data reflecting the level of supra-system coupling with the safety function as reported by safety director respondents across Carnegie classifications. The table shows that less than 50% of respondents in each Carnegie classification reported a high degree of satisfaction with their supra-system coupling. However, it should be noted as a limitation that the cut point at 6, where the 50th percentile fell, has 19 cases distributing the number of cases n=27 and n=39 in the high and low categories, respectively.

Table 4.21 Level of Supra-System Coupling in Public Research Universities

	High Degree—Supra-System Coupling	Low Degree—Supra-System Coupling	Total
Carnegie VHR	N=14; 46.7%	N=16; 53.3%	N=30; 100%
Carnegie HR	N=9; 37.5%	N=15; 62.5%	N=24; 100%
Carnegie R	N=4; 33.3%	N=8; 66.7%	N=12, 100%
Total	N=27	N=39	N=66

Summary of Sub-Problem Task 2

In order to solve the sub-problem task, two Relationship/Coupling Indexes were developed. One index reflected the safety function coupling with system (intra-institutional) subgroups. The second index showed coupling with the supra-system. Similar to the HRO Index, coupling indexes were developed from a specified group of survey items, tested for inter-item correlation and overall reliability, and summed for each university (n=74 system-level and n=66 at the supra-system level). The system index was dichotomized into the following categories: 1) high degree of intra-institutional coupling; and 2) low degree of intra-institutional coupling. Each respondent institution was placed in one of the two categories based on the intra-institutional index score (high = >33; low = ≤ 33). The supra-system index was

dichotomized into the following categories: 1) high degree of supra-system coupling; and 2) low degree of supra system coupling (high = > 6; low =≤ 6).

There was a wide distribution of the coupling index frequencies across the Carnegie classifications. The success of relationships with the academic core for the safety function was reported as limited. Carnegie VHR institutions appear to demonstrate a higher level of satisfaction with both system and supra-system relationships. However, a majority of respondents in each group reported a low degree of satisfaction with the relationship between the safety function and their state system.

Determine the Degree of Safety Governance Capacity in Public Research Universities--Sub-Problem Task 3

Fifty of 75 respondents (n=50; 66.7%) reported that their campus had a general safety committee. A skip pattern was used in the survey so that only those with a positive response to the presence of a general safety committee would advance to answer a series of statements. The purpose of these survey questions was to elicit responses regarding the level of agreement with 13 statements relevant to the activities of the committee and relationship with the larger organizational system and its elements. The 5-point Likert responses were scored as in previous sections: 5 =strongly agree through 1 = strongly disagree. Item 6 was reverse-phrased to reduce response bias.

Frequencies of responses for the 13 statements were examined. Table 4.22 displays the 13 statements in abbreviated form along with the mean for the responses of the aggregate data in descending order based on the mean.

As noted in Table 4.22 below, non academic participation, success in creating change, recommendations presented to the top executive, and active engagement of relevant stakeholders to solve safety issues have the highest level of agreement among respondents. In contrast, acknowledged as a major voice, waits for problems to present, senior executive involvement, high visibility, and production of an annual report have the lowest level of agreement.

Table 4.22 Descriptive Statistics for General Safety Committee Characteristics

N=50	Mean	Mode
1. Non Academic Departments Actively Participate	3.74	4
2. Successful Creating Change	3.54	4
3. Recommendations To Top Executive	3.50	4
4. Actively Engage Relevant Stakeholders	3.50	4
5. Minutes Available	3.48	4
6. *Active Discovery of Problems (Dropped)*	3.26	4
7. Timely Response to Committee from Administration	3.22	4
8. Academic Departments Actively Participate	3.16	4
9. Safety Committee is viewed as a Major Voice	2.98	4
10. Waits for Problem to be Presented (reversed-phrased)	2.94	4
11. Senior Administration Actively Involved	2.84	4 and 2
12. *Safety Committee has High Visibility (Dropped)*	2.62	3
13. *Safety Committee provides an Annual Report (Dropped)*	2.58	2

The aggregate data suggest that participation in the general safety committee is stronger among non-academic staff from the administrative shell and lower among the faculty core. This finding suggests the potential for a limited variety of issues brought to the attention of the institutional safety committees especially with the reported lack of visibility across institutions. The respondents, in general, reported that committees are effective at initiating change but lack a major voice within the institutions. The success in initiating change may be related to the higher level of agreement with the concept that committees themselves provide a platform to actively seek out safety

issues and arrange conversations with stakeholders to mitigate problems rather than statically waiting for issues to be reported.

Cronbach's alpha, used to test reliability for the 13 general safety committee items, was .869 with all 13 items indicating good reliability. This statistic reflects reverse coding of reverse-phrased statement 6 waits for problem to present. However, items 6, 12, and 13 had inter-item correlations below .3 and the alpha if deleted for each item was greater than the overall alpha (.876, .877, and .880, respectively). Therefore, items 6, 12 and 13 were deleted. The remaining 10 items were analyzed using SPSS and the new Cronbach's alpha was .898 with all inter-item correlations greater than .3. Deleting the 3 items improved the overall reliability as well as the inter-item correlation.

The remaining 10 items were summed across each of the 50 cases to develop an index, or overall composite score, to represent a perceived degree of safety committee effectiveness for each public institution as reported by the respondent representing that institution, the safety function director. Because there were 10 questions with a Likert-type scale ranging from 1 to 5, the range for the index is 10 to 50. A score of 10 would represent the perception that the general safety committee operates at a low degree of effectiveness based on unique safety governance characteristics. In contrast, a score of 50 would represent the perception that the general safety governance of the university closely aligns with positive effectiveness characteristics. Indices have been used by Venette (2003) to analyze perceptions of various organizational characteristics.

Figure 4.4 displays the case sum scores and frequency distribution of the scores across the 50 cases. The x-axis represents groupings of index scores between 11 and 48. The y-axis represents the frequency of scores within the individual groupings. For example, there was one university that scored between 11 and 15 on the index.

SPSS was used to determine the cut point of 33.5 to divide the distribution into two equal groups. The dichotomized index may be interpreted as scores < 33.5 reflect a low degree of safety governance effectiveness. In contrast, scores > 33.5 reflect a high degree of safety governance effectiveness.

Figure 4.4 Frequency Distribution of General Safety Committee Index Scores

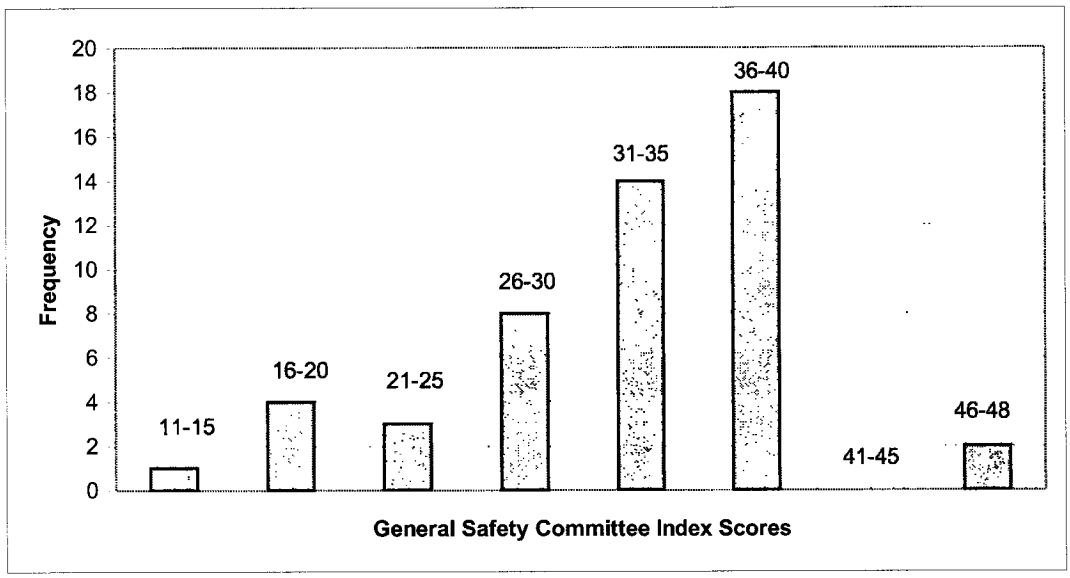


Table 4.23 below displays the response findings for safety governance capacity by respondents whose institutions were reported to have general safety committees. Respondents from both Carnegie VHR and HR reported greater than 50% of their institutions function within the high range of the governance index (VHR n=13, 52%;

HR n=9, 52.9%). However, Carnegie R level respondents reported the lowest performance at less than 40% within the high range of the index (n=3; 37.5%).

Table 4.23 Level of Safety Governance Capacity Across Carnegie Classifications

	High Degree—Safety Governance Index	Low Degree—Safety Governance Index	Total
Carnegie VHR	N=13; 52%	N=12; 48%	N=25; 100%
Carnegie HR	N=9; 52.9%	N=8; 47.1%	N=17; 100%
Carnegie R	N=3; 37.5%	N=5; 62.5%	N=8, 100%
Total	N=25	N=25	N=50

Table 4.24 below presents the relationship of degree of reliability with the presence or absence of a general safety committee and the high and low scoring category on the governance index. Using the dichotomized variables for both the HRO Index and Governance Index, a 2 X 2 table was created. To examine whether or not there is an association between the two categorical variables a chi-square analysis was run on SPSS. All cells met the assumption that expected counts for each were greater than 5.

Table 4.24 HRO Index X Safety Governance Index

	High Degree—Safety Governance Index	Low Degree—Safety Governance Index	Total
High Degree—HRO Index	N=20	N=8	N=28
Low Degree—HRO Index	N=4	N=17	N=21
Total	N=24	N=25	N=49

The results of the chi-square analysis suggest that there was a significant association between the level of HRO characteristics and level of safety governance characteristics χ^2 (1) = 13.18, $p < .001$. This seems to represent that based on the odds ratio, high scoring HRO institutions were 10.64 times more likely to report the

presence of high scoring safety governance in public research universities with general safety committees.

Summary of Sub-Problem Task 3

To solve this sub-problem, survey data representing respondent (n=50) perceptions regarding both general safety committees or governance bodies and topic-specific safety committees or governance bodies were analyzed. An index was developed for general safety committee institutions, tested for reliability, and dichotomized into high and low capacity based on a calculated cut point. A table was created to examine and compare the governance scores across the three Carnegie classifications. Further, the strength of association between HRO Index score and Governance Index score was tested using chi-square and found to be significant.

Characterize the Content and Construction of Information on University Websites Relevant to EHS and the Management of Risk—Sub-Problem Task 4

The approach to answering the research question, as discussed in Chapter 3, has been the emphasis on a case-comparative method. The addition of the web review data to the survey data was designed to augment and corroborate the findings from the single organizational respondent by systematically collecting data from a publically available information source. This allows the capture of data as presented and, in turn, interpreted as a representation of the explicit institutional message regarding safety to the various system elements. Collectively, the two information sources allow for

greater depth of understanding and analysis of an assemblage of universities as complex organizations in relation to their unique sub-systems of safety.

Case Selection

From the pool of 75 valid survey respondents representing public research institutions, 19 universities were selected for a website review. The web review population was selected based on several factors. Six of the seven Lombardi Top 25 institutions were selected because of the earlier returned of surveys. In addition, based on case sums for the HRO Index (17 items), the extreme high and low cases for each Carnegie research classification (n=6) were selected for an institutional website review. The final seven universities were selected on the basis of geography, so that a diversity of states would be included.

Table 4.25 below presents the profiles of the cases selected for the web review including case number (maintained from the original IPEDS list), Carnegie classification, Lombardi Top 25 membership, membership category on HRO Index (previously dichotomized) and membership in extreme case selection based on HRO Index score. The Carnegie category included 11 VHR, 4 HR, and 4 R institutions. The HRO Index included 12 institutions scoring in the high category and 7 scoring in the low category. The 6 extreme cases, the highest and lowest scoring in each Carnegie category based on the case sum for the HRO Index, were included. Home states for institutions are listed.

Table 4.25 Web Review Profiles

Case #	Carnegie	Lombardi	HRO Index	Extreme Case	State
88, 89, 121, 133, 151	VHR	Yes	High	No	CA, MI, NC, WA
17, 110	VHR	No	High	No	FL, KY
61	VHR	No	High	Yes	NY
74	HR	No	High	Yes	MT
130, 158	HR	No	High	No	NV, VA
12	R	No	High	Yes	NC
141	VHR	Yes	Low	No	PA
109	VHR	No	Low	Yes	KS
48	VHR	No	Low	No	OH
125	HR	No	Low	Yes	MO
86	R	No	Low	Yes	AR
20, 54	R	No	Low	No	GA, OR

Case Analysis

As discussed in Chapter III, a Website Review Protocol (see Appendix F) was developed and used to guide but not restrict discovering relevant, available information through an internet search across multiple facets of institutional connections with the subsystem of safety at each of the 19 purposively selected university websites. The master protocol was composed of four multi-dimensional categories for collecting data: 1) vertical relationships, 2) horizontal relationships, 3) safety governance, and 4) organizational system reliability. The dimensions were scaled on a ranking system to aid in streamlining the analysis.

The Website Review Protocol documents containing pre-structured prompts were used with unrestricted limits on volume of references and descriptive text. To consolidate the volume of information to a more manageable degree, a meta-matrix, or a master chart with inclusion of all relevant data, was created to display condensed information, as described in Miles and Huberman (1994). The matrix was oriented to

allow for a cross-case display of the data to develop coherent descriptions of organizational context across the selected 19 institutions of interest.

Table 4.26 presents a matrix with data reduced from the extensive Web Review Protocols. The presentation enables ease of comparison of the data across cases. The scale for each item in the protocol was based on a 4-point system, i.e., 1 = information absent; 2 = information cursory; 3 = information moderate; and 4 = information extensive. The researcher[6] rated each sub-dimension item based on the extent and content of the message discovered on the relevant institutional website regarding the subsystem of safety. At the completion of each protocol, an average score was determined for each dimension. A dichotomized scoring schema was developed. If the average score for a dimension was rated either a 1 or a 2, the dimension was placed in the low category. Similarly, an average score of 3 or 4 placed the dimension in the high category. This process was applied for the first four dimensions (Vertical, Horizontal, Governance, and Organizational Reliability) in Table 4.26.

Initially, the protocol was developed with a parallel set of framing sub-dimensions throughout the document. However, during the analysis the framing strategy was changed from evaluating each sub-dimension to evaluating the overall framing message to the institution by the safety function. Therefore, the construct of framing was evaluated on a more general basis as interpreted from the mission statement or other statements found on the main safety function website. If a safety

[6] The use of a single reviewer of websites for this research project was a limitation. With less time constraints, a second reviewer would have been selected to establish reliability.

message frame could not be determined from the safety function website then an alternate statement from another institutional web source would be used (Human Resources, etc.). The framing evaluation included the following scoring schema: 1 = compliance only; 2 = compliance and mitigation; and 3 = compliance, mitigation, and value added.

Table 4.26 Case Data Extracted and Dichotomized from Web Review Protocols

Case #	Vertical	Horizontal	Governance	Organizational Reliability	Framing
12, 88, 133, 151	High	High	High	High	3
109	High	High	High	High	2
89, 121	High	High	Low	High	3
110	Low	High	High	High	2
48	Low	High	Low	High	2
158	Low	Low	Low	High	2
74	High	Low	High	Low	2
141	High	Low	Low	Low	2
130	High	Low	Low	Low	3
20	High	Low	Low	Low	1
17	Low	Low	Low	Low	3
61	Low	Low	Low	Low	2
54, 86, 125	Low	Low	Low	Low	1

Eight cases rated 3 in regard to framing were discovered during the web review. As expected, the majority of the universities with this rating also scored High on the HRO Index (n=6; 75%). The two remaining institutions scoring Low on the HRO Index did not reflect the message framed by the safety function to the institution. At the other end of the spectrum, the universities with a 1 rating in regard to framing were all within the Low HRO Index grouping. These findings suggest a certain degree of consistency between message framing of the safety function and HRO Index rating. It also reveals organizational dissonance when the message presented by the safety function does not match the behaviors as discovered across other dimensions. For

example, an interesting anomaly exists within both case #130 and case #17 in that the safety function uses an advanced framing message while the scoring for most other dimensions remained low.

Referring to Table 4.26 above, the case data were ordered based on the aggregated rating of HRO dimensions as the first priority so that universities with a High score were placed together. The first five cases in the matrix all scored High across all four dichotomous dimensions suggesting that each of the four institutions possesses a high degree of both vertical and horizontal coupling, a high degree of safety governance capacity, and an organization reflecting a high degree of HRO characteristics. Each of the four safety functions framed its message to the larger institution as enabling good decision-making in the management of risk that emphasizes compliance, mitigation, and value added benefits. The fifth institution was rated at 2 suggesting that the message framing by case #109 promoted both compliance and mitigation but no evidence of value added was discovered. In contrast, the last three cases, as reported by the safety function director, scored Low across all four dimensions suggesting that each of the three institutions possesses a low degree of both vertical and horizontal coupling, a low degree of safety governance capacity, and an organization reflecting a low degree of HRO characteristics. Each of these three safety functions framed its message to the larger institution as enabling decision-making based on a model of compliance-only.

By grouping similar cases, evidence of trends has emerged in Table 4.26. In the cases with a High HRO score, there appear to be higher scores across the other three variables. A similar relationship has emerged between Low HRO scores and

lower scores across the other variables. Further, a downward trend of framing was noted with the higher scoring institutions demonstrating a more complex faming schema, while the lower scoring institutions projected a compliance-only frame.

Survey and Website Review Data Amalgamation

To form a more complete composite of the university cases under study, relevant web review and survey generated data were combined into a single table. Appendix I presents the 19 cases in a case-ordered matrix (Miles & Huberman, 1994). The matrix was designed to consider the effect of HRO scores, developed from the survey and either corroborated by or diverging from the web review, as the principle outcome. The other variables are possible predictor variables; and the comparison between the web review rating and survey scoring is presented.

Referring to Appendix I, the first column lists the case numbers of the institutions undergoing web review. These were maintained from the original IPEDS list. The second column provides an abbreviated list of classifications for each of the cases based on Carnegie (C) designation (1=Research activity level; 2=High Research level activity; and 3=Very High Research level activity). In addition, an L indicates that the institution is listed in the Lombardi Top 25 research group. The third column lists the results from the survey after the variable was dichotomized into either high (H) or low (L) representing the degree of coupling of the safety function with the state system of higher education where reported. An NA designation was used for missing data or an NA selected on the survey.

Column 4 presents the data from the web review as averaged across the vertical dimension. The vertical sub-dimensions included both supra-system as well as vertical relationships within each university. Therefore, column 3 and column 4 are not directly comparable. Column 5 provides the relationship/coupling data from both the web review (Horizontal dimension Web—HW) and the survey (Relationship Safety Index—RSI). As demonstrated in Appendix I, in the first 7 rows and the last 4 rows the case data from the two sources aligned well. For the first 7 cases (rated H=High), this suggests that there is clarity and sophistication of the safety mission, a high degree of safety function transparency, and a high degree of organization within the institution. For the lower (L) scored cases this suggests a lower degree of autonomy, power, and organization as evidenced both across the institutional website and through survey responses.

Column 6, Governance, compiled data from the web review dimension average (W), the survey bank of questions on general safety committees (SI), and the responses from the survey question #34 regarding the relationship among committees with a multiple choice of five responses composing a continuum of interaction (SCC). Fifty of 75 responded to the governance survey questions representing those institutions reporting the presence of a general safety committee. A skip pattern was in place so that institutions without general safety committees were not invited to complete the questions. Therefore, dashed lines were used in Appendix I to designate the missing data. A scale from 1 to 5 was used to solicit a description of the interaction among safety committees based on the assumption that each university had more than one safety-related committee. The scoring was as follows: 1=each committee operates

autonomously; 2=some informal interactions occur among committees, as needed; 3=regular, informal interactions occur among committees; 4=regular, formal interactions occur among committees; and 5= regular, formal interactions and, in addition, an overarching policy committee is present.

The next column presents scores for message framing based on review of safety function websites. The scoring schema for the examination of framing include 1=compliance-only; 2=compliance and mitigation; and 3=compliance, mitigation, and value added. One limitation to this study is the individual university's investment in the safety function and, in turn, the subsequent investment in development of institutional programs and the level of transparency of a health and safety website. For example, one university scoring 1 on framing did not have a discoverable safety function website. Therefore, language regarding health and safety was examined as contained in the employee handbook which stated,

> "Everything possible is done to provide you with safe working conditions. Accident prevention is largely a part of your responsibility since accidents are often due to carelessness. Horseplay and practical jokes are strictly prohibited and may be grounds for dismissal. If you should see some unsafe condition existing on campus, please report the condition to an appropriate authority, such as your supervisor, the Department of Public Safety or Physical Plant."

This language suggests the presence of a bare minimum program, implying compliance, with very limited resources to enhance decision-making regarding the risk to resources. The statement suggests that the institution has reached a static state of safe working conditions. It describes an institutional message minimizing HRO characteristics, such as preoccupation with failure by suggesting that all potential accidents have been anticipated and controlled. Further, it advances the simple notion

that accidents are the fault of employees' carelessness. While there is evidence of hazard reporting, it does not provide evidence that there are tools for investing in elevating employees' awareness level of hazard identification or situational awareness. Thus, it places HRO characteristics of reluctance to simplify and sensitivity to operations as minimized elements running counter to Weick and Sutcliffe (2001).

An example of language used by a university case under study (case #12) that achieved a score of 3 may be captured in the framing of the safety function mission statement to emphasize "excellence through a process of continuous improvement which relies upon dedication to customer service, community outreach, leadership, education, emergency preparedness, program management, empowerment and professionalism." Further, in the EHS vision statement the language suggests that the safety function is striving to achieve a high degree of cultural relevance within the institution as stated "[o]ur vision is to move the University community to the highest level of Safety, Health, Emergency and Environmental Management by the integration of these practices into the core values of the University culture."

The high scoring institution portrays the advancement of an institutional mindset moving well beyond compliance and mitigation to emphasize the safety function role in contributing to the success of the university. In regard to HRO characteristics, the statement contains phrases suggesting congruency with the HRO characteristics preoccupation with failure and commitment to resilience "...excellence through a process of continuous improvement..." and HRO characteristics sensitivity to operations and deference to expertise "...customer service...community outreach...education... empowerment..." In addition, this particular university had the

highest raw score representing respondent perception of HRO characteristics of all 19 cases.

The column labeled Investment provides a comparison of budget ratios and staffing ratios from survey data. The legend for the budget ratios is based on safety function investment as a dollar figure per the sum of institutional faculty, staff, and students. The key for the table is B1=less than $40 per FTE; B2=$40 to $80 per FTE; and B3 = more than $80 per FTE. Where data were missing in the survey a dashed line is used. The budget ratios across the 19 cases are somewhat mixed. However, the lowest ratio of investment, B1, is consistent across the bottom 6 universities scoring *Low* on the HRO index.

Similar to the budget ratio, the legend for staffing ratio is based on a ratio of safety function staffing to the sum of faculty, staff, and students. The key for the table is S1=1 Safety FTE per less than 2000 institutional FTE; S2=1 Safety FTE per 2000 or more but less than 3000 institutional FTE; S3=1 Safety FTE per 3000 or more but less than 4000 institutional FTE; S4=1 Safety FTE per 4000 or more but less than 5000 FTE; and S5=1 safety FTE to 5000 or more institutional FTE. Among the High-rated institutions based on HRO characteristics, the 13 institutions possess a high-density staffing ratio of either S1 or S2. Three of the HRO Index Low-rated institutions possess one of the two high-density staffing ratios while 3 of the HRO Low-rated universities report a low-density staffing ratio of either S4 or S5.

The column labeled Reporting contains information from the survey. Fourteen of 19 respondents said that their formal reporting structure included the Finance/Administration executive. There were anywhere from two to four reporting

levels between the safety function director and the institutional executive. There does not appear to be an identifiable difference in reporting structures between High and Low HRO scoring institutions.

In regard to columns Facilitators and Barriers, respondents were given a list of items and asked to mark each item that they perceived posed as a facilitator of safety function success within their individual institutions. The same list was duplicated for reporting their perception as possible barriers. The list included, AE-academic environment, C-ability to create change, ES-executive support, OB-operating budget, OR-other resources, R-respect of faculty, S-staffing level, SC-scope of work, and SS-salaries for safety function staff.

In regard to items that were perceived as facilitators, the three high reliability universities at the top of the matrix consistently listed ability to create change, respect of faculty and executive support as factors. Ten of 19 respondents identified the academic environment as posing a barrier. Fourteen of 19 respondents characterized executive support as a facilitator. In contrast, four of nineteen cases identified executive support as a barrier. These cases were within the bottom ten on the matrix.

The last column in Appendix I provides the data from both the web review (W) and the survey index (SI) in regard to HRO characteristics. This is the outcome variable of interest. Within the top seven institutions in Appendix I, there was corroboration between the web data and the survey data. There was a mixed result in the middle eight cases. The bottom four cases showed corroboration within those low-rated cases.

Comparing the seven high rated universities using both survey and web review indexes (H/H) and the four low rated universities using both survey and web review indexes (L/L), the average number of facilitators for high rated universities was 4.14 and for low rated universities was 1.25. The average number of barriers was 2.43 for H/H rated universities and 4 for L/L rated institutions. In general, universities with high composite HRO scores reported a greater number of facilitators and fewer barriers than universities with low HRO scores. The reverse was true for low scoring institutions.

Summary of Amalgamation

Priority variables from the survey and parallel dimensions discovered from the web review were compiled into a matrix (Appendix I) in order to construct a visual sorting of data from the 19 cases selected for the web review. Cases were listed and loosely grouped along a continuum based on a combination HRO Index score and predictor indices. The high reliability universities were placed at the top of the matrix and the low reliability universities were placed at the bottom. There were many points of agreement identified when comparing the two data sources. The aggregation of the two data sources provided a more complete picture of each of the 19 cases.

Characterize the Organizational Arrangements of Public Research Universities in Terms of HRO Capacity—Sub-Problem Task 5

The analysis of sub-problem task 5 characterizes the arrangement of organizational conditions leading to either a High or Low HRO Index rating on the

dichotomous index developed for this research. The Governance Index was not used because of the lower number of respondents to that series of questions from the survey.

Since this research has generated voluminous data fragments, a process for data reduction and simultaneous case grouping along lines of commonality was imperative. Ragin (1987, 2000) provided a methodological framework and supporting analytical software[7] (Ragin, et al. 2006) for pursuing cross-case analysis while maintaining facets of both variable and case oriented strategies called qualitative comparative analysis (QCA). The methodology was selected because it was able to manage a large number of cases (75 universities); possessed a case-comparative logic (logical data reduction); used binary variables (presence or absence of a condition—e.g., the presence of a high degree of HRO characteristics or the absence of a high degree of HRO characteristics); and provided a way for the investigator to specify and study the major features of social units and social processes that combine in different ways to produce different wholes (examine various variables of interest and their relevancy to HRO characteristics).

To begin this process, a reorganization of the data into a truth table provided a fundamental method to sort data into their different combinations of values on the independent variables (Ragin, 1987). The truth table is a raw data matrix of binary or dichotomized data. In a dichotomized matrix, capital and lower case letters represent high and low degree of presence of a variable, respectively. In a binary matrix, the use

[7] Link to fsQCA software download page http://www.u.arizona.edu/~cragin/fsQCA/software.shtml

of 1 = the presence of a variable (the same as the use of an upper case letter) and 0 = the absence of a variable (the same as the use of a lower case letter). The combinations found in a truth table are referred to as primitive terms. Subsequently, these primitive terms from the table can be reduced and minimized using Boolean algebra strategies facilitated by the use of QCA software (Ragin, 2006).

Table 4.27 displays an arrangement of data representing five diverse predictors of the outcome variable, HRO Index. Since there are five predictors, there are $2^5 = 32$ possible combinations of dichotomized variables. Column 1 lists the 32 possible combinations. The five predictor variables selected include column 2, System Index represented by "S" equal to a high score on the System Index and "s" equal to a low score on the System Index. Column 3 lists cases scoring high on the Relationship/Coupling Index represented by "C". The lower case "c" represents cases scoring low on the coupling index. Column 4 represents the dichotomized FTE Ratio. Since approximately 50% of all cases reported this ratio to be <1 safety FTE/3000 institutional population, that ratio was used to divide the population. Therefore, "F" represents cases with ratios <1/3000 and "f" represents cases with FTE ratios > 1/3000. Column 5 suggests that in each of the case combinations either an "R" signifying that there is one formal structure between the safety function and the institutional chief executive or an "r" suggesting that there is more than one formal structure represents the reporting level. Respondents reported whether or not executive support was either a facilitator or barrier for safety function success.

Table 4.27 Truth Table—Five Diverse Predictors of HRO Degree in Public Universities

No.	System Index (S)	Coupling Index (C)	FTE Ratio (F)	Reporting Level (R)	Executive Support (E)	HRO Index (Y)	Case Numbers
1	S	C	F	R	E	H	151
2	S	C	F	R	e	H	82, 94
3	S	C	F	r	E	H	133, 42, 19, 88, 10, 130, 68
4	S	C	F	r	e		
5	S	C	f	R	E	H	74, 59,
6	S	C	f	R	e		
7	S	C	f	r	E	H	164, 30, 140
8	S	C	f	r	e	H	138
9	S	c	F	R	E	h	103
10	S	c	F	R	e		
11	S	c	F	r	E	H	158
11.1	S	c	F	r	E	h	161
12	S	c	F	r	e	H	84
12.1	S	c	F	r	e	h	62, 98
13	S	c	f	R	E		
14	S	c	f	R	e	h	75
15	S	c	f	r	E	h	3, 20
16	S	c	f	r	e	h	72
17	s	C	F	R	E	H	61, 43, 6, 119
17.1	s	C	F	R	E	h	106, 28
18	s	C	F	R	e		
19	s	C	F	r	E	H	17
20	s	C	F	r	e	H	110
20.1	s	C	F	r	e	h	55
21	s	C	f	R	E	H	12
22	s	C	f	R	e		
23	s	C	f	r	E	H	13, 52
23.1	s	C	f	r	E	h	141
24	s	C	f	r	e	H	23, 135
25	s	c	F	R	E		
26	s	c	F	R	e		
27	s	c	F	r	E	h	116
28	s	c	F	r	e	h	149, 165, 99, 125, 101
29	s	c	f	R	E	H	41, 153, 51
30	s	c	f	R	e	h	36, 25
31	s	c	f	r	E	H	47
31.1	s	c	f	r	E	h	18
32	s	c	f	r	e	h	7, 97, 44, 127, 32, 37, 109, 120, 86, 54, 58

Column 6 displays an "E" when the response was affirmative and an "e" when the response was left blank or marked as a barrier. In column 7 the HRO Index lists the dichotomous variable of "H" representing a high score (presence of high reliability) or "h" a low score (absence of high reliability) for the dependent variable. Case numbers, column 8, list the specific cases with characteristics as presented across the predictors. Cases listed have no missing data for the predictors of interest.

Table 4.27 above presents the 32 case combinations. The six additional rows on the chart (11.1, 12.1, 17.1, 20.1, 23.1, and 31.1) represent case combinations with contradictory outcomes, that is, universities exhibiting both the presence of high reliability and universities exhibiting the absence of high reliability. Eight of the causal combinations lack empirical cases (4, 6, 10, 13, 18, 22, 25, and 26). These vacant combinations are referred to as remainders or counterfactuals. Therefore, there are 24 causal combinations with empirical evidence among respondents.

Table 4.28 below presents the outcome frequencies and percentages for the truth table. The fsQCA v. 2.0 software package was used to generate data for the table. There were 65 usable university cases. Universities scoring high on the HRO Index aligned within 10 of the case combinations in the truth table occupying 41.7% of the 24 possible combinations with empirical cases. There were 23 cases representing 35.4% of the 65 total cases analyzed. In contrast, universities scoring low regarding HRO characteristics aligned with eight of twenty-four case configurations (33.3%). There were 24 low HRO scoring universities representing 36.7% of the total 65 cases analyzed.

Table 4.28 Truth Table Outcome Frequencies and Percentages

Outcome	Configurations #	Configurations %	Cases #	Cases %
HRO Present	10	41.7%	23	35.4%
HRO Absent	8	33.3%	24	36.9%
Contradictory	6	25.0%	18	27.7%
Total	24	100%	65	100%

As noted in Table 4.28 above, there were six contradictory configurations (25%) with 18 cases (27.7%) aligning within those configurations. Within the set of contradictory configurations, 10 cases scored high on the HRO Index and 8 cases scored low.

Table 4.29 below presents the eighteen positive and negative cases (contradictory cases were removed). The table displays the predictor variables as binary (1, 0) data to represent presence or absence. In addition, the frequency of each primitive statement is shown. Table 4.29 is ordered based on the presence or absence of the outcome variable (1 = HRO Present; 0 = HRO Absent) and in descending number of empirical case frequency. As noted in Table 4.29, the most frequently occurring combination representing universities scoring high on the HRO index was S*C*F*r*E → H. This combination with a frequency of 7 out of 23 high scoring cases (30.4%) demonstrates high scoring of the predictors within supra-system coupling, intra-institutional coupling, safety function staffing, and executive support while scoring low on organizational positioning. The most frequently occurring combination representing universities scoring low on the HRO Index was s*c*f*r*e → h. The combination with a frequency of 11 out of 24 low scoring cases (45.8%) demonstrates low scoring of all five predictors. Interestingly, the second most frequently occurring combination with a low HRO Index score was s*c*F*r*e → h.

The combination with a frequency of 5 out of 24 low scoring cases (20.8%) suggests an adverse outcome in the presence of high safety function staff investment in combination with all other predictors rated as low.

Table 4.29 Truth Table Showing Five Causes of High Reliability with HRO Presence or Absence

Supra-System Coupling	System Coupling	Safety FTE	Reporting	Executive Support	HRO Present	Frequency
1	1	1	0	1	1	7
0	0	0	1	1	1	3
1	1	0	0	1	1	3
0	1	0	0	0	1	2
1	1	0	1	1	1	2
1	1	1	1	0	1	2
1	1	0	0	0	1	1
0	1	0	1	1	1	1
0	1	1	0	1	1	1
1	1	1	1	1	1	1
0	0	0	0	0	0	11
0	0	1	0	0	0	5
0	0	0	1	0	0	2
1	0	0	0	1	0	2
1	0	0	0	0	0	1
0	0	1	0	1	0	1
1	0	0	1	0	0	1
1	0	1	1	1	0	1

The process of qualitative comparative analysis allows for additional simplification. Boolean algebra was used to pursue this reduction process. The key operators for Boolean algebra include: multiplication symbol (*) indicates combined conditions (logical *and*); addition (+) indicates alternate combinations of conditions (logical *or*); and "→" indicates "is sufficient for." For example, referring back to Table 4.27 case combinations representing the equations for 1 and 2, respectively, can be written as follows:

S*C*F*R*E → H and S*C*F*R*e → H.

The first equation should be read: the presence of a strong relationship with the state system of higher education (S) AND the presence of strong relationships within the university (C) AND the presence of a dense FTE ratio (F) AND the presence of a reporting structure with one level from the chief executive(R) AND the presence of strong executive support is sufficient to produce high reliability in public research universities. Only case #151 was found to possess that combination of characteristics. The second equation would read similarly for the first four predictors. However the last predictor would read AND absence of executive support is sufficient to produce the presence of high reliability. Cases #82 and #94 aligned with that case combination.

With all of the combinations determined, the next step is to simplify the equations by combining and minimizing using combinatorial logic. The rule for minimization as stated by Ragin (1987):

> "If two Boolean expressions differ in only one causal condition yet produce the same outcome, then the causal condition that distinguishes the two expressions can be considered irrelevant and can be removed to create a simpler, combined expression" (p.93).

For example,

$S*C*F*R*E + S*C*F*R*e \rightarrow H$	is equal to
$S*C*F*R*(E + e) \rightarrow H$	can be reduced to
$S*C*F*R \rightarrow H$	is a partially minimized equation

Table 4.30 below converts the truth table elements from Table 4.27 into a series of equations listing all of the case combinations present with the data. As demonstrated in the table, there were 10 combinations of variables that produced high

reliability as an outcome (column 1). Column 2 presents 8 variable combinations producing the absence of high reliability (i.e., low reliability). Eight variable combinations had no empirical cases (remainder cases). Six cases in the low reliability column produced both outcomes (contradictory cases). These equations will be further reduced.

Table 4.30 Truth Table Equations Segregating Outcomes and the Presence of Empirical Cases

Presence of High Reliability (H) / Truth Table Case Combination	Absence of High Reliability (h)	Remainder Cases/ Counterfactual Cases	Contradictory Cases
S*C*F*R*E→ H (1)	S*c*F*R*E→ h (9)	S*C*F*r*e (4)	S*c*F*r*E (11) → H + h
S*C*F*R*e→ H (2)	S*c*f*R*e→ h (14)	S*c*f*R*e (6)	S*c*F*r*e (12) → H + h
S*C*F*r*E→ H (3)	S*c*f*r*E→ h (15)	S*c*F*R*e (10)	S*C*F*R*E (17) → H + h
S*C*f*R*E→ H (5)	S*c*f*r*e→ h (16)	S*c*f*R*E (13)	S*C*F*r*e (20) → H + h
S*C*f*r*E→ H (7)	S*c*F*r*E→ h (27)	S*c*f*R*e (18)	S*C*f*r*E (23) → H + h
S*C*f*r*e→ H (8)	S*c*F*r*e→ h (28)	S*C*f*R*e (22)	S*c*f*r*E (31) → H + h
S*C*F*r*E→H (19)	S*c*f*R*e→ h (30)	S*c*F*R*E (25)	
S*C*f*R*E→ H (21)	S*c*f*r*e→ h (32)	S*c*F*R*e (26)	
S*C*f*r*e→ H (24)			
S*c*f*R*E→ H (29)			

The fsQCA v. 2.0 software package (Ragin, et al. 2006) using the Quine 3.0 minimization selection was used to develop the algorithm employing Boolean algebra to minimize the primitive expressions and formulate the final reduced Boolean equations. The software produced the three final equations that represent

organizational conditions found in the respondent public research universities based on the input of 65 primitive equations from the truth table.

The minimization of Equation 1 utilizing maximum complexity with a high degree of HRO outcome is as follows:

Equation 1: H = S*C*E + C*f*r*e + s*f*R*E + C*F*r*E + S*C*F*R

Type: 1 2 3 4 5

The minimized equation delineates five different types of organizational arrangements present in survey responses from universities scoring high on the HRO scale. Type 1 combination S*C*E is a prime implicant[8] of the primitive expressions S*C*F*R*E, S*C*F*r*E, S*C*f*R*E, and S*C*f*r*E. Type 1 combines a high degree of supra-system coupling, a high degree of intra-institutional coupling, and a high degree of executive support. As previously discussed, Weick (1976) has described educational organizations as loosely coupled systems. Systems that are either tightly coupled or loosely coupled can cause accidents (Perrow, 1999; Grabowski & Roberts, 1996). The coupling construct suggests the existence of interconnectedness among or between system elements with implied action of alternating independence and interdependence as conditions change. The presence of the coupling variables (S*C) suggests that a heightened degree of responsiveness exists between both 1) the safety function and the state system of higher education which in these institutions provides an explicit degree of guidance and support for the safety function regarding the management of institutional risk (69.6% of high scoring HRO institutions concurrently reported high

[8] As described by Ragin (1987), " [a] Boolean expression is said to imply another if the membership of the second term is a subset of the membership of the first." For example, in Equation 1, SCE implies the primitive expression SCFRE. SCE is a prime implicant.

scoring supra-system coupling); and 2) the safety function and the vertical and horizontal elements of the member university. In addition, these institutions reported that strong executive support within the university was a facilitator of success for the safety function.

The Type 2 combination C*f*r*e is a prime implicant for the primitive expressions S*C*f*r*e and s*C*f*r*e. This combination demonstrates a high degree of vertical and horizontal coupling in combination with a low safety staff FTE to institutional population ratio, low reporting level, and low degree of executive support. The combination suggests the crucial properties of interacting social systems in organizations that allow for responsiveness of coupling mechanisms affecting the safety function to expand and contract depending on the circumstances. Within this combination, the high degree of institutional coupling assures high reliability even with a low level of safety resources, low reporting, and low evidence of executive support.

The Type 3 combination, s*f*R*E, is the prime implicant for the primitive expressions, s*C*f*R*E and s*c*f*R*E. This organizational arrangement reveals a combination of low safety staffing with high reporting position and high executive support. This suggests a shared definition of institutional risk and shared risk reduction strategies between the safety function director and administrative entity. The prominence of this arrangement suggests that the emphasis on the centralized authority within these institutions drive and support elements of accountability across the institution even with low system support, and low safety function staffing. This is the only prime implicant where coupling has been minimized from the primitive

expressions because of the presence of three cases representing institutions scoring low on coupling with a high HRO outcome. The concern with the higher level of centralization is that "it can weaken local containment and resolution of problems" (Weick & Sutcliffe, 2001; p. 170).

The Type 4 combination--C*F*r*E—represents the prime implicant for the primitive expressions S*C*F*r*E and s*C*F*r*E. This combination leading to high reliability represents high institutional coupling combined with high safety function staffing ratio and high executive support. This combination suggests the presence of a signature condition, simultaneous centralization and decentralization, found in HROs (Weick & Sutcliffe, 2001). Even though the formal reporting of the safety function is below the level of the top institutional executive group, the high level of executive support, the high level of safety function investment demonstrated by the staffing ratio, and high degree of vertical and horizontal interrelationships suggests a well developed safety culture that is both responsive and accountable.

The Type 5 combination S*C*F*R provides prime implicant coverage for S*C*F*R*E and S*C*F*R*e. This combination leading to high reliability represents high supra-system support, high intra-institutional coupling, and a high degree of safety function investment, along with the reporting level of the safety function at the level of a top administrator. Type 5 is similar to Type 4, in that this arrangement appears to represent a balance of centralization with decentralization. Centralization is represented in the guidance, communication, and support offered to the safety function through the relationship with the supra-system and vertical intra-institutional elements of the coupling variable. Strong horizontal coupling, high investment in safety

function resources, and a safety culture encouraging action to solve problems characterize decentralization. There are two general statements that emerge from a birds-eye examination of the combination of organizational factors in place in public research institutions exhibiting a high degree of HRO characteristics. The first is the predictor, high degree of intra-institutional vertical and horizontal coupling, is consistently present in various combinations with other predictors in four of five minimized expressions. Further, only 1 in 10 (10%) primitive expressions with a high HRO outcome contained low coupling. In addition, only 3 in 23 (13%) of high HRO cases contained low coupling. The second generalization is that the combination of high reporting level and high degree of administrator support suggest leadership in safety culture development. However, as pointed out there is a delicate balance between centralization and decentralization for which high performing HROs have been successful in developing.

The minimization of Equation 2 with a low degree of HRO outcome is as follows:

Equation 2: h = c*f*e + S*c*f*r + s*c*F*r + S*c*F*R*E

Type: 1 2 3 4

The goal of this section was to describe combinations of predictors leading to high scoring HRO institutions. However, examination of these minimized, primitive equations may add to the depth of understanding of organizational arrangements found in universities. As noted in Equation 2 above, each of the four minimized combinations leading to low HRO scoring has low coupling scores. The Type 4 combination S*c*F*R*E is the most anomalous. With high scoring on supra-system

coupling, safety function staffing, reporting level, and executive support, the question of unique barriers to intra-institutional socialization of safety remains unanswered. However, this combination was found to be present in only one case.

Equation 3 represents unique arrangements of organizational conditions in public research universities that predict either the presence or absence of high reliability characteristics. There is no clear outcome to each these four organizational arrangements. These are termed contradictory.

Equation 3: s*f*r*E + S*c*F*r + s*C*F*r*e + s*C*F*R*E

Type: 1 2 3 4

There were 6 contradictory combinations discovered across the 32 possible combinations. These were reduced to four combinations using the Boolean minimization algorithm. However, two of the six were unable to be reduced and remain in their primitive state. While a high degree of intra-institutional coupling was found in 90% of cases within combinations with clear high HRO outcomes, a few highly coupled cases represented here provide empirical evidence of contradictory outcomes even in the presence of high coupling. In regard to Type 3 combination, there was only one case for each possible outcome. However, Type 4 combination had four cases reporting a high HRO outcome and two cases reporting a low HRO outcome.

Thus, three separate minimized equations were derived based on the development of the three dichotomized indexes—supra-system coupling (S), intra-organizational vertical and horizontal coupling (C), and safety FTE ratio index (F). In addition, two predictive variables from the survey responses were added, safety

function reporting level (R) and executive support (E) as a facilitator. The use of Boolean reduction and grouping strategies aided by fsQCA software (Ragin et al., 2006) has resulted in the description of organizational arrangements that when either present or absent in certain configurations predict the outcome regarding the degree of reliability found in public research universities.

Further Examination of Contradictory Cases

Table 4.31 below provides frequency data of the 18 cases that were characterized as contradictions since nine of the cases scored high on presence of a high degree of HRO characteristics and nine cases scored low (or absence of high) degree of HRO characteristics. The table lists the six contradictory combinations in descending frequency of case membership. A total of eighteen cases were characterized as contradictory case combinations. Ten of the cases scored high on HRO characteristics and eight cases scored low (H = 6, 13, 43, 47, 52, 61, 84, 110, 119, and 158; h = 18, 28, 55, 62, 98, 106, 141, and 161).

Table 4.31 Truth Table Showing Five Causes of High Reliability with HRO Contradictory Cases

Supra-System Coupling	System Coupling	Safety FTE	Reporting	Executive Support	HRO Present	Frequency
0	1	1	1	1	C	6
0	1	0	0	1	C	3
1	0	1	0	0	C	3
1	0	1	0	1	C	2
0	0	0	0	1	C	2
0	1	1	0	0	C	2

Table 4.32 below presents the placement of each contradictory case within the intersection of its corresponding primitive equation and Carnegie classification to

better visualize any trends that may emerge as a result. As evident in Equation 1, a high degree of system coupling (C) was an essential component within each reduced combination with a high HRO Index outcome. Table 4.32 contains three primitive equations (17, 20, and 23) with a high degree of system coupling. Neither of the low scoring HR universities possessed high coupling and high HRO characteristics. However, four of six universities possessed high institutional coupling combined with low HRO characteristics suggesting other factors are in play, such as governance.

Table 4.32 Contradictory Primitive Combinations Across Carnegie Classifications

	VHR-High	VHR-Low	HR-High	HR-Low	R-High	R-Low
S*c*F*r*E (11)		161	158			
S*c*F*r*e (12)		98	84	62		
s*C*F*R*E (17)	61, 43	28, 106	6		119	
s*C*F*r*e (20)	110	55				
s*C*f*r*E (23)	52	141			13	
s*c*f*r*E (31)				18	47	

Table 4.33 below displays 18 contradictory cases as each relates to findings regarding governance index scoring. As discussed earlier, universities with general safety committees and high HRO scores are 10.64 times more likely to score high on the governance index. In Table 4.33, 5 of the high scoring HRO cases out of 18 (27.8%) also had high governance scores. The converse follows this same finding, i.e., 5 of the low scoring contradictory cases scored low on the governance index. This finding accounts for 55.6% of the contradictory cases. Six cases total (three high scoring HRO and three low scoring HRO) were institutions without general safety committees as represented by a dashed line making a conclusion difficult. Two high scoring HRO cases scored low on the governance index. There were no low scoring

HRO cases with high governance scores. This suggests that governance may be an additional plausible variable in examining social systems and their relationship to HRO performance. However, that examination was limited in this project.

Table 4.33 Governance as an Additional Predictor in Contradictory Cases

hro*gov	hro*GOV	hro*---	HRO*gov	HRO*GOV	HRO*---
Case 161		Case 62	Case 110	Case 158	Case 61
Case 98		Case 28	Case 13	Case 84	Case 6
Case 106		Case 55		Case 43	Case 119
Case 141				Case 52	
Case 18				Case 47	

Summary of Sub-Problem Task 5

To solve sub-problem task 5, three sets of mutually exclusive combinations of organizational arrangements have been derived. The three equations represent a variety of social system arrangements as found in public research universities. Equation 1 summarizes the common conditions in high reliability universities; equation 2 summarizes the conditions in low reliability universities; and equation 3 summarizes the conditions in contradictory cases where other factors play a role. Additional examination of contradictory cases illuminated governance as a variable of interest that may have played a role in the lack of clear outcome for some of the expressions. Through the development of a logical series of tables, algorithms, and equations, the use of dichotomized variables has provided a path to both reduce and organize a large amount of data. The approach has provided a method for synthesizing, visualizing, and comparing data from a large number of public research institutions to better understand organizational conditions and social processes as related to the theory of high reliability.

There are several prominent findings from the treatment of data in this section. The findings from this analysis suggest that a high level of horizontal and vertical coupling of the safety sub-system within a university plays a dominant role in determining the presence of a high level of HRO characteristics. Conversely, a low level of vertical and horizontal coupling of the safety sub-system within a university plays a dominant role in determining the presence of a low level of HRO characteristics. This suggests that when tactics for the management of risk are directed toward bridging loosely coupled university systems, the mindfulness of actions within sub-systems increases, i.e., the mental mapping occurs for anticipating and containing the unexpected (Weick & Sutcliffe, 2001; Orton & Weick, 1990). However, as demonstrated in a minority of cases, when system coupling of the safety sub-system across the university is low, the presence of a high level of reporting combined with executive support appear to ensure a culture that sustains high reliability. In general, supra-system coupling, safety staffing ratio, and reporting level appear to have less critical roles in ensuring high reliability. Finally, a high level of safety governance performance appears to coexist with the presence of high reliability in a strong majority of university cases.

Conclusion

In summary, Chapter 4 presented findings from both the survey and web review. The results and analyses were reported regarding each of five sub-problem tasks for the purpose of answering the research question. In the next chapter,

conclusions are drawn based on these findings, implications of the results are provided, limitations are discussed, and areas for future study are profiled.

CHAPTER V. CONCLUSIONS AND IMPLICATIONS

Introduction

The solution for addressing each of the sub-problem tasks has been discussed in detail in Chapter IV. These solutions are summarized as 1) the creation of an HRO Index to measure the degree of HRO capacity from survey data; 2) the creation of both Supra-System and Coupling Indices to measure the degree of relationship between both state systems of higher education and intra-institutional agents from survey data; 3) the creation of a Safety Governance Index to measure governance capacity of general safety committees where present from survey data; 4) completion of a Web Review Protocol on a subset of survey institutions examining vertical and horizontal relationships, safety governance and organizational reliability; and 5) the characterization of organizational arrangements of universities using the Boolean treatment of data incorporating items from both the survey and web review.

Analysis of the data yields several important discoveries. Findings illustrate an exploratory application of HRO theory to public research universities while examining the implications of unique contexts of social systems within these institutions. The discoveries are interpreted from the vantage point of the leadership of the safety function in combination with the observations of information projected from the publically available institutional website. In this chapter, conclusions based on the constructs underpinning this research are reviewed, discoveries resulting from analysis of data are synthesized, implications of the findings regarding universities as high

reliability organizations are presented, limitations and assumptions are discussed, and ideas for future research are generated.

Table 2.1 in Chapter II introduced the constructs of interest for this research. The intention in Chapter V is to review those constructs and present the dominant revelations discovered in Chapter IV where constructs of interest cross-cut the social action and social structure elements to produce a discussion of universities as complex social systems and the sub-system of safety within. In addition, the HRO capacity of universities will be discussed as revealed through discussion of ongoing social processes.

Overview of Respondent Population and Results

Based on the 45% response rate for this project combined with the broad geographic landscape representing 76% of US states, at the time of the survey, the top safety leadership positions in public research universities are currently populated by a strong majority of white, male individuals. As reported in the findings, graduate degrees are highly desirable, possibly preferred, credentials in recruitment for EHS director positions. The dominance of academic backgrounds in both EHS/Public Health fields (40%) and Science/Engineering (38%) suggests a professional niche for individuals with course work embracing both prevention theories and scientific/technical theories, respectively.

Several factors examined suggest a direct relationship with increasing complexity of the institution based on Carnegie criteria of increasing research level. Salaries, safety function budget ratios, and safety function staffing ratios increased

across classifications as research funding increased. In contrast, Carnegie classifications and research complexity did not reveal a strong relationship across HRO scores, governance capacity, or framing.

Vertical and Horizontal Relationships

Vertical Relationships--Supra-System

As detailed in Chapter II, the safety function is part of the safety sub-system and interacts across numerous other sub-systems within each university. Based on institutional characteristics, the arrangement of social conditions for achieving quality performance affects the execution of action for managing risk and preparing for crisis. In this research, vertical relationships between the safety function and the state system of higher education (where existing) were examined. A majority of high scoring HRO institutions also reported a high degree of supra-system coupling. In addition, while respondents reported a moderate level of satisfaction in their general relationship with supra-system agents, the satisfaction with the level of support is lower.

In reviewing the websites at the state supra-system level, statements relevant to the safety function or the university as a whole ranged along a continuum from the provision of a well-formulated guiding framework encompassing risk management and EHS holistically, to absent (or undiscovered) guidance, policy, or even reference to safety. In one particular state that articulated an extraordinary level of EHS framework development at the supra-system level, the corresponding institutional EHS function websites tended to reflect the same highly structured, value-adding, over-arching message intra-institutionally. In addition, these institutions exhibited a

high level of HRO capacity. This supports the theory of the value of balancing centralized direction with decentralized adaptive flexibility in order to create conditions to build HRO capacity (Weick, 2001).

When examined across Carnegie classifications the distribution of percentage of high and low supra-system coupling was relatively consistent with a slight majority in the low coupling category

Vertical Relationships--System

In general, there is a very high level of satisfaction regarding both communication with and support from the university administration for safety function activities. This evidence suggests that the leadership of the administrative shell grasps the gravity of the institutional role of EHS in addressing risk within the university system. In general, the data reveal that university administrators are highly risk-averse. However, not explored in this research is the examination of how university administrators define and prioritize risk versus how the EHS leadership define and prioritize risk. In terms of HRO capacity, administrators display strong characteristics of preoccupation with failure and a reliance on safety function staff expertise. The strong presence of these characteristics suggests that there is a substantial platform, at least in part, for advancing HRO capacity in a majority of public research universities.

However, universities are composed of shared governance structures, as discussed in Chapter II. The decision-making capacity in a university is composed of "two overlapping worlds...the organization and the academic" (Morrill, 2003; p.2). As discovered in this research both support from, and communication with, academic

leaders scored relatively low in terms of satisfaction. This suggests that there may be a certain degree of inconsistency in developing a culture designed to enhance "mindfulness" (Weick & Sutcliffe, 2001) across the whole of the university.

To enhance mindful thought and expression across the academic core, a mental model of organization emerges that encourages an aggressive response when the unexpected arises and prepares for resilience and rapid restoration of system and sub-system functioning. This suggests staging for an institutional culture shift targeting the academic core to build an anticipatory mindset. The evidence from the Boolean treatment of data suggests that targeted coupling is a promising social orbit for encouraging academic inclusion. To maintain a balance of both centralization and decentralization of the message, the coupling should target the executive over the academic core, academic governance, academic union leadership (if present), and academic department leadership as well as individual faculty.

In general, university administrators consider health and safety as a core value only at a moderate level. In other research, high performing HROs maintain a critical balance of centralization and decentralization. Weick and Sutcliffe (2007) describe the balance dynamic required as striving for "...tight social coupling around a handful of core cultural values and looser coupling around the means by which these values are realized" (p.150). In universities where the safety leadership has a well-established relationship with the administration, the negotiation of an explicit message from the formal institutional authority framed with HRO trending elements could aid in building a strong safety culture rich in HRO capacity. This move toward orderliness reflects the voice of compensations by encouraging the use of enhanced leadership

and/or focused effort to balance the autonomous actions of the loosely coupled organization as is found in universities (Orton & Weick, 1990).

Horizontal Relationships

Horizontal relationships refer to the more informal social intercourse developed as essential to co-produce safety decision processes. In general, safety function directors reported a moderate to high level of satisfaction with relationships across academic research groups. Since much of this particular academic sector contains guild work engaging in high-risk activities such as science and engineering laboratories, the normally loosely coupled relationship between the safety function and science faculty would expectedly transition to a tighter coupling during high risk activities to collaboratively provide evaluation, guidance, and feedback.

The finding of the high degree of loose coupling between the safety sub-system and the academic core is a highly challenging and unique cultural aspect in higher education. The challenge, as reported in the survey, is most likely represented in the high response rate to the *nature of academia* identified as a barrier to safety function success. Assuming that culture is malleable and open to reconfiguration as described by Smircich (1983), then it becomes incumbent on the safety sub-system agents (safety function leadership and safety governance leadership) to work to "...construct or negotiate some kind of social reality" (Weick, 1976; p.13). The discovery of bridging strategies that allow for intermittent tighter coupling and the use of language to frame shared meanings and build mental maps are essential tactics to employ (Grabowski & Roberts, 1996). The need for migration of constructed

information suggests the criticality of utilizing both of Hastings' (1993) dimensions of the information transfer process. These include hard networks (technology-driven connections) using web-based information transfer strategies with carefully crafted and framed language and soft networks (people-driven connections) capitalizing on social interactions to exert influence in creating a majority practice to make consistent decisions to manage risk (Axelrod, 1997). However, a potential confounder is the institutional culture as driven by the administration. Therefore, as horizontal strategies are embraced, vertical support must set the precedent.

The Coupling Index contained items incorporating both horizontal and vertical elements absent supra-system items. Examining the degree of coupling across the Carnegie classifications, only universities in the very high research category reported a majority of cases with a high degree of coupling. However, the difference across the Carnegie classes may be an artifact of small and unequal number of cases in each Carnegie class of respondents.

Horizontal Relationships—Networks

Networks are only superficially explored in this research. Axelrod's (1997) findings from simulations of agent-based models with the intent of understanding complex social systems provide thoughtful ideas for this application. The value of designating a social contact as an interface with the safety function in each department is the opportunity to introduce and transfer mental mapping of HRO characteristics as an operational norm. A system of departmental safety coordinators is reportedly created among 38.7% of research cases. The concentration of coordinator programs is

highest within the VHR classification (≈50%). HR and R had approximately 33% each within their respective classifications. The majority of each classification reported both a moderate time commitment to training and a moderate effectiveness of the program. There was no consistent pattern discovered in regard to HRO capacity and either presence or performance of safety coordinator programs.

Universities are composed of many sub-systems or sub-cultures in a loosely coupled environment. Hastings' dimensions (technology-driven and people-driven) of information transfer networks provide processes to improve coupling. Extending Axelrod (1997), as the number of interactions increases between the safety function and the various university sub-cultures (academic guilds and administrative units) cultural boundaries diminish and "cultural convergence" (p.160) can take place. This, in theory, would enable greater ability for a cultural shift toward building HRO capacity. However, in public research universities a minority of institutions has pursued this avenue as a vehicle for enabling change.

The web review institutions reveal a variety of network-type structures. In regard to safety coordinator programs, a few are highly developed with regular on-going training and discussion as well as the creation of informational web pages for both distributing and sharing information. Further, the role of these coordinators is highly specialized carrying a certain amount of responsibility for safety within their respective departments. A few universities have evolved less guided coordinator programs. Other network-type structures present in web-reviewed institutions include designation of building emergency managers; safety coordinators designated for laboratories only; guided development of departmental safety committees; and a mix

of coordinators and emergency building managers based on institutional operation. Several of the reviewed websites did not have any network-type structure.

Safety Governance

Networks and Coupling

Interconnected, flexible social subsystems or networks are structures found in HROs and form an additional dimension of knowledge-based groups. Extending Hill and Hupe's (2003; p.110-111) governance paradigm, safety governance is described as a form of network management. As evidenced in this research, when general safety committees are present, respondents report that committees, composed mainly of non-academic staff, actively pursue safety-related issues, and are successful in creating change. However, the administration is relatively slow to respond to recommendations. While there is a high degree of upward migration of issues, the activeness of response by the executive is more subdued allowing discovered weaknesses greater incubation time. According to Weick and Sutcliffe (2001, 2007), this demonstrates a lowered capacity for preoccupation with failure and sensitivity to operations. Further, committee coupling is reported to be low with both administration and academic staff. For requisite variety (Weick, 1987) to fully address the complexity of sub-system safety issues in universities, the active inclusion of both administration and faculty is a necessity. This is especially the case when considering the characterization of universities by Lombardi (2001) as the academic core possessing the primary responsibility for the overall quality of the university. Therefore, the creation of a strong, consistent, and inclusive safety culture across

safety governance as well as loosely coupled subsystems could provide the vehicle for encouraging Weick and Sutcliffe's (2001) organizational mindfulness in universities.

As discovered in the survey, universities exhibit a low degree of flexibility in the spontaneous formation of a new committee to address a new threat. This relative unresponsiveness is suggestive of a substandard HRO capacity in terms of commitment to resilience, sensitivity to operations, and deference to expertise (Weick & Sutcliffe, 2001). This identifies an area in need of development through greater administrative coupling and seeking legitimacy from the formal and informal governance structures.

High Reliability

Safety Function Expertise, Power, and Positioning

The unique perspective used in this research for the survey portion directly tapped into one of the five characteristics of HRO theory, deference to expertise. The safety function director, an organizational expert across a broad and varied spectrum of institutional risk management categories, provides a unique lens through which to examine the organizational context in which the sub-system of safety operates in universities. The HRO literature is replete with discussion summarizing the tension in critical decision-making in organizations between hierarchical rank and expertise. HROs are able to negotiate a hybridization of a "hierarchical decision structure with a specialist decision structure" (Weick & Sutcliffe, 2001; p.74). The presence of this hybridization is particularly observable when an organization is under duress and a

shifting pattern of leadership necessitates the planned emergence of the knowledge-competent individual(s) supported by an available executive level. However, some implied evidence that hybridization is supported, at least to some extent, in universities can be argued from these findings.

The salary of safety function director at ≥$80K (65% of all respondents and 91.4% of VHR respondents) suggests an intentional investment by institutional executives as well as implies an elevated level of formal power in the management of institutional risk that increases with increasing research level. The affordance of formal power hints at a heightened ability to influence critical responses to institutional crisis (Pfeffer & Salancik, 1974). Day to day operational evidence of institutionally recognized expertise is characterized with a high degree of perceived trust of the safety function within the institution and a high degree of perceived respect for expert knowledge exhibited by the safety staff. In addition, the safety function directors report a moderate influence on daily operations. Furthermore, greater than 50% of safety functions will receive a budget increase in the next fiscal year suggesting the dedication to an increasing appropriation of funds even in very competitive public university environments. Pfeffer and Salancik (1974) characterize this resource dedication as increasing subunit power in universities.

Further evidence supporting the potential for hybridization of decision-making emerges in the survey/web review data amalgamation. High HRO scoring universities are positioned either one (4 cases) or two (8 cases) levels between the safety function and the university chief executive. Low HRO scoring universities have reporting structures with one (1 case), two (5 cases), or three (1 case) levels between the safety

function and the chief executive. While there appears to be flexibility in organizational positioning and executive visibility of safety sub-systems, based on this limited number of cases, the outlier may also suggest that there is a point at which the safety function is too far removed from the executive level and that the voice from the safety sub-system becomes subsumed by competing organizational noise.

Problem Framing

As advanced in Chapter 2, the social effect in the use of language to frame problems provides a mental mapping that, in turn, determines the reaction of sub-systems and elements in organizations (Katz & Kahn, 1966; Grabowski & Roberts, 1996; and Rochefort & Cobb, 1994). The amalgamation of the web review and survey data sources provided a side by side comparison of respondent reported and researcher observed information regarding safety function message framing and HRO status of the 19 universities examined.

In general, a strong majority of institutions with high HRO scores on both web and survey indices as outcomes are observed presenting an explicit safety sub-system statement exhibiting characteristics of enablement, facilitation, and an otherwise value- adding constructed message. The institutions with mixed high and low HRO scoring for web and survey data display a dominance of mid-continuum framing characteristics projecting a message of both compliance and mitigation. Absent from the frame is the utilitarian message claiming the greater good of organizational success and/or public responsibility in regard to institutional safety, health, and environmental decision-making. The institutions with low scoring on both web and survey HRO

indices demonstrates a consistently low evolution of message framing limited to the external mandate of compliance and absent any evidence of internal institutional benefit. Thus, the web review as a complementary data collection strategy provided a method to corroborate survey findings, augment survey data, and offset the limitation of using a single organization respondent for the survey in examining HRO characteristics in universities.

Further, the complementary nature of using two distinct data collection methods is demonstrated in the examination of two cases, #17 and #130. In an examination of the web review data, these cases appear as outliers or at least anomalous cases with high framing scores but low scores in most other areas including HRO capacity. With the addition of the survey data and the amalgamation of the data sources, the reported scores are higher than interpreted on the institutional and EHS websites. This provides a provocative line of exploration regarding the construction of institutional and safety sub-system electronic information and its subsequent interpretation.

Culture

This research did not specifically target underlying culture as central to the research question. However, there are implications in the research findings to enhance understanding of culture as it relates to safety decision-making in universities. Universities are unique in that the combined forces of the academic core and the executives of the administrative shell may drive the formation of culture in the organization. Prevailing organizational cultures and sub-cultures shape the

interpretation of information and actions. These social forces are capable of producing both "...collective sustained responses...and collective blindness to important issues..." (Turner & Pidgeon, 1997; p.47).

While administrators have expressed a high level of concern about high-risk errors according to respondents, this has provoked only a moderate level of effort toward the expression of safety as a core value in universities. In turn, this moderated, centralized message, as expected, has produced a moderated, decentralized action in terms of establishing manager accountability, developing a sense of openness for reporting hazards/errors, and empowering individuals to mitigate a hazard upon discovery. Hence, simply stated, the beliefs, values, and actions as communicated by the university executive(s) are merely reflected in the university faculty and staff beliefs, attitudes, and behaviors expressed as norms (Weick & Sutcliffe, 2001). In the case of public research universities, this identifies a challenge in creating an organization exemplifying mindfulness as described in Weick and Sutcliffe (2001).

Summary of Conclusions

There are several conclusions that can be drawn from this study in terms of the propositions (vertical relationships, horizontal relationships, safety governance, and organizational reliability) presented in Chapter II, Table 2.1. In regard to vertical relationships, the findings suggest that a high degree of executive coupling with the safety function is a good predictor of high HRO capacity based on survey responses from EHS directors in the selected IPEDS population. In terms of horizontal relationships, high system coupling with the safety function is a good predictor of high

HRO capacity. The relationship between the entire safety sub-system and the academic core may be described as very loosely coupled.

Universities with general safety committees reporting high governance capacity are likely good predictors of high reliability. General safety committees reportedly have loosely coupled relationships with the institutional executives and academic core.In terms of the presence of HRO characteristics among the universities in the study group, deference to expertise and preoccupation with failure were the highest scoring. In contrast, sensitivity to operations and commitment to resilience were the lowest scoring.

Limitations and Assumptions

Limitations

There are several limitations of note in this study. Most of these are a function of human error related to survey design and administration, and probably did not have a fundamental impact on the findings and conclusions, but nonetheless must be acknowledged. Post hoc several flaws were identified in the questionnaire design and distribution. In survey question #3 a response choice "Black" for ethnicity was inadvertently left out in both the pilot and final survey, as pointed out by several respondents. In addition questions #45 and #46 could have been consolidated to reduce redundancy. Also, the last question on the survey, an open ended solicitation for final feedback, was inadvertently deleted in the construction of the *WebSurveyor* on line survey.

More comprehensive pre-testing of the survey could have benefited the end product. The survey was very long and complex. In the introductory statement to the final survey a time of 15 minutes was the approximate completion time presented to respondents based on pilot group input. While some respondents completed the survey in less that the stated approximate time, as tracked by *WebSurveyor*, some individuals spent more than the estimated 15 minutes and commented on the personal time burden. The pilot survey was administered to a sample of EHS directors either not in the survey population or alternate EHS individuals at universities. While prompts were provided in the pilot review at the end of the survey, the length and complexity may have acted as a deterrent for investing additional time in formulating comments.

Additional incremental critique on survey design from survey experts may have eliminated unnecessary questions, improved clarity, and invited more substantive feedback. Dillman (2007) has created a guided step process that would be helpful in the future. In addition, an earlier detailed survey construction review may have aided in reducing the low reliability found from testing some items from indices that were subsequently dropped. Further, peer review comparing hard copy and the on line version of the web survey in *WebSurveyor* may have provided a logical intervention in eliminating errors prior to distribution of either the pilot or final survey.

There are notable limitations regarding the design in the collection of data. In regard to the survey, using a single respondent from each institution presented risks to interpreting the data as representative of the larger institutional system. The web review protocol, while structured with prompts including a system of grading, may

also have benefited from a second reviewer and scoring for inter-rater reliability. However, it should be noted that the completion of 19 web reviews was very time intensive in and of itself. In addition, the collection of data from a subset of university websites may have limited the inclusion of interesting discoveries from the total of the respondent population. However, the time commitment for review for 75 university websites would have been substantial and unrealistic for this particular project.

Also important to note is that this project provides an understanding of universities during a snapshot of time. Underlying dynamics, such as university-specific changes or unique histories, e.g., collecting data on items such as recent regulatory compliance fines or negative media coverage, were not a consideration. However, recent national events, such as the trauma of "active shooter" scenarios on college campuses, may have resulted in the high degree of presence of emergency planning activities as reported in the survey but that relationship was not explored.

The population selected for the study is a single IPEDS group, public research universities within the 50 United States. Therefore, the extrapolation of findings to other IPEDS categories may be limited. However, it does prompt curiosity in terms of future comparative research.

Assumptions

There are several assumptions made at the onset of this project that need to be noted. A faulty assumption entering into this project is that general safety committees would be a standard governance practice in universities. This assumption may have

blurred interpretation in some analytical schemes where committee items were included and led to the exclusion in the Boolean treatment of data.

Two other assumptions of note include: 1) the assumption that the appropriate respondent was selected for the survey to represent the organizational complexity of universities; and 2) the assumption that all universities would have equally developed and technologically sophisticated institutional and safety function websites – but as observed during the website data collection, not all institutions have invested the same advanced level of resource dedication to technology, transparency, and development. However, despite these limitations and assumptions, I am confident that the findings and conclusions as applied to the population studied in this project are reliable and representative of the perception of individuals holding a pivotal role in managing risk to institutional resources.

Policy Implications

This study has pursued a unique application of High Reliability Organization theory to public research universities by examining various institutional elements in the collection of survey data through a single lens augmented with the interpretation of institutional website information. Other studies have emphasized a more broad and representative collection of data either from employees across high-risk organizations to determine if each qualifies as an HRO or across a social sub-system of a larger organization to determine high reliability capacity (Venette, 2003). This precise and targeted data collection and subsequent analysis is intended to form a confluence of the early intentions of HRO theory constructionists, the research and pragmatic work

ongoing in extending HRO theory, the still emerging field of health and safety management, and universities as complex social systems that represent an entire continuum of risk potential.

There are at least seven internal and external groups that may benefit from the findings of this research.

1. For safety function leadership the findings suggest that:
    a. Applying HRO theory to a public research university offers promise for guiding the development of an institutional model for managing EHS risk.
    b. Building relationships both vertically and horizontally within a university with added emphasis on the academic executive, faculty governance, and faculty guilds may enable the shift toward a university exhibiting a greater degree of HRO characteristics.
    c. Building HRO theory-centric safety governance structures may enhance the management of risk to the institution.
2. For university executives the findings suggest that:
    a. Tighter coupling with the safety subsystem that is guided by HRO theory may advance executive knowledge in the complexity of institutional risk.
    b. Tighter coupling with the safety subsystem that is guided by HRO theory may illuminate value in re-calibrating the cultural beliefs generated at the executive level to enhance the management institutional risk.

3. For research administration the findings suggest that:
    a. Ensuring the development of an adequate safety subsystem is critical to facilitating research information transfer and oversight.
    b. Engaging in tighter coupling with the safety subsystem guided by the integration of HRO theory is essential to effective research oversight.
    c. Enabling the development of an intra-institutional safety policy infrastructure is critical for building a strong safety culture.
4. For institutional researchers the findings provide understanding in regard to:
    a. The value of an HRO theory-based safety subsystem and information infrastructure for assurance of support in the grant process.
    b. The safety subsystem as a reliable source of information for graduate assistants to enhance safety decision processes.
    c. The value of a peer-review safety governance subsystem for assuring high performance in managing risk.
5. For graduate education the findings suggest the presence of an opportunity to engage in tighter coupling between the structures guiding graduate education and the safety subsystem especially in high-risk departments in consideration of relevant policy development, and formal or informal curriculum augmentation.

6. For funders of grants the findings suggest an assemblage of potential criteria and language beyond regulatory compliance for possible inclusion in the grant process as related to internal institutional mechanisms of oversight to enhance the ethical and safe conduct of research.
7. For accrediting agencies the findings suggest an assemblage of potential criteria and language beyond regulatory compliance for possible inclusion in the requirements for institutional, departmental and/or programmatic accreditation that may enhance institutional performance and student competency and learning.

Contribution of the Research to Human Knowledge

This research contributes value to the collection of human knowledge by the unique design and analysis of examining the social sub-systems within the context of a larger system of a particular organizational type. It provides a way of characterizing organizational arrangements of public research universities while maintaining the integrity of organizational complexity. Further, it extends the application of high reliability organization theory to public research, universities that encompass the entire continuum of risk.

Further, this research possesses the potential for contributing to management practices in universities. Given that this work is part of a Ph.D. program in Public Administration and Policy, the findings and conclusions may provide insightful guidance related to policy development and governance. The framework discussed in

this research could generate helpful ideas regarding the process of research management and oversight.

Suggestions for Future Research

Five ideas emerge from this work as topics for further research.

1. Create a comparative case study design to examine other IPEDS and/or non-U.S. universities in terms of HRO characteristics and organizational arrangements.
2. Design a study to examine differences in the interpretation of risk across sub-cultures in universities.
3. Examine outlier or extreme cases discovered in this research in more detail to extract a greater understanding in regard to HRO dimensions.
4. Examine the design of safety governance and network structures in greater detail relevant to the presence or absence of HRO characteristics.
5. Examine the use, design, and effectiveness of safety information transfer mechanisms to guide decision-making including both social and technological processes.

Conclusion

In this final chapter, conclusions based on the constructs underpinning this research, introduced in Chapter II, were reviewed, discoveries as revealed from the findings in Chapter IV were reported, implications of the research were delineated,

limitations and assumptions were acknowledged, and ideas for further research were promoted. The purpose of this dissertation was to examine arrangements of organizational factors in public research universities demonstrating either high or low degrees of high reliability organization (HRO) capacity. Reviewing relevant literature, establishing an appropriate method, reviewing results, and drawing conclusions and implications met this purpose. Applying HRO characteristics to universities provides one way of creating an orderly and systematized theoretical structure to improve understanding of loosely coupled, highly autonomous, organizations with shared leadership structures.

Public research universities are charged with the creation of internal quality (Lombardi, 2001; p.7). Part of the quality equation is the development of a supporting infrastructure that enables good decision-making to prepare resources to better manage risk and crisis (Lauwerys, 2002; Weick & Sutcliffe, 2001; Mitroff, Diamond, & Alpaslan, 2006). The safety function and its sub-system elements serve an uncompromising role to help create the infrastructure needed for support, guidance, facilitation, and enablement of a university community to successfully manage risk. In the future, the research presented in this study may contribute to universities placing higher regard on developing HRO capacity in order to continuously improve the safety subsystem infrastructure.

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APPENDIX A. PRE-NOTIFICATION OF UPCOMING INVITATION TO PARTICIPATE IN PILOT SURVEY

Dear _____

In two weeks you will receive an invitation to participate in pre-testing a survey as part of a study designed to illuminate new insights into strategy and structure of safety and other organizational factors in universities that may affect the implementation of environmental, health and safety policy. Your role for this phase will be to work through the test questions and provide feedback on problems such as instruction and question clarity, word meaning, thoroughness of answer selection, flow of questions, time for completion, and provide other comments that you think would improve the quality of the survey.

The study is part of my doctoral degree requirements at Portland State University, Portland, Oregon. Your participation will be strictly voluntary and your responses will be maintained confidentially. At the end of the study, I look forward to sharing my findings with interested individuals in environmental health and safety departments in universities across the United States

The survey protocol has been approved by the Human Subjects Research Review Committee at Portland State University. If you have any concerns or questions about your participation in the study or your rights as a survey respondent, please contact the PSU Human Subjects Research Review Committee at 503-725-4288. If you have any questions about the survey, please contact either myself using the contact information below or my dissertation chair, Dr. Sherril Gelmon at gelmons@pdx.edu or at 503-725-3044.

Thank you for your time and consideration. Your insights as a safety professional practicing in a university would be invaluable to improving the questionnaire, and, thus, the quality of this research.

Sincerely,
Rita Sumner
Doctoral Student
Portland State University
Portland, Oregon
E-Mail: sumnerr@pdx.edu
Telephone: 503-725-5267

APPENDIX B. INVITATION TO PARTICIPATE IN PILOT SURVEY

Dear _____

Two weeks ago you received an announcement of an upcoming invitation to participate in pre-testing a survey designed to illuminate new insights into the strategy and structure of safety and other organizational factors in universities that may affect the implementation of environmental, health, and safety policy. Today, I am excited to formally extend that invitation to you!

It is my understanding that you have a leadership role in Environmental Health and Safety function at __(Name of University)__. In that role you probably have observed and experienced a variety of challenges in regard to reaching your departmental goals and have gained much knowledge in regard to understanding the university environment in which you practice your profession. Therefore, you would be an outstanding candidate to take part in this questionnaire improvement process!

The final survey will be sent to directors of environmental health and safety functions as part of a selected population of 165 public universities across the United States. You were selected because you are either the director at an institution not in the study population or the director of your department is in the study population and you would be able to serve as an alternate voice. In either case, I look forward to receiving your comments. The data from the survey will be used for my doctoral dissertation in partial completion of an academic program at Portland State University.

Your response to this invitation is voluntary. Your responses, comments, and opinions expressed on this survey are completely confidential and will be used only to improve the final questionnaire. The responses and comments you provide will not be associated with you as an individual or your institution. My intention, at the completion of my academic program, is to share my findings with interested individuals.

This is a web-based survey that eliminates the use of paper, provides rapid return to the researcher, and allows you, the respondent, relative ease of completion. Your decision to complete the survey with comments serves as your record of informed consent to take part in this research process.

The survey protocol has been approved by the Human Subjects Research Review Committee at Portland State University. If you have any concerns or questions about your participation in the study or your rights as a survey respondent, please contact the PSU Human Subjects Research Review Committee at 503-725-4288. If you have any questions about the survey, please contact either myself using the contact information below or my dissertation chair, Dr. Sherril Gelmon at gelmons@pdx.edu or at 503-725-3044.

I hope you will engage in this opportunity to share your experiences and insights. If you accept this invitation please click on the link below. It will guide you to the beginning of the survey.

Sincerely,
Rita Sumner
Doctoral Student
Portland State University
Portland, Oregon
E-Mail: sumnerr@pdx.edu
Telephone: 503-725-5267

<LINK TO SURVEY>

APPENDIX C. PRE-NOTIFICATION OF UPCOMING INVITATION TO PARTICIPATE IN SURVEY

Dear_____

In two weeks you will receive an invitation to participate in a survey as part of a study designed to illuminate new insights into the strategy and structure of safety and other organizational factors that may affect the implementation of environmental, health and safety policy. As director of the environmental health and safety function at __(Name of University)__, you are in a particularly powerful position to provide valuable input to this study.

The study is part of my doctoral degree requirements at Portland State University, Portland, Oregon. Your participation will be strictly voluntary and your responses will be maintained confidentially. At the end of the study, I look forward to sharing my findings with interested individuals in environmental health and safety departments in universities across the United States.

The survey protocol has been approved by the Human Subjects Research Review Committee at Portland State University. If you have any concerns or questions about your participation in the study or your rights as a survey respondent, please contact the PSU Human Subjects Research Review Committee at 503-725-4288. If you have any questions about the survey, please contact either myself using the contact information below or my dissertation chair, Dr. Sherril Gelmon at gelmons@pdx.edu or 503-725-3044.

Thank you for your time and consideration. Your experience, insight, and perspective from your role as director of your department will be highly anticipated and valued.

Sincerely,
Rita Sumner
Doctoral Student
Portland State University
Portland, Oregon
E-Mail: sumnerr@pdx.edu
Telephone: 503-725-5267

APPENDIX D. INVITATION TO PARTICIPATE IN SURVEY

Dear _____

Two weeks ago you received an announcement of an upcoming invitation to participate in a survey designed to illuminate new insights into organizational factors that tend to contribute to risk decision making processes within public university systems specifically regarding safety, health, and environmental aspects. Today, I am excited to formally extend that invitation to you!

For the purpose of this research, your name and institutional e-mail address were collected from your departmental website. In your role as director, you have detailed experiences, insights, and organizational knowledge about ___(Name of University)___ that would provide critical data leading to better understanding of the current state of the environmental health and safety function in public United States universities. Your input is vital!

Your response to this invitation is voluntary. Your responses, comments, and opinions expressed on this survey are completely confidential and will be used only to report in summary or aggregate data. The responses and comments you provide will not be associated with you as an individual or your institution. The data from the survey will be used in my doctoral dissertation in partial completion of an academic program at Portland State University. My intention, at the completion of my academic program, is to share my findings with interested individuals.

This is a web-based survey that eliminates the use of paper, provides rapid return to the researcher, and allows you, the respondent, relative ease of completion. Your decision to complete the survey serves as your record of informed consent to take part in this research process.

The survey protocol has been approved by the Human Subjects Research Review Committee at Portland State University. If you have any concerns or questions about your participation in the study or your rights as a survey respondent, please contact the PSU Human Subjects Research Review Committee at 503-725-4288. If you have any questions about the survey, please contact either myself using the contact information below or my dissertation chair, Dr. Sherril Gelmon at gelmons@pdx.edu or 503-725-3044.

I hope you will engage in this opportunity to share your experiences and insights. If you accept this invitation please click on the link below. It will guide you to the beginning of the survey.

If you have been contacted in error, please notify me at the e-mail address below.

Sincerely,
Rita Sumner
Doctoral Candidate
Portland State University
Portland, Oregon
E-Mail: sumnerr@pdx.edu
Telephone: 1-503-725-5267

<LINK TO SURVEY>

APPENDIX E. SURVEY INSTRUMENT

The Safety Function in Public Universities

This survey should take about 15 minutes. If you choose to submit this survey, please complete and submit is by October 15. If you begin the survey but are not able to complete it at that time, you can go back through the original email to the survey link and continue.

Thanks again for sharing your insights, experiences, and comments as a director of the safety function in public higher education!

A. First, I would like to collect some general background and professional information about you.

1. What is your age group? (Please check one).
   - ☐ Less than 25 years
   - ☐ 25-29 years
   - ☐ 30-34 years
   - ☐ 35-39 years
   - ☐ 40-44 years
   - ☐ 45-49 years
   - ☐ 50-54 years
   - ☐ 55-59 years
   - ☐ 60 years or more

2. What is your gender? (Please check one).
   - ☐ Male
   - ☐ Female
   - ☐ Prefer not to answer

3. Please indicate your ethnic identity. (Please check one).
   - ☐ American Indian/Alaskan Native
   - ☐ Asian (e.g. Filipino, Japanese, Chinese, etc.)
   - ☐ Caucasian/White
   - ☐ Hispanic or Latino
   - ☐ Native Hawaiian/Other Pacific Islander
   - ☐ Multi-ethnic or racial background
   - ☐ Other (please specify) _____

4. What is the highest formal education degree you have achieved? (Please check one).
   - ☐ High School Diploma/GED
   - ☐ Some College or Associate Degree
   - ☐ Bachelors Degree or equivalent
   - ☐ Some Post-Baccalaureate
   - ☐ Masters Degree
   - ☐ Doctoral Degree
   - ☐ Other (please specify) _____

5. What was your major in your terminal degree? (Please specify). _____

6. How many years have you been in your current position? (Please check one).
   - ☐ Less than 1 year
   - ☐ 1-3 years
   - ☐ 4-6 years
   - ☐ 7-9 years
   - ☐ 10 or more years

7. How many years have you worked in the environmental health and safety profession? (Please check one).
   - ☐ Less than 1 year
   - ☐ 1-3 years
   - ☐ 4-6 years
   - ☐ 7-9 years
   - ☐ 10 or more years

8. Please indicate which of the following certifications you hold. (Please check all that apply).
   - ☐ Certified Industrial Hygienist (CIH)
   - ☐ Certified Safety Professional (CSP)
   - ☐ Occupational Health Nurse (OHN)
   - ☐ Registered Sanitarian (RS)
   - ☐ Certified Health Physicist (CHP)
   - ☐ Professional Engineer (PE)
   - ☐ National Registry of Radiation Protection Technologists (NRRPT)
   - ☐ Currently, I do not hold any safety-related certifications
   - ☐ Other (Please specify) _____

9. What is your current job title? (Please specify). _____

10. How would you describe your institutional role? (Please check one).
    - ☐ Primary director for environmental health and safety
    - ☐ Shared responsibility for environmental health and safety with at least one other director

11. Do you belong to any of the following profession organizations? (Please check all that apply).
    - ☐ NSMA (National Safety Management Association)
    - ☐ CSHEMA (Campus Safety Health & Environmental Management Association)
    - ☐ NEHA (National Environmental Health Association)
    - ☐ AIHA (American Industrial Hygiene Association)
    - ☐ APHA (American Public Health Association)
    - ☐ ASSE (American Society of Safety Engineers)
    - ☐ Currently, I am not a member of any safety-related professional organizations
    - ☐ Other (Please specify)_____

12. What is your current salary range (Not including benefits)? (Please check one).
    - ☐ Less than $40,000
    - ☐ $60,000-69,999
    - ☐ $40,000-49,999
    - ☐ $70,000-79,999
    - ☐ $50,000-59,999
    - ☐ Equal to or greater than $80,000

B. Second, I would like to find out some information about your department.

13. I would like to understand the formal reporting structure for your position. Please indicate the position titles between you and the University President (or equivalent). (Please specify each reporting level by position title).
    EHS Director reports to: _____
    Reports to: _____
    Reports to: _____
    Reports to: _____

14. In your opinion is this the best reporting structure for your department? (Please check one)
    - ☐ Yes
    - ☐ No

    Comments _____

SKIP PATTERN

15. What change(s) in reporting structure do you think would improve your department's ability to conduct EHS operations? (Please specify). _____

16. How many total FTEs (Full Time Equivalents) are employed by your department including management/professional, technical, and support? (Exclude student employees). (Please specify number).
    _____ FTE

17. How many student FTEs does your department generally employ in an academic term? (Please specify number).
_____ FTE

18. What are the particular program areas for which you are responsible? (Check all that apply).

- ☐ Chemical Safety
- ☐ Biological Safety
- ☐ Laboratory Safety
- ☐ Risk Management/Worker' Comp
- ☐ Indoor Air Quality
- ☐ Hazardous Waste Management
- ☐ Universal Waste Management
- ☐ Waste Recycling
- ☐ Homeland Security
- ☐ Fire Safety
- ☐ Emergency Management Planning
- ☐ Pandemic Flu Planning
- ☐ Medical Surveillance
- ☐ Ergonomics
- ☐ Public Health
- ☐ Radiation/Laser Safety
- ☐ Sustainability
- ☐ Other (please specify) _____

19. Are any of these program areas are under at least one other individual's authority at your institution?
(Check all that apply).

- ☐ Chemical Safety
- ☐ Biological Safety
- ☐ Laboratory Safety
- ☐ Risk Management/Workers' Comp
- ☐ Indoor Air Quality
- ☐ Hazardous Waste Management
- ☐ Universal Waste Management
- ☐ Waste Recycling
- ☐ Homeland Security
- ☐ Other (please specify) _____
- ☐ Fire Safety
- ☐ Emergency Management Planning
- ☐ Pandemic Flu Planning
- ☐ Medical Surveillance
- ☐ Ergonomics
- ☐ Public Health
- ☐ Radiation/Laser Safety
- ☐ Sustainability
- ☐ None

SKIP PATTERN

20. Are any of these services contracted out to external vendors? (Please check one).
- ☐ No
- ☐ Yes

Comments _____

SKIP PATTERN

21. Please list EHS services that are contracted out.

_____

22. What was the total expenditure for EHS in your department in the most recently completed fiscal year? Please include salaries, benefits, supplies, and any other associated operational costs. (Please specify—do not use commas). $ _____

23. Did you experience any budgetary change for your department in the current fiscal year? (Please check one).
- ☐ Increase
- ☐ Decrease
- ☐ No Change
- ☐ Unsure

24. Do you anticipate any budgetary change for your department for the next fiscal year? (Please check one).
    - ☐ Increase
    - ☐ Decrease
    - ☐ No Change
    - ☐ Unsure

25. In your opinion are your current staffing levels adequate? (Please check one).
    - ☐ Yes
    - ☐ No

SKIP PATTERN

26. What staff position(s) would you add? (Please specify).

    _____

27. In your opinion, what are the greatest barriers to your department's success? (Please check all appropriate).
    - ☐ Operating budget
    - ☐ Number of staff
    - ☐ Salaries for EHS staff
    - ☐ Adequacy of other resources
    - ☐ Scope of authority
    - ☐ Executive support
    - ☐ Ability to make change
    - ☐ Respect of the faculty
    - ☐ Nature of the academic environment
    - ☐ Other (please specify) _____

28. In your opinion, what are the greatest facilitators of your department's success? (Please check all appropriate).
    - ☐ Operating budget
    - ☐ Number of staff
    - ☐ Salaries for EHS staff
    - ☐ Adequacy of other resources
    - ☐ Scope of authority
    - ☐ Executive support
    - ☐ Ability to make change
    - ☐ Respect of the faculty
    - ☐ Nature of the academic environment
    - ☐ Other (please specify) _____

29. Do you have a particular leader within your university who champions EHS? (Please check one).
    - ☐ No
    - ☐ Yes

SKIP PATTERN

30. How would you characterize the EHS champion at your university? (Please check one).
    - ☐ Executive/administrator
    - ☐ Faculty leader
    - ☐ Other management staff
    - ☐ Other (please specify) _____

C. Next, I would like to find out about safety-related committees and other structures at your institution.

31. Does your university have a general safety committee as described in the OSHA rules? (Please check one).
    ☐ Yes
    ☐ No

SKIP PATTERN

32. Please indicate your level of agreement with each of the following statements regarding the general safety committee at your university. Please choose one answer for each statement.

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
a. The safety committee is viewed as a major voice at this university.					
b. Academic departments actively participate in the safety committee.					
c. Non-academic departments actively participate on the safety committee.					
d. Senior decision-makers are actively involved in the safety committee.					
e. The safety committee is actively engaged in discovering safety system problems.					
f. The safety committee waits for safety issues to be presented by the university community before acting.					
g. The safety committee makes recommendations for change as needed including to the President (or equivalent).					
h. Recommendations made by the safety committee are responded to in a timely manner.					
i. The safety committee actively engages relevant stakeholders to initiate change.					
j. The safety committee has been successful in initiating changes that enhance the system of safety.					
k. The safety committee has a high degree of visibility at this university.					
l. The safety committee compiles an annual report of this university.					
m. The minutes are readily available to the university community.					

33. Which of the following safety-related, institutional-level committees and/or structures are currently active on your campus (names may vary)? (Please check all that apply).
    - ☐ Radiation Safety Committee
    - ☐ Laser Safety
    - ☐ Laboratory Safety Committee
    - ☐ Animal Care Committee
    - ☐ Bio-safety Committee
    - ☐ Security Committee
    - ☐ Emergency Management Planning Committee
    - ☐ Environmental Health and Safety Policy Committee
    - ☐ Sustainability Committee
    - ☐ None
    - ☐ Other. (Please specify) _____

34. Which of the following statements best describes the relationship among the safety-related committees at your university? (Please check one).
    - ☐ Each committee operates autonomously with little or no interaction.
    - ☐ There are some informal interactions among or between committees if the need arises.
    - ☐ There are regular informal interactions between or among safety-related committees.
    - ☐ There are formal and regular interactions between or among safety related committees.
    - ☐ There are formal and regular interactions and there is an overarching policy committee that provides an approval mechanism for EHS policy and/or programs.
    - ☐ Not applicable.

35. Are there departmental-level safety committees at your institution?
    - ☐ Yes, many departments/groups have their own safety committees
    - ☐ Yes, a few departments/groups have their own safety committees
    - ☐ There are no departmental-level safety committees

36. Does your institution have a departmental safety coordinator program (or equivalent) at your university? (Please check one).
    - ☐ Yes
    - ☐ No

SKIP PATTERN

37. How would you rate the amount of time investment in training departmental safety coordinators by EHS staff? (Please select one).
    - ☐ High
    - ☐ Moderate
    - ☐ Low

38. How would you rate the degree of effectiveness of the departmental safety coordinator at your university? (Please select one).
    - ☐ Highly effective
    - ☐ Moderately effective
    - ☐ Not very effective

D. The next set of questions is about your university.

39. What is the location of the main campus of your university? (Please check one).
    - ☐ Urban
    - ☐ Suburban
    - ☐ Rural

40. What is the total number of FTE for all faculty, staff, and students for the Fall 2006 term? (Please specify number—do not use commas).
_____ FTE

41. Has your university enacted any of the following systems of accountability? (Check all that apply).
☐ Environmental Management System (EMS)
☐ Corporate Social Responsibility (CSR)
☐ International Standards Organization (ISO)
☐ Sarbanes-Oxley (SOX)
☐ No formal system in place
☐ Other (Please specify) _____

SKIP PATTERN

42. Is your department actively engaged in the accountability system process(es)? (Please check one).
☐ Yes
☐ No

43. Which of the following academic or operational activities exist at your institution and are staffed by university employees? (Please check all that apply).
☐ Medicine
☐ Veterinary Medicine
☐ Nursing
☐ Pharmacology
☐ Engineering
☐ Dentistry
☐ Other Health Sciences
☐ Nanotechnology
☐ Agriculture/Forestry
☐ Teaching Hospital
☐ Animal Care facility
☐ Food Service
☐ Landscaping
☐ Facilities Maintenance
☐ Student Health Clinic
☐ Employee Health Clinic
☐ Employee Wellness Program
☐ Residence Life
☐ Logistics/Supplies
☐ Other (Please list)_____

E. Next, I would like to find out about the social context of your university in regard to environmental health and safety.

44. Please indicate your level of satisfaction with the following statements. (Please check one answer for each statement).

	Very Satisfied	Somewhat Satisfied	Neutral	Somewhat Dissatisfied	Very Dissatisfied	NA
a. EHS relationship with state system of higher education.						
b. State system of higher education support for EHS.						
c. Level of support from university administrators.						
d. Frequency of communication with university administrators.						

e. Level of support from faculty senate and other academic leaders.						
f. Frequency of communication from faculty senate and other academic leaders.						
g. Level of support from your direct from supervisor.						
h. Level of support for departmental safety coordinator program (or equivalent).						
i. Level of engagement between EHS and research community.						
j. Opportunity to collaborate with EHS directors at other universities within this state.						

45. Please indicate your level of agreement for each statement. (Check one answer for each statement).

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
a. Administrators at this university regard health and safety as a core value.					
b. Administrators consistently provide adequate resources to support safety development and implementation activities.					
c. Faculty are personally involved in critical safety activities.					
d. Non academic managers are personally involved in critical safety activities.					
e. Employees at all levels are empowered to initiate and achieve safety improvements.					
f. EHS is a trusted resource at this university.					

46. Please indicate your level of agreement with each of the following statements. (Check one answer for each statement).

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
a. Administrators at this university are very concerned about making high-risk errors.					
b. Managers/supervisors including faculty at this university are very concerned about making high-risk errors.					
c. University members are comfortable reporting errors and adverse events.					
d. Analyzed errors are viewed as learning opportunities at this university.					
e. There is a supported and active safety network at this university.					
f. Analyzed errors and adverse events are reported in simplistic terms.					
g. Mutual respect is evident when diverse opinions are expressed at this university.					
h. Recommendations by the safety committee to the university are given careful consideration.					
i. Managers/supervisors including faculty have access to specific training that informs them of their role and accountability for environmental health and safety policies, programs, and best practices.					
j. Interdepartmental and interdisciplinary collaboration is encouraged to address shared environmental health and safety information for this university.					
k. The creation of a new committee to address an emerging environmental health and safety issue would be fully supported.					
l. The activity of planning for emergencies actively engages individuals from across this university.					

m. Skill and knowledge development for all individuals relevant to environmental health and safety is a priority at this university.					
n. My opinions as safety director are taken into account in the daily operations at this university.					
o. My departmental staff is recognized as experts on environmental health and safety issues across this university.					
p. Employees at this university are expected to follow standard operating procedures without question.					

Thank you for completing this survey!

APPENDIX F. WEBSITE REVIEW PROTOCOL

Date: _____
Public University: _____
State: _____

University Safety Infrastructure, Governance, and Institutional Relationships
Website Review Protocol

The goals of this analysis for the research project are:

- To understand social systems[1] and social actions[2] of university systems, supra-systems, the safety subsystems including EHS[3] functions, safety governance structures, safety networks.
- To augment, complement, corroborate information and identify gaps in data collected through the previously distributed survey.
- To identify commonalities, differences, unique aspects, and trends among universities as systems and their embedded ehs[4] subsystems.
- To combine findings and analysis with results from the survey.

The format parallels the conceptual areas identified in the sub-questions and explicated in the operational definitions.

The process for completion of the analysis is:

- To review the university supra-system's homepage relevant to environmental health and safety and relevant system and safety subsystem interaction (if state has state system of higher education or equivalent);
- To review the institution's homepage relevant to environmental health and safety;
- To review President (or equivalent) and other executive-level statements relevant to the ehs subsystem;
- To identify departmental (or other sub-system) index web pages with statements and/or links to any facet of the ehs subsystem;
- To review the EHS website to examine the safety function's structure and demographics, planning and implementation strategies, knowledge transfer strategies, and etc;
- To search for and review safety-related governance structure(s) and processes;
- To search for and review safety-related network structure(s) and processes;
- To search for academic curriculum components coupled to EHS;
- To examine message framing across each institutional system for clues to the existing social system and social action elements.

The following dimensions reflect the core project concepts and their attending indicators. Two scales will be used for assessing the core dimensions and their elements. The first scale will be based on a 4-point rating system and will be used to rate the degree of explicit presence of each element of a dimension, i.e., **Absent, Cursory, Moderate, and Extensive**. The second scale will be based on a 3-point rating system and will be used to categorize the use of language in framing various facets regarding the subsystem of institutional safety, i.e., **Compliance-Only, Compliance & Mitigation, and Compliance, Mitigation, and Value Added.** In addition, text and/or interpretive comments of the researcher will be included to contextualize both rating schemes.

---

[1] Social systems include descriptions of systems theory, coupling, and networks.
[2] Social actions include descriptions of culture, problem framing, and power.
[3] EHS (upper case) refers to the Environmental Health & Safety function (or equivalent).
[4] ehs (lower case) refers to the subsystem of institutional safety including safety function, safety networks,and safety governance elements

This protocol has been adapted from: Mikkelsen M, Gelmon S.B., Seifer, S.D., Kauper-Brown, J. (2005). *Community-engagement scholarship for health collaborative: Website analysis protocol.* Seattle: Community-Campus Partnerships for Health Website: http:// www.ccph.info.

DIMENSION 1: VERTICAL RELATIONSHIPS

1.1 If present, the state system of higher education website provides explicit statement(s) regarding safety at the institutional level.
Presence:
Framing:
Comments:

1.2 If present, the state system of higher education website provides explicit statement(s) of accountability regarding safety at the institutional level.
Presence:
Framing:
Comments:

1.3 If present, the state system of higher education website provides evidence of guidance or support for EHS function at the institutional level.
Presence:
Framing:
Comments:

1.4 University executive(s) provide explicit statement(s) of support for EHS/safety at the university level.
Presence:
Framing:
Comments:

1.5 The University website provides explicit evidence of the development of a formal system of accountability that includes the EHS function.
Presence:
Framing:
Comments:

1.6 EHS website provides explicit statement(s) of accountability for multiple levels of the university.
Presence:
Framing:
Comments:

1.7 EHS website provides an accessible strategic plan containing explicit goals and an annual report detaining accomplishments toward goals.
Presence:
Framing:
Comments:

1.8 EHS website provides explicit opportunity for organizational learning from errors.
Presence:
Framing:
Comments:

1.9 EHS website provides a targeted training program(s) for supervisors and managers.
Presence:
Framing:
Comments:

1.10 EHS website provides evidence of a safety audit system (active or passive).
Presence:
Framing:
Comments:

1.11 There is explicit evidence of EHS and supra-system interface.
Presence:
Framing:
Comments:

1.12 There is explicit evidence of EHS and system executive interface.
Presence:
Framing:
Comments:

DIMENSION 2: HORIZONTAL RELATIONSHIPS

2.1 There is explicit evidence on the EHS website that a system of departmental safety coordinators (either volunteer or appointed) has been developed.
Presence:
Framing:
Comments:

2.2 The role of departmental safety coordinators is explicitly stated on (or linked to) the EHS website.
Presence:
Framing:
Comments:

2.3 There is evidence of an active and on-going skill and knowledge development process for safety coordinators.
Presence:
Framing:
Comments:

2.4 The EHS website provides explicit evidence of the conveyance of emergent information (newsletter, website updates on index page, and etc.).
Presence:
Framing:
Comments:

2.5 The EHS website (or elements of its content) is (are) linked from other intra-institutional websites.
Presence:
Framing:
Comments:

2.6 There is explicit evidence that all students are considered units within the safety subsystem.
Presence:
Framing:
Comments:

2.7 There is explicit evidence of external community inclusion in the university safety subsystem.
Presence:
Framing:
Comments:

2.8 There is explicit evidence of EHS partnerships with external public agencies (e.g., regulators, municipalities, other universities, and etc.).
Presence:
Framing:
Comments:

2.9 There is explicit evidence of safety communication with university leaders.
Presence:
Framing:
Comments:

2.10 The EHS website provides an explicit and clear statement of its functional role.
Presence:
Framing:
Comments:

2.11 The EHS website provides explicit and clear policy implementation guidance for affected stakeholders.
Presence:
Framing:
Comments:

2.12 The EHS website provides orienting information regarding the institutional subsystem of safety.
Presence:
Framing:
Comments:

2.13 There is evidence that EHS provides (or contributes to) student academic instruction.
Presence:
Framing:
Comments:

DIMENSION 3: SAFETY GOVERNANCE

3.1 The EHS website provides explicit role, mission, and goals (or link to) statements regarding safety governance structures within the institution.
Presence:
Framing:
Comments:

3.2 There is explicit evidence of inter-relationships among safety governance structures.
Presence:
Framing:
Comments:

3.3 There is explicit evidence of an inter-relationship between faculty (informal) governance and safety governance structures.
Presence:
Framing:
Comments:

3.4 There is explicit evidence of an inter-relationship between the formal governance structure and safety governance structures.
Presence:
Framing:
Comments:

3.5 There are explicit and clear methods for accessing safety governance structures.
Presence:
Framing:
Comments:

3.6 There is openness and transparency of safety governance subsystem activities.
Presence:
Framing:
Comments:

3.7 There is a clear and accessible safety governance annual report and self-assessment either individually or in aggregate form compiling all safety governance structure information into one report.
Presence:
Framing:
Comments:

3.8 There is clear evidence that university decision-makers are actively engaged with the safety governance structures and processes.
Presence:
Framing:
Comments:

DIMENSION 4: ORGANIZATIONAL (SYSTEM) RELIABILITY

4.1 There are explicit and clear hazard, near miss, and accident identification and reporting processes.
Presence:
Framing:
Comments:

4.2 There is evidence of both skill building and empowerment of the university community in identifying and reporting hazards, near misses, and accidents.
Presence:
Framing:
Comments:

4.3 There is evidence of an explicit system response process (to reported hazards, near misses, and accidents) linked to a subsequent organizational learning process.
Presence:
Framing:
Comments:

4.4 There is clear evidence of an existing network of slack resources capable of ad hoc response to emerging problems.
Presence:
Framing:
Comments:

4.5 The safety subsystem is explicit and transparent to the university community.
Presence:
Framing:
Comments:

4.6 The EHS website (and possible others) facilitates the transfer of knowledge and resources to moderate and decrease the effect of unanticipated events.
Presence:
Framing:
Comments:

APPENDIX G. FIRST SURVEY REMINDER EMAIL

October 15, 2007

Dear _____
Two weeks ago you received an invitation with a link to a web based survey to participate in a study designed to illuminate new insights into organizational factors that tend to contribute to risk decision making processes within public university systems specifically regarding safety, health, and environmental aspects. The invitation is still open and I value your insights and organizational knowledge based on your experience at UNIVERSITY.

I have received feedback regarding the time investment to complete the survey. In the introduction to the survey, I have stated that it should take approximately 15 minutes. However, based on the data that is tracked along with the submission of the survey the most rapid completion was 12 minutes and the longest completion time was more than an hour. The majority of respondents spent between 20 and 25 minutes.

If you accept this invitation please click on the link below. It will guide you to the beginning of the survey.

Your response to this invitation is voluntary. Your responses, comments, and opinions expressed on this survey are completely confidential and will be used only to report in summary or aggregate data. The responses and comments you provide will not be associated with you as an individual or your institution. The study is part of my doctoral degree requirements in the Ph.D. in Public Administration and Policy program in the College of Urban and Public Affairs at Portland State University, Portland, Oregon. My intention, at the completion of my academic program, is to share my findings with interested individuals.

The survey protocol has been approved by the Human Subjects Research Review Committee at Portland State University. If you have any concerns or questions about your participation in the study or your rights as a survey respondent, please contact the PSU Human Subjects Research Review Committee at 1-503-725-4288 or toll free at 1-877-480-4400. If you have any questions about the survey, please contact either myself using the contact information below or my dissertation chair, Dr. Sherril Gelmon at gelmons@pdx.edu or 1-503-725-3044.

Sincerely,
Rita Sumner
Doctoral Candidate
Portland State University
Portland, Oregon
E-Mail: sumnerr@pdx.edu
Telephone: 1-503-725-5267

<LINK TO SURVEY>

APPENDIX H. SECOND SURVEY REMINDER EMAIL

October 25, 2007

Dear _____
This is the last formal invitation to participate in a research project designed to illuminate new insights into organizational factors that tend to contribute to risk decision making processes within public university systems specifically regarding safety, health, and environmental aspects. The invitation is still open and I value your insights and organizational knowledge based on your experience at UNIVERSITY.

If you accept this invitation please click on the link below. It will guide you to the beginning of the survey.

Your response to this invitation is voluntary. Your responses, comments, and opinions expressed on this survey are completely confidential and will be used only to report in summary or aggregate data. The responses and comments you provide will not be associated with you as an individual or your institution. The study is part of my doctoral degree requirements in the Ph.D. in Public Administration and Policy program in the College of Urban and Public Affairs at Portland State University, Portland, Oregon. My intention, at the completion of my academic program, is to share my findings with interested individuals.

The survey protocol has been approved by the Human Subjects Research Review Committee at Portland State University. If you have any concerns or questions about your participation in the study or your rights as a survey respondent, please contact the PSU Human Subjects Research Review Committee at 1-503-725-4288 or toll free at 1-877-480-4400. If you have any questions about the survey, please contact either myself using the contact information below or my dissertation chair, Dr. Sherril Gelmon at gelmons@pdx.edu or 1-503-725-3044.

Sincerely,
Rita Sumner
Ph.D. Candidate
Portland State University
Portland, Oregon
E-Mail: sumnerr@pdx.edu
Telephone: 1-503-725-5267

<LINK TO SURVEY>

APPENDIX I. CASE ORDERED PREDICTOR META-MATRIX: Degree of High Reliability Organization Characteristics as Related to Supra-System and System Context in Public Research Universities (Web Review and Survey Data Amalgamation)

	Predictor/Context Elements											Outcome
Case	**Category[1]**	**Vertical Supra SI**	**Vertical System W**	**Relationship HW/RSI**	**Governance W/SI/SCC[2]**	**Framing W[3]**	**Investment Budget/Staff BSR[4]/SSR[5]**	**Salary S[6]**	**Reporting[7] S**	**Facilitators S[8]**	**Barriers S[9]**	**HRO Index W/SI**
12	C3	L	H	H/H	H/H/2	3	B2/S2	6	VCF, C	C, ES, R, SC	AE, S	H/H
88	C1/L	H	H	H/H	H/H/4	3	B2/S1	6	AVCF, VC, C	C, ES, R, S	AE, OB, SL, SS	H/H
133	C1/L	H	H	H/H	H/H/5	3	B--/S1	6	AVCCS, VCF, C	C, ES, R, OB, OR, S, SS, SC	AE	H/H
151	C1/L	H	H	H/H	H/L/2	3	B2/S1	6	EDHSA, P	ES, R, SC	AE, OB, OR, S, SS	H/H
89	C1/L	NA	H	H/H	L/--/5	3	B3/S1	6	AVCSS, VCA, P	ES, OB, R	AE, OR, S	H/H
121	C1/L	NA	H	H/H	L/--/2	3	B3/S1	6	AVPF, CFO, P	C, ES, R, SC	AE	H/H
110	C1	H	L	H/H	H/H/4	2	B2/S1	6	AVPCS, VPF, P	C, R, SC	OR	H/H
74	C2	H	H	L/H	H/H/4	2	B1/S2	6	VPR&D, P	ES, OB, S, SC, SS	OR	L/H
141	C1/L	L	H	L/H	L/L/3	2	B1/S2	6	VCGR, VC, C	ES, R	AE, S	H/L

[1] C1=Carnegie classification--very high research; C1/L=Carnegie classification very high research and Lombardi Top 25; C2=Carnegie classification--high research; C3=Carnegie classification--research

[2] SCC=safety committee coupling—1=each committee operates autonomously; 2=some informal interactions among committees as needed; 3=regular, informal interactions; 4=regular formal interactions; and 5=regular, formal interactions and an overarching policy committee

[3] Web Review source--1=compliance-only; 2=compliance and mitigation; and 3=compliance, mitigation and value-added

[4] BSR=budget ratio from survey--B1=<$40/FTE; 2=$40-$80/FTE; 3=>$80/FTE

[5] SSR=staffing ration from survey—1=1 FTE/<2000 FTE; 2=1 FTE/<3000 FTE; 3=1 FTE/<4000 FTE; 4=1 FTE/<5000 FTE; 5=1 FTE/>5000 FTE

[6] Salary from survey source 1=Salary <$40,000; 2=Salary<$50,000; 3=Salary<60,000; 4=Salary<$70,000; 5=Salary<$80,000; and 6=Salary≥$80,000

[7] Reporting structure from survey source VCF=Vice Chancellor Finance; C=Chancellor; AVCF=Associate Vice Chancellor Finance; AVCCS=Associate Vice Chancellor for Campus Services; EDHSA=Executive Director Health Sciences Administration; AVCSS=Associate Vice Chancellor Safety Services; AVPF=Associate Vice President Finance; CFO=Chief Financial Officer; AVPCS=Associate Vice President Campus Services; VPR&D=Vice President Research & Development; VCGR=Vice Chancellor for Government Relations; VPR=Vice President Research; EVP&P=Executive Vice President and Provost; AVPFac=Associate Vice President Facilities; SVPF=Senior Vice President Finance; VPRA&F=Vice Provost Administration and Finance; PR=Provost; Assistant Vice Chancellor Business Services; DPS=Department of Public Safety; ADFac=Assistant Director Facilities; DFac=Director of Facilities

[8] AE=academic environment; C=ability to create change; ES=executive support; OB=operating budget; OR=other resources; R=respect of faculty; S=staffing level; SC=scope of work; SS=staff salaries

[9] AE=academic environment; C=ability to create change; ES=executive support; OB=operating budget; OR=other resources; R=respect of faculty; S=staffing level; SC=scope of work; SS=staff salaries

130	C2	H	H	L/H	L/L/2	3	B3/S1	6	VPR, EVP&P, P	ES, OB, R	AE, ES	L/H
158	C2	H	L	L/L	L/H/4	2	B2/S1	6	AVPFac, VPF, P	ES, R	S	H/H
17	C1	H	L	L/H	L/H/1	3	B2/S1	6	VPF, SVPF, P	AE, ES, OR	OB, S, SS	L/H
61	C1	H	L	L/H	L/--/2	2	B2/S1	6	VPF, P	C, ES, OB, R, S, SS	OR, SC	L/H
48	C1	NA	L	H/H	L/--/2	2	B1/S2	6	AVP, SVP, P	AE, ES	AE, C, OB, S, SC	H/L
109	C1	H	H	H/L	H/L/5	2	B1/S2	6	VPRA&F, PR, C	C, OR, R, SS, SC	AE, ES	H/L
125	C2	L	L	L/L	L/--/1	1	B1/S1	6	AVCBS, VCF, C	R	ES, OB, S, SC	L/L
20	C3	H	H	L/L	L/--/2	1	B1/S5	4	DPS, VPF, P	ES, OR, SC	AE, OB, S, SS	L/L
54	C3	H	L	L/L	L/L/1	1	B1/S4	3	ADFac, DFac, VPF, P	OR	C, ES, S, SC	L/L
86	C3	L	L	L/L	L/L/1	1	B1/S5	1	VCF, C	--	AE, OB, SC, SS	L/L