CHARACTERIZATION, COORDINATION AND LEGITIMATION OF RISK IN CROSS-DISCIPLINARY SITUATIONS

A Dissertation

by

DOROTHY COLLINS ANDREAS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2010

Major Subject: Communication

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Approved by:

Chair of Committee,	J. Kevin Barge
Committee Members,	Charles Conrad
	Barbara Sharf
	Tarla Rai Peterson
Head of Department,	Richard Street, Jr.

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ABSTRACT

Characterization, Coordination, and Legitimation of Risk in Cross-Disciplinary Situations.

(August 2010)

Dorothy Collins Andreas, B.S., Texas A&M University; M.A., Texas State University

Chair of Advisory Committee: Dr. J. Kevin Barge

In contemporary times, policy makers and risk managers find themselves required to make decisions about how to prevent or mitigate complex risks that face society. Risks, such as global warming and energy production, are considered complex because they require knowledge from multiple scientific and technical disciplines to explain the mechanisms that cause and/or prevent hazards. This dissertation focuses on these types of situations: when experts from different disciplines and professions interact to coordinate and legitimize risk characterizations.

A review of the risk communication literature highlights three main critiques: (1) Risk communication research historically treats expert groups as uniform and does not consider the processes by which they construct and legitimize risk understandings. (2) Risk communication research tends to privilege transmissive and message-centered approached to communication rather than examine the discursive management and coordination of different risk understandings. (3) Rather than assuming the taken-for-granted position that objective scientific knowledge is the source of legitimacy for technical risk understandings, risk communication research should examine the way that expert groups legitimate their knowledge claims and emphasize the transparency of norms and values in public discourse.

This study performs an in-depth analysis of the case of cesium chloride. Cesium chloride is a radioactive source that has several beneficial uses medical, research, and radiation safety

applications. However, it has also been identified as a security threat due to the severity of its consequences if used in a radiological dispersal device, better known as a "dirty bomb." A recent National Academy of Sciences study recommended the replacement or elimination of cesium chloride sources. This case is relevant to the study of risk communication among multi-disciplinary experts because it involves a wide variety of fields to discuss and compare terrorism risks and health risks.

This study uses a multi-perspectival framework based on Bakhtin's dialogism that enables entrance into the discourse of experts' risk communication from different vantage points. Three main implications emerge from this study as seen through the lens of dialogism. (1) Expert risk communication in cross-disciplinary situations is a tension-filled process. (2) Experts who interact in cross-disciplinary situations manage the tension between discursive openness and closure through the use of shared resources between the interpretative repertoires, immersion and interaction with other perspectives, and the layering of risk logics with structural resources. (3) The emergence of security risk Discourse in a post-9/11 world involves a different set of resources and strategies that risk communication studies need to address.

In the case of cesium chloride issue, the interaction of experts negotiated conflict about the characterization of this isotope as a security threat or as being useful and unique. Even though participants and organizations vary in how they characterize cesium chloride, most maintained some level of balance between both characterizations—a balance that was constructed through their interactions with each other. This project demonstrates that risk characterizations risks shape organizational decisions and priorities in both policy-making and regulatory organizations and private-sector and functional organizations.

DEDICATION

This dissertation is dedicated with love to my parents, Elmo and Karen Collins. Mom, your example and support inspires me to reach for my goals. Dad, your career and service inspires my scholarship.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Barge for his wise advice and guidance throughout this research project. I also would like to thank my committee members, Dr. Conrad, Dr. Sharf, and Dr. Peterson for their encouragement and support for the dissertation and throughout the course of my graduate program. And many thanks to Dr. Rick Street whose mentoring helped me to see myself as a scholar and researcher.

I also want to extend my gratitude to the engineers and scientists who develop technologies to improve our lives and the public servants who work to protect us—especially the ones who were willing to participate in this study.

Finally, thanks to my parents for their encouragement and support. And a never ending debt of love and gratitude to my husband, Josh, who displayed infinite patience for late nights, wiping away tears, proofreading drafts, and a belief in my abilities to succeed.

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CHAPTER I

INTRODUCTION

A nuclear engineer, a computer scientist, and an industrial psychologist walk into a room. This sentence sounds like the beginning of a joke in the classic genre of "Three people walk into a room: a doctor, a lawyer and an officer…" or "a priest, a rabbi, and an atheist…" The humor of this genre stems from the human tendency of various groups to engage situations in different ways and solve problems using different approaches. However, in the case of this study, the opening sentence does not begin a joke—it describes the types of expertise called upon to address the risks of working with nuclear power. Each expert represents a distinct disciplinary tradition toward knowledge creation that focuses on different aspects of the risk under question.

In contemporary times, policy makers and risk managers find themselves required to make decisions about how to prevent or mitigate complex risks that face society. Risks, such as global warming and energy production, are considered complex because they require knowledge from multiple scientific and technical disciplines to explain the mechanisms that cause and/or prevent hazards (Horlick-Jones & Sime, 2004). Due to this complexity, decision makers frequently call upon technical experts across multiple disciplines to share information and make formal risk judgments (Bier, 2001; Renn, 1998). They subsequently use the experts' risk judgments to justify actions and policies that prevent and mitigate risks. Experts, decision makers, and policy makers do more than exchange objective information in these situations; rather, they assign meaning to the risks under consideration. However, due to disciplinary differences that provoke methodological disagreements and challenges to professional identity, it can be difficult to coordinate cross-disciplinary risk understandings (Horlick-Jones & Sime,

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This dissertation follows the style of *Journal of Applied Communication Research*.

2004; Thompson, 2009). Even when experts have similar backgrounds in nuclear physics and engineering, they may reach different conclusions about the legitimacy of models regarding adverse health effects of radiation for use in policy decisions (Silva, Jenkins-Smith, & Barke, 2007). This dissertation focuses on these types of situations: when experts from different disciplines communicate with each other about risks and how they characterize, coordinate, and legitimize risk understandings.

Experts have traditionally characterized risk by explicating cause and effect relationships in mechanical, ecological, and biological systems. Several professional, governmental, and scientific associations and institutions have attempted to address concerns associated with methodological variations in technique due to differences in disciplinary expertise. Since the 1980's, the American Society of Mechanical Engineers has been working to develop standards for probabilistic risk assessment. In 2006, the U. S. Office of Management and Budget published standards for judging the quality of risk assessment methods and results across different disciplines. An ongoing collaborative project between government agencies from Europe, Canada, and the U. S. is attempting to integrate different risk assessment methodologies to develop a unified tool that prioritizes risks in a manner that aids risk decision making. Such efforts at integration and unification illustrate the concern that policy makers have about divergent assessments and characterizations of risk due to disciplinary differences in methodology and technique. The ability to construct a unified tool or common foundation for assessing risk and conducting risk analysis is constrained by varying quality of models for representing the systems under investigation (Adair, 2002). These constraints include different scientific methods to address physical phenomena and uncertainty about how the different input values of the models impact its outcomes. When discussing the case of the degraded reactor pressure vessel at Davis-Besse Nuclear Power Station that was not predicted by the models (or

even considered "credible," Perin (2005) writes that "even though model-makers themselves may be aware of the limits of their simplifications, models may find themselves doing more heavy lifting than intended when the world goes its own way" (p. 203).

In addition to methodological difficulties, experts who address multi-disciplinary risk problems face these common characteristics: (1) uncertain facts, (2) disputed social values, and (3) high stakes, which make decisions urgent (Horlick-Jones & Sime, 2004). Given the incommensurability of several disciplines and the complex characteristics of multi-disciplinary risks, it is unlikely that a unified or common set of standards for assessing risks across multiple disciplines can be developed or is even desirable. As a result, it becomes increasingly important for individuals associated with risk and risk analysis to understand how certain understandings of risk are introduced and developed, and become the basis for making risk decisions and policies. Instead of trying to address the incommensurability of the expertise by presuming that a common methodological approach will achieve consensus, decisions about complex risks need be negotiated and managed among disciplinary experts, managers, and other stakeholders (Horlick-Jones & Sime, 2004).

Scientific and risk analysis methods allow experts to gain insight about characteristics of the physical hazards present in the system under investigation, but the experts must articulate this knowledge in a legitimate form and coordinate it with others' expertise. In this way, the communication process extends scientific and risk assessment methods in a way that enables experts to impact the quality of decisions made about risk policy. For example, Tompkins' (1977) research at NASA demonstrates that only "easy" decisions were made by demonstrations of scientific evidence and the "difficult" decisions were made through rhetorical processes. The information from the multiple scientific perspectives about "the difficult decisions created in fact an exigence of ambiguity" (Tompkins, 1977, p. 24). In these situations, "the limits of 'scientific'

decision making, [call] for a self-conscious approach to rhetorical arguments from the *topoi* of reliability, schedule and cost, making tradeoffs but avoiding the 'foul compromise'" (Tompkins, 2005, p. 18). This means that communication processes are critical in the negotiation of what counts as risk and how it should be managed.

The next three sections provide a backdrop to understand the context in which risk communication practices invoke expertise to coordinate and legitimize decisions about managing risk. The first section defines risk and briefly discusses the evolution of risk assessment for the purpose of highlighting how the reliance on quantitatively-oriented risk assessment procedures create technical presentations and risk justifications that mask the sources of legitimacy for different expert understandings risk. The next section discusses how processes of risk communication negotiate the ontological dialectic between materialism and constructivism. The final section discusses how the practices of risk management create resources that experts may use to legitimize certain risk understandings.

Risk and the Evolution of Risk Assessment

People potentially face many different types of natural and technological risk in contemporary life including hurricanes, cancer, global warming, terrorist attacks, heart disease, effluents from chemical plants, nuclear proliferation, and swine flu. Despite the seemingly infinite list of potential risks that people may experience and their variations in mechanism of action or the degree of their consequences, these risks share a common definitional element. A risk consists of the "possibility that human actions or events lead to consequences that affect aspects of what humans value" (Renn, 1998, p. 51). This definition captures three features common to risk: (1) a notion of probability or likelihood, and (2) a future orientation, and (3) a formula or mechanism to make a judgment about possible future outcomes with their probabilities (Elliot, 2003; Renn, 1998). Additionally, most researchers consider these future

events as having adverse outcomes (Elliot, 2003; Linell, et al., 2002; McComas, 2006; Slovic, 1999), although Renn (1998) provides a discussion for why the term 'risk' should be used for "uncertain outcomes regardless of whether they are positive or negative" (p. 51).

From ancient times to the industrial revolution to the present, members of society have always had ways to identify and manage risks (Covello & Mumpower, 1985). For example, in the fifth century B.C.E. people associated malaria with swamps (although they did not know why), in the first century Romans observed adverse effects from lead exposure, and in the eighteenth century Sir Percival Pott linked juvenile chimney sweeps with increased incidence of scrotal cancer. Throughout the years, societal members have always had the ability to identify and articulate dangers to their health and well being. Despite an ever changing menu of potential risks, both ancient and contemporary ways of talking about risk function rhetorically to place blame and attribute morality in society (Douglas, 1990). For example, the taboos linked with certain sexual behaviors rhetorically functioned to make them seem immoral in order to protect society from adverse consequences such as disease, unwanted pregnancy, and extra-marital affairs. Douglas (1990) writes that "a vocabulary of risk is all we have for making a bridge between the known facts of existence and the construction of a moral community" (p. 5).

Our contemporary notions of risk result from two major developments in society: (1) the Enlightenment, and (2) Industrialization. In the seventeenth century, the thinkers in the Enlightenment developed the basic mathematical and scientific tools used in contemporary technical risk analysis (Covello & Mumpower, 1985; Taylor-Gooby, 2008). During the 16th century, in the field of mathematics, theoreticians such as Pascal developed formal probability theories. In the 17th century, mathematicians first applied probability theories to develop life expectancy tables. Meanwhile, the scientific disciplines improved methods to infer cause and effect in the natural world. However, these scientific explanations for hazards and adverse

outcomes developed slower, especially for medical explanations, due to a lack of scientific research and popular beliefs attributing adverse health events to religious beliefs. Although insurance practices have used mathematics since Roman times, during the 18th and 19th centuries insurance practices combined probability theory and improved cause and effect inferences to develop formal risk assessments which experts subsequently applied to other types of risks (Covello & Mumpower, 1985). As the source of societal risks shifted to human technologies (e.g., chemical plants, pesticides, nuclear power, oil spills) and the methods of risk assessment became more technically sophisticated, decision makers struggled with how to use this knowledge in risk management (Renn, 1998).

While the mathematical and scientific fields developed methods to analyze risk, the industrialization of society fundamentally changed the source of hazards to humans. Beck (1992) claims that people now exist in a "reflexive modern" society that has become aware of the unintended consequences of technological development. These unintended consequences consist of pervasive technological risks that impact health, safety, and the environment. The industrialization of society has brought about a systematic production of risks that calls for more systematic risk management (Ale, 2005; Covello & Mumpower, 1985; Löfstedt, 2005). In the later part of the twentieth century, as methods and computing tools improved, the practice of risk management began to rely more on results of risk assessments to guide decisions. One way this happens is that policy makers set criteria and an industry uses risk assessment to demonstrate that it meets the criteria (Ale, 2005). Another example of the use of risk assessment is how the U.S. nuclear industry began using probabilistic risk assessment as a tool for gaining insight about risk priorities in nuclear power plants and using this information to make cost-beneficial safety decisions before the U.S. Nuclear Regulatory Commission (NRC) began using it as a tool for

oversight and regulation--despite the fact NRC pioneered the probabilistic risk assessment technique (Garrick, 2004; Kadak & Matsuo, 2007; Keller & Modarres, 2005).

As quantitative risk management methods and techniques have taken greater prominence in society, critics have voiced concern over the practices of risk assessment and criteria standards because they presume that an acceptable level of hazard exposure exists (Beck, 1992). Furthermore, the current practice of risk assessment functions in a system of knowledge production that masks how experts characterize risk and important differences about different expert risk understandings (Beck, 1992; Renn, 1998). Despite its methodological uncertainties, the results of risk assessment have received relatively unchallenged legitimacy which affords this procedure significant influence over risk decisions. As Levenson writes: "the belief grows that the numbers actually have some relation to the real risk of accidents, rather than being a way to evaluate specific aspects of the design" (as quoted in Perin, 2005, p. 202). These critiques suggest that research is needed that help unmask the technical presentation and justification of risk in order to gain insight into the sources of legitimacy for different expert understandings of risk.

Materiality and Risk Communication

McComas (2006) defines risk communication broadly as the "iterative exchange of information among individuals, groups, and institutions related to assessment, characterization, and management of risk" (p. 76). This definition describes the content and process of risk communication and McComas' further discussion addresses how "inherent to the understanding of risk, and the practice of risk communication, is an awareness that risk encompasses both objective and subjective qualities and that risk judgments are, to some degree, a by-product of social, cultural, and psychological influences" (p. 76). Thus, risk communication not only

contains messages about risk, communication is the process through which the social construction of risk occurs.

Several disciplines study risk and risk communication—political science, psychology, risk assessment, public relations, public administration, communication, ecology, science, and engineering (McComas, 2006; Wardman, 2008). With so many disciplines interested in risk communication, and each bringing their own ontological and epistemological assumptions, one should not be surprised about the variety of approaches. However, the ontology constituting these various approaches can generally be divided into two categories that treat risk as a material reality or as a social construction (Metzner-Szigeth, 2009). As a growing body of empirical research differentiated several rationalities by which people understand risk, the social constructionist approach has gained traction (Renn, 1998; Slovic, Finucane, Peters, & MacGregor, 2004). However, this is not an uncontested position as policy-makers continue to rely on realist models of risk and risk communication in their guidance (Horlick-Jones, 1998; Kristensen, Aven, & Ford, 2006) and several researchers try to bridge the realist and constructivist positions on risk (Funtowicz & Ravetz, 1992; Metzner-Szigeth, 2009; Rosa, 1998).

Latour (2004) addresses the ontological question of science in general by drawing attention to how Western society privileges a subject/object distinction in knowledge production to the point that separate groups of people address questions of fact and questions of value—scientists and politicians accordingly. This separation of fact and value prevents science/technical groups and policy/decision-making groups from having meaningful conversations with each other and limits the scope for how the material and symbolic worlds interact with each other. In the case of understanding risk, the subject/object divide artificially separates technical experts and non-technical groups such as policy makers and lay citizens.

At its very essence (separated from analysis, communication, and management), the concept of "risk" appears dialectical because its distinctions between the concepts of "danger" and "risk" hint at a balance between reality and possibility: danger is ontologically real and risk is socially constructed (Renn, 1998). In other words, the physical occurrence of danger can really exist, but interactions among people socially construct the meanings and possibilities associated with this occurrence (Metzner-Szigeth, 2009; Renn, 1998; Slovic, 1999). Beck (1992) describes this tension as "the not-yet-event as stimulus to action" that draws "a distinction between *already destructive consequences* and the *potential element* of risk" (p. 33). Taylor and Kinsella (2007) express the relationship between social construction and material danger by calling researchers to consider how "the nuclear word contributes to… the nuclear world" in ways that imbue material and social objects "with qualities such as necessity, inevitability, legitimacy, priority, authority, and validity" (p. 3). Approaches to studying communication about risk must embrace the underlying symbolic/material tension through careful study of how humans' social constructions interact with natural realities and vice versa (Metzner-Szigeth, 2009; Peterson, 2007; Peterson, Peterson, & Grant, 2004).

Establishing a position about the dialectical nature of risk corrects the assumption that experts only deal with material reality because the dialectical nature of risk forces them to also grapple with its social construction. Beck (1992) uses spatial imagery to illustrate this aspect of risk overlapping in societal spaces:

> Risks lie *across* the distinctions between theory and practice, *across* the borders of specialties and disciplines, *across* specialized competences and institutional responsibilities, *across* the distinction between value and fact (and thus between ethics and science), and *across* the realms of politics, and the public sphere, science and the economy, which are seemingly divided by institutions. (p. 70)

Goodnight's (1982; 1987) theory of the public sphere helps to envision the rhetorical implications of this boundary spanning by drawing attention to choices that "appear as patterns

of differentiated activity, spheres in which some practices are emphasized and others discounted" (Goodnight, 1987, p. 428). A sphere "denotes branches of activity—the grounds on which upon which arguments are built and the authorities to which arguers appeal" (Goodnight, 1982, p. 216). Goodnight distinguishes three spheres of argument (technical, public, and private) which contain different forms of reasoning, evidence, functions, and uses of time. One example that he discusses is how Rachel Carson introduced the discussion of environmental risks in the public sphere but "as the implications of public interest demanded trade-offs that could be made only by technical judgments, ecology was given over to the technical sphere" with "public leaders [providing] parameters for scientific argument" (Goodnight, 1982, p. 222). This example illustrates how these spheres are not to be used as a taxonomy of rhetoric but rather help characterize shifts and overlaps that contribute to or detract from the quality of public deliberation. Visualizing overlaps between technical, private, and public spheres helps "to recognize existence of rhetoric deployed by professional groups to fulfill number of political functions" (Horlick-Jones, 1998, p.84).

As technical experts try to express risk by talking explicitly about "invisible causality relationships between objectively, temporally, and spatially very divergent conditions" (Beck, 1992, p. 72), they also find themselves trying to defend their understandings against objections, especially in cross-disciplinary interactions, and make them seem legitimate to decision-makers who must answer to the public sphere. Hence, technical experts communicating about risk find themselves in a liminal space in which they must negotiate the inherent ontological tension between realism and constructivism. Ceccarelli (2001) characterizes the relationship between rhetorical practice and science "as a convergence of discursive opportunities and material constraints" (p. 316). The experts cannot (and should not) deny the physical, chemical, and

biological aspects of the hazards under question, yet their discourse and attempts to make their understandings plausible construct the meanings of risk in a social space.

Risk Management and Legitimation of Risk

Policy and management decisions about risk form the backdrop against which risk communication among technical experts takes place and these conversations usually include risk managers. The practice of risk management involves questions about how members of society present, justify, and argue about risks (Klinke & Renn, 2002; Löfstedt, 2005). Ultimately communication among technical experts results in a risk management decision that legitimizes one group's particular risk understanding. Unfortunately, decisions about risk often mask the systemic production of knowledge which becomes the rational and legitimate basis for decisions made about the risk (Beck, 1992). Risk management theories recognize the need to negotiate the ontological dialectic; however, the rational actor model underlies these theories and practice of risk management, giving preference to the perspectives that treat risk and consequences as a material reality (Garvin, 2001).

The process of risk management addresses five main issues: (1) realism versus constructivism, (2) relevance of public risk perception as criteria for risk regulation, (3) appropriate handling of uncertainty in risk assessments, (4) legitimate role of risk-based and precautionary-based approaches, and (5) integration of analytical and deliberative processes (Klinke & Renn, 2002). In response to these tensions, Klinke & Renn (2002) suggest three general categories of risk strategies. A *risk-based strategy* relies on the results of risk assessments to characterize important risks and set criteria for responding to the risks. A *precautionary-based strategy* relies on preventative measures to minimize the occurrence of risks. A *discourse-based strategy* relies on deliberation and other social processes to characterize important risks and responses to them. Risk management strategies generally start with the

political regulatory process but, in the face of challenges to the legitimacy of bureaucratic institutions, groups developed other strategies (Löfstedt, 2005). Public deliberation, especially popular in the U. S., relies on democratic public participation mechanisms for making decisions about risks. The technocratic/scientific perspective relies strictly on the results of quantitative risk assessments and emphasizes its benefit for weighing risk versus risk priorities. The rational process relies strictly on economic priorities by considering how much risk can be managed (i.e., how many lives can be saved) for the amount spent.

In response to the issues and available strategies, scholars have developed numerous models to describe the effective processes of risk management that incorporate risk assessment with other types of information. Some models emphasize realist perspectives with their concomitant preference for technical aspects of risk assessment, uncertainty, and expertise which results in a marginalization of feelings, values, and social judgments as consequences rather than characteristics of risk (for an example see Kristenson, Aven, & Ford, 2006). Other models acknowledge how the "dual nature of risk demands a dual risk management approach" that equally incorporates constructivist and realist perspectives of risk (Klinke & Renn, 2002, p. 1076).

For example, about ten years ago, the NRC incorporated risk assessment information in its regulatory structure – a process they call "risk-informed regulation" (Kadak & Matsuo, 2007). The NRC technical staff traditionally relied on deterministic approaches to gauge safety in nuclear power plants—defense-in-depth measures engineered into the reactor designs (similar to precautionary-based strategy). Initially, they felt hesitant about using probabilistic risk assessment (PRA) in the regulatory structure (similar to risk-based strategy). However, the NRC conducted a self-assessment of its organization culture and determined systematic ways to train technical staff in how to use PRA and balance it with deterministic judgments (Clark, Caruso,

Parry, & Mrwoca, 2008). The risk-informed and deterministic approaches to regulation in nuclear power plants illustrate different ways that engineering expertise characterizes a risk. The NRC's experience illustrates one organization's attempt to incorporate formal risk assessment into its risk management practices.

From a more cynical perspective, Ale (2005) illustrates how industry and local politics manipulated risk assessments to produce numbers in ways that allowed them pursue their business interests while meeting legal regulatory requirements. Based on this experience, Ale cautions against viewing risk purely as a social construction—in this case a mathematical construction—because if a risk manifests, it produces real damage and human harm regardless risk assessment numbers.

Regardless of the preferred model, the practice of risk management relies on the rational-actor model which assumes that people make decisions based on the "orderly administration of objective knowledge" (Garvin, 2001, p. 448; Taylor-Gooby, 2008). The emphasis on the rational actor model can be seen in Brewer's (2005) model of risk decision making that accounts for three categories of risk perception and decision making tendencies: normative knowledge, availability, and individual specific (NAVIS). The NAVIS model provides a thorough review of the cognitive biases, heuristics, and other social influences on decision making processes and offers ways to counter these influences to achieve more rational decisions. Apostolakis and Pickett (1998) also illustrate the values of the rational-actor model in their attempts to quantify public deliberation in a decision analytic tool. Perin's (2005) study of incidents at nuclear reactors uncovers how managers achieve the principle of command and control through a tradeoff of underlying "logics": (1) a calculated logic that relies on metrics to promote efficiency and optimization, (2) real-time logic that relies on experiential knowledge to make judgments during actual events, and (3) policy logic that relies on corporate, stations, and

regulatory orders to deal with the paradoxes of complex technical systems. Her studies demonstrate a repeated preference to seek command and control over the alternate principle of doubt and discovery by relying on calculated and policy logics. These patterns demonstrate how rational types of knowledge have more legitimacy in risk management at nuclear reactors. This rational-actor approach to risk management may explain why policy makers formally include risk assessment techniques and psychometric approaches risk policy and avoid including approaches from other social scientific and critical risk research (Horlick-Jones, 1998; Taylor-Gooby, 2008).

This brief review of risk management maps out a spectrum of organizational choices about the appropriate process to make risk decisions that ultimately may become resources for technical experts to draw upon when trying to legitimize a risk. As long as the rational actor model underscores risk management practices, then objective and technical knowledge continues to be more legitimate resources in conversations among experts. In these communicative processes, the experts construct seemingly objective understandings of risk that mask the production of knowledge and make it difficult to challenge a risk judgment.

Focus and Organization of Dissertation

This overview of risk, its history, ontological foundations, and risk management practices, foregrounds the overlaps and tensions between technical and social information. The goal of this dissertation is to explore these overlaps in experts' risk communication in cross-disciplinary situations. Experts draw upon different disciplinary assumptions to explain causal mechanisms and severity risks which produce divergent conclusions and recommendations that are difficult to reconcile. Additionally, the dialectical nature of risk inherently requires the experts to negotiate both technical and social knowledge. Risk communication among experts in cross-disciplinary situations occurs against a backdrop of risk management, a process that

ultimately legitimizes some perspectives over others. Experts and other social actors demonstrate awareness of this backdrop by selecting and coordinating forms of evidence and reasoning that they believe will be accepted as more legitimate. The high stakes and contentious nature of risk decisions warrant a close examination of the processes by which experts communicate with each other about risk in order to problematize the taken-for-granted assumptions about their seemingly exclusive use of technical knowledge. For this reason, the overarching research question for this study considers how experts communicate about risk in cross-disciplinary situation. Specifically this study considers the types of evidence and appeals technical experts rely on to characterize a risk, the strategies they use to legitimize particular risk understandings, and the negotiation and coordination of their different perspectives.

Chapter II covers relevant risk communication research and connects it with research about interdisciplinary group interaction and the sociology and rhetoric of science. Chapter III builds a dialogic, multi-perspectival framework that helps gain insight into the overlaps of different types of knowledge used in risk communication. Chapter IV describes the methodology this study uses to examine the research questions. Chapters V, VI and VII discuss the findings and results of the case studies and the Chapter VIII summarizes the results and discussions implications.

CHAPTER II

LITERATURE REVIEW OF RISK COMMUNICATION

The field of risk communication has experienced much growth since its inception in the late 1970's. An important research thread within risk communication has focused on the differences between expert and lay groups (e.g., Bostrom, Morgan, Fischhoff, & Read, 1994; Fischoff, 1995; McComas, 2006; Plough & Krimsky, 1987; Renn, 1998; Slovic, 1999; Uggla, 2008). This literature review focuses on three main processes regarding risk communication among experts: how they characterize risk, how they coordinate different understandings, and how they legitimize or de-legitimize certain understandings. This chapter also provides background concerning the social construction of expertise—a process that impacts risk characterization, coordination, and legitimation. I conclude the chapter by drawing out three main critiques to justify my focus on studying risk communication among experts: (1) Risk communication research historically treats expert groups as unitary and does not consider the processes by which they construct and legitimize risk understandings. (2) Risk communication research tends to privilege transmissive and message-centered approached to communication rather than examine the discursive management and coordination of different risk understandings. (3) Rather than assuming the taken-for-granted position that objective scientific knowledge is the source of legitimacy for technical risk understandings, risk communication research should examine the way that expert groups legitimate their knowledge claims and emphasize the transparency of norms and values in public discourse.

Expertise and Risk Communication

Questions about legitimate meanings of risk are often underscored by concepts of expertise and who counts as an expert in the field of risk communication. Historically, risk communication research has focused on the expert/lay divide with a special emphasis on

understanding lay constructions of risk. This body of research implicitly treats expert groups as unitary and does not consider the processes by which they construct and legitimize risk understandings. This section discusses the expert/lay divide in risk communication and then unpacks notions of expertise as it relates to understandings of risk.

Expert/Lay Divide

A major focus in risk communication research seeks explanations for why "technical experts" view risk differently than "lay citizens." In general, technical experts tend to use scientific and/or engineering expertise to quantify risk through formal methods whereas lay citizens tend to arrive at risk understandings through affective, experiential, psychological, and cultural means (Elliot, 2003). Not surprisingly, technical risk perceptions tend to have more legitimacy in decision making among policy makers and social risk perceptions act as a powerful force in the public discourse and often drive public resistance to risk technologies. While this body of research provides useful insight into why lay citizens tend to view risks differently than technical experts, it has inadvertently reinforced the dichotomy between these two groups thereby obscuring differences within these two groups (Horlick-Jones, 1998; Lidskog, 2008).

One dominant approach to the study of risk perceptions of lay groups is the psychometric paradigm. Though the majority of studies operating from this paradigm have explored lay groups, many of the psychological factors they articulate are germane to expert groups. According to the psychometric paradigm, a person forms his or her risk perception based on multidimensional factors of dread and fear and depends on the context of the event (Renn, 1998; Slovic, 1987). The psychological factors spatially fit on two axes called "lack of knowledge" and "dread" about the risk. A greater presence of either factor increases people's perception of risk. The psychometric paradigm seems to improve explanations for human risk perception better than the previously favored approach of cost-benefit analysis to explain risk

decisions (Kunreunther, Easterling, Desvousges, & Slovic, 1990). In addition to examining the underlying factors, the psychometric paradigm examines how affect acts as a heuristic, or cognitive shortcut, that focuses a person's attention and becomes the primary influence on his or her risk perceptions (Peters, Lipkus, & Diefenbach, 2006; Peters & Slovic, 1996; Slovic, Finucane, Peters, & MacGregor, 2004). This affect may take the shape of an emotion (Lowenstein et al., 2001), a visual image (Peters & Slovic, 1996), trust (Peters, Covello, & McCallum, 1997), innumeracy (Reyna & Brainerd, 1998), or a narrative (Finucane & Satterfield, 2005; Satterfield, Slovic, & Gregory, 2000).

Several scholars have used the psychometric paradigm to describe how people use different cognitive frames to arrive at their risk judgments. Plough and Krimsky (1987) characterized risk communication as an interaction between people with "technical" and "cultural" ways of understanding risk. Fiorino (1989; 1990) subsequently suggested how risk communication could be distinguished according to people's use of either "technical" or "democratic" ways of understanding. More recently, a growing number of researchers differentiate with technical and social frames (Elliot, 2003; McComas, 2006). In general these dualistic approaches use research from the psychometric paradigm to characterize experts as perceiving risks based on technical and analytic judgments of probability, costs, and trust in technology and lay people as perceiving risks based on social judgments that involve psychological, cultural, and trust factors. This tendency to categorize individuals according to two risk perception frames implicitly assumes an either-or logic, that a person may use one type of rationality or another. However, in practice, people most likely use both types of rationalities in a "dance of affect and reason" (Slovic, Finucane, Peters, & MacGregor, 2004, p. 314).

The psychometric paradigm with its focus on cognitive frames usefully explains why technical experts have a difficult time communicating with lay citizens. These groups operate

from incommensurate cognitive frames and need some form of translation in order to understand each other (Elliot, 2003; Fischoff, 1995, Wardman, 2008). These kinds of insights from risk perception research forced risk professionals to consider other approaches of understanding risk beyond risk analysis methods (Fishoff, 1995; McComas, 2006).

Even though most of this research considers the differences between technical expertise and social knowledge between groups, psychometric research recognizes that these types of cognition are not limited to particular groups. Rather, technical experts and lay citizens employ different types of knowledge in accordance with their values and beliefs about what counts as knowledge and risk. Affect organizes and enables individuals' abilities to use technical rationalities when perceiving a risk (Slovic, Finucane, Peters, & MacGregor, 2004). For example, narrative reasoning helped participants make sense of technical information and use this information for making a policy decision (Satterfield, Slovic, & Gregory, 2000). More specific to technical experts, a few studies demonstrate that values, beliefs, and norms may influence scientists' risk perceptions (Barke & Jenkins-Smith, 1993; Wright, Pearman, & Yeardly, 2000) and determining a policy preference (Silva, Jenkins-Smith, & Barke, 2007), although perhaps to a lesser degree than non-technically trained individuals (Slimak & Dietz, 2006).

Despite the insights gained from the psychometric paradigm, three main critiques redirect the attention of this study to a discursive approach. First, scholarly emphasis on the two frames has "resulted in a strengthening of intractable epistemological positions" (Scherer & Juanillo, 2003, p. 229). The different groups may recognize the different understandings of risk, but they do not know how to incorporate each others' perceptions. Researchers can begin to remedy this situation by moving beyond a mere acknowledgement of the differences and

"recognize the underlying assumptions about the epistemological moorings of each language" (Scherer & Juanillo, 2003, p. 229) and attend to dialectical resources available in the discourse.

Building on the first critique, the second critique challenges the psychometric paradigm because it privileges information processing and neglects representation concerned with symbols, social reality, and social knowledge (Joffe, 2003). The outcome of risk perception research has resulted in a "deficit model" of risk communication which continues to privilege technical risk understandings and does not question how the discourse provides resources for technical perspectives to become privileged. Research that examines the discursive role of language for shaping risk perceptions may help address this concern (Scherer & Juanillo, 2003).

A final critique of the psychometric paradigm comes from Rowe and Wright's assertion (2001) that much of the research about differences between expert and lay risk perceptions fails to problematize the definition of "expert." Their review of the literature demonstrates that, with few exceptions, the "expert" samples of these studies may not really constitute the experts in the area of risk assessment or the topic under question—in such cases the participants were considered "expert" if they held a position or title of authority. Rowe and Wright suggest that scholars can make more meaningful claims about the differences between expert and lay perceptions of risk if they create a specific definition of expert and acknowledge experts' variable performance on risk judgment tasks. Indeed, studies that compare expert and lay risk perception of industrial risks may have contradictory findings based on the different treatments of expertise (Wright, Pearman, & Yeardly, 2000).

Expertise in Risk Communication

Any answer to the question of how technical experts legitimize their risk judgments must address what constitutes expertise and how it functions in the study of risk. As pointed out in the previous section, much of the risk communication research fails to problematize the

concept of expertise (Rowe & Wright, 2001) as well as recognize the heterogeneity of technical experts (Garvin, 2001). This section challenges the tendency to treat expertise as a personal trait and draws on sociological and rhetoric of science perspectives to lay a foundation for exploring the discursive relationships between expertise and knowledge production.

One alternative to viewing expertise as a personal trait considers the experts' variable performance on judgment tasks—tasks that they can learn about and improve (Bolger & Wright, 1994; Rowe & Wright, 2001). Expert performance is a function of ecological validity, the degree experts make judgments outside field of expertise, and learnability, the degree to which experts learn good judgment in a task domain (Bolger & Wright, 1994). If a person positioned in an authoritative role, traditionally considered an expert, rates low on either of these characteristics, he or she may not make better judgments than a lay person (Rowe & Wright, 2001). This type of variation comes from differences in learning and experience rather than personal characteristics or traits. Additionally, differences exist between scientific and technical disciplines and individuals' levels of expertise (Horlick-Jones, 1998).

Scholars from the rhetoric of science perspective challenge the view of expertise as a personal trait by highlighting the negotiation of scientists' *ethos* (Cochran, 2007; Prelli, 1997). Ethos, a concept borrowed and developed from Aristotle's *Rhetoric,* considers how individuals' character and credibility influence the effectiveness of communication. Ethos can range from a centripetal force, in which the rhetor controls the process of ethos construction, to a centrifugal force in which the locus of ethos construction is distributed more or less equally among the rhetor, audience, and context (Cochran, 2007). The concept of ethos foregrounds how an individual's ability to produce expert knowledge is contingent on his or her ability to construct a credible character (Prelli, 1997).

Scholarship has extended the relationship between character and expertise to include the aspect of morals and values which are embedded in the ways that people, even technical experts, characterize a risk (Douglas, 1990; Wynne, 1992). For example, Silva, Jenkins-Smith & Barke (2007) demonstrate that values, norms, and institutional affiliation partially influenced nuclear physicists' and engineers' choice of the most realistic model of radiation exposure and preferred model for determining policy (for similar research see Barke & Jenkins-Smith, 1993 and Slimak & Dietz, 2006). Scholars who study rhetoric of science traditionally argue that the scientific rhetoric contains limited sources of rhetorical invention due to epistemological commitments to the hypothetic-deductive scientific method (Cochran, 2007). This quality makes it insufficient for moral and political issues (Janasoff, 1990) because the rhetoric is inflexible and unable to adapt messages for the social context (Cochran, 2007). The case of technical experts during the Three Mile Island nuclear reactor accident demonstrates how technical experts were unable to adapt to the expectations of the public sphere (Farrell & Goodnight, 1981). However, even though Cochran supports claims about inflexibility of scientific rhetoric, her research project illustrates how experts in research labs construct *ethos* with their publics—a process that necessarily involves adaption to include morals and values. Furthermore, Ceccarelli (2001) argues that characteristics that create differences between scientific rhetoric and public discourse are illusory and that scientific texts do have polysemic qualities. The relationship between values and expertise merits close attention because the study of risk is a science closely linked with policy decisions (Horlick-Jones, 1998).

Silva, Jenkins-Smith, and Barke (2007) treat values as cognitive artifacts, however a discursive approach may help explicate reasons for divergent findings about expertise and values. For example, healthcare professionals discursively construct their expertise in varying ways that depend on their status (Candlin & Candlin, 2002). Healthcare professionals who have

lower status tend to construct expertise implicitly by drawing on contextual resources and appealing to the patients' reasoning while health care professionals with higher status tend to construct their expertise with explicit appeals to their knowledge and status (Linell et al., 2002).

A final observation about the construction of expertise comes from the results of studies that document the influence of institutional affiliation on experts' policy preferences (Barke & Jenkins-Smith, 1993; Silva, Jenkins-Smith, & Barke, 2007). For example, in a national physics lab, relationships between knowledge and power within two major institutions, the discipline of physics and the laboratory organization, shape the production of expert knowledge. In this study, two teams produced different results through the rational scientific method, but they relied on discursive resources of the lab to negotiate the production of consistent results (Kinsella, 1999).

The sociological and rhetoric of science perspectives emphasize processes of the social construction of expertise (many of the aforementioned scholars hail Thomas Kuhn's paradigm model as a starting point for their scholarship). Contemporary scholars argue for re-definition of expertise that breaks down the false divide between values and facts (Latour, 2004) and the expert/lay divide (Horlick-Jones, 1998). Such actions might involve "extended peer communities" that include interested publics alongside traditional experts (Funtowicz & Ravetz, 1992) and emphasize social learning and the exploration of underlying values of the knowledge claims (Wynne, 1992). In a discussion about expertise and risk assessment, Funtowicz and Ravetz (1992) observe that "to experience discomfort at discovery of the uncertainties inherent in *science* is mark of nostalgia for a secure and simple world that will never return" (p. 255) because "scientific arguments evolve in a continuous dialogue that is incapable of reduction to logic...when a party finds its interests threatened, it can always find a methodological issue with which to challenge unwelcome results" (p. 260). Hence, a close examination of the discursive strategies of technical risk communication provides a better understanding of how experts,

charged with making sense of the uncertainties of risk, negotiate technical knowledge, character morals, and values in the construction of their expertise.

Coordination of Multi-Disciplinary Expertise

The complexity of the social issues of risk requires cross-disciplinary interaction among risk experts and managers but such interactions often unfold in difficult and unproductive ways. Many of the difficulties arise from expectations that communication is a transmissive process and the presence of epistemological and terminological differences between the disciplines. This section discusses the critiques of risk communication from a transmissive model and strategies for coordinating multi-disciplinary knowledge. This background helps lay a foundation for a constructivist model of risk communication to examine the processes by which expert groups manage, negotiate, and coordinate their differences.

Transmissive and Message-centered Models of Risk Communication

Originally, practitioners conceived of risk communication as a field to develop knowledge about how to explain technical risk understandings to the lay public (Fischoff, 1995; Leiss, 1996). Yet, in the public sphere, social groups perceive risks differently than the technical experts who produce the risk assessments. The response to the executive summary of the landmark “Reactor Safety Study” in 1975, the first probabilistic risk assessment of nuclear reactors, illustrates the differences between lay and expert perceptions of risk. Audiences and scholars criticized the executive summary for comparing quantitative probabilities of risks of death from a reactor accident and risks of death from other causes such as smoking or a meteor strike (Covello, 1991; Keller & Modarres, 2005). Such comparisons seemed rational to the engineers because they compared mathematically calculated probabilities; however, they provoked strong reactions and disagreement in the public sphere because people felt that they unfairly compared voluntary and involuntary risks.

The apparent differences for how people understand a risk demonstrated the need for research in risk communication through persuasive or participatory processes (Fischoff, 1995; Leiss, 1996). Most notably, Fischoff (1995) characterized the history of risk communication through attempts to persuade audiences about a risk perception and attempts to invite audiences to participate in deciding about a risk perception. He notes how, as risk communication practices matured, institutions have shifted from more persuasive approaches to more participatory approaches.

Chess (2001) suggests that organizations' institutional environments offer a better explanation for why they use persuasive or participatory approaches rather than maturity. This perspective represents how scholars and practitioners often view risk communication as a public relations activity by which industries can legitimize their activity to the public (Chess, 2001; Chess, Saville, Tamuz, & Greenburg, 1992; Leiss, 1996; Wardman, 2008). The practice of risk communication emerged, in part, as a response to industrial accidents such as Bhopal (Chess, 2001) and Three Mile Island (Dionisopoulas & Crable, 1988; Sandman & Paden, 1979). Chess (2001) used institutional theory (Meyer & Rowan, 1977; Scott, 1987) to illustrate how organizations operate in a taken-for-granted environment of rules, norms, roles, and expectations and strategically use communication to achieve legitimacy, a congruence between social values attributed with activity and acceptable norms in larger society. Communication studies also illustrate how the oil and gas industry (Crable & Vibbert, 1983) as well as the nuclear industry (Diosinopoulas & Crable, 1988) strategically placed rhetorical resources in the public sphere in order to draw on them later in times of crisis.

Rowan (1994) recasts the persuasive and participatory question from classical rhetorical point of view by emphasizing that all communication functions to inform, persuade, and build credibility. Risk communication is a meaning-making activity in addition to a decision-making

activity (Hamiton & Wills-Toker, 2006; Rowan, 1994). In this vein, the social amplification of risk model describes interaction among psychological, social, economic, political, and cultural processes that heightens the collective public perception of risk (Kasperson, Renn et al., 1988). As information moves through these social institutions, it gains greater amplification and the public becomes more aware and concerned about a risk. Trust in institutions plays an important role in mediating the amplification effects (Kasperson et al., 1988). Social trust is the public's belief that institutions behave in ways that are competent, predictable, and caring. An organization's lack of social trust can increase the perception of risk (McComas & Trumbo, 2001; Metlay, 1999). For example, studies of the siting of the high-level radioactive waste repository at Yucca Mountain (Kasperson, Golding, & Tuler, 1992) and of Sweden's risk communication to Denmark about a Swedish nuclear plant located only twenty miles from Copenhagen (Löfstadt, 1996) demonstrated that the absence of trust contributed to the amplification of risk.

Some scholars praise the social amplification of risk as a comprehensive model and possible tool for theoretically integrating different risk communication paradigms (McComas, 2006). However, others criticize it for treating the communication process as transmissive and failing to recognize the politics of risk (Murdock, Petts, & Horlick-Jones, 2003; Wardman, 2008). The metaphor of "amplification" assumes the sender-receiver model of communication and with it the implication that one can improve communication by simply removing "noise." Additionally, the social amplification model assumes that all institutions can equally contest each others' claims in a democratic manner and this fails to account for the greater influence of more powerful groups. As an alternative metaphor, Bordieau's field of play metaphor may better illustrate how these social institutions are situated and constrained in fields in which they can contest or complement each others' meanings (Murdock, Petts, & Horlick-Jones, 2003). This

metaphor foregrounds assumptions about complex social and political communicative construction of risk.

Even though many scholars recognize the public's active role in construction of the meanings of risk (Fessendon-Raden, Fitchen, & Heath, 1987; Fischoff, 1995; Leiss, 1996; Joffe, 2003; Scherer & Juanillo, 2003; McComas, 2006), the bulk of risk communication research implicitly uses a transmissive model of communication (Wardman, 2008). Some researchers propose an interactive view of risk communication that integrates the multiple understandings of risk (Fischoff, 1995; Scherer & Juanillo, 2003; Kasperson et al., 1988; McComas, 2006). However, research studies treat risk communication as messages about a risk—evidenced in the multiple studies that examine the impact of messages or communication events on people's risk perceptions (Bostrom, Morgan, Fischhoff, Read, 1994; Kunreuther et al., 1990; Lofstedt, 1996; McComas, 2003; McComas & Trumbo, 2001; Peters & Slovic, 1996; Uggla, 2008; Visschers, Meertens, Passchier, & deVries, 2007). Many of these scholars advocate the constitutive nature of risk, even if they do not study the processes by which social constructions come to exist (McComas, 2006; Plough & Krimsky, 1987; Renn, 1998; Slovic, 1999).

Scholarship that emphasizes risk messages offers advice for how to adapt communication for audiences' concerns and background knowledge (Bostrom et al., 1994; Covello, 2006) and the contextual situation (Sandman, 2003; Sellnow, Ulmer, Seeger, & Littlefield, 2009). This practical approach for risk communication has roots in the expert/lay paradigm and the concomitant deficit model of communication. Because of this, risk communication efforts often have the effect of reinforcing power structures because risk psychology "proves" the irrationality of the public (Joffe, 2003; Wardman, 2008). Even approaches that seem more participatory and egalitarian may inadvertently reinforce the expert/lay divide (Lidskog, 2008). These paradigms of risk communication may have become

more acceptable in the technical sphere and organizational practice because their ontologies accept risks as more objective and hence the social construction of risk perspectives became eclipsed (Horlick-Jones, 1998). Additionally, “disciplines that offer an understanding of behaviour as the predictable response to incentives which are in principle manipulable by policy” have more relevance to policy-makers than more complex social scientific explanations (Taylor-Gooby, 2008, p. 866). Even though the transmissive, message-centered model of communication has applicability for public outreach activities, risk communication among experts must study communication as a constitutive process by which groups interactively negotiate meaning and coordinate differences.

Research that studies the influence of messages on risk perception may seem useful for drawing connections between these phenomena, the creation of "best practice toolboxes” results in the systematic embedding of risk communication in regulations and corporate governance and invites users to engage in activity without awareness of imprints the theoretical underpinnings of these approaches (Wardman, 2008). This results in applications of risk communication that mask power, distort risk management, and detract from considering whether risk communication really translates into socially valued communicative action. Such a critique helps us see that communication not only contains messages about risk but that the social construction of risk occurs in communicative processes. To address these concerns Wardman (2008) proposes a framework to examine the theoretical underpinnings of major bodies of risk communication research. Additionally, a consideration of how risk communication theories explain and address the ontological dialectic extends Wardman’s framework.

Interaction among Technical and Scientific Experts

While little empirical research exists about risk communication among technical and scientific experts, we can lay a foundation by examining practices of expert elicitation in risk analysis, research in multi-disciplinary research teams, and the negotiation of credibility.

Expert judgment in risk analysis. In contrast to sociology and rhetoric of science perspectives that foreground social and discursive practices of producing knowledge, the risk assessment community develops quantitative tools to capture experts' knowledge and control for the influence of bias in expert judgments. In the absence of empirical data about the mechanisms of a risk situation, risk analysts rely on a technique called "expert elicitation" for input into the risk assessment (Chhibber, Apostolakis, & Okrent, 1992). For example, accidents at nuclear power plants rarely occur, and this creates a void of "hard" data about causes of accidents and systems' performance under accident conditions. Thus, disciplinary experts provide professional judgments about the degree of belief an event will happen based on their knowledge and experience—these become computational inputs about system component success and failure rates (Ortiz, Wheeler et al., 1991). Expert elicitation panels usually include disciplinary experts, professionals in decision sciences, and risk managers from different cultural and ethical backgrounds (Zio & Apostolakis, 1997). These "subjective probabilities" become aggregated through either a behavioral, consensus-based technique or a mathematical process (Zio & Apostolakis, 1997). Expert elicitation is a widely accepted practice in probabilistic risk assessment. Due to their commitment to objectivity, these practitioners create techniques to measure and control for the potential bias in their judgments (for one example see Zio & Apostolakis, 1997).

Without going into much detail, for the purposes of this study, it is enough to know that the field of risk analysis rigorously studies and conducts the expert elicitation process to achieve

objectivity. The absence of data, that provokes the need for expert elicitation, illustrates the great uncertainties that risk assessment faces and the degree to which expert judgment provides input. Despite efforts to achieve objectivity, this community of experts is subject to overconfidence, statistical vulnerabilities of low probability events, and institutional pressure related to costs and politics (Freudenberg, 1988). In the end, this process masks the social role of discourse in expert elicitation process. Skinner (2008) poignantly illustrates this in his comparison between the "dry" and ineffective technical report warning about risks of a volcano eruption and the relevant and humorous accounts of expert elicitation told by a technical participant after the fact. Studies like this begin to unmask the production of risk knowledge by attending closely to communication among technical experts and understanding how they legitimize their risk understandings.

Multi-/Inter-/Trans-disciplinary knowledge. Since society faces complex, multifaceted, and multidisciplinary risks, decisions about these risks necessarily involve experts from several disciplines (Horlick-Jones & Sime, 2004). This practice parallels trends in academia to promote interdisciplinarity (Collins, 2002). The federal government and other funding institutions promote interdisciplinary scholarship in efforts to gain insights and make decisions about the complex social problems (Collins, 2002; Horlick-Jones & Sime, 2004; Thompson, 2007; 2009). Even though scholars readily recognize the need for interdisciplinary research to address complex risks, little research exists about communication in interdisciplinary research teams (Thompson, 2007; 2009) and risk communication among technical experts (Bier, 2001).

When discussing interdisciplinary research, one must distinguish among terms that people frequently use synonymously (Collins, 2002; Horlick-Jones & Sime, 2004). "Discipline" refers to a branch of learning that shares characteristics of accepted content. "Multidisciplinary" refers to cooperation among disciplines yet they retain their distinctions. "Interdisciplinary"

refers to research that integrates the disciplines to produce a unified outcome based on a new way of knowing. Thompson's (2007; 2009) research about a multidisciplinary research team illustrates the difficulty of transcending the disciplinary specialization to achieve interdisciplinary research. Barriers to interdisciplinary research include disciplinary culture, time, evaluation, publication, employment, funding, promotion, and recognition (Kostoff, 2002).

The little existing research about interdisciplinary groups, demonstrates the difficulty that they have in coming to a shared understanding of problems and how to research them. These difficulties arise from different research traditions and the fact that different members of the team, due to assigned expertise, focus on different facets of the problem at hand. Thompson's (2007; 2009) ethnographic research with a multidisciplinary research term draws out four processes associated with multidisciplinary collaboration: (1) debating over expertise and posturing for power, (2) sharing learning and language, (3) developing a shared vision, and (4) integrating data. Eight communicative resources contribute to the processes: trust, presence, humor, encounter talk, discussion about language, boredom, challenging statements, and reflexive communication. Of these processes and resources, shared language, trust, and reflexive communication contribute most to interdisciplinary collaboration. In particular, Thompson (2007) notes that communication to develop a shared language must move beyond equations and measurements and move to concepts. For example abstract diagrams helped to facilitate the conversation because each disciplinary participant could locate his or her position in the diagram and propose revisions (Milligan et al., 1999 also report a similar strategy as effective). Additionally, Thompson observes that participants invented terms if they could not agree on definitions.

Thompson (2007; 2009) observes several hindrances that limited the team's ability to accomplish interdisciplinary collaboration. Disagreements about definitions and language usage

challenged individuals' disciplinary identity and often led to interpersonal conflict and team attrition. Research using dialectical theory in healthcare teams illustrates similar emphasis on identity and relationship construction (Martin, O'Brier, Heyworth, & Meyer, 2008). When a team has unequal understandings of each person's role it contributes to a tension between autonomy and connectedness. A team's struggle with decisions to maintain routines or develop new approaches to problem-solving contributes to a tension between predictability and uniqueness. These contextually-based tensions are inevitable; however awareness about these identity tensions can serve as a tool for self-reflexive talk about improving relationships and interdisciplinary research (Thompson, 2007; 2009; Martin et al., 2008).

Although previous research has emphasized interpersonal characteristics of multidisciplinary research, Thompson's (2007) study also highlighted institutional influences on the process. The research team negotiated four task-oriented dilemmas in order to collaborate: (1) selection of measurement sites, (2) negotiation of simple/complex descriptions of phenomena, (3) negotiation of tensions between social and natural sciences, and (4) the production of a written product. Thompson examined systemic factors and outcomes of interdisciplinary research by integrating these findings into a computer model. In this model, the level of professional facilitation, experience working on research teams, influx of new money, and institutional support had the most influence on interdisciplinarity in team research.

Even though much of this section treats scientific and technical experts as monolithic in their construction of knowledge according to tenets of the scientific method, each discipline carries its' own expectations about what counts as data and appropriate methods of data collection and analysis (Horlick-Jones & Sime, 2004). For example, in the nuclear field, engineering risk assessment and health risk assessment provide different understandings of risk (Jones, 1995). Each expertise focuses on different potential consequences of nuclear

technologies (core melt vs. radiation exposure) and different phases of events leading to the consequences. Engineering risk assessment characterizes the risk of failure of nuclear reactor safety systems—usually measured as probability of core damage failure. Health risk assessment characterizes risk of harmful substances (such as radiation or chemicals) to human health—usually measured in cancer fatalities. In this example, the experts agree that radiation exposure is a real potential hazard (even if they view it unlikely due to safety measures); however they orient themselves to different facets of this risk. Such variations illustrate how differences between technical disciplines may lead to difficulty communicating with each other about risks.

Ethos and expertise in interaction. The relationship between ethos and expertise becomes relevant for research among multidisciplinary research teams because, in order to construct legitimate knowledge, scientists must engage in the construction of *ethos* with their audiences (both peer experts and lay). Prelli (1997) lists several possible *topoi* that scientists may draw upon to critique or defend a research project: impartiality, objectivity, commitment, novelty, humility, and communality. Individuals draw on these topoi differently based on the context of the situation. Furthermore, Prelli (1997) claims that the question of experts' *ethos* may become more important in "boundary" work in which experts' knowledge becomes used in policy situations or popular science (as in the case of risk communication and risk management).

Additionally, the relationship between *ethos* and expertise helps explain how attacks to credibility impede multidisciplinary research teams' knowledge production process (Thompson, 2007; 2009). Myers (2006) observes that individuals perceive attacks to credibility as face threats. Risk talk tends to contain several credibility attacks because it inherently involves values associated with choices about a risk. Myers documents five categories of commonplaces that people draw on during facework in risk conversations: (1) possibility, a concept to deal with uncertainty, (2) scale, a concept to deal with calculation, (3) proximity, a concept deal with

agency, (4) time, a concept to deal with cause and effect and morality, and (5) self and others, a concept to deal with responsibility. Myers' categories arise from risk conversations among non-technical people and it remains to be seen whether technical experts use these commonplaces in conversations with peers. They may use these commonplaces because, as social humans, they attend to conversational norms. However, if nature of scientific rhetoric deprives it of flexibility and rhetorical sources of invention, experts may not use these commonplaces in technical conversations.

In summary, this section discussed interaction among experts in risk analysis, multi-disciplinary research, and the negotiation of ethos. Many of these processes may also appear in risk communication among technical experts. Risk assessments systematically incorporate expertise using mathematical techniques to produce subjective probabilities. Despite awareness and attempts to control for bias, these practices aspire to achieve objectivity and mask the discursive construction of expertise. Finally, this section reviewed interpersonal and institutional difficulties in multi-disciplinary communication. These concepts may transfer to multi-disciplinary conversations and decisions about risks. However, we must exercise caution in their application due to differences in context. Multidisciplinary research teams (such as the one studied by Thompson, 2007; 2009) tend to work together for long periods of time and meet with a regular frequency and have more characteristics of groups and teams. Situations of multidisciplinary risk communication may occur less frequently, in special meeting situations such as public workshops. Additionally, organizations with functional barriers along disciplinary lines may limit internal cross-disciplinary exchanges about risk.

Interaction with Risk Managers

The published scholarship about risk communication among technical experts and managers reflects a bias toward the rational-actor model and transmissive model of

communication. Bier (2001) summarizes government surveys about risk managers' preferences for the content and characteristics of risk messages. Managers prefer risk communication to contain these characteristics: (1) comprehensive and understandable, (2) applicable and useful for decision at hand, (3) credible and defensible, (4) clear and brief with balanced treatment of contentious issues, (5) clear about basis for choosing key assumptions, and (6) relevant to a policy framework. In order to improve decision making about risk, managers desire content that includes the legal requirements, possible adverse effects of regulating hazard, available options to reduce risk, extent of public concern, and reliability of information. The bulk of Bier's review discusses the four types of uncertainty associated with risk assessment (outcome uncertainty, assessment uncertainty, state of knowledge, and population variability) and emphasizes that risk communication should distinguish among the types of uncertainty when comparing risks, uncertainty of effectiveness, and uncertainty about magnitude. Even though Bier's review provides a thought-provoking view of managers' preferences for legitimate risk communication from analysts, it assumes a transmissive model. Further research should examine communication among risk experts (managers and analysts) and systematically explore the processes and interactions by which disciplinary groups construct and coordinate this desirable content.

A large body of research in public participation collectively provides a critique of the rational-actor model in the risk management context. This research challenges how the assumptions of the rational actor model and one-way communication from the policy-makers to the public limit permissible types of knowledge and quality of interaction (Fiorino, 1990; Peterson & Franks, 2006; Tuler, 2000). Public participation research privileges the democratic and dialogic processes of the discourse-based risk management strategies (Barge, 2006; Fiorino, 1990; Hamilton, 2003; 2007; Hamilton & Wills-Toker, 2006; Klinke & Renn, 2002; McComas, 2003). Public participation for purposes of risk management tends to emphasize decision-making

processes and ignore an important function of risk communication, the meaning making process (Hamilton & Wills-Toker, 2006). Challenging the rational-actor paradigm proves to be difficult because policy makers and bureaucratic agencies control the power and discursive structures to inform, persuade, and create meaning (Ratliff, 1997). The public participation research sets a backdrop of risk management interaction that foregrounds issues of content and processes that make risk understandings more or less legitimate to risk managers and the public. When experts interact among themselves they demonstrate awareness of public participation which may serve as a resource for legitimation.

In summary, this section has discussed the transmissive model of risk communication, research about interaction among multi-disciplinary experts, and interaction with risk managers. Even though the transmissive model of risk communication has utility for public outreach, a constitutive approach can examine the construction and legitimation of risk among experts. The research about interactions among technical experts and risk managers lays a foundation for what strategies and content may legitimatize risk understandings and a closer examination of the processes can demonstrate how experts construct and legitimize meanings of risk, and how they coordinate the inevitable differences.

Legitimation and Construction of Risk

For purposes of this study, legitimation simply refers to the ways that a risk understanding fits with social norms and expectations and becomes a more acceptable perspective. The use of a risk understanding to inform a risk decision acts as a litmus test of legitimation; however it is also important to examine the processes of how experts construct and coordinate legitimate risk understandings among themselves. The process of legitimizing a risk relies on actors' abilities to use social norms and values acceptably in conjunction with scientific facts. A critical body of research considers the role of power and ideology in the constitution and

legitimacy of risk understandings. This section discusses cultural and institutional sources of legitimizing risk and the social learning perspectives that emphasize the transparency of norms and values in public discourse. Each of these perspectives treats risk as a social construction in order to demonstrate how dominant paradigms distort or mask power and sources of legitimacy. However, despite these theoretical contributions, these perspectives provide insufficient levels of detail about constructive processes from a discursive point of view and focus on differences between expert and lay groups rather than differences among expert groups.

Social Learning Perspective

The social learning perspective explicitly argues that different groups must recognize the conditional nature of knowledge and that “the main challenge to risk assessment and technology assessment is to unearth and debate conditions of legitimate authority for different risk knowledges in a social learning process" (Wynne, 1992, p. 276). This approach to understand risk recognizes that "different social values and interests seem to be embedded within the competing technical knowledges, structuring them in ways that reflect covert social interests, although they appear natural and objectively given" (Wynne, 1992, p. 278). For example, following the Chernobyl nuclear accident, sheep farmers used their local knowledge about typical sheep behavior to correct expert assumptions about the presence of radioactive material in the environment (Wynne, 1992). This emphasis on conditional knowledge helps explain foundations of the social groups who act on a “field of play” (Murdock, Petts, & Horlick-Jones, 2003). Additionally, the notion of “covert social interests” embedded in “competing technical knowledges” explains the implicit role of values in experts’ policy preferences (Silva, Jenkins-Smith, & Barke, 2007) and explains organizations’ efforts to appear legitimate despite the social interests. Additionally, institutions (policy setting organizations or scientific disciplines) tend to simplify complex social risks and make sense of complexities and ambiguities (Wynne, 1992).

The social learning approach acknowledges power differences between types of knowledge. Instead of the traditional approach of debating technical differences, the social learning approach suggests that the best way to address the differences begins with explicit articulation of the taken-for-granted values that underlie their epistemologies. Three categories of taken-for-granted values include (1) the pursuit of truth which society often associates with scientists, (2) the common good which society often associates with policy-makers, and (3) moral concerns which society often associates with advocacy groups and citizens (Strydom, 2008). As the social actors interact with each about risk they inevitably learn about each others' values. Risk understandings become legitimate under the purview of public interest without which "a critical discourse in which the participants collectively learn through the mutual exposure of biases, distortions, half-truths, illusions, and rationalizations cannot come about" (Strydom, 2008, p. 15). Wynne (1992) maintains that "nothing in this interpretive perspective denies the importance and value of science; it allows the opportunity to place scientific knowledge on a more legitimate, properly conditional, and ultimately more effective footing" (p. 279).

Not surprisingly, few examples exist of groups who use risk communication as an opportunity to make the underlying assumptions of their risk understandings transparent. Taylor (1996) accomplishes this by artificially juxtaposing personal and embodied experiences with nuclear weapons with the scientific messages disseminated for political and military purposes. In one example, Taylor (1997) explores the underlying assumptions of photographs and narratives of victims of nuclear weapons. He compares the underlying assumptions of these embodied and contextualized representations with the underlying values and assumption of the objective and isolated risk messages of the technical discourse of the epidemiology studies. The juxtaposition of these different types of knowing makes the social interests apparent, however Taylor's effects

to construct this type of interaction highlights the effect of the more powerful, epidemiological discourse that often silences the voices of the victims.

Even though social learning perspectives (Wynne, 1992; Strydom, 2008) help articulate questions about the legitimacy of knowledge and their relationship to power, these perspectives have cognitivist orientations that locates the sources of underlying values in collective human cognition. Therefore, these perspectives do not help address the communicative process of the legitimation of risk. Additionally, these perspectives focus on differences among technical and lay groups and do not explicitly theorize about underlying values as sources of legitimation in risk communication among expert groups.

Cultural Risk Perspective

According to cultural theory, risks become politicized by processes that link hazardous events with blame and these become accounts about who should take responsibility for the hazards (Dake, 1992). This theory of risk has its roots in Mary Douglas' book, *Purity and Danger,* and became fully explicit in Douglas and Wildavsky's book, *Risk and Culture* (Tansey & O'Riordan, 1999). This perspective sorts individual cultural risk tendencies—their understanding and trust of technology and institutions—into four cultural groupings using two dimensions: (a) group, and (b) grid. The group dimension describes the extent to which an individual identifies with a particular collectivity. The grid dimension describes the symbolic action of these groups along a continuum of routine and personalized. The four cultural groups include: (1) individualist, (2) hierarchist, (3) egalitarian, and (4) isolates (Tansey & O-Riordan, 1999; Wildavsky & Dake, 1990). Individualist cultures value technology for economic purposes, hierarchical cultures value technology for control and trust institutions to control risks, egalitarian cultures tend to fear technology as an inequalizer and lack trust in institutions, and isolates distrust knowledge from science and avoid solving social problems. From this

perspective risk communication consists of the different cultural groups' accounts that establish responsibilities for certain hazards. This perspective enables consideration of how "questions over the acceptability of potentially dangerous technologies are actually questions about the distribution of power, the credibility of authority, and the legitimacy of decision-making practices and procedures" (Mirel, 1994, p. 47). For example, Peterson (2003) explains how the different cultures act as social frames that accord legitimacy (or illegitimacy) to decisions made in three examples of intractable conflicts.

Cultural risk theory foregrounds the role of individual risk perceptions as devices by which people seek to maintain a particular way of life (Dake, 1992). This risk paradigm provides a holistic picture of how society constitutes risk through the role of social knowledge, trust, politics, and morality. Furthermore, Douglas (1990) describes a rhetorical view of risk as a "bridge between the known facts of existence and the construction of a moral community" (p. 5) which encompasses notions of danger and justice. The more a community can draw strong connections between cause and effect of a danger, the more they can use risk as a rhetorical device to uphold a particular moral code. Proponents of the cultural view of risk question the value of improved communication techniques for reconciling different risk opinions because even the techniques are grounded in power and moral points of view (Douglas, 1990). This view of risk usefully emphasizes the social construction of risk and its rhetorical function to legitimize existing power structures and moral codes. However, this theory has a macro level of analysis and does not provide details about the processes of how social actors use the rhetorical resources of the discourse (more or less successfully) to legitimize their risk understandings.

Two ethnographic examples illustrate how dominant cultural discourses function to legitimize risks by making them seem invisible. The discourse communities surrounding the La Hague peninsula in France (the location of nuclear reactors and a nuclear reprocessing facility)

restricted the residents from explicitly articulating their concerns to the point that they claimed they could not see the plant from their property—but only because they were facing away it (Zonabend, 1993). The communities around Carlsbad, New Mexico combined the cultural code of economy with the code of "isolation" to create a premise that the "nothingness" attribute of the land was economically suitable for siting the Waste Isolation Plant (WIPP) for low-level radioactive waste (Morgan, 2007). This economic and cultural discourse held up against arguments from other critics and minimized health concerns so much that they did not manifest in the discourse.

Each of these case studies raise questions about how cultural discourse can marginalize health concerns and make risk seem acceptable to the communities who rationalize their duty to bear the risks of a hazardous technology. They demonstrate how cultural discourse distorts power during the process of legitimizing a risk and provides rhetorical resources for social actors to legitimize a risk (Douglas, 1990). However, these examples, and cultural theory overall, primarily focus on non-technical social actors. Ultimately, cultural theory helps articulate questions about morality and legitimation of risk in society and these arguments can reasonably transferred to an examination of technical expert groups. However, it is also important to focus on micro levels of discourse in order to understand the processes by which people construct legitimate and non-legitimate understandings of risk.

Institutional Theory

While cultural theory provides a societal view of the construction of risk, institutional theory explains how organizations gain credibility from their environments by legitimizing inconsistencies between organizational structures and organizational practices, such as the differences between technical and managerial practices (Scott, 1987). Organizations use symbols such as ceremony and rituals to legitimize their structures. This ceremonial activity becomes

significant by following the categorical rules of myths, rather than the organization's actual concrete managerial and technical practices. These categorical rules of myths may actually appear inconsistent with the organizations' practices and outputs. Therefore, organizations tend to decouple managerial and technical practices in order to buffer their inconsistencies from the external environment. For example, the case of Sybron Chemical constitutes effective risk communication, in part, because the organization closely coupled risk managers with external risk communication activity by requiring managers to respond to public input and inquiry (Chess, Saville, Tamuz, & Greenberg, 1992). However, most organizations decouple risk decision-making, risk assessment, and risk communication activity. In order to build legitimacy with an environment, organizations try to make processes appear rational by drawing "ceremonial" connections between decision-making, assessment, and public participation. Since experts' values may have more influence on their policy preferences than normally recognized in the desirable rational actor model (Barke & Jenkins-Smith, 1993; Silva, Jenkins-Smith, & Barke, 2007), organizations may feel the need to deemphasize this phenomenon to appear legitimate.

For example, the Hanford Plutonium Works museum illustrates how an institution used decoupling to appear legitimate (Taylor & Freer, 2002). The discourse of the scientific, military institution used several strategies to decouple the weapons from the victims. The museum represented the victims through epidemiological studies that objectify and isolated human bodies in overly scientific and "cold" museum displays and represents the weapons through mystifying and secretive discourse of the weapons productions organizations. Additionally, the museum drew upon discourse from Cold War military and political rhetoric that makes the dangers of nuclear weapons seem acceptable because of their role in protecting the nation. This example illustrates how an institution decouples its practices while ceremonially representing itself in a manner that makes itself more legitimate to the public.

In summary, the social learning perspectives emphasize the importance of foregrounding the values and assumptions that underlie experts' understandings of risk. Cultural and institutional theories demonstrate processes by which society and organizations construct legitimate and non-legitimate understandings of risk. Cultural theory highlights the relationship between social values and rhetorical constructions of risk. Institutional theory highlights how organizational practices that hide decoupled activities act as legitimation devices, such as meeting social expectations and ceremonial activities. The review of this section creates a foundation for examining processes by which experts legitimize risk understandings and resources that they may draw upon.

Statement of Research Questions

As noted in Chapter I, the complexity of contemporary risks increasingly forces policy makers to attend to understandings of risk from multiple disciplinary experts (Horlick-Jones & Sime, 2004). These experts may discuss results from risk analyses or simply share scientific knowledge about the risk of concern. In either case, the experts draw upon different disciplinary assumptions and methodologies to explain the hazard's causal mechanisms and the degree of severity of the risks. These differences often produce divergent conclusions and recommendations which makes multi-disciplinary expert perspectives difficult to reconcile. However, the high stakes and contentious nature of risk decisions warrants a close examination of the processes by which experts from multiple disciplines communicate with each other about risk. For this reason, the overarching research question for this study is as follows: How do experts from different disciplines communicate with each other about risk?

In pursing this broad question, this study takes into account two main aspects of the inherent nature of risk. First, as a future-oriented concept, risk struggles with a dialectic tension between realist and constructivist ontologies: the source and effects of the hazard are based on

material phenomenon; however, until it manifests, the meaning of the risk is constructed in social processes. Second, as a result of this tension, communication about risk finds itself in the overlap between technical and public spheres, drawing on both scientific and social knowledges, arguments, and evidence. Building on these fundamental tensions, which become recurring themes, the review of literature focuses the general question of expert risk communication into four specific areas of inquiry: the societal resources and types of evidence and appeals technical experts use to characterize a risk, the strategies they use to legitimize particular risk understandings, and the negotiation and coordination of their different perspectives.

Historically, risk communication research treats expert groups as unitary and does not consider the processes by which they construct and legitimize risk understandings. Much of the risk communication field explores conflicting risk perceptions between technical and lay frames with an emphasis on the psychological and social aspects of lay risk perception. The failure to problematize how experts construct risk understandings contributes to the systematic masking of production of expert knowledge (Beck, 1992). By treating experts' risk characterizations as more rational, this body of research inadvertently reinforces the differences between these groups. In order to unmask these processes, the first two research questions for this study asks the following research questions:

RQ1: What are the societal resources that enable and constrain expert's talk about risk?

RQ2: What types of evidence and appeals do experts rely on to articulate their characterizations of risk?

In addition to the overly simple treatment of experts, risk communication research tends to privilege transmissive and message-centered approaches to communication rather than discursively examining how individuals manage and coordinate different risk understandings. Rather than assuming a transmissive flow of messages and information, this study takes a

constitutive approach to communication. A constitutive approach avoids treating communication as a secondary phenomenon resulting from psychological, sociological, cultural, or economic factors but rather "itself is the primary, constitutive social process that explains all these other factors" (Craig, 1999, p. 126). Craig (1999) finds it useful to maintain both transmissive and constitutive models as a useful dialectic in communication theory. However, this study takes a constitutive approach because it enables consideration of the processes behind the construction of meaning about risks (Wardman, 2008). This allows for more specific inquiry about the following question:

RQ3: How do experts from multiple disciplines negotiate and coordinate their different perspectives?

In addition to considering the resources and coordination used in the characterization of risk, this study examines which of the expert understandings become constructed as more or less legitimate. Decision-makers use more legitimate understandings in risk decisions and experts' awareness of risk management procedures impacts their choice of legitimation strategies. Some risk communication theories address questions of legitimacy at a macro, social scale but inquiry must also focus on micro discursive processes within expert groups. For this reason, the final question for this study asks:

RQ4: What strategies do experts use to legitimize their particular risk understandings and justify choices that result from the risk understandings?

The dialectical nature of risk requires the groups to negotiate both technical and social knowledges, regardless of their assigned role as expert or lay. Given the abundance of research about lay risk perspectives, this study addresses the less studied processes by which experts characterize, coordinate, and legitimate their risk understandings. The next chapter justifies a discursive approach to pursuing these research questions and creates a dialogic, multi-

perspectival framework that helps gain insight into the specific discursive actions of experts' risk communication in multi-disciplinary situations.

CHAPTER III

A DIALOGIC APPROACH TO RISK COMMUNICATION

The previous chapter addressed the issues of how risk communication research treats expert groups as unitary and privileges transmissive and message-centered approaches to communication rather than discursively examining the construction of different risk understandings. This chapter builds a framework to address these issues by using a discourse analytic approach to examine the process by which experts characterize, coordinate, and legitimize their meanings of risk. In particular, it will examine interactions of experts across different technical disciplines.

Discourse theories are well suited to study this type of question because discourse considers how the active language use constitutes social reality with a special emphasis on meaning (Alvesson & Karreman, 2000). Individuals naturally and unselfconsciously use language in contextually appropriate way to do things—order, request, persuade, accuse—that construct their social worlds. This activity often results in much variation in talk and discursive analysis provides the contextual reasons to explain the differences (Potter & Wetherall, 2001). A discursive approach to risk communication takes the constitutive nature of risk seriously and provides insight into the characterization, coordination, and legitimation of risk through active, contextual use of language (Joffe, 2003; Sarangi & Candlin, 2003).

This chapter creates a dialogic, multi-perspectival framework that is suitable for analyzing the complex variations in interactions. First, the chapter describes Bakhtin's (1981a; 1981b) dialogism as the organizing theory for the framework. Then, it integrates Potter and Wetherall's (1987) discursive psychology, Laclau and Mouffe's (2001) discourse theory, and Gidden's (1984) structuration theory. The last section discusses how a Bakhtinian dialogic

framework opens up discourse to demonstrate that experts' characterization of risk inherently involves coordination and legitimation processes.

Creating a Discursive Multi-Perspectival Framework

This study aims to avoid treating discourse as an entity that simply exists "out there" and, instead, treats it as a "product of self-interested rhetoric" (C. Conrad, personal communication, February 2009) that focuses "on the symbolic processes through which social and organizational actors draw upon existing social-linguistic structures to produce, reproduce, and legitimize systems of privilege and domination" (Conrad, 2004, p. 429). The field of discourse analysis has several theoretical perspectives about the scale of discourse and individual relationships to discourse (Alvesson & Karreman, 2000). Creation of a multi-perspectival framework takes advantage of multiple treatments of discourse to unpack its constructive processes (Phillips & Jørgensen, 2002). When a coherent framework integrates different theories, their unique perspectives enable the examination of expert risk communication from different vantage points (Phillips, 2000; Phillips & Jørgensen, 2002). By taking care to create a consistent framework under Bakhtin's dialogism, this study offers a useful explanation of the nuances and variations of expert risk communication phenomena that people often take for granted, treat as uniform, and make inaccessible to outside groups.

I chose Bakhtin's dialogism as an organizing theoretical framework because it enables the articulation of questions about how experts' communication about risk has multiple layers of meaning. As the Chapter II highlights, these layers may incorporate morals, values, scientific information, political views, and other disciplinary points of view. Bakhtin (1981a) writes that discourse is "a struggle among socio-linguistic points of view" (p. 273) and that it is "oriented toward an understanding that is responsive" (p. 280). These descriptions capture the dialogic aspect of discourse with its notions of struggle and anticipation of response. Concepts from other

theories—Potter and Wetherall's discursive psychology, Laclau and Mouffe's discourse theory, and Gidden's structuration theory—extend the dialogic framework. Subsequent sections describe what these additional theories contribute to the study, distinguish the similarities and differences with Bakhtin, and "translate" the theoretical concepts into dialogic terms (Phillips & Jørgensen, 2002).

Bakhtin's Theory of Dialogue

Clark and Holquist summarize Bakhtin's ideas about dialogue "as the extensive set of conditions that are imminently modeled in any actual exchange between two persons but are not exhausted in such an exchange…ultimately dialogue means communication between simultaneous differences" (as quoted in Stewart, Zediker, & Black, 2004, p. 36). These quotations emphasize the "set of conditions" available in discourse and the interaction "between simultaneous differences"—two concepts that are at the core of Bakhtin's dialogic theory. As Wertsch (2001) notes, the main question for Bakhtin, "who does the talking," is really a question about "who owns the meaning" (p.222). Bakhtin's dialogic view of discourse unpacks "polyvocality" and "language as a site of struggle" in ways that help unravel the layers of meaning in expert risk communication and the legitimation of these practices—regardless of, or in conjunction with, the expectations of the rational actor model and scientific method.

Polyvocality. The concept of polyvocality considers the "many-voiced" nature of language and how these voices interanimate each other. Polyvocality conceptually emphasizes that the meanings of utterances are located both in the historical layered ideologies and the anticipated rejoinders. This makes utterances forms that "reflect the specific conditions and goals" of human activity (Bakhtin, 1981b, p. 60). Bakhtin writes that:

> The living utterance, having taken meaning and shape at a particular historical moment in a socially specific environment, cannot fail to brush up against thousands of living dialogic threads, woven by socio-ideological consciousness around the given object of an utterance. (Bakhtin, 1981a, p. 276)

By describing the utterance as "living," Bakhtin invokes the dynamic nature of meaning construction within language. The weaving metaphor of this quotation foregrounds the layers of ideological consciousness that the construction of meaning in social contexts incorporates. Volosinov (considered to be Bakhtin's pen name early in his career) believed that language always has an "evaluative accent" that reveals complex and sometimes subtle ideological positions (Wertsch, 2001). Later in life Bakhtin wrote that:

> Thus at any given moment of its historical existence, language is heterglot from top to bottom: it represents the co-existence of socio-ideological contradictions between the present and the past, between differing epochs of the past, between different socio-ideological groups in the present, between tendencies, schools, circles and so forth, all given in a bodily form. (Bakhtin, 1981a, p. 291)

This quotation illustrates how ideology becomes dialogically woven into language and incorporates contradictions of the social conditions that gave rise to the meaning of the communication.

Bakhtin's concept of utterance helps us further understand polyvocality. He describes utterances as individual forms through which "language is realized [and] reflect the specific conditions and goals…not only through their content (thematic) and linguistic style…but above all through their compositional structure…inseparably linked to the *whole* of the utterance" (Bakhtin, 1981b, p. 60). Another parties' rejoinder, or response, is what the utterance is "inseparably linked to" because "understanding comes to fruition only in the …responses, as the activating principles [that] presuppose the ground for active and engaged understanding" (Bakhtin, 1981a, p. 282). Rejoinders are "relations between question and answer, assertion and objection, assertion and agreement, suggestion and acceptance, order and execution, and so forth" (Bakhtin, 1981b, p. 72). The relationships between rejoinders and utterances illustrate the polyvocality of discourse because they "presuppose *other* (with respect to the speaker) participants in speech communication" (Bakhtin, 1981b, p.72). Rather than considering objective

and stable meaning that is arbitrarily link to symbols, Bakhtin uses the utterance as a unit of analysis that draws attention to the active processes of understanding.

> In the actual life of speech, every concrete act of understanding is active: it assimilates the word to be understood into its own conceptual system filled with specific objects and emotional expressions, and it is indissolubly merged with the response, with a motivated agreement or disagreement…understanding and response are dialectically merged and mutually condition each other; one is impossible without the other. (Bakhtin, 1981a, p. 282)

Language as a site of struggle. The previous section about polyvocality foregrounds how language is a site of struggle about ideology. Bakhtin also describes a related struggle that takes place within discourse: whether or not meaning will become centralized or decentralized. Bakhtin (1981a) observes that "the processes of centralization and decentralization, of unification and disunification, intersect at the utterance" (p. 272). The weaving metaphor quoted above creates a picture of how threads of meaning touch and overlap. Bakhtin calls this discursive space the dialogic zone of contact. To the degree that discourse permits other voices to interact, Bakhtin writes that

> language is transformed from the absolute dogma it had been within the narrow framework of a sealed-off and impermeable monoglossia into a working hypothesis for comprehending and expressing reality…only polyglossia fully frees consciousness from the tyranny of its own language and is shown the myth of language. (Bakhtin, 1981b, p. 61)

This quotation describes how discourse can artificially seal itself off from other voices to attain dogmatic qualities and appear monologic—a description of centralizing, or centripetal, forces. However, decentralizing, or centrifugal forces, promote the expansion of the dialogic zone of contact and transform discourse. The degree to which discourse creates boundaries to isolate meaning or expands connections among meanings, largely determines the outcomes of centripetal or centrifugal forces.

Bakhtin labels language with centripetal forces as authoritative discourse that constructs artificial boundaries and centralizes meaning in the discourse. Bakhtin (1981a) describes

"authoritarian discourse" as language conditions in which "a word may be conjoined with authority…it demands our unconditional allegiance…permits no play with the context framing it…one must totally affirm it or totally reject it" (p. 344). In other words, authoritarian discourse sets boundaries, distances itself from other possible voices, ignores nuances of meaning, and "leads to a reification of the word" (p. 346). Examples of risk communication between experts and lay groups demonstrate how technical risk communication operates as authoritative discourse that only permits risk to be narrowly understood in scientific terms (Kinsella & Mullen, 2007) and spoken about within the proper scope of an institution's statutory authority (Ratliff, 1997).

Bakhtin labels language with centrifugal forces as internally persuasive discourse that seeks out available multiple meanings, hence moving the discourse to decentralization. Internally persuasive discourse is open discourse that "awakens new and independent words" and "is able to reveal even newer ways to mean" (Bakhtin, 1981a, p. 346). Internally persuasive discourse removes boundaries and increases the dialogic zone of contact. By freely permitting interaction and overlap, this type of discourse frees "consciousness from the tyranny of its own language" and shows "the myth of language" (Bakhtin, 1981b, p. 61) For example, sheep farmers in Belarus, following the nuclear power plant accident at Chernobyl, used their experiential knowledge of sheep behavior to challenge government claims about low levels of radiation in the environment (Wynne, 1992).

In summary, Bakhtin's dialogism creates an overarching framework that consists of two core concepts used in this study: "polyvocality" and "language as a site of struggle." A weaving metaphor foregrounds the layers of meaning that make up the polyvocal nature of language. The layers may include ideologies, morals, history, economics, politics, and science. By locating the meaning of the utterance in the rejoinder, Bakhtin emphasizes how multiple voices and points of

view become layered in language. The discussion of language as a site of struggle highlights discursive processes that centralize or decentralize meaning. Overall, dialogism enables this study to consider questions about how multiple layers of meaning may (or may not) incorporate other points of view.

Extending Bakhtin with Other Theories

Bakhtin provides a rich, holistic framework for examining the struggle among several potential meanings in expert risk communication. Additionally, discursive psychology, Laclau and Mouffe's discourse theory, and structuration theory extend and elaborate his concepts. When creating a multi-perspectival framework, Phillips and Jørgensen (2002) instruct the researcher to elaborate on ontological and epistemological similarities that make it appropriate to connect theories while also drawing useful distinctions. This section discusses the benefits of connecting these theories with Bakhtin's dialogism, highlights similarities, and draws distinctions among the theories.

Dialogism and the three supplemental theories share consistent (although not identical) treatments of the constitutive nature of language, ideology, power, and the role of humans. These consistencies make it appropriate to integrate them, despite differences that will be pointed out later. Phillips and Jørgensen (2002) draw these distinctions for discursive psychology, Laclau and Mouffe's discourse theory, and structuration theory and I extended them for Bakhtin's dialogism based on my readings of his material and discussions in Wertsch (2001) and Billig (2001). First, the theories share a fundamental assumption that language contributes to the social construction of the world, although unlike the other three, Giddens' structuration theory has an underdeveloped, or more linguistic, treatment of language (Conrad, 1993; Heracleaous, 2006). Each of the theories views meaning as dependent on the social context and provides a critique of the stable, unchangeable view of the structure of language (i.e. the view of Saussure's

structuralism). In different ways, each theory connects ideological struggle with the struggle over meaning and treats power as produced in discourse or social action, rather than simply compulsion or dominance. All of the theories seek to understand change and recognize that change occurs in creation and reproduction of situated language use and action. Even though all of the theories ascribe some level of knowledgeable human action to explain change, they vary in the degree to which they recognize the situational constraints on agency. Most importantly for the main topic of this study, each of these theories reject the pursuit of a totalizing ideology but rather seek ways to explain how several discourses (or resources in the case of structuration theory) provide different, and possibly contradictory, ways to speak in social situations.

The following sections describe the three supplemental theories and acknowledge important distinctions—some of which helpfully extend Bakhtinian concepts to enrich the study of expert risk communication. Other distinctions are noted but not included in the multi-perspectival framework. The end of each section translates the concepts into Bakhtinian terms to improve the coherence of the framework for this study.

Discursive psychology. Potter and Wetherall (1987) developed discursive psychology to address what they considered to be inadequacies of the cognitivist paradigm. Cognitivist theories treat language as reflections of underlying mental representations. Alternately, discursive psychology "treats written and spoken language as constructions of the world oriented towards social action" (Phillips & Jørgensen, 2002, p. 96). Furthermore, rather than viewing the meaning of any given word as universal, this theory emphasizes the contextual nature of language, which makes meanings dependent on individuals' language use. People assign meaning to experiences "by virtue of the words which are available, and the resulting meanings contribute to producing the experience rather than being merely a description of the experience" (Phillips & Jørgensen, p. 103). As a theory, discursive psychology explains how accounts become established as stable

constructions of the world and the design of certain constructions to appear as facts that can undermine alternate constructions.

The concept of "interpretive repertoires" helps articulate how individuals use and produce language in contextually appropriate ways and highlights the dynamic and multi-voiced nature of language (Wetherall & Potter, 1988). An interpretive repertoire consists of a "limited number of terms that are used in a particular stylistic and grammatical way" (Phillips & Jørgensen, 2002, p. 107). The contextually appropriate terms are the resources that people use to construct reality. People use interpretive repertoires flexibly which means that they can be both "identifiable entities that represent distinct ways to give the world meaning and malleable forms that undergo transformation in rhetorical use" (Phillips & Jørgensen, 2002, p. 107).

The creation and use of interpretive repertoires extends dialogism by foregrounding the processes behind the polyvocal nature of language. Discursive psychology describes meaning construction as an iterative process that is consistent with Bakhtin's threads of meaning metaphors while providing additional insight about how individuals strategically draw on resources in ways that contribute to authoritarian discourse or internally persuasive discourse. Similar to Bakhtin's dialogism, discursive psychology believes that utterances provide insight into individuals' goals and activity in specific historical and social contexts (Wetherall & Potter, 1988). Bakhtin's concept of utterance foregrounds polyvocality because the anticipated rejoinder is as much part of the meaning as the speaker's text. Even though discursive psychology is less specific about this aspect of utterances, the contextually appropriate use of interpretive repertoires necessitates that individuals be sensitive to responses.

Both Bahktin's dialogism and discursive psychology recognize discourse as the site of ideological struggle, but discursive psychology foregrounds the role of the individual. Discursive psychology emphasizes the strategic actions of individuals more than dialogism but is consistent

with Bakhtin's views of speakers as knowledgeable. Discursive psychology explains that discourses "categorize the world in ways that legitimate and maintain social patterns" (Phillips & Jørgensen, 2002, p. 108). People have a reciprocal relationship with the discourse by actively taking up positions while also becoming products. This reciprocal relationship creates "dilemmas of stake" which are individuals' attempts "to establish accounts as factual and stable and deconstruct other accounts as the product of personal or group interests" (Phillips & Jørgensen, 2002, p. 113). Ultimately, this theoretical view demonstrates how individuals' positioning in particular discursive categories creates power differences among groups. Hence, discursive psychology provides more theoretical description to the relationship between individuals and discourse in the ideological struggle. This level of theoretical description invites closer analysis of the text, which helpfully provides methodological tools to examine language choices.

Laclau and Mouffe's discourse theory. Laclau and Mouffe (2001) developed this discursive theory as part of their political theory to describe how discursive conditions create hegemony. Their concepts have been applied to discourse analysis (Phillips & Jørgensen, 2002) and help provide theoretical nuance behind the layering of ideology in language and how struggles result in authoritative discourse. Laclau (1993) views discourse as "addressed not to *facts* but to their *conditions of possibility*" (p. 431) and views the task of the analyst to examine how groups struggle to assign meaning within the conditions. This theoretical approach helps to identify how key signifiers in a discourse become imbued with meaning and how different understandings of reality stand in relation to each other. The notion of "articulation" foregrounds the relationships among "elements," which are polysemic signs whose meanings are not yet fixed within the discourse (Phillips & Jørgensen, 2002). Floating signifiers are signs to which different discourses struggle to assign meaning. At times signs reach closure, a temporary stop in meaning fluctuation. Similar to authoritarian discourse, closure is accomplished by excluding

other possibilities for meanings which exist in an entity called the field of discursivity. Nodal points receive much attention in discourse theory because these signs attain fixed meaning and become the organizing principle for other signs.

The description of discursive conditions for several possibilities of meaning and Bakhtin's threads metaphor consistently describe the polyvocality of language. Furthermore, the struggle to assign meaning to floating signifiers aligns with Bakhtin's concepts of language as a site of ideological struggle. Laclau and Mouffe believe that the struggles between potential meanings for key signifiers have political significance because groups that establish the meanings gain power. This process creates what they call objectivity—a "sedimented discourse" that "appears given and unchangeable" and "seemingly does not derive its meaning from its difference from something else" (Phillips & Jørgensen, 2002, p. 36-37). Laclau and Mouffe equate objectivity with ideology because it masks the contingencies of knowledge and hides alternative possibilities of meaning. Ultimately, Laclau and Mouffe believe that individuals cannot escape this ideological function of discourse. If an alternate meaning does gain discursive closure, then that simply represents a change to a different ideology.

With its emphasis on the struggle over floating signifiers for political significance, Laclau and Mouffe's discourse theory provides a useful analytic tool to examine how experts assign meaning to key risk terms. Such analysis would examine specific terms that the discourse seems to be organized around. Then it would consider whether the terms have fixed, taken-for-granted meanings or whether the experts disagree and assign different meanings to the terms. If the terms have fixed, taken-for-granted meanings, this could provide clues to shared ideologies and assumptions that are implicit in the experts' risk talk. Furthermore, the analysis would explore the field of discursivity, the alternate possibilities of meaning. If the terms are floating signifiers, then the analysis would examine the strategies and interactions by which experts try to

assign meaning and coordinate their understandings. In this way, Laclau and Mouffe's discourse theory usefully extends dialogism by providing specific concepts to explain how, in the struggle for power, different discourses try to fix meaning to floating signifiers and the ideological implications for instances when signs reach closure.

Structuration theory. The sociologist Anthony Giddens (1984) developed structuration theory to explain the reciprocal relationships between social systems and human practice. Rather than privileging either the structures of social systems or the actions of human agents to explain social phenomena, structuration theory captures the explanatory power of both social systems and human practice by describing their reciprocal relationship through the production and reproduction of structures (Banks & Riley, 1993; Conrad, 1993; Heracleous, 2006; Poole & McPhee, 2005). The system consists of relatively stable (although not static) and observable patterns of interactions across time and space. Examples of systems include organizations, cultures, classes, political systems, and economic systems. Human practice consists of the patterns of particular activities that are meaningful for the actors who participate in them. Examples of human practice include daily activities and discursive practices of organizational members. Structures are the rules and resources that people draw on when interacting with each other. Through the enactment of structures, human practices form the observable patterns that constitute the system. Yet, in a reciprocal relationship, the system enables and constrains the human practices through the rules and resources (structures) that are available to its members. Throughout the process of producing and reproducing the system, structures are both the medium and the outcome of human practices. Agents are the individuals who all have some knowledge of the structures in the system, although they may have different levels of consciousness about this knowledge (Poole & McPhee, 2005). Agents may faithfully appropriate the structures in line with the spirit of the system or they may appropriate the rules

and resources in an ironic manner that benefits the agent but violates the spirit of the system (Poole & DeSanctis, 1992; Poole & McPhee, 2005). Over time, these patterns of reinforcement or transformation either help maintain the stability of the system or contribute to its changes.

Even though structuration theory has a less developed concept of language and discourse, the notion of knowledgeable actors who act appropriately in a context is consistent with the emphasis that Bakhtin puts on situational context for meaning of an utterance. Furthermore, the possibility of agents to use structures faithfully or ironically is consistent with the multiple possibilities for meaning that is the heart of dialogism. Structuration theory extends the concept of language as a site of struggle by describing legitimation processes. It provides analytic tools to explain why society recognizes some actions as more legitimate because individuals tend to draw on resources (from science, policy, regulation, economics, etc.) that add legitimacy to their actions. Admittedly, Giddens did not write his theory to deal with physical systems such as natural laws, however his theory does provide a tool to examine how expert draw upon these types of systems as resources in their discourse. This sets a stage for more clearly seeing the reinforcement of authoritarian discourse or possible changes from the centrifugal forces of internally persuasive discourse. Furthermore, dialogism, like other discourse theories, focuses on text and language but the incorporation of structuration theory allows this multi-perspectival framework to connect communication events with the larger political and economic environment.

A Dialogic Response to Risk Communication

Bakhtin's weaving metaphor provides a suitably complex and active view of how multiple voices and meanings become layered together in discourse—including expert risk communication. He writes:

> The word, directed toward its object, enters a dialogically agitated and tension filled environment of alien words, value judgments and accents, weaves in and out of

> complete interrelationships, merges with some, recoils from others, intersects with yet a third group and all of this may crucially shape discourse, may leave its trace in all its semantic layers (Bakhtin, 1981a, p. 276).

This excerpt aptly describes the dynamic environment of communication that can be applied to cross-disciplinary expert risk communication among technical experts. Historically, risk communication research treats expert groups as uniform and does not consider the processes by which they construct, coordinate and legitimize risk understandings. Bakthin's theories provide analytic tools to articulate and examine questions that demystify expert risk discourses. As noted in Chapter I, experts' discourse about risk exists in a liminal space between the tensions of material and constructivist ontologies. One way to address this is how Bakhtin describes his study as moving "in spheres that are liminal, i.e. on the borders of all the aforementioned disciplines, at their junctions and points of intersection" (as quoted in Stewart, Zediker, & Black, 2003, p. 27). From this point of view, Bakhtin's conceptualizations of polyvocality and language as a site of struggle help us move beyond a transmissive model of communication and discursively examine how different risk understandings are managed and coordinated.

Bakhtin's dialogic theory does not presume that the layering of voices is or should be egalitarian. In the way, his ideas are distinguished from other dialogue perspective that presume or prescribe democratic conditions for dialogue (Fiorino, 1990). As an alternative to using dialogue theories to promote idealized conditions, Barge and Little (2002) use Bakhtin's theories to illustrate how "dialogic wisdom" can be enacted in daily practice of organization life. This dialogic wisdom is "a form of situated judgment" by which individuals can create coordination by "inviting others to participate in particular conversation positions" and use sensibilities of wholeness, uniqueness, and emergence to "engage others within the flow of experience" (p. 395). This application of dialogism highlights the sense-making aspect of communication amidst

several possible meanings. Often research on risk communication at public meetings emphasizes the use of dialogue to promote democratic decision-making at these forums (Fiorino, 1990; Tuler, 2000), but a Bakhtinian approach highlights rich and complex opportunities for these forums to serve sense-making functions (Hamilton & Wills-Toker, 2006).

Even though Bakhtin's writing does not specifically address issues of risk, he does make distinctions between the objects of study in social issues and in the sciences and mathematics. For example, in legal/ethical discourse an individual's position and use of discourse can influence the substantive content of the law. Alternately, even though scientists deal with polyvocality, Bakhtin draws a distinction with scientific discourse because scientists' use of discourse does not change the substance of the content they study (Bakhtin, 1981a, p. 349-351). This would seem to indicate a realist ontology because scientists' discourse cannot change the essence of the material phenomenon. However, Bakhtin did not witness the study of risk, in which scientific and mathematical risk assessments are given primacy for identifying and prioritizing risks for purposes of setting policy. These recent developments make risk as much a social issue as it is a topic of scientific and mathematical study. Despite Bakhtin's useful distinctions between social and scientific issues, given the current context of risk studies, one can appropriately use Bakhtin's dialogism to examine the dialectical ontology through multiple layers of meaning in experts' risk communication.

The following discussion uses a dialogic framework to demonstrate that, at a theoretical level, risk characterization necessarily involves processes of coordination and legitimation. The first section discusses coordination between (1) dialectical tension of the materialist and constructivist ontologies, (2) social and technical information, and (3) experts' perspectives from different scientific disciplines. The next section uses the dialogic zone of contact and utterances to explain processes of legitimation. Finally, the last section uses examples from risk

communication research to bring the dialogic concepts together with the other theories in the framework.

Characterization of Risk Involves Coordination

Coordination between materialist and constructivist ontologies. A dialogical analysis of expert risk communication demonstrates how the discourse provides resources for the experts to handle the ontological dialectic and how the experts draw on the resources to coordinate their risk understandings. Chapter I raised the point that risk has a dialectical tension between materialist and constructivist ontologies because it is a conception of the possibility of an undesirable event. If the risk does manifest then the negative consequences to human life and costs to society are painfully real. Most of expert risk talk consists of physical cause and effect relationships about hazards—scientific and technical discourse underscored by the realist ontology. However, if the hazards have not yet manifest then the experts' talk also contributes to the social construction of the risk's meaning by making claims about priorities that are underscored by political, economic, or moral values. In this way, expert risk talk imbues the possibility of risk and its perceived causal agents with values and expectations (Douglas, 1990; Taylor & Kinsella, 2007). The identification and management of risk becomes a contested topic in this socially constructed space.

Few researchers question whether lay people constitute their risk understandings through social processes. On the other hand, scholarship tends to treat expert risk understandings as realist and do not consider how experts' communication negotiates the dialectical tension with constructivism. The emphasis on the dialectical tension does not minimize the importance of a scientific or engineering study of a risk, but rather, creates an "opportunity to place scientific knowledge on a more legitimate, properly conditional, and ultimately more effective footing" (Wynne, 1992, p. 279). Bakhtin's dialogical emphasis on the polyvocal nature of language

addresses the processes of how experts coordinate the dialectic between realism and constructivism when talking about risk.

Coordination between technical and social information. Bakhtin's dialogism explains why we can expect to find social and moral information layered in risk communication among technical experts. The notion of the evaluative accent, always present in language (Wertsch, 2001), helps articulate the moral aspect of risk. Dialogic perspectives of intractable conflict explain that such conflicts are difficult to manage because moral aspects shaped the meaning of any technical information brought to bear (Littlejohn, 2006). This parallels Douglas' (1990) argument that risk is a moral judgment about responsibility and blame. A dialogic view of language expects these moral "accents" of risk communication, even in technical risk talk, because the traces of other voices are always present (Wertsch, 2001).

Research from the psychometric paradigm provides evidence that social norms, cultural values, and institutional affiliation may influence experts' risk perceptions (Barke & Jenkins-Smith, 1993; Silva, Jenkins-Smith, & Barke, 2007). This research raises questions about how and why experts' understandings of risk are constituted in ways that incorporate these various types of information. The polyvocal nature of language invites exploration of traces of value judgments and other social issues layered in the discourse. A dialogic approach enables close attention to risk communication among experts, which provides detailed insight into the evidence and appeals they use to incorporate technical and social elements into their risk understandings.

Coordination between different expert perspectives. Due to the complex social problems, technical experts from several disciplines must interact in risk management situations. As groups struggle to fix the meaning of key risk terms, each group contributes a risk understanding from a different angle of expertise. A dialogic framework enables analysis to examine how these

different expert perspectives become layered in the communication and coordination among participants.

Given the struggles documented in cross-disciplinary research teams, one can reasonably expect that communication among risk experts involves conflict and disagreement (Horlick-Jones & Sime, 2004). Thompson (2007; 2009) reports that disagreements about definitions and language use challenged individuals' disciplinary identity and often led to interpersonal conflict and team attrition. When successful, the scientists developed shared language by using abstract, conceptual diagrams that help them move beyond talking about appropriate data, equations, and analysis methods. They also needed trust and reflexive communication to address the conflicts about disciplinary identity (Thompson, 2007; 2009)—which are aspects of construction of their expert *ethos* (Cochran, 2007; Prelli, 1997). Therefore, a close study of risk communication among technical experts must consider how the different groups struggle to assign meaning to the risks at hand.

Risk Characterization as a Process of Legitimation

Dialogic zone of contact. Risk communication among technical experts has been relatively unproblematized compared to research on lay audiences and inadvertently reinforces the notion that the experts' use of technical information is more legitimate and rational (Horlick-Jones & Sime, 2004; Joffe, 2003). Bakhtin's dialogism provides a discursive explanation for power differences among scientific knowledge and social knowledge. Even in highly scientized discourses, the dialogic view of discourse offers a critical entry point to see that other voices are present. The notion of boundaries and contact become important in risk communication because the technical expert perspective tends to behave as an authoritarian discourse, setting up boundaries, insisting on singular meanings, and decreasing opportunities for dialogic contact with lay and social meanings. In this way, the expert discourse mobilizes centripetal forces to

unify and centralize meanings about a risk and decrease the dialogic zone of contact. These processes become apparent as technical experts try to construct risk understandings that appear more factual than others.

Despite the strong tendencies toward authoritarian discourse, Bakhtin (1981a) observes that "alongside the centripetal forces, the centrifugal forces of language carry on their uninterrupted work; alongside the verbal-ideological centralization and unification, the uninterrupted processes of decentralization and disunification go forward" (p. 272). In risk communication, this means that even though technical and scientific discourses have more power and legitimacy in risk decisions, the other layers of meaning (such as social norms, values, etc.) are still present in the discourse. When given opportunities to interact with scientific discourses, social and ideological meanings may decentralize the discourse to create alternative understandings that have the potential to be legitimate. Therefore, even in communication among technical experts, who are likely to maintain the authoritarian discourse, the dialogic "threads" are still present in the discourse and have the potential to surface. However, it is important to recognize that regardless of the centralized or decentralized nature of discourse, ideological values underscore scientific discourse and when these values align the combination further promotes centripetal forces. A close examination of the discourse of expert risk communication can identify the layers of meaning and gain insight into their role for constructing legitimate risk understandings.

Utterance and rejoinder. Bakhtin's notion of the utterance presumes interaction by insisting that meaning lies in the interaction between speaker and the anticipated response. Furthermore, when describing utterances, he writes:

> The processes of centralization and decentralization, of unification and disunification, intersect at the utterance; the utterance not only answer the requirements of its own language as an individualized embodiment of a speech act, but it answers the

> requirements of heteroglossia as well; it is in fact an active participant in such speech diversity (Bakhtin, 1981a, p. 272).

For risk communication, this means that utterances (and rejoinders) are the site to discover whether the discourse promotes unitary meanings or encourages diversity of meanings. In situations that have a strong tendency toward centralized meaning (such as expert risk communication) statements that align with the authorities are viewed as more legitimate.

The psychometric paradigm seeks perception-based explanations for the influence of emotion, social norms, values, politics, etc. on legitimate risk understandings (Joffe, 2003; Wardman, 2008). As a dialogic alternative, Billig (2001) uses Bakhtin's ideas to advocate that

> we should study memory, perception, or emotion by investigating relevant 'language games' or what Bakhtin called 'genres of utterance.' Attention should be paid to the way in which people talk about their memories, perception, and emotion. In doing so, we will discover the outward criteria for the social usage of the words (p. 211-212).

The "criteria for the social usage of words" becomes apparent by connecting Bakhtin's concept of utterance (and rejoinder) with viewing attitude statements as socially constructed. The attitude statement (or risk perception) is not simply the speaker's position. It implies the views of other social actors' positions. In this way, the communicative construction of risk understandings also carries meanings about responses to past positions and anticipation of future responses. When expressing a position about a risk, experts are knowledgeable actors who know what kind of responses to expect. They craft their statements in anticipation of these rejoinders. This naturally-occurring polyvocal aspect of discourse allows analysis to consider the ways experts strategically try to legitimize their understandings.

Bringing Concepts Together in the Dialogic Framework

Bakhtin's dialogism provides a theoretical framework that demonstrates how, as one unpacks the layers of meaning, it becomes apparent that the characterization of risk always involves processes of coordination and legitimation. Additional theories--discursive psychology,

Laclau and Mouffe's discourse theory, and structuration theory—contribute to the dialogic framework by providing more theoretical nuance to the concepts of polyvocality and language as a site of struggle. This section illustrates how the multi-perspectival dialogic framework works together by performing a brief reanalysis of risk communication about options for storing radium at Fernald, a former Department of Energy weapons facility (Hamilton, 2003). The original research article provided an insightful and thorough rhetorical analysis of a public meeting between expert and lay groups that helped to shed "light on mechanisms by which participants strategically communicate with one another to create a mutual understanding of risk experiences and on how those mechanisms stem from larger meaning systems for risk" (Hamilton, 2003, p. 292). The Fernald study draws a conclusion about overlaps of risk rationalities that is a starting premise for this dissertation: "participants demonstrated a capacity to combine elements of technical and cultural rationality in ways that suggest that they are not monolithic frameworks for understanding risk, but rather sources of rhetorical appeals" (Hamilton, 2003, p. 300). The Fernald study provides suitable material for reanalysis with the dialogic multi-perspectival framework in order to show how interpretive repertoires, struggles over key signifiers, and structuration processes enable explanations of polyvocality and ideological struggle within the construction and legitimation of risk communication.

Summary of Hamilton's analysis of the Fernald case. The original analysis used Plough and Krimsky's (1987) social and technical rationality "risk orientations as broad meaning systems that serve as sources of rhetorical invention for participants as they interpret risk experiences, formulate persuasive appeals, and promote mutual understanding by strategically combining aspects of these rationalities" (Hamilton, 2003, p. 293). Hamilton identified rhetorical strategies that participants used to enact their frames of acceptance drawing upon and combining the larger orientations to risk—technical and cultural rationalities. Using Kenneth Burke's

"frames of acceptance," she identified three rhetorical strategies: (1) defining a situation, (2) identification, and (3) circumference. When defining a situation, the participants highlighted certain meanings by selecting aspects of the situation consistent with a particular motive or attitude while muting other aspects of reality. Participants used identification processes to "develop common ground and join interests by demonstrating an understanding of their opponent's circumstances or views and by highlighting similarities in their thoughts" (Hamilton, 2003, p. 294). When participants used the circumference strategy they used certain words to narrow or widen the scope of the context or location. Articulating these strategies helped Hamilton identify the underlying meaning systems that participants used to label their experiences.

Prior to the public meeting used as a text for this case, cancer researchers approached Fernald site officials to request the extraction and use of radium for research and medical treatment. The public was concerned that this would delay clean-up on the site and that the researchers were trying to do this in secret. The medical researchers and local citizens each labeled the risk differently and in strategic ways that muted alternate concerns about the hazards of radium. The local citizens considered radium "a potential threat to their life span" whereas the researchers considered it "the key to a potential cure for cancer" (Hamilton, 2003, p. 294). The researcher "defined this situation as one in which a promising cancer therapy was dependent on Fernald's radium and that the radium was only usable if it was extracted before it was vitrified"—a strategy that "attempted to narrow the range of possible reactions that Fernald neighbors might have to his request and to persuade them to support supplying the radium before it was vitrified." (Hamilton, 2003, p. 296). The citizens "defined the situation as one in which radium extraction might prolong their health and environmental risks by delaying Fernald cleanup and 'post-vitrification extraction' offered a solution that would enable cleanup to

continue and the cancer research team to receive a supply of radium in the future"—a strategy that "limited [the researchers'] rhetorical choices to solutions that would address both sets of concerns" (Hamilton, 2003, p. 296). Ultimately, the site officials rejected the medical researchers request in order to maintain the clean-up schedule.

Reanalysis with dialogic framework. The polyvocality of language can be seen in the processes by which social and technical information become layered together through the labeling strategies. Both the researcher and citizen groups label the risk by layering social and technical information which can be seen in the way that Hamilton (2003) used technical and cultural rationalities as "sources of invention." This analysis parallels discursive psychology's explanation of how individuals create meanings of risk by drawing on resources made available to them through interpretive repertoires. The researcher's labeling choices emphasize the technical aspect of cancer treatment research and the social aspect of the desirability of a breakthrough cancer treatment. The citizens' labeling choices emphasize the technical mechanisms of the radium's hazard to their community and the social aspects of the democratic, participation process they had negotiated with DOE. As Hamilton points out, the participants' labeling strategies narrowed the range of acceptable options. This insight is further enhanced by Laclau and Mouffe's discourse theory which explains that "radium" is a floating signifier and the groups use labeling strategies to fix the meaning so that it gains political power to influence the decision. In addition to the discursive explanations, structuration theory illustrates the relationships between reified systems (e.g., science, policy, regulation, medicine, economics, etc.) and the strategic actions of the participants to legitimize some risk understandings and de-legitimize others. The researchers drew upon the medical system and its values about the treatment of illness as bases to legitimate their risk understandings and desired outcome to obtain the radium. Alternately, the citizens drew upon the political and regulatory systems to legitimate

their risk understandings and desired outcome to maintain the reclamation schedule. Through these language choices, the participants layered social and technical information to characterize their risk understandings through processes of coordination and legitimation.

Additionally, the Fernald case illustrates how the participants operated under the taken-for-granted authoritarian discourse of scientific expertise. One example occurred in the beginning of the situation, when the researchers first approached only the site officials—a choice that Hamilton describes as rooted in assumptions of the technical rationality and prevented interaction with social information about risk. However, after a newspaper reported this issue, the local citizens expanded the dialogic zone of contact by moving the interaction site into the public sphere, and more specifically a public meeting. This increased contact provided greater opportunity for citizens and researchers to draw upon both technical and cultural rationality as interpretive resources. This increased set of options for interpretive repertoires illustrates how the field of discursivity operates in Laclau and Mouffe's discourse theory. Initially, the researchers treated interaction with the site officials, authoritarian discourse, as the more objective and legitimate approach for making their request. However, the citizens used alternate understandings from the field of discursivity to legitimate their understandings and in this way expanded the dialogic zone of contact.

The polyvocality of language also can be seen in the processes by which multiple voices to become layered together through the identification strategies. The labeling strategies illustrated how these participants strategically drew on interpretive repertoires to characterize their risk understandings. Additionally, their strategic choices illustrate the ways that they coordinated their perspectives by using knowledge of expected responses to establish more legitimate and factual accounts. The researcher made identification appeals by disclosing personal information about himself as a cancer survivor and that he lived two from miles from

the Hanford clean-up site (also a former DOE weapons facility). These identification appeals strategically anticipated that, due to similarities, the citizens would respond more favorably to his otherwise technical appeals. The local citizens used identification to demonstrate that they "understood his sense of urgency about cancer research" by describing "funerals of friends, neighbors, family members, and Fernald workers who died of cancer" (Hamilton, 2003, p. 297). Through these identification strategies the researcher and the citizens attempt to coordinate their voices by layering their personal experiences and sympathies into the discussion. The use of personal experience with the risks of radiation and consequences of cancer draws upon the cultural rationality as an interpretive repertoire.

From Laclau and Mouffe's discourse theory we can also consider why both groups appealed to personal similarities as a taken-for-granted identification strategy. It seems to suggest that legitimacy attributed to personal suffering has reached a taken-for-granted status that is sedimented in the discursive resources. However, the question of variation also comes to mind: Why did the citizens rely on this strategy more heavily than the researcher and what insight can be gained from understanding this variation? The researcher relied more heavily on the taken-for-granted assumptions about science and a pattern of logic that comes from the technical rationality: if the citizens could fully understand all of the information then they would agree to let us extract the radium. Meanwhile, the citizens' identification with personal suffering appeared to sympathize with the researchers' goals but ultimately legitimized their goals to maintain their participatory role in the clean-up process and the site's current schedule. Hence, a closer analysis about taken-for-granted assumptions in sedimented discourse provides additional explanation about variable use of the identification strategy.

Finally, the struggle between centripetal and centrifugal forces helps explain how the circumference strategies in the Fernald case functioned to influenced the dialogic zone of

contact. Hamilton characterizes the primary tension in this debate as between the local or global context for radium use. Both positions could stop cancer but in different ways: the researchers could use radium to treat cancer, whereas the citizens would prevent cancer by cleaning up the radium. The researchers used a wide, global circumference "by locating [the use of Fernald's radium] within the context of the broad impact that this research could have for all cancer victims and the desperate need for an effective treatment" (Hamilton, 2003, p. 296). The local citizens characterized the scene at Fernald as one in which the "extraction of the radium might impact the clean-up schedule, and how delays might prolong cancer risks in their community" and used a cancer cluster map to "to focus on the continued threat to the life span of the Fernald neighbors from prolonged exposure" (Hamilton, 2003, p. 297). Hamilton points out that the researchers' wide circumference failed to include the citizens' local and narrow desires to prevent further suffering as a premise for making a decision whereas the citizens' narrow circumference legitimized the choice to maintain the clean-up schedule.

The researchers' circumference draws upon the technical rationality as an interpretive repertoire—a rationality that emphasizes the authority of medicine to pursue scientific research. As an authoritarian discourse, medicine centralizes meaning around the imperative to develop medical treatments that are beneficial to everyone. However, the citizens' redefinition of the circumference, to emphasize prevention of cancer in their local community provided an alternate centralization of meaning. The interaction of these two centralizing discourses had the effect of decentralizing the meaning about the use of radium. This created a wider dialogic zone of contact in which both groups had to draw upon multiple interpretive repertoires and non-discursive resources (such as policy, regulation, medicine) to assign meaning to the floating signifier of radium. The researchers' heavy reliance on technical rationality as a source of rhetorical invention (or interpretive repertoire) reveals an ideology rooted in scientific

understanding and institutional processes. This ideology has historical precedence for hegemony in environmental discourse (Ratliffe, 1997) and is widely criticized for masking the contingencies of knowledge and hiding alternate possibilities for meaning (Beck, 1992; Renn, 1998). The citizens' successful use of the cultural rationality as a source of rhetorical invention demonstrates a shift to an ideology that values democracy and participation in addition to the policy and regulatory preferences for maintaining the clean-up schedule. Therefore, the discursive closure that the citizens' gained by fixing their meaning to "radium" represents a change to a different ideology—one that seems more transparent but probably also masks knowledge contingencies and alternate meanings.

The labeling, identification, and circumference strategies demonstrate the ways that participants' communication increased the dialogic zone of contact and changed the conditions about what could be said in this situation. Hamilton's analysis provides a good explanation of how the participants' strategically drew upon technical and cultural rationalities to coordinate their risk understandings. However, the brief reanalysis of this case demonstrates how the dialogic, multi-perspectival framework provides an explicit explanation of how groups' characterization of risk always involve coordination and legitimization processes.

Summary

This chapter has created a dialogic, multi-perspectival framework that enables discourse analysis to unpack the layers of meaning and demonstrate how the characterization of risk (i. e. risk communication) always involves processes of coordination and legitimation. In particular, this framework draws upon Bakhtin's dialogism to highlight the polyvocal nature of discourse and language as the site of ideological struggle. Discursive psychology contributes an explanation of how individuals strategically draw upon interpretive repertoires as discursive resources. Laclau and Mouffe's discourse theory helps explain the struggle to assign meaning to

floating signifiers so that the terms can gain political influence. Structuration theory helps explain how individuals are enabled and constrained by reified systems, such as science, politics, and economics.

This dialogic framework is necessary for a study of expert risk communication because historically this discourse is treated as unitary with taken-for-granted assumptions about the role of science for influencing experts' risk understandings. Research about how scientific experts are influenced by social information, such as norms and values (Silva, Jenkins-Smith, & Barke, 2007), institutional affiliation (Kinsella, 1999), and ethos (Prelli, 1997; Cochran, 2007), raises questions how these become layered into discourse. This multi-perspectival framework enables this study to enter the discourse of experts' risk communication from different vantage points. It describes how the layers of meaning become coordinated between realist and materialist ontologies, between social and technical information, and between the voices of different groups. It also describes how the centripetal forces contribute to authoritarian discourse or centrifugal forces expand the dialogic zone of contact. However, observations about boundaries of dialogic contact may be more nuanced in communication among experts because technical experts may feel more pressure to act within the authoritarian discourse of science and maintain the firm boundaries. The next chapter provides methodological details about how this study uses case study methodology and the dialogic framework to address the research questions.

CHAPTER IV

METHODS

This dissertation examined a case of risk communication among technical experts regarding the continued use of cesium chloride. This case provided the opportunity to generate rich and authentic data from public meetings, in-depth semi-structured interviews, and external documents. The data analysis used methodological tools from the multi-perspectival dialogic framework established in the previous chapter.

For this study, I chose a discourse analytic approach. Alvesson and Karreman's (2000) framework establishes a vocabulary to articulate methodological choices in relation to the scale of discourse and each theories' positions on the relationship between language and meaning. This approach is consistent with the multi-perspectival framework set up in the previous chapter. Alvesson and Karreman (2000) begin with the observation that discourse analysis includes a wide range of perspectives that fall into two general categories: "little d" discourse is the "study of social text-talk and written text in its social action contexts" (p. 1126) and "big-D" Discourse is the study of "general and prevalent systems for the formation and articulation of ideas in a particular period of time" (p. 1126). They set up two axes as a framework to describe different types of discourse analysis. The first axis considers the connection between language and meaning: determinant discourse collapses the distinction and "directly implies or incorporates social and psychological consequences" (p.1133) and autonomous discourse maintains the distinction and "stands on its own or is loosely coupled to the social (individual)" (p.1133). The second axis considers the scale of the discourse and sorts it into four general categories: (1) micro-discourse consists of a detailed study of language in specific context, (2) meso-discourse is relatively sensitive to language use in context but generalizes to broader patterns in similar context, (3) Grand Discourse presents a group of discourses in an integrated framework, and (4)

Mega Discourse makes a more or less universal connection to the discourse material. Alvesson and Karreman demonstrate that a discourse theory's position in the framework enables one to ask different types of questions and have different levels of interpretation. I have selected discourse analytic tools that cover the micro-, meso-, and Grand-discourse perspectives.

Case Study Approach

The case study approach examines phenomena using data from a situational context and is an especially appropriate approach for research about a complex context (Titscher, Meyer, Wodak, & Vetter, 2002). Since the topic of risk communication among technical experts is relatively unexplored, I have chosen to use a case study methodology for gaining insight into this phenomenon. Additionally, since case studies are useful to explore the explanatory power of a theory (Titscher, Meyer, Wodak, & Vetter, 2002), I selected this approach to help explore the usefulness of dialogic theory for explaining how risk characterizations are discursively constructed and legitimized. Cases should be selected based on how well the situation fits the typology of the issues under investigation. I selected a case in which experts from different professions and disciplines interacted with the purpose to characterize risks. The case study selected for this study is about the continued use of cesium chloride. Furthermore, since literature establishes that risk communication often occurs in risk management situations, the selected case occurs with the backdrop of regulatory activity. Even though this topic is of great interest to key stakeholders, it does not generate broad public attention and controversy and this allows public interactions to retain specialized, technical content.

Before discussing the case, I wish to position myself to the research. During my doctoral program, I began part-time employment as a communication specialist for the U.S. Nuclear Regulatory Commission (NRC). The NRC is a Federal agency of the U.S. with the mission "to regulate the nation's civilian use of byproduct, source, and special nuclear materials to ensure

adequate protection of public health and safety, to promote the common defense and security, and to protect the environment" (U.S. Nuclear Regulatory Commission, 2009a). This means that the NRC regulates and oversees civilian uses of nuclear technologies that include nuclear power plants, the nuclear fuel cycle (mining, processing, and storage), medical applications, and industrial applications. My assignment was to develop public communication tools about a research project that studied severe accidents at nuclear reactors. Even though this project is completely unrelated to the case that I use for the dissertation, I am acquainted with co-workers who worked on the project related to this case.

The cesium chloride case came to my attention when the workshop on this topic was announced at the NRC. I attended the meetings out of curiosity and found out that the person who arranged the logistics was the same person I had worked with during the summer. Even though my position with the NRC does not create a legal conflict of interest for performing the research associated with this dissertation and I did not perform this research in my capacity as an NRC employee, I wish to make readers aware of my personal position in relation to the cases under examination. I do not expect the results of this dissertation to directly influence NRC policy decisions (in fact, the NRC made a decision about the continued use of cesium chloride in April 2009), but rather hope that the results will be used to improve risk communication among technical experts in general.

Continued Use of Cesium Chloride

Cesium-137 Chloride (CsCl) is a radiological material identified by the International Atomic Energy Commission (IAEA) as having the possibility to "pose a significant risk to individuals, society and the environment if improperly handled or used in a malicious act (U.S. Nuclear Regulatory Commission, 2008a, p. 44781)." Recent risk and consequence studies performed by Federal agencies showed that it may be prudent to require additional security

features for facilities that use cesium chloride, such as irradiators used for the sterilization of blood, calibrators used in radiation instruments and dosimeters, and devices for biological and medical research. Furthermore, a recent National Academy of Sciences study recommended the replacement or elimination of cesium chloride sources (National Research Council, 2008). At this point the NRC staff was assigned responsibility to provide recommendations about phasing out cesium chloride in its current form, finding a new form a cesium chloride, or finding an alternative such as an x-ray irradiator or using a cobalt-64 source. In order to solicit input from the varied group of stakeholders, the NRC held a public workshop on September 29-30, 2008. In April 2009, the Commissioners of the NRC directed the staff to develop a policy statement that details expectations about security of cesium chloride sources and continue research to find a replacement and to the Commission's expectations for security (U.S. Nuclear Regulatory Commission, 2009b).

This case is relevant to the study of risk communication among multi-disciplinary experts because it involves a wide variety of fields to discuss and compare terrorism risks and health risks. These disciplines include but are not limited to nuclear physicists, health physicists, medical professionals, biomedical researchers, nuclear engineers, risk analysts, security analysts, technicians, and equipment manufacturers. From a risk communication point of view, this case is rich with multiple potential hazards (security threats, radiation exposure, loss of medical benefits) and this requires the participants to not only advocate their points of view but coordinate them with others in a complex environment. The regulatory backdrop of this issue involves technology that is already widely used and any changes to licensing and oversight will impact well-established operations.

Data Collection

Since the majority of the research questions are better answered through micro-analyses of discourse, the primary data collected for this study lends itself to this level of analysis. However, I also gathered a third group of data, not for detailed discourse analysis, but to provide evidence of relevant themes and issues that operate at a meso- or Grand-discourse level.

Naturally Occurring Interaction in Public Forums

Naturally occurring interaction in public forums consists of transcripts of public meetings in which participants from different expert groups discuss their understandings of a risk at hand. These are authentic interactions, set in the context of regulatory decisions about socially and technically complex risks associated with the application of nuclear technologies. These texts lend themselves to both micro- and meso-level analyses. Within the transcripts, I was able to analyze micro-level actions and interactions among the participants. Additionally, since these meetings involved technical experts from different disciplines who were set in context of regulatory decision-making, this data set also lent itself to meso-level analysis. As documents of public, Federally-sponsored meetings, these transcripts were available through the NRC website.

The workshop on continued use of cesium chloride was held on September 29-20, 2008 at the Bethesda North Marriott Hotel & Convention Center in Rockville, Maryland (near NRC headquarters) to discuss (1) alternative forms of cesium-137 chloride, (2) alternative technologies, (3) phase-out and transportation issues, (4) additional enhanced security, and (5) potential future requirements for use of the material. Over 200 people attended from a variety of groups including blood bank, hospital, research, and calibration user communities, security analysts, manufacturers of irradiators, calibration machines, and radioactive sources, and Federal and State agencies with jurisdiction over the issue. The workshop used an expert panel and roundtable format with a professional facilitator to encourage discussion of the five main issues

(listed above). Designated experts sat at a table in the front of the room while the audience sat in rows of chairs that had an aisle in the middle with two microphones for the audience members to use when making comment. Most of the panel members gave about a three minute statement at the beginning of the session and then the floor was open for audience members and panelists to discuss the topic. Despite the highly structured format and contentious topic, the interactions at the meeting were of high quality and generally civil. Furthermore, despite the diverse issues that participants wanted to address, at several points in the workshop the interaction could be almost characterized as a conversation with panelists and audience members authentically responding to each others' comments and questions. The format of the workshop partially limited the participants' ability to directly express their views about disagreeing with the security characterization because the agenda was organized around information-gathering questions. The NRC agenda questions for the workshop are listed in Appendix B. Most of these questions are designed to gather information that the NRC can use to make a decision about whether or not to follow the NAS report recommendation. The workshop lasted sixteen hours (over two days) and the transcript is 528 pages of typed, double-spaced text.

Interviews with Experts

Interviews with experts in the disciplines and professional groups provided opportunity for the experts to provide more in-depth discussion of their positions regarding the risks under consideration. Interviews allowed for elicitation of experiential knowledge through stories, accounts, explanations, and participants' contextual use of language forms (Lindlof & Taylor, 2002). These accounts shed insight into the processes that participants used to construct their views about risks associated with cesium chloride. The participants talked about their expertise and how they came to be involved with the cesium chloride issue. Their comments were self-reflexive about how they formed and changed their views through recollections about

interactions that they had with other professional and expert groups. The participants' accounts tell about who was involved, when and where these interactions occurred, what information and arguments were exchanged, and why the participants chose to accept or reject certain views. Interview participants were recruited from the lists of attendees at the meeting. Based on organizational affiliation, I sorted the list of attendees into categories of professional groups: blood banks, hospitals, universities, manufacturers, state regulators, federal regulators, and security specialists. I then randomly selected individuals to contact from each these categories. I contacted the participants through email and phone at least three times. This resulted in 15 interviews with participants from professional groups that included state and federal regulators, blood banks, hospitals, universities, and manufacturers. Even though all interview participants had a science or engineering background, they had varying levels of expertise about the cesium chloride issue (Bolger & Wright, 1994). Unfortunately, I did not interview a security specialist due to the extra caution they take about who they speak with regarding security-related issues. Since several potential participants live in the Washington D. C. area, I was able to arrange one trip to conduct 8 interviews in person. Additionally, I conducted 7 interviews over the telephone.

Given constraints on the participants' schedules, interviews averaged 38 minutes. The shortest interview was 13 and a half minutes and the longest interview was about 90 minutes. Total interview time was 9 hours and 27 minutes. In order to allow me to listen and conversationally participate in the interviews, I recorded the interviews (with permission) and transcribed them verbatim for later analysis. Two participants declined to be recorded and in these cases I took thorough notes and immediately following the interview recorded my recollection of the interview. The transcription of interviews resulted in 271 total pages of double-spaced text.

During the interviews I established rapport with the participant and expressed genuine interest by demonstrating curiosity (Lindlof & Taylor, 2002). Since I am not an expert in these highly technical topics with specialized jargon, some participants were reluctant to talk about topics that are "over my head." I addressed this hurdle using two strategies: (1) early in the interview, I explicitly asked the participant to speak to me as an expert and promised to ask questions about unfamiliar terms and concepts, and (2) throughout the interview, I demonstrated my knowledge of the issue by using technical vocabulary and asking detailed questions. The overall strategy for the interview questions was to ask the participant to address the same issue more than once in the interview and then ask follow-up questions that posed alternative or problematic facts for the participant. This approach provided opportunities for the participants to create a variety of texts that allowed the analysis to probe connections between accounting practices and functional variations (Potter & Wetherall, 1987). The interview guide is provided in Appendix A.

External Documents

External documents include policy statements, press coverage, press releases, and position papers related to the two cases. I gathered these materials by searching the NRC website, websites of stakeholder groups that participated in the meetings, the internet in general, the LexisNexis database, and the U. S. Federal Register. The searches were limited to documents published since 2007, unless a participant explicitly made reference to an older document. These documents were not for full discourse analysis, but rather provided evidence for political, economic, regulatory, technical, and other potential themes and issues. Evidence of these issues supported claims about categories of discourse that participants may use as resources. Since this data is broader than the immediate context of the meetings and interviews, it supports meso- or Grand-level discourse analysis.

Analysis

As I argued in Chapter III, Bakhtin's dialogism enables an analysis of the polyvocality and ideological struggle for meaning in the experts' risk communication. I used the tools of analysis from the multi-perspectival framework (Jørgensen & Phillips, 2002) created in Chapter III in order to enter the discourse from different vantage points (Alvesson & Karreman, 2000). I used the three theoretical perspectives—structuration theory, discursive psychology, and Laclau and Mouffe's discourse theory—as analytic tools that built on each other in order to support conclusions emerging from my use of Bakhtin's dialogic framework.

Prior to conducting the detailed analyses, I oriented myself to the data by reading through the transcripts to get a holistic sense of the discourse and jotted down initial thoughts and observations. I used Altas, a qualitative computer package, to help initially identify codes and themes that helped focus the more detailed analysis. In Atlas, I marked participants' complete turns as the unit of analysis. Then, for each unit of analysis, I coded the topic, the form of reasoning, types of information, appeals to values and credibility, statements of coordination, and risk logics. The multiple coding within a unit of analysis enabled me to then identify patterns of co-occurrence that I used in the later steps of analysis.

Analysis with Structuration Theory

The first phase of analysis used structuration theory as a framework to establish how participants draw on rules and resources in ways that legitimize certain risk understandings. The previous two phases of analysis identified participants' discursive strategies, interpretive repertoires, and patterns of imbuing key terms with meaning. These results established a set of discursive rules and resources available to the participants in the larger system. The structuration analysis provides an extension by examining how the participants use both discursive and non-discursive resources. Structuration theory is suitable for grand-level of discourse analysis

because it organizes the discourses established in the previous phases into an integrated framework. Even though Gidden's description of structuration theory has an underdeveloped concept of language, the rhetorical and communicative emphasis of the other theories improves its usability for discourse analysis (Conrad, 1993; Heracleous, 2006). It considers discourse to be autonomous because the theory maintains a distinction between language and meaning. Once again, this phase moved the analysis to a different area of Alvesson & Karreman's framework in order to provide useful insight and interpretation from a different perspective.

The goal of structuration theory analysis is to explain the structures present within the system and how participants appropriate these structures to legitimize risk understandings. The data analysis is inter-textual and moves reflexively between the meeting texts, interviews, and external documents. Barley and Tolbert (1997) list three broad steps for conducting this data analysis under the framework of structuration theory. The first step sets up a chronology of events noted in interview data and external documents. It also identifies enabling and constraining structures within the context. This analysis attends closely to the participants' interpretations of the norms or violations of behaviors and events. Norms ("that's just how we do it") and violations of the norms are manifestations of the rules and resources that the actors regularly draw on to reproduce the structures (McPhee & Iverson, 2002). This step of the analysis is reported in Chapter V.

The next step identified discursive and non-discursive themes and examines them at two different levels: root themes and surface themes. The root themes are a manifestation of the deeper structures within the system and the surface themes are the participants' appropriations of those structures. The analysis considers the stability or transformation of the themes. This step of the structuration analysis is reported in answer to RQ 4 in Chapters VI and VII. The final step draws connections between the system, participant behaviors, and structures. At this step, the

analysis discusses how structures enable and constrain the participants and the implications for how risk understandings become more or less legitimized. This step of the structuration analysis is discussed in Chapter VIII.

Analysis with Discursive Psychology

The second phase of analysis used methods associated with discursive psychology. Since Potter and Wetherall's (1987) discursive psychology is a detailed study of individuals' language use in a specific context, it enters discourse at micro-discourse the end of Alvesson and Karreman's framework. It considers discourse to be autonomous because the theory maintains some distinction between language and meaning (Alvesson & Karreman, 2000).

Discourse psychology asks the analyst to examine specific language choices that lead to the rhetorical organization of the talk. This is a suitable entry point because it enables an understanding of which strategies participants use to articulate their understandings of risk. According to guidance from Potter and Wetherall (1987), I used the patterns of co-occurrences identified in the open-coding stage to identify how participants' strategies draw upon interpretive repertoires. This step represents a first move from micro- to meso-level discourse analysis. Potter and Wetherall (1987) define an interpretive repertoire as "a lexicon or register of terms and metaphors drawn upon to characterize and evaluate actions and events" (p. 138). In order to establish whether participants' were using interpretive repertoires, I moved reflexively between the strategies and the text with a special emphasis on the function of the strategies for the participants. I categorized strategies based on what seemed to be a functional rule for use of the strategies and placed equal importance on looking for examples of how the rules of interpretive repertoires operated and exceptions to those rules. If, in a given contextual use, a participant had good reason that justified the exception, then it supported the existence of an interpretive repertoire. However, I revised the rules for the interpretative repertoire when exceptions seemed

to be common. Through this analysis, I was able to use the interpretive repertoires "to distinguish contrasting sets of terms used in different ways" (Potter & Wetherall, 1987, p. 153).

In addition to indentifying the existence of interpretive repertoires, I explored the salience of these repertoires for the participants by considering whether they were "genuine features of interpretation" (Potter & Wetherall, 1987, p. 153). Following guidance from Potter and Wetherall (1987), I examined situations in which multiple interpretive repertoires were applied to the same case. If I captured a set of genuine interpretive repertoires, then "these cases should cause problems requiring discursive solutions" (Potter & Wetherall, 1987, p. 153). In these instances, I identified tropes, or rhetorical devices, that participants used in attempt to resolve paradoxes that arise from applying multiple repertoires to the same case. The participants' use of tropes in these situations demonstrates that he or she was consciously or unconsciously aware that the discursive actions created a paradox that needed resolution.

Analysis with Laclau and Mouffe's Discourse Theory

The third phase of analysis used methods associated with Laclau and Mouffe's discourse theory. This analysis built on the structural resources and interpretive repertoires established in the previous phases of analysis. Laclau and Mouffe's discourse theory is suitable for a meso-level of discourse analysis because, even though it is sensitive to contextual language use, it focuses on the abstract mapping of broader patterns in similar context (Phillips & Jörgensen, 2002). It considers discourse to be deterministic as it collapses the distinction between language and meaning and views discourse as limiting possibilities for participants. Given these differences, this phase moves the analysis to a different area of Alvesson & Karreman's framework, but this can provide useful insight and interpretation from another perspective.

I used the tools of Laclau and Mouffe's discourse theory to explicitly examine the coordination or conflict regarding the meaning of key terms and floating signifiers. Following

guidance from Phillips and Jørgensen (2002), I first identified the key signifiers in the text. Key signifiers are important terms with privileged status that may include "nodal points" around which the discourse is organized, "master signifiers" that organize identity, and "myths" which organize a social space. Then, I investigated how participants combined key signifiers with other terms with "chains of equivalence" in ways that imbued the key signifier with meaning. This step involved highlighting the key signifiers and identifying terms and concepts used near or in conjunction with the key signifiers. For the next step, I examined how the chains of equivalence represent different risk characterizations by comparing how participants use different sets of terms and concepts to imbue key signifiers with meaning and patterns of this usage. Then, I determined whether any of these key signifiers have achieved closure and explored reasons that the discourse allowed such closure. Finally, I considered the social consequences if any particular meaning achieves closure and gains hegemony in the discourse (Phillips & Jørgensen, 2002).

Summary

This dissertation used a case study of regulatory action about continued use of cesium chloride to explore the dialogic, discursive construction of risk communication among technical experts. The case provides a contextual situation for the collection of data of interaction among different technical experts regarding the risks and benefits of the issues. The data set includes transcripts of a public workshop that contain interactions among experts, transcripts of interviews with workshop participants, and external documents that provide historical record. The analysis of the data systematically moves through the levels of discourse to create an integrated picture of how the polyvocal nature of the discourse and use of non-discursive resources to enable or constrain the struggle to legitimize certain risk understandings.

CHAPTER V

RESULTS: SOCIETAL AND DISCURSIVE RESOURCES

This chapter uses structuration analysis to address the first and second research questions by identifying societal and discursive resources that enable and constrain participants as they interact about the cesium chloride issue. These rules and resources are building blocks and sources of legitimation. Enabling structures include (1) the medical institution, (2) the security institution, (3) regulatory bodies, (4) legislation, (5) and principles of capitalism, industrialization, and the Enlightenment. Constraining structures include (1) secrecy about security information, (2) politics, (3) legality of banning sources, and (4) participants' limited points of view. Norms and violations relate to rationality, information, and procedures. Since the format workshop partially constrained participants' ability to directly respond to the Recommendation #3 of the NAS Study to eliminate cesium chloride, they strategically used evidence, reasoning, and appeals to take nuanced positions that implied their level of agreement with the recommendation. The second section of this chapter describes three taxonomies of how the participants used evidence, appeals, and reasoning to express their views about the (1) uses and alternatives for cesium chloride, (2) security issues, and (3) risk logics.

This chapter focuses on identifying the social context and resources for legitimation. Subsequent chapters attend to their functional use to coordinate and legitimize participants' views. Chapter VI uses Potter and Wetherall's discursive psychology to identify patterns of how participants use these structural resources as interpretative repertoires. Chapter VII then uses Laclau and Mouffe's discourse theory to examine how participants used the structures and interpretative repertoires in instances of conflict and coordination.

Societal Resources that Enable and Constrain Participants

In order to explain why certain discursive resources were recognized by participants as more legitimate, I used elements of Giddens' structuration theory to analyze a broad view of the societal resources that enabled and constrained the participants' actions at the workshop and interview accounts. The results of this analysis: (1) identifies categories of participants, (2) constructs a chronology of events from their perspectives, (3) identifies enabling and constraining structures, (4) identifies norms and violations, and (5) offers a description of connections between the societal institutions, participant behaviors, and the structures. The results of the fifth step are embedded in the analysis of Chapters VI and VII and described in the conclusion of each of those chapters.

Categories of Participants

There are several professional groups and disciplines who are involved with the cesium chloride issue. The first category are the user communities: hospitals and blood banks who use cesium irradiators to irradiate blood for transfusion, researchers who use cesium irradiators for medical and agricultural research, and radiation protection professionals who use calibration equipment to maintain consistency and accuracy in dosimetry. The next category of participants are the source and equipment manufacturing communities—for cesium chloride there is only one manufacturer in Russia, one British distributor, and only a handful of companies that manufacture the irradiators and calibrators. A third category of participants includes regulators and government officials who ensure that radioactive materials are used safely, securely, and in accordance with state, national, and international policy. Radiation safety officers at hospitals and research institutions are a group of participants who act as a bridge between the user communities and the regulators. Another category of participants are security specialists who analyze the potential for terrorists to misuse otherwise beneficial technologies and develop plans

to prevent these scenarios from occurring. Politicians are also part of the context, but are not directly present in the workshop or interview accounts. Rather, they are often portrayed as individuals who try to control the situation from behind the scenes. Finally, the patients who receive medical benefits from cesium chloride technologies and members of the public who bear the risk of the security threat are part of the context. Like the politicians, these groups are not directly present in the data; however, unlike the politicians they are not afforded any acknowledgement of having a legitimate means to weigh in on this issue. When the public is explicitly mentioned, one participant treats their views as irrational and another participant highlights the injustice of their absence from this conversation. Patients appear contextually in statements and accounts as beneficiaries of medical services of cesium chloride technologies.

Throughout the interviews, the participants recounted interactions they had with members of different professional disciplines described above. An examination the sites of interaction (Table 5.1) makes it apparent, that in order for a person to gain access to these forums, they must be networked into professional organizations. Additionally, some of these forums, like the sub-committee meetings, conference calls, and the NRC workshop were the first time that some participants had meaningful interactions regarding cesium chloride across disciplinary lines.

Table 5.1 Sites of Interaction

Sub-committee meetings during the NAS Study
Meetings of professional organizations
Chat rooms, email, and listservs of professional organizations
Conference calls and individual phone calls
Meetings with members of an organization
Public meetings, including the NRC-sponsored workshop
Conversations before and after the formal sessions of the NRC-sponsored workshop
Formal letters of comment and requests for information to the NRC

Participants' Perspectives of Event Chronology

The next step of a structuration analysis is to construct a chronology of events. The following chronology is created based on news reports, press releases, and the answer that interview participants gave to the question: "When did you form your view about the cesium chloride issue?"

Two participants attributed the timing of their views to events prior to the terrorist attacks of September 11, 2001. The earliest event timing came from a researcher who had been working with cesium chloride in his research since the late 1950's. This is the time when the Atomic Energy Act allowed civilian uses of radioactive materials and President Eisenhower's "Atoms for Peace" speech encouraged such activity. At this time, the researcher formed his views about his preference for using cesium-137 in his research based on its energy properties. Another participant attributed the beginning of his views on radiation source use and replacement to the DOE offsite source recovery project (OSRP) that began in the late 1990's (although Los Alamos National Laboratory has been collecting sources since 1979). The mission of this program is remove excess, unwanted, abandoned, or orphaned radioactive sealed sources that pose a potential risk to health, safety, and national security and send them to a storage facility at Los Alamos or return them to manufacturers for recycling. This program represents a conscientious effort by the U.S. government to maintain an accounting of all radiation sources and since 2003 has taken on the security dimension of its mission.

Several participants pointed to the terrorist attacks on September 11, 2001 as helping them to form the view that terrorists could use any technology to cause harm to the U. S. Following these attacks, government agencies began increasing security around all radiation sources, including cesium chloride. Additionally, one participant discussed his involvement with the radiation of mail to the U.S. Congress to check for anthrax. During this event, he formed the

view that as a scientist, he needed to stay involved with these security decisions in order to ensure that they were not driven by fear.

In the years following 9/11, Congress took increasing interest in security of radioactive materials and the Energy Policy Act of 2005 made provisions for an interagency task force to examine the risk of dirty bombs and for the NRC to commission a study with the National Academy of Sciences to examine radioactive source use and replacement (Dolley, 2008b; 2008c; Markey, 2005a; 2005b). The participants who worked on this task force or sub-committees of the NAS study marked this time period as when they began to form their views. Participants who worked in these settings were aware of the Congressional interest because aides were frequently present at the meetings. In 2006, Congressman Edward Markey and then Senator Hilary Clinton sent a letter to the NRC regarding nuclear security that included, among other things, a request for increased oversight of radioactive materials to prevent their use in a radiological dispersal device (Markey, 2006). In 2008, Markey and Clinton proposed legislation in both congressional houses to incentivize the replacement of radioactive sources, such as cesium chloride; however this legislation has not been passed (Markey, 2008a).

In the timeframe between 2005 and 2008, several user communities described how they began implementing increased controls. For one participant, the interactions that he had within his organization at this time were critical events that shaped his views about use and security of cesium irradiators. Also, around the 2006 timeframe, two participants who used cesium irradiators in medical settings formed their views about the feasibility of x-ray irradiators as an alternative. One participant was moving a cesium irradiator and considered replacing it with an x-ray irradiator so that he could avoid compliance issues with the cesium irradiator. However, after research, he decided that due to cost and reliability issues, it was not in the best interest for his organization. The other participant did purchase an x-ray irradiator and said that he formed

his views about its expense and lower reliability when the x-ray irradiator began requiring more maintenance.

In February of 2008, the NAS study *Radiation Source Use and Replacement* was published. This study examined several radioactive sources and included the following recommendation that directly related to cesium chloride.

> Recommendation 3: In view of the overall liabilities of radioactive cesium chloride, the U. S. government should implement option for eliminating Category 1 and Category 2 cesium chloride sources from use in the United Stated and, to the extent possible, elsewhere. The committee suggests these options as the steps for implementation:
>
> i. Discontinue licensing of new cesium chloride irradiator sources.
> ii. Put in place incentives for decommissioning existing sources.
> iii. Prohibit the export of cesium chloride sources to other countries, except for purposes of disposal in an appropriately licensed facility (National Research Council, 2008, p. 9).

The publication of this study was announced in an NAS press release and covered with a small blurb in the *Washington Post* and more detailed articles in the *Montreal Gazette* (Boswell, 2008) and trade press *Defense Daily* (Lobsensz, 2008) and *Inside NRC* (Dolley, 2008a). Additionally, Congressman Markey praised the NAS study's recommendations in a press release (Markey, 2008a).

Several participants mentioned professional conferences in the spring of 2008 as the point in time when they learned of NAS Study's Recommendation #3 and this is when they formed their views that, to some level, disagreed with the recommendation. During the summer of 2008, the participants from professional societies started to receive calls from their membership expressing concern about this recommendation. These user communities began to interact with each other in chat rooms and over email and expressed a lot of anger about the recommendation. In August 2008, the NRC announced that it would have a public workshop regarding this issue and invited participants to serve as panelists at roundtable sessions (U.S. Nuclear Regulatory Commission, 2008b; 2008c). In the time immediately preceding the

September 2008 workshop, the user communities held several phone conferences to gather information from each other. Additionally organizations gathered information from members in order to prepare for presentations at the workshop. Also, in the week before the NRC workshop, the *USA Today* ran an article about the Department of Homeland Security's "red teams" that could extract the cesium chloride from irradiators in less than two minutes, and described the in-device delay program (commonly called "hardening") that re-engineers the cesium irradiators to make the sources more difficult to steal (Hall, 2008). For one participant, his involvement in this program was an important activity that shaped his view about the security concerns of cesium chloride.

In December 2008, NRC staff recommended that the NRC improve security for cesium chloride sources rather than prohibit the use of them and continue to research alternatives. This was announced in an NRC press release and an *Inside NRC* article (Dolley, 2008c). At this time, Congressman Markey ran a press release expressing his displeasure at the NRC staff recommendation and promised further support of programs to enhance security related to radioactive sources (Markey, 2008b). In April 2009, the NRC Commissioners (the presidentially-appointed decision makers for the NRC) voted to agree with the staff's recommendation and directed them to write a policy statement that provided the details of the increased security and program of research for alternatives. Then Commissioner Jackzo (he is now the Chairman of the NRC) dissented from this vote because he would have preferred the NRC to begin rule-making on this issue (Dolley, 2009).

In recent years, fears about radiological terrorism with cesium chloride were present in the press and fiction. In 2006 and 2007 there were two articles appearing in the *Washington Times* and the *New York Times* (respectively) about the radiological terrorism—both mentioned cesium chloride explicitly (de Borchgrave, 2006; Zimmerman, Acton, & Rogers, 2007).

Additionally, in 2007, an Australian fiction book incorporated a scenario in which terrorists stole cesium chloride from medical providers and used it to poison water in several Australian cities (Porter, 2007). Most recently, in 2010 a U. S. television drama series, *NCIS,* featured an episode in which cobalt-60 (a radionuclide that is offered as an alternative to cesium chloride) was stolen from a dentist's office and used on a dirty bomb.

This chronology provides a high level context for the issues around civilian use of radiation sources, with a special focus on the use of cesium chloride. Principles about uses of radioactive sources date back to the 1953 with Eisenhower's "Atoms for Peace" speech and the Atomic Energy Act of 1954, both of which encouraged civil use of nuclear materials and emphasized the importance of always maintaining control of sources. The 1950's are when scientists began using cesium chloride as an irradiation source for research. The OSRP program demonstrates a long-term interest in securing radioactive sources. However, as it did in many sectors of society, the terrorist attacks of September 11, 2001 increased the urgency for improving security around sources and this activity was given further legitimacy and resources with the Energy Policy Act of 2005. Throughout the policies and programs that shaped some participants' views, several participants marked turning points of their views based on their experiences using irradiators. The final insight from this high-level view demonstrates that information spread quickly through professional communities after the publication of the NAS study, and that the NRC workshop was an important response to the concerns that several user communities had about the recommendations of that study.

Enabling and Constraining Structures

An important step of structuration analysis is to identify structures present within society that enable and constrain the actions of individual actors. As individuals enact the structures, they reinforce society. Individuals can also appropriate structures an ironic manner that is not the

intended spirit. The following sections describe enabling and constraining structures that participants appear to be appropriating or feel restricted by. They are described in this section and the analysis of interpretative repertoires (Chapter VI) and coordination (Chapter VII) identifies their use by participants. For purposes of this dissertation, these descriptions are necessarily simplistic, however, the generalizations are not intended to imply that these structures are uniform and lack complexity.

Enabling structures. Enabling structures are the rules and resources that are available to the participants. These structures are both a medium and outcome of interactions about use of technology with radioactive sources. Enabling structures for the cesium chloride issue include (1) the medical institution, (2) the security institution, (3) regulatory bodies, (4) legislation, (5) and principles of capitalism, industrialization, and the Enlightenment.

In the U. S. the medical institution is a powerful entity comprised of organizations that provide patient care, research health issues, educate future healthcare providers, sell medical services and products, and a complex network of insurance companies. The practices of the medical institution are regulated by the U. S. Department of Health and some agencies under the U.S. Department of Agriculture. Organizations within this institution are motivated to prevent or treat human illness and several organizations also have a profit motive. This structure is a resource that enables participants to make general claims about the value of technology for patient care.

Since the terrorist attacks on September 11, 2001, the security institution is an increasingly powerful institution in the U. S. with the mission to protect the public by preventing terrorist attacks and providing resources in the case of an attack. It is primarily composed of agencies within the U. S. Department of Homeland Security (DHS) who liaison with other federal agencies with jurisdiction over areas of concern. In the case of cesium chloride, the

security divisions of the NRC, the Department of Energy (DOE), National Institutes of Health (NIH), Food and Drug Administration (FDA), and Department of Defense (DOD), fall into the category of the security institution. Other organizations in the category include contractors with the federal agencies, especially national laboratories such as Sandia National Labs who provided research for the security studies related to cesium chloride and Oak Ridge National Labs that are experts in research about radioactive sources. This structure enables participants to express concerns about cesium chloride in terms of protecting the public. It also provides the "9/11 logic" which is a reasoning that if terrorists would use airplanes as a weapon and are willing to commit suicide for their cause then they could use any technology to harm the citizens of the U.S.

Another set of important institutions for the cesium chloride issue are regulatory bodies who create policies and oversee the safe and secure use of radioactive sources. In the U. S. the federal agency for this is the NRC, but there are also 38 agreement states that have been delegated primary responsibility for regulatory oversight of radioactive sources. At the international level, the International Atomic Energy Commission (IAEA) is the regulatory body that coordinates regulatory programs in all nations that use nuclear technologies for civil or military applications (or at least they try to have authority in all nations). The regulatory structure enables participants to believe that their use of radioactive sources can be done safely to minimize the risks of the hazardous material. Fundamental to regulation and policies regarding civil uses of radioactive material is a radiation protection logic that reasons that as long as users measure and minimize exposure to and dose from the sources, then the health of users and the public will be protected.

Closely related to the regulatory structure is the legislative structure. This structure consists of a variety of federal legislation and policies. Legislation can be as fundamental as the

Atomic Energy Act of 1954 that allowed for civil uses of nuclear technology by private organizations for commercial purposes. In more recent times, the Energy Policy Act of 2005 provided resources for additional study to improve security of radioactive sources, and periodically Congressman Markey and other elected officials will propose legislation or add amendments to funding bills that are related to the use of radioactive materials. Also fundamental to the use of radiation sources is the IAEA Safety Standards: Categorization of Radioactive Sources published in 2005 (International Atomic Energy Commission, 2005) sorted radionuclides based on the amount of dose that would be required to impact harm to human health. Throughout the workshop and meeting participants draw upon this policy when they refer to "Category 1," Category 2," and "Category 3" sources with Category 1 sources presenting the most risk. For the cesium chloride issue, Category 1 and Category 2 sources are of the most interest. The legislative structure enabled participants to use radioactive sources for civil purposes and refer to policies that helped them do so safely.

A final structure related to the issue of cesium chloride is a general belief, characteristic of late Western societies, that technology is a resource to solve social problems (Habermas, 1984). This belief stems from the history and precedence of capitalism, industrialization, and the Enlightenment. This belief is fundamental to the preceding structures and enables participants to express their beliefs in the importance of cesium chloride technology, the importance of proposing solutions that are supported by the market, and the possibility of finding a technological alternative to the cesium irradiators that pose a security threat.

Constraining structures. Constraining structures are rules and resources that limit participants' actions. Again, these structures are both the medium and outcome of interactions about the use of nuclear technologies. Constraining structures for the cesium chloride issue

include (1) secrecy about security information, (2) politics, (3) legality of banning sources, and (4) participants' limited points of view.

One important constraining structure is the secrecy about security issues. Security-related information is often considered secret or top secret which requires individuals to have a federal security clearance and need-to-know in order to gain access to this information. Such protections around this information are necessary in order to prevent U. S. enemies and terrorists from gaining access to information that they could use to cause harm to U. S. interests. This is a fundamental and well-respected aspect of dealing with security-related issues, especially among federal employees. However, this aspect of dealing with security-issues also poses a constraint on the actions of individuals who cannot share the fullness of their understanding about why cesium chloride is considered a security risk in an attempt to persuade others to believe them and take appropriate actions. For some participants, this secrecy was frustrating because they could not see the whole context of the problem, evaluate the quality of information or the efficacy of the proposed solutions. Additionally, two participants pointed out that due to secrecy, security reports rarely receive peer-review. This can prevent overly-conservative or underestimated conclusions from being corrected which leads to poor quality of information for decision-makers. The secrecy of security information constrained security-specialists from being able to fully persuade some participants of the security threat and constrained some participants from being able to evaluate the quality of information related to changes that they were going to have to make. One participant, who respected the importance of secrecy, could not help but feel frustrated with how regulators simply said "trust us" and provided only "piecemeal" information to them about the security changes they were going to have to make in her organization.

Even though legislation is an enabling structure, participants observed that the presence of politics around the cesium chloride issue seemed to constrain the NRC. They recognized that

elected officials who sat on congressional committees that oversaw the NRC were very interested in the cesium chloride issue. One interview participant felt that the cesium chloride issue was "sadly the result of a bizarre political process where certain congressmen or senators felt that they would get positive press based on how tough they were on terrorists." Indeed, Congressman Markey publicly expressed his agreement with the NAS study's recommendations and displeasure at the NRC's decision to not follow them explicitly. As a result, some participants noted that the NRC staff had to be careful in how they responded to the recommendations of the NAS study, which may explain one reason that they solicited so much input from user communities and held the workshop. Several participants expressed views that Congress "could put pressure on the regulatory agencies to actually implement some of those recommendations." This congressional desire to be "tough on terrorists" constrained the NRC from being free to form their own professional judgment about the risks and subsequent policy about use of cesium chloride. Additionally, a couple of participants noted a political tendency of managers in federal agencies to use fear appeals in order to increase the importance and funding for their programs. For these participants, the element of politics created constraints on the types of information used in decision making.

The third constraining structure is the legal issues associated with banning radioactive sources. First, several participants pointed out that current legislation does not encourage a "banning" of radioactive materials. Additionally, participants frequently mentioned the legal constraint of not having a disposal option for cesium chloride if it was banned—they even alluded to the Yucca Mountain controversy and the inability of the federal government to provide for disposal of any radioactive materials. A unique angle on legal constraints of the disposal problem came from one participant who pointed out that cesium chloride does not fit into the current configuration of OSRP and other non-proliferation programs. Currently the

OSRP program is designed for other radioactive isotopes but not cesium chloride. Non-proliferation programs are able to collect radioactive materials that could be used to build nuclear weapons but currently, cesium chloride is legal to use when licensed by NRC and agreement states and does not qualify for non-proliferation programs. This participant was careful to acknowledge that not all of his colleagues held this view, though. Ultimately, these legal issues constrained the NRC or any other entity from banning cesium chloride before creating a disposal pathway.

Finally, several interview participants believed that they or others in the situation were constrained by a limited point-of-view—that is, they were initially unable to understand other participants' perspectives and often failed to ever really achieve full understanding. One participant said the communicating about the cesium chloride issue was "like the proverbial elephant with the three blind men." Participants also noted that this was inevitable because any one person could not know everything but it was important to have individuals who represent all perspectives present at the interactions in order to correct false information. One participant explicitly connected this constraint with the political constraint when describing how "people contrive more vulnerability and risk so that they can build their programs" while at the same time other "people might also say less to make management easy." As a result of these different points of view, "people who deal with risk communications should recognize both extremes and most likely the truth of the situation lies somewhere in the middle." The participants believed that a limited point-of-view constrained their abilities to accurately share and interpret information.

Norms and Violations

A third step for analysis with structuration theory is to identify norms, moments in which participants treat particular structures and behaviors as if they are taken-for-granted.

Conversely, this step identified moments in which participants feel that the norms are violated. In the interviews and workshop, participants demonstrated that they held norms about how individuals should behave rationality and follow procedures. Violations of these norms occurred when emotion seemed to guide decisions, other parties shared or withheld too much information, and there was talk of elimination or "banning" cesium chloride.

Norms

Typical of the rational-actor model (Garvin, 2001), participants' interviews upheld the norm of rationality as important basis for decision making. This is apparent in their approval of the NRC decision to allow to continued use of cesium chloride with security enhancements based on a belief that it "is the most rational outcome." Participants constructed themselves as providing a rational voice in the interactions—sometimes they even saw themselves as more rational than other participants. They felt that they had high quality and relevant experiences that enabled them to contribute important information to the interactions. One participant who worked on the NAS study said "I had actually seen a lot more of these sources than some of the other people there and [knew] how they were used and how the radiation safety came into play and some of the security measures." Some participants also felt that their rationality helped them to see a more complete picture of the situation of how decisions would impact users and the actual role of the government.

Closely linked with the norms about rationality, participants held expectations about following procedures of sharing information and creating policy or rule-making. Again, participants approved of the NRC's process of gathering information related to the cesium chloride issue, especially because the NRC took into account the user communities' perspectives about how a decision to eliminate cesium chloride would impact the beneficial functions of cesium technology. Several participants have a lot of experience working with federal agencies

and they all praised the NRC's information gathering approach in terms similar to the following excerpt:

> I think NRC did a good job in saying, 'Okay, let's just get everybody together and announce this and get some feedback from the community to find out more about it. What are the different applications? What will be the impact, if such a ruling will be in place - eliminating cesium chloride?'

Additionally, participants had expectations about procedures that federal agencies should follow when creating policy or rule-makings. This expectation began with rational information gathering, as described above, but also included an expectation that the agency with legal jurisdiction should be the one to make the decision. Several participants expressed the view that it was the NRC's decision about whether or not to phase out cesium chloride. One participant who participated in a working group for the NAS study identified this belief as the one thing the group could agree on, so they "basically punted this decision back to the NRC and said if the NRC wants to phase out cesium chloride they should conduct their standard rule-making process."

Violations

The most common violation the participants responded to was that decision-makers would make decisions based on politics, emotion, or both. Several interview participants felt that some politicians had "radiophobia" to and this led to "mind sets … to ban all radioactive materials--I'm sure as the sun rises that some people consider that." One participant noted that another federal agency was only "tangentially involved in regulating the radiation. And so they felt [that] a terrorist could use this and it needs to be eliminated--not really comprehending the fact that the bigger picture is what they're used for and what the beneficial uses are." These participants reacted to a violation of the rational decision-making process based on a holistic point-of-view. A third participant expressed his sense of this violation by contrasting ideal

conditions for rational decision with the real political constraints that violate what he views as a norm of rationality.

> One would hope that governmental bureaucracies that exist for public safety, whether they may be the NRC or the Environmental Protection Agency, will be encouraged to do their job as best as possible and is free from political constraint, and it is always unfortunate regardless of who's in power when public servants need to tailor their communications because of who happens to be in government control at the time.

Another violation is the distortion of information. Several interview participants hinted at this violation, but workshop participants addressed it more specifically. This distortion is attributed to fear and political pressures that are disseminated in the media. The following excerpt expresses one participant's concerns about distortion in contrast with the norms of scientific information and rational decision-making.

> As a consequence of conflicting threat assessment and media depictions of threats, we have become even more polarized over the nature and severity of national security threats to the United States and fundamentally disagree about how to frame and negotiate these threats. These trends can distort perceptions and … disproportionately shape our policy choices and specifically about the issue before us today. Therefore, especially in cases where alarmist predictions are not backed by good evidence, we should strive to ask the right questions to the extent that that is possible. We should ask for a comprehensive evaluation of sources and exculpatory evidence for these predictions, which will help us determine the appropriate variables for informed cost-benefit analysis and sustained high-quality reasoning about the security and safety challenges of our time.

A third information-related violation occurred at the workshop when a security specialist was trying use additional information to support his concerns about cesium chloride but he was asked to stop speaking because he may have been crossing the line of sharing too much security-related information.

> Security Specialist: If you do a study of the economic impact of a major dirty bomb using cesium chloride, as [my colleague] and I did … some years back, we found that an attack in lower Manhattan on the 10th of September, 2001 could have caused just about as much property damage and economic loss, all told, as the terrorist attack the following day. Again, we were exploiting the physical properties -
> DHS Official: Excuse me, if we could make sure we don't get into any specifics in the use, it would be very helpful.
> Security Specialist: I'm sorry?

> DHS Official: If we could make sure - I'm … from the [DHS] Office of Nuclear Security and Response.
> Security Specialist: Who and what?
> DHS Official: I'm … from the Office of Nuclear Security Incidents and Response. We just want to make sure that this is something that's public, essentially something for the public.
> Security Specialist: I'm going into no specifics whatsoever. Okay?
> Facilitator: And sir, we are just trying to make sure we are covered, okay?
> Security Specialist: Thank you for that pleasant intervention.

This particular violation illustrates how the security specialist felt a constraint about secrecy. He was trying to use his professional knowledge to convince other groups about the risks of cesium chloride, but since other officials did not want to risk having security-related information in the public record, they asked him to stop speaking. The security-specialist clearly felt that his credibility was attacked, responded to this request with sarcasm, but complied with the request. This was a particularly memorable moment as recounted by an interview participant a year and half later.

> …Somebody actually had to be reprimanded at the meeting verbally … because of security risks of what they were saying I guess about the dispersability of cesium chloride… I do Federal Agency meetings almost for a living and I've never seen a situation like that happen even at…controversial meetings.

The interview participant recognized the unusual act of meeting officials asking a participant to stop speaking and this cued him to the violation of the secrecy norm related to security information.

Finally, participants reacted to violations of established procedures and precedent. In particular, participants were very sensitive to the fact that, in their view, it is not legal to ban radioactive materials that are being peacefully used for the benefit of society. For example, at the workshop, a security specialist who used the word “eliminate” in his comments provoked a series of angry comments that caused the facilitator to redirect the meeting. Interview participants also reacted to the idea of “banning” cesium chloride by saying things like, “we don't have the authority to ban … if anybody has the authority to ban, it will be [the NRC].”

Basically, they felt that any procedure other than an NRC rule-making, would be an inappropriate procedure for determining whether cesium chloride should be eliminated.

Summary

In summary, the history of the safe use of radioactive materials, including cesium chloride, dates back to the 1950's with an important premise to keep track of the materials. This has not always been handled well by the federal government, but in the 1990's, DOE's OSRP program increased efforts to locate and secure sources. Since the terrorist attacks on September 11, 2001, Congress and the federal agencies have increased security around all radioactive materials. Additionally, the Energy Policy Act of 2005 provided resources to study this issue further—a study by NAS that resulted in the recommendation to eliminate cesium chloride for security reasons. Since the publication of this study in 2008, there have been several interactions about the benefits and security of cesium chloride.

Throughout this history, there were several enabling and constraining structures that participants drew upon. Enabling structures include (1) the medical institution, (2) the security institution, (3) regulatory bodies, (4) legislation, (5) and principles of capitalism, industrialization, and the Enlightenment. Constraining structures include (1) secrecy about security information, (2) politics, (3) legality of banning sources, and (4) participants' limited points of view. By drawing on the enabling structures and reacting to the constraints, participants' actions at the workshop and accounts in the interviews demonstrated norms and violations regarding rationality, information, and procedures. In particular, participants displayed a strong norm of expecting the NRC and other decision makers to make a rational decision based on high quality scientific information and the impact on the beneficial uses of cesium chloride. Ideally, this rational decision should avoid influence of politics and fear if possible; however,

interview participants understand the power that certain politicians have over the budgets of federal agencies and the power that the security institution has over nearly all sectors of the U. S.

This section of the structuration analysis demonstrates the resources and constraints that participants draw upon throughout their interactions about the cesium chloride issue. Participants act and react both consciously and subconsciously to the powerful institutions, norms, and constraints of the situation. For example, several interview participants are aware that political interests potentially explain why the NRC underwent a long information-gathering process before making their decision to allow the continued use of cesium chloride—largely based on the values of using technology to provide medical care and radiation protection. On the other hand, interview participants also understand the importance of security to ensure that terrorists cannot use beneficial technologies for the public harm. Both of these positions are set up in the societal institutions and mutually constrain each other.

Use of Evidence, Appeals, and Reasoning

In addition to societal resources and constraints, structuration theory also attends to actions of individuals. This section provides an explanation for how participants strategically positioned their views in relationship to each other and Recommendation #3 of the NAS Study. In the NAS study, cesium chloride is characterized as a security threat and this is the basis for Recommendation #3. Participants from user communities wanted to characterize cesium chloride as a unique isotope that provides a beneficial technology. This characterization becomes a premise for expressing disagreement with NAS Recommendation #3—either its security basis or the feasibility of alternatives to replace cesium chloride technologies. However, the structure of the workshop partially constrained direct expression of views about disagreeing with the security characterization because the agenda was organized around information-gathering questions. The NRC agenda questions for the workshop are listed in Appendix C. Most of these questions were

designed to gather information that the NRC can use to make a decision about whether or not to follow the NAS report recommendation. In response to Question 3.1-5 about whether the NRC should "discontinue all new licensing and importation of these sources and devices," several participants stepped to the microphone and answered, "no." The facilitator joked that he was not intending to take a vote, but the reaction illustrates how participants wanted to express their disagreement with the recommendation to eliminate cesium chloride due to its security threat. An NRC manager clarified the question by saying that, "while 'no' is a perfectly reasonable answer for you to say… we need a regulatory basis to say no and yes, we disagree with you or we agree with you or we agree with you in part [and] so we really need your help in flushing out no, but why."

Given this constraint, participants generally made comments that addressed the agenda questions using discursive strategies that layered in their views about Recommendation #3. This section describes three taxonomies of how the participants used evidence, appeals, and reasoning to express their views about the (1) uses and alternatives for cesium chloride, (2) security issues, and (3) risk logics.

Talk About Alternatives

Most of the talk about alternatives used deductive reasoning using either scientific or economic principles. Talk about alternatives is full of very specific detail about operations of the equipment, organizational operations, specific activity and energy level of radiation sources, and physical and chemical properties of the isotopes and their forms. Occasionally, participants used inductive reasoning from a professional experience that offered a cautionary tale about the use of an alternative or recalled a historical experience of phasing out of another radiological alternative. When talking about alternatives, it was more common for participants to try to build their credibility by appealing to their organizational affiliation or external expertise. An appeal to

the organizational affiliation may try to establish their stance as neutral or substantiate their comment as being supported by the knowledge and expertise of the organization. Participants also tried to build credibility and consensus by directly appealing to the expertise other participants to add support to their comment or referring to the dominant view of their organizations' members. These credibility appeals function to create a sense of objectivity which is the hallmark of rational decision making. The information about impacts of phasing out cesium chloride is layered in talk that appears informative. Therefore disagreement with the NAS recommendation is implicitly present in most participants' comments and this may explain why there were shades of distinction in their views. The participants talked about whether the alternatives were feasible, possible, or preferable. Table 5.2 describes the shades of distinctions that participants took when articulating their views and how these distinctions function as implicit positions toward NAS Recommendation #3.

Table 5.2 Distinctions Between Participants' Positions About Alternatives

Description of Position	Function	Example
Alternatives can work and would be preferable to cesium chloride	Demonstrates some level of agreement with NAS Recommendation #3	Should we pursue safer forms of cesium-137 or technologies assuming they exist and are economically viable to the end user and I think all of you would agree that we should because if we don't the potential impact of not doing so could be substantial as already mentioned.
Alternatives are not ready to fully replace cesium chloride technologies	Argues for extended time to follow NAS Recommendation #3	So I just wanted to caution people into thinking in terms of time to market of a viable work horse X-ray technology to supplant the use of cesium-137. We're talking several years down the road, and that's after the prototype comes to market.
Since different applications require different technologies, there are instances when alternatives might be preferable	Suggests that NAS Recommendation #3 should not apply to all technologies	So you look at each one differently and maybe you can come up with different solutions. Maybe for the blood banks for those that are not using a very high through-put, an x-ray machine is a good option. For United Blood Services or the Red Cross where they have a lot of through-put, maybe you consolidate your cesium chloride there and you increase the security and really beef it up at those facilities.

Table 5.2 continued

Description of Position	Description of Position	Description of Position
Could use an alternative technology but there large obstacles to this possibility such as expense and reliability	Demonstrates that implementing NAS Recommendation #3 is extremely problematic	It is easily demonstrable that cesium chloride sources utilized in blood irradiators have a much more reliable performance record than machine-produced technologies. And both the cost and continuity of operation or failure should be considered financially, and then the possible impact on human life.
Strong expressions of preference for using cesium in their applications	Demonstrates that following NAS Recommendation #3 could have negative impacts	Cesium-137 is the instrument of choice for much of the research. It is the standard. It is the standard because it has uniform irradiation effects. It has very unique cell interactions. This is one of the areas where I got very clear guidance from my faculty.
Alternatives are not suitable for a given application	Demonstrates that following NAS Recommendation #3 could have negative impacts	If we had to go to another form of radiation, we'd have to recharacterize that, and that would take many years of research.

Talk About Security

At the workshop, explicit talk about security is less frequent than talk about alternatives because the agenda questions did not ask participants to share their views about security risks. Never-the-less, participants did find opportunities to talk about security issues by reframing the agenda questions in a way that would allow them to more directly respond to the premise for Recommendation #3 of the NAS study. As it becomes apparent that several workshop participants did not believe the cesium chloride is a serious enough security threat to warrant elimination, a few participants felt the need to reinforce the report's claim. Most of the talk about security at the workshop used inductive reasoning from professional experience and appealed to personal credibility. Security specialists reasoned from professional knowledge about security-related issues, frequently using analogic reasoning to past events. Participants from user communities reasoned from their professional experience of implementing the increased controls and working with the equipment in its organization setting. One exception to the tendency to use

inductive reasoning about security topics is when participants talk about dispersability or solubility—in these cases they tend to reason deductively from the physical and chemical properties of cesium chloride to either explain the severity of the consequences or consider a technological solution of an alternative cesium-137 form. Table 5.3 describes the range of positions that participants took when expressing their views to reinforce the premise for NAS Recommendation #3 or challenge the level of security concern that is merited for cesium chloride.

Table 5.3 Distinctions Between Participants' Positions about Security

Description of Position	Function	Example
There is a real security threat associated with cesium chloride	Supports the premise of NAS Recommendation #3	The only radiological dispersion devices scenarios that I'm aware of, and I have been writing on this since about 2001, the only RDD scenarios that can kill in excess of 1,000 people at a crack exploit the physical properties of cesium chloride.
Description of consequences of RDD	Reinforces the premise of NAS Recommendation #3	If you do a study of the economic impact of a major dirty bomb using cesium chloride… we found that an attack in lower Manhattan on the 10th of September, 2001 could have caused just about as much property damage and economic loss, all told, as the terrorist attack the following day.
Increased controls and hardening minimizes security concerns	Challenges the basis for NAS Recommendation #3	We agree that the hardening program … slows somebody who might want to acquire the sources down, and allows our security programs to kind of kick in gear and mount a response. Those are things that we feel are very appropriate and do add another layer of security on top of that.
Elimination of CsCl is an extreme action	Expresses disagreement with NAS Recommendation #3	It's the elimination of the cesium chloride irradiation is an extreme action. And the comparison that I would make is if after 9/11 we had eliminated air travel.
Elimination of CsCl creates other security threats	Demonstrates that NAS Recommendation #3 has not taken full account of its unintended outcomes	Most medical facilities are certainly not set up to store a cesium chloride irradiator if it's taken out of the secure area that we've gone to great lengths to set up now to have security pathways approved for. The last thing I would think we would want to do is move it out to what we call the storage area.

Table 5.3 continued

Description of Position	Function	Example
Real concern is a lack of security in other countries	Supports the third aspect of NAS Recommendation #3	And it seems to me that any solution which is intended to address an improvement to security here in the U.S. needs to take account of what the availability of that material is for terrorist activities overseas.
Can/should address solubility and dispersability	Supports the basis for NAS Recommendation #3, OR Offer a technological solution to the NAS recommendation	I've talked a little bit with [source distributors] about the dispersability issue and whether if we were to start with pollucite form whether we could design it in such a way that it minimized certain dispersible effects. So one good thing about designing it from scratch is we could try to build some of those aspects into it.

Risk Logics

Even though the workshop agenda is designed to solicit information about alternatives to cesium chloride and potential impacts of government decisions, assumptions about how to determine a risk underlie the informative and persuasive statements. I call these categories of assumptions "risk logics." Each risk logic differs in the linguistic resources that it makes available to participants as they characterize the issue of concern (or try to demonstrate that it is less of a concern). Table 5.4 describes the four risk logics that participants employed to justify their views about whether or not to continue the use of cesium chloride given a security threat. In the case of the cesium chloride issue, the "focus on consequences" logic is legitimized by the security institution. The "probabilistic risk assessment" logic is used the least frequently, but when it is used, it is legitimized by the technology structure and reinforces the norm of rationality because of its engineering-based approach to calculating risk and balancing concerns of consequence with concerns of likelihood of an event occurring. The acceptable risk logic maintains that society can bear risks of certain technologies and is legitimized by the existence of regulatory agencies. The risk/benefit logic adds the reasoning that this acceptability must be in

proportion to the benefits the technologies provide and is further legitimized by the belief in beneficial uses of technology.

Table 5.4 Risk Logics

Name of Logic	Description of Logic	Example
Focus on Consequences	If a threat could result in a large societal consequence then it is considered a large risk and should be removed if possible.	If you do a study of the economic impact of a major dirty bomb using cesium chloride… we found that an attack in lower Manhattan on the 10th of September, 2001 could have caused just about as much property damage and economic loss, all told, as the terrorist attack the following day.
Probabilistic Risk Assessment	Rhetorically used to suggest that another view focuses too much on the consequences of a negative event. This should be balanced with estimation of the likelihood of the event's occurrence.	What can go wrong? How likely is it? What are the consequences?So those three elements in anything come together to really help you define the risk. It's not just about what are the consequences. It's about how likely is it and what can go wrong … But I think in the context of cesium chloride or irradiators or any other radioactive material or even reactors, which is a very common way we assess those, we use probabilistic risk assessment.
Acceptable Risk	Society cannot avoid risk and should set tolerable levels. The implication is that regulatory bodies will enforce the levels.	Nothing that we're going to do is going to give zero risk except complete elimination of radionuclides. I think that's recognized. So the question becomes what is an acceptable risk and that's something we should be thinking about as we go through and formulate our comments.
Risk/Benefit	A decision about a risk should be based on whether the benefits of technology outweigh the risks.	So before we spend millions and millions of dollars trying to recall all of these cesium chloride sources, we [should] really make sure that it's a smart decision in terms of our limited resources for homeland security and that we're doing the right thing here.

Summary

The results in this chapter partially answer the overall research question for this study about how experts from different disciplines communicate with each other about risk. In particular, the analysis with structuration theory reveals societal and discursive resources that participants draw upon when characterizing cesium chloride.

The first research question considers the societal resources that enable and constrain experts' talk about risk. Structures such as the U. S. medical institution, regulatory bodies, national and international legislation and policies, and belief in technology provide rules and resources that enable participants to perform more legitimate norms such as rationality in decision-making and procedures for sharing information and creating policies. Most interview participants recognized that they are constrained by a limited point of view but they balanced this constraint with their view of themselves as rational.

The emerging security institution enables participants to take action to protect the public from terrorist threats—the impetus for the concerns about cesium chloride. The structural constraints lead to norm violations such as decisions based on politics and emotion, distortion of information, sharing too much security-related information, and expressed desires to ban radioactive materials. However, this structure also constrains participants due to secrecy about security information.

The second research question considers the types of evidence and appeals that experts relied on to articulate their characterizations of cesium chloride. Since they were constrained by the agenda structure of the workshop, participants used their characterizations of cesium chloride (as a beneficial technology or as a security threat) as an implicit way to express agreement or disagreement with NAS study Recommendation #3. Therefore, participants used evidence, reasoning, and appeals to invoke their nuanced positions related to the elimination of cesium chloride through their talk about the feasibility of alternatives and security issues. When participants talked about alternatives they tended to reason deductively from operations or scientific principles with the exception of using inductive reasoning from a cautionary historical tale about the elimination of another radionuclide. Participants from user communities were the most frequent contributors to talk about alternatives and they tended to build their credibility by

appealing to their organizational affiliation or external expertise. When participants talked about security they tended to reason inductively from professional experience with appeals to their personal credibility. Security specialists reasoned from professional knowledge about security-related issues, frequently using analogic reasoning to past events. Participants from user communities reasoned from their professional experience of implementing the increased controls and working with the equipment in its organization setting. One exception to the tendency to use inductive reasoning about security topics is when participants reasoned deductively about dispersability and solubility to explain the severity of the consequences or consider a technological solution of an alternative cesium-137 form.

CHAPTER VI

RESULTS: INTERPRETATIVE REPERTOIRES

This chapter uses discursive psychology to address the second research question by analyzing participants' strategic use of the societal and discursive resources identified in Chapter V and the third and fourth research questions by describing processes of coordination and legitimation. The participants enacted the enabling and constraining structures through two primary interpretative repertoires that provided resources for them to characterize cesium chloride according their view: (1) necessity of technology interpretative repertoire and (2) security threat interpretative repertoire. These interpretative repertoires were identified using methods from Potter and Wetherall's (1987) discursive psychology. Each repertoire is characterized by its use of reasoning, evidence, appeals, risk logics, and the responsibility of the government. The elements of each repertoire are summarized in Table 6.1 Even though there was a tendency for security analysts to draw upon the security threat interpretative repertoire and user groups to draw upon the necessity of technology interpretative repertoire, these repertoires were linguistic resources available to all participants. Furthermore, participants could use the interpretative repertoires in an ironic manner and did so several times with the security threat repertoire.

Table 6.1 Elements of Interpretative Repertoires

	Necessity of Technology (NTIR)	Security Threat (STIR)
Function	Functions to demonstrate that the application of a technology (i.e., cesium chloride) provides necessary social and scientific benefits.	Functions to demonstrate that an object or issue poses a security threat
Forms of reasoning and types of information	Deductive – using scientific principles, operational information, and economic principles	Inductive - when using information professional knowledge, past events, and economic consequences Deductive - when using scientific principles about dispersability and solubility

Table 6.1 continued

	Necessity of Technology (NTIR)	Security Threat (STIR)
Strategies to build credibility	Draw upon external expertise or organizational affiliation	Draw upon personal expertise by referring to credentials and unique knowledge
Appeals to values	Used values of medical need, safe use of equipment, and quality control of product or service	Used values of public interest and fear appeals
Risk Logic	Risk/benefit Acceptable risk	Focus on consequences Used PRA logic as possibility to improve legitimacy of security assessment
Responsibility of government	Emphasized role of government to protect the public by regulating uses of technology	Emphasized the role of government to protect the public by minimizing security threats

Necessity of Technology Interpretative Repertoire

The necessity of technology interpretative repertoire (NTIR) functions to demonstrate that the application of a technology (i.e., cesium chloride) provides necessary social and scientific benefits. This repertoire uses deductive reasoning with either scientific principles that demonstrate the uniqueness of cesium for necessary applications or economic principles that demonstrate reasons to allow continued use of the technology (at least in the near-term). Participants using this repertoire tended to build credibility by appealing to organizational affiliation and external expertise—this was probably an attempt to make statements appear more objective. Participants using this repertoire tended to appeal to values such as the need for patient therapies and quality control issues. This repertoire provided resources for participants to use acceptable risk, risk/benefit, and PRA risk logics. The risk/benefit logic enabled the main function of this repertoire to demonstrate that the necessary benefits of technology outweigh the risk. The PRA logic supplemented the main function of this repertoire to redirect attention from security consequences by balancing them against the likelihood of an event that would initiate

the consequences. Finally, this repertoire highlights the responsibility of the government to set a regulatory framework of acceptable risk levels that ensure that technology is used safely.

In summary, the main function of the necessity of technology repertoire is to demonstrate the unique and useful characteristics of cesium application. The combination of the acceptable risk logic with the emphasis on the regulatory responsibility of government mutually reinforces each other and creates a source of legitimacy for arguments drawn from NTIR. Additionally, the risk/benefit logic draws on structural resources about beneficial technology with a special emphasis on the economic resources and constraints. Use of NTIR is rarely challenged by other participants. However, participants draw on this repertoire when they distinguish their nuanced views about the feasibility of alternatives and these distinctions become a source of disagreement that are discussed in Chapter VII.

NTIR in Relationship to Recommendation #3

At the workshop participants primarily drew on NTIR to position their views in relationship to Recommendation #3 of the NAS Study. In the first example of NTIR a participant used deductive reasoning from scientific principles to emphasize how the unique characteristics of cesium chloride enable agricultural researchers to achieve their necessary function of insect sterilization. This statement counters a belief that an alternative form of cesium-137 is feasible because the participant's work could not handle the estimated increase in irradiation time for a ceramic or glass form.

> We currently own and operate nine Huseman Category 1 irradiators that we use primarily for sterilizing insects. And in our line of work we simply can't tolerate too much of an increase in time, which you're sort of implying if you had … decreased your activity by about a half, because in our line of work the time is critical because we try to destroy the gonadotropic tissue in the insects. But if they are in those irradiators too long, we start getting secondary damage to the insect.

In the second example of NTIR a participant uses deductive reasoning from operational data that was gathered from the membership of a professional organization for blood banks. This

statement emphasizes (1) that there are a lot of cesium irradiator users that would be impacted by NAS Recommendation #3, and (2) that cesium irradiators are more reliable and cost effective than x-ray irradiators.

> The membership currently has 65 cesium irradiators out there that have an average purchased year of 1996. These irradiators have a shelf life, or a lifespan of 25 years. They have significant value remaining in the irradiators that are in our facilities. And we estimated that value to be over $3 million. When we look at decommissioning a comment that was made earlier has been the cost of decommissioning… This is the total phaseout cost…We are looking at over $21 million to decommission and switch out all the irradiators…The obstacles that he mentioned this morning remain the same, and these have been gone over repeatedly…The question is how do we overcome these obstacles? Unlike what I've heard in the research arena, the blood banks could convert over to X-ray technology to irradiate blood…So if y'all would like to help us, we will take those funds also. Then the biggest thing we could ask, since … our industry could switch over to X-ray, it has got to be done in an orderly - give us enough time to do it. And I would imagine that 10 years is probably required to accomplish this for our industry.

Ultimately, based on economic principles, this statement demonstrates the expense of replacing cesium irradiators and argues that the implementation of NAS Recommendation #3 should take place over a long period of time.

In the third example of NTIR, a workshop participant emphasizes the government's responsibility as a regulator and uses of the risk/benefit logic.

> The basic principle, one of the basic principles of radiation safety is that of justification and that is any use of radiation, radioactive materials should have a net benefit which is greater than the net risk of that use…We think that cesium chloride sources should be subject, through the normal licensing process both for new licenses and renewals, to evaluation of justification of that source, and that it be incumbent upon the licensee to demonstrate in the license application that the net benefit of the new or continuing use of a cesium source outweigh the risk in detriment. The risk equation has changed since 2001 and that is really what justified this and that needs to be looked at, of course, but we would suggest that license applications investigate alternate technologies and determine the licensee's or I should say document the licensee's determination that no suitable alternative exist on whatever basis, whether economic, availability to do the required job or whatever. And the NRC should develop guidelines for determining that sort of thing as part of the licensing process...But the discussion of the regulatory basis does trace to the basic principle of justification. And the big question now, is who should conduct the risk analysis. Well, we think everybody who has a dog in the fight should be involved in the risk analysis which is both radiation safety professionals, users, manufacturers and so on and also involving people with specific expertise in the new

> risk environment that would include Homeland Security, the FBI and the National Nuclear Security Administration.

Early in the statement, the participant invokes the risk/benefit logic. He then clearly addresses his position that the NRC should not follow NAS Recommendation #3 based on the responsibility of the government to set acceptable risk levels and license and regulate materials within these parameters—the acceptable risk logic. This statement hints at scientific and economic principles, but mainly primarily draws on risk logics and government responsibility to express his view that technology is necessary and should not be eliminated without a risk/benefit analysis and following licensing procedures. Additionally, the participant draws on the structural resources of radiation protection logic and reinforces the norm of bureaucratic processes.

NTIR In Relation to Societal Benefits

As interview participants positioned their work in relationship to society, they talked about how the functions of both their applications of cesium chloride technologies and applications for other industries are necessary for society.

> Patients who are immuno-compromised need the blood products that are irradiated. Then, when you get beyond -- it was fascinating at the workshop to find out all of the other uses for the Cesium -- the research arena -- that uses the medical research arena, then even the nuclear power plants that use them for calibration…But, the benefit is for the patients.

> My colleagues and I, professional society, and my people that I work with were all of the same view that this … would be damaging to the end user…If you took away our one gold standard that we do use, which we feel is being regulated and being held safe as is, you would really damage our capability of doing our work, and providing resources to the public that the public is really probably not even aware of.

Both examples illustrate how the participants draw upon resources of NTIR. In particular, both participants appeal to values of the benefits of their applications: medical benefits for patients and the protection of the public that calibration equipment makes available. Also, the participants build credibility external of themselves. The first participant references other professional groups to bolster her view and the second participant references his

professional society and colleagues. Additionally, the second participant also emphasizes the role of regulatory role of the government. These types of comments were typical of interview participants and demonstrate how they use NTIR when explaining their views in relation to society.

NTIR in Relation to Other Groups

Interview participants also drew upon NTIR when making accounts about how they were related to other professional groups. A couple of participants were very clear that they would make different arguments to their colleagues and NRC staff than they would to the public or Congress. If they were discussing this issue with colleagues or NRC staff they would say something similar to this quotation:

> I think it's safe. I think your controls that we have implemented make these types of amounts of radiation safe. And, go ahead and, if you feel it's necessary, increase those types of controls but don't take away our ability to do our work.

If they were discussing this issue with a member of Congress or the public they would say something similar to these quotations:

> Understand my work first. Understand the controls that you already have in place. And if you want to increase that, that's fine.

> Well, be assured that the facilities that have these sources are very highly secure and the risk is minimal of that event.

Responses to both categories of groups use resources from NTIR. These comments foreground the responsibility of government to regulate technologies for the purpose of enabling them to continue to receive the benefits. Additionally, the accounts invoke the acceptable risk logic by explicitly calling the risk "minimal" or implying that, if necessary, the regulatory bodies can increase security controls to get risk to the acceptable level.

Security Threat Interpretative Repertoire

The security threat interpretative repertoire (STIR) functions to demonstrate that an object or issue poses a security threat. This repertoire uses both inductive and deductive reasoning. Inductive reasoning is used to reason from hypothetical scenarios, historical events, or professional experiences. Deductive reasoning is used when talking about the scientific characteristics of dispersability and solubility of cesium chloride that make the potential for its consequences so great. Participants are more likely to build credibility based on personal expertise and make appeals to public interest of protecting security; however, this does not preclude them from building credibility through organizational affiliation, external expertise, or appealing to other values. This repertoire enables participants to use two risk logics. Participants draw attention to consequences as a fear appeal that functions to highlight the severity of the risk. Additionally, some participants appeal to the PRA risk logic as a tool that could help bolster their claims. Finally, this repertoire highlights the responsibility of government to protect the public from terrorist threats.

The following example illustrates how a security analyst uses STIR to respond to several comments at the workshop.

> I was very disappointed with the attitude that I heard on a couple of people's part…Nobody is actually talking necessarily about taking away your cesium gamma spectrum. We're talking about taking away cesium chloride, and let me point out that the only … radiological terrorist scenarios you can dream up that kill a lot of people use and exploit cesium chloride. I'm not at liberty to discuss what those are, but they're pretty bad. You've talked about security. Well, security is not just in the fingerprinting or even in the locks and keys. It's in an ongoing security check that prevents good employees from going bad. I could mention the name of Aldrich Ames and Hansen, just to name a couple of good employees who went real bad. So to say that you've implemented the security measures is not to say that those security measures can ever be considered adequate unless you have really intrusive, ongoing personnel monitoring. I think we are going to have to face the fact that cesium chloride in a water soluble form is going to have to come out of circulation.

He reasons inductively from professional knowledge (that he cannot share because it is considered sensitive) and also from historical examples of unreliable employees. This statement focuses on the consequences of a terrorist attack and clearly highlights the responsibility of government to prevent such an attack. At the beginning of the statement he briefly alludes to the dispersability of cesium chloride and he concludes his statement with an expression of agreement with NAS Recommendation #3.

Participants may use STIR when making an explicit point about security, but since most of the workshop focused on the feasibility and impacts of alternatives, this talk was discouraged. The following example occurs very early in the workshop when a participant is not allowed to complete his thought because the facilitator moves on to the next question.

> Participant: To address that question, I guess, is -- the concern is the solubility of the cesium-137 chloride. Just I'm also on the emergency preparedness side, and dispersability, and the ability to leach into concrete, and so forth. So if it gets released, for example, in the City of New York, let's say, while you're talking about economic impact, that could be billions of dollars. That could be underestimating it. So, I mean, it is a real potential, and that's why there is concern…So --
> Facilitator: Okay. Any further discussion before we move on to the next question? Okay.

The facilitator may not have realized that the oncologist wanted to continue, but it is also possible that the facilitator was trying to minimize comments based on STIR due to concerns about its sensitive nature or controversial nature.

Ironic Use of STIR

Some participants used STIR in an ironic manner with an extreme case to demonstrate that concern about the cesium chloride security risks is overstated.

> When you compare that with the proliferation of X-ray technology, for instance, you have to consider that there will be terrorism uses of X-ray technology as well. I mean, one can envision a portable generator being put into a truck or on a float and driven through crowds, maybe this happening 100 cities at a time. You know, how are you going to stop that?

In this example an equipment manufacturer used inductive reasoning from a hypothetical scenario to emphasize possible security-related consequences from one of the alternative technologies. Admittedly, his scenario is far-fetched, but that characteristic highlights his view that the characterization of cesium chloride as a security threat is hard to believe. This example is not a perfect use of STIR because it emphasizes the responsibility of government to regulate nuclear materials and challenges the efficacy of the government to prevent all imaginable terrorist scenarios.

In another session of the workshop, participants were upset by the expressed suggestion to eliminate cesium chloride as the best solution to remove the security threat, several participants used STIR in an ironic manner. For example, a calibration physicist draws attention to a potential unintended consequence of increased controls around cesium chloride.

> If we would increase the security in the facilities that have cesium chloride, then as you say there would be a terrorist which would like to get a hold of cesium. Now if he has increased security, would he prefer to get something else, cobalt for example? I understand that because the cost to clean up cobalt would be much less, but still do you have still the psychological or social impact?

A security analyst does not seem bothered by this ironic use of the STIR and counters by focusing on the greater vulnerability of cesium chloride by deductively reasoning from operations information—a noted deviation from the typical strategy of using inductive reasoning about consequences.

> Well, that's a concern that you want to have a risk balanced across the spectrum. But again from my perspective, I'm looking at where the long pole is in the tent right now. Where are the high risk factors right now? What do we need to do in the near term to try to reduce that? … If that [hardening program and increased controls] forces the terrorists to move to cobalt, well, we already have the increased controls with cobalt and, as I mentioned, cobalt, anything can be made dispersible, but it takes more skill. It takes a larger team, more equipment, more money and more time and the time is of the essence. That's the critical factor here. If you steal it and then you have to use it, that takes time. That's why cobalt is less risk.

After this exchange, several participants used STIR in an ironic manner to redirect attention on to other security risks than cesium chloride. For example, “In a comparison between cesium and … biological terrorism…what would be worse?” This repeated ironic use of the STIR is a strategy by which user groups were trying to overtly resist the characterization of cesium chloride as a security risk. This strategy differs from the usual strategy embedded in the NTIR to characterize cesium chloride as unique and useful. The facilitator, who sensed the building tension and distraction from the agenda question, redirected the conversation by saying, “remember we're here to talk about the feasibility of the isotopes other than cesium-137.”

Management of Tension Between NTIR and STIR

Potter and Wetherall (1987) encourage analysts to consider whether interpretative are “genuine features of interpretation” (p. 153) by examing situations in which multiple interpretive repertoires are applied to the same case. If the analysis has captured a set of genuine interpretive repertoires then “these cases should cause problems requiring discursive solutions” (p. 153). In the cesium chloride discourse, participants draw on both NTIR and STIR and consciously or unconsciously use rhetorical devices to resolve paradoxes that arise from applying multiple repertoires to the same case.

By the end of the workshop, some participants indicated that they had adjusted their views and recognized security threat as more legitimate than before. This did not cause them to fully support NAS Recommendation #3, but at least they understood why they were looking at this issue.

> I learned yesterday and had my eyes opened when we had the discussion from Sandia… That will also influence some of my comments a little bit later (W8:86).
> But, again, the discussions that we have had just over the last two days, quite frankly, I have changed two or three of my positions in terms of what I perceive as risks to be less laissez-faire and more restricted on access to and use of some of the source materials that might actually be used in a non-conventional manner is the best way to say it.

A year and a half later, during the interviews the participants began by recounting their understanding of the cesium chloride issue. Most participants recounted their understanding of the cesium chloride issue by discussing both the security concerns and the benefits of cesium chloride applications. The following examples illustrate typical patterns by which participants would answer the first question.

> …Essentially there was a plan to consider eliminating the use of cesium chloride in the US and the reason for this is because of risks involved for malicious use of cesium chloride, that it could be used in some sort of weapon developed by terrorists such as a dirty bomb or a similar thing. And, well, having all these facilities that use cesium chloride around increases that risk. So, that was the motivation for, I guess, the National Academy of Sciences as a result of this, NRC I think sponsored the National Academy of Sciences to investigate further into what are the different uses of cesium and see if there was a possibility of finding a replacement to minimize this risk or to fix that problem. I think, they did a thorough job, they wrote a nice report on that…What came later after that report was published, the NRC, I guess, took that into consideration together with other things and decided, well, they were going to, they have to, make a decision or recommendation to see if this should be banned or not; the use of cesium chloride. So, I think at that point in time the user community started to find out about this and of course everybody had different reactions. Some because they just don't want to change, others because, like in my case particularly, I know that there are no replacements for the type of applications I use for my work…I think NRC did a good job in saying – "Okay, let's just get everybody together and announce this and get some feedback from the community to find out more about it. What are the different applications? What will be the impact, if such a ruling will be in place - eliminating cesium chloride?"

> Cesium, as it is found in many blood bank irradiators and some other types of freestanding irradiators, is a radioactive source used to irradiate blood products to prevent all sorts of mayhem and havoc as a result of a certain small subset on our patient population. And that radioactive source is a highly dispersible salt and once it's spread is really hard to pick up since it's both water soluble and chemically reactive, as opposed to other sort of sources. And so, while it is extremely, extremely unlikely that someone could actually successfully break into a radioactive source and spread it around, we can turn this -- it is so hard and so impossible to contain, after the fact that there were well meaning individuals thinking that maybe we should not have this around, and that way, it can't be spread around.

In these accounts participants use resources from STIR to acknowledge the characterization of cesium chloride as a security threat. The first participant seems to lend more credence to the security threat, whereas the second participant's sarcastic tone indicated that he

was less convinced about the security threat. This variability of responses was typical among the participants; however, regardless of this variability, both participants balanced the security characterization by using resources of NTIR to discuss benefits of their technologies. They invoked NTIR to address the "elimination" element of Recommendation #3 from the NAS report. From a purely logical point of view, the use of both repertoires seems to create a paradox. However, this is a typical feature of discourse and analysts should look for how participants use rhetorical devices to manage the paradox (Potter & Wetherall, 1987). Interview participants used four categories of rhetorical devices that ultimately re-established the importance of NTIR: (1) colloquialisms, (2) risk logics, (3) timing and research, and (4) increased controls.

Colloquialisms

Some participants used colloquialisms when they were discursively managing the felt inconsistency between acknowledging security risks while also wanting to maintain continued use of cesium chloride technologies. For example, they used phrases like "on the other hand," and "I understand both sides of the story" to bridge the two characterizations of cesium chloride. The following quotation shows how one participant used the "baby and bathwater" expression to connect the two characterizations.

> Everybody agreed that these were very important implications and that we shouldn't throw the baby out with a bath water, that it was important to continue to be able to use devices and equipment that contains cesium chloride. But that, you know, that we all acknowledge the risks around it but you really had to balance the risks and the benefits and that a lot folks, you know, were supporting increased security and that's fine but not, you know, it's not throw, throw this all out.

The colloquialism device does not necessarily resolve the tension between security threats and technological benefits, but it discursively allows the participants to include both concerns in their accounts.

Risk Logics

Participants also used the risk/benefit logic to manage the paradox between the security concern and desire to retain use of cesium chloride technology. The following example illustrates how one participant explicitly labels risk as "comparative."

> Risk is a relative term, a comparative term. It's obviously -- cesium 137 in current form is, you know, dispersible. There is obviously security risks that are present in that particular isotope in that particular chemical form than many of the other materials that are used by hospitals. But that's not really, that's not really our focus area per se; it's the security aspects of it. We're more interested in, you know, comparing cesium chloride use on blood irradiators in research versus the alternatives and what are the, you know, benefits and cons of that and I think if I remember it correctly we commented that we weren't really comfortable with the research of those out there right now about the alternatives to cesium chloride particularly in blood irradiation.

This participant acknowledges the security risk but then foregrounds the benefit of continuing use of cesium irradiators and the lack of viable alternatives.

In the second example, an interview participant acknowledges the risk of consequences, but then explicitly invokes a cost/benefit logic to weigh the cost of mitigating against the security threat at the expense of institutions that provide important benefits and, by implication, may not be able to afford the technology to provide these benefits if cesium irradiators are eliminated.

> Yet one cannot gainsay the seriousness of an event should the source material be widely disseminated if you clearly put pulse on this problem. But in public planning, like in medicine, one increasingly needs to be aware of the cost and benefit of the intervention on -- that there might be a considerable benefit, one does not deny. But at what expense should we not be allocating our limited resources in a way that would do the most good for the most people. And so, to be spending a gazillion dollars on something that may never, in our lifetime, happen -- doesn't seem particularly wise at a time when we're creating new record deficits.

These examples illustrate a common approach to managing the tension between the security concern and desire to continue to get benefits from cesium chloride technologies. This strategy uses a risk/benefit logic to demonstrate that benefits of cesium chloride technologies outweigh security risks or the costs of decisions based on consequences of unlikely security

events. Additionally, the participants are careful to hedge these kinds of statements with phrases such as “that’s not really our area of focus” or “one cannot gainsay the seriousness of an event.”

Timing and Research

Similar to the “truth will out” device identified by Gilbert and Mulkay (1984; Potter & Wetherall, 1987), participants relied on a belief that given enough time and research, there could eventually be a solution that would enable them to continue their important functions. This could involve research to develop a less dispersible and soluble form of cesium-137, improved x-ray technology, or a new pathogen technology that would replace blood irradiation technology. The following quotations illustrate how participants invoked their beliefs in research given enough time.

> I think it all hinges on research and the other really need to somehow work together to get an alternate source of cesium, that is, in its ceramic or other form that’s not soluble. I think that everybody has to, kind of, focus from the research aspect, really come forward, you know, and push what you really need to do.
>
> …Five years from now, there’ll probably be some better x-ray alternatives. And 20 years from now, there’ll probably be no need for x-rays at all because we’ll probably be tickling our blood and don’t need to worry about this since virtually all of the pathogen reduction technology would make blood irradiation completely unnecessary.

Even though participants use this strategy of time and research to manage the tension between security concerns and technological benefits, ultimately they are drawing on resources from NTIR and re-establishing this as an important interpretative repertoire.

Increased Controls

The most common strategy for managing the tension between security concerns and need to continue using cesium chloride technologies was to reference the increased controls and hardening programs that make cesium irradiators less vulnerable to theft. Participants noted that “there has been a lot of progress already in terms of securing radioactive cesium chloride sources” and expressed a view that “the NRC has done an adequate job of upgrading security

requirements and this is demonstrated by performance." Additionally, some participants referenced increased controls with the risk/benefit logic to show how it balanced the security risk. The following example also invokes the acceptable risk logic when she included the disclaimer that "there's no perfect solution."

> Well, here you have two things, you have the benefits of cesium and then you have a risk. But, what you want to do is, there's no perfect solution to anything, but you can make it as perfect as possible. So, it's a matter of, can you decrease the risk and make that balance change? And I think, in this case, you can. In the federal government agencies that have cesium sources are very secure and the risk is minimum. So, basically, you just have to identify where these sources are and make sure that you have enough security in those places that you make the risk small as in other places and if you can't do that then those places probably should not be allowed to have cesium sources.

The most common response was that the participants were willing to do whatever it takes to retain use of the cesium chloride technologies. This strategy is similar to the "that's how it is" strategy identified by Gilbert and Mulkay (1984; Potter & Wetherall, 1987) by which participants simply accepted the state of affairs and would continue their work within that context. The following examples illustrate how participants expressed these ideas.

> Not just irradiation, but in nuclear medicine, we use hundreds of isotopes every day. We just can't stop using these isotopes. I'm totally in support of using precautionary measures. I don't mind, to whatever extent, if the NRC asks us to do anything else, I'm willing. That's what I told [the NRC], and that's what I'm telling you now.

> You have concerns about access and control of the sources, presuming that we're talking about large sources which is what they need to do these experiments…But given the option of no access to the source versus access to the source, the scientists are willing to go through that.

In these examples, the participants set up a contrast between being able to use their technologies and not being able to use their technologies. Given this simple choice, they chose to use the technologies and follow the regulatory guidance to ensure security.

The strategy of referencing increased controls allows participants to acknowledge the security concern, but point to specific guidance and policies (that they cannot describe in detail due to the secrecy of security information) that they follow in order to lessen the vulnerability of

cesium chloride sources to theft. This strategy draws upon the regulatory aspect of government responsibility, acceptable risk logic, and risk/benefit logic which are resources from NTIR. The participants' attempts to manage the paradox of using resources from both STIR and NTIR ultimately re-establish NTIR as a more important interpretative repertoire for communities who manufacture, use, and regulate cesium chloride technologies.

Summary

The results in this chapter partially answer the overall research question for this study about how experts from different disciplines communicate with each other about risk by providing insight into the second, third, and fourth research questions. In particular, the analysis with discursive psychology illustrates patterns by which participants drew on resources from two interpretative repertoires to characterize cesium chloride and express their views about whether or not to eliminate it.

The second research question considers what types of evidence and appeals experts rely on to articulate their characterizations of risk. The interpretative repertoires organize the answer to this question and demonstrate that participants have predictable patterns for drawing on NTIR or STIR depending on whether they want to characterize cesium chloride as a unique and useful isotope or a potential security threat. NTIR is a resource that enables participants to characterize cesium chloride as a beneficial technology by reasoning deductively from scientific principles, operational information, and economic principles. When using NTIR participants appeal to external expertise of and organizational affiliation and values of medical need, safe use of equipment, and quality control of a product or service. NTIR relies on risk/benefit and acceptable risk logic and foregrounds the role of government to protect the public by regulating uses of technology. STIR is a resource that enables participants to characterize cesium chloride as a security threat by using inductive reasoning from professional knowledge, past events, and

economic consequences and deductive reasoning from scientific principles about dispersability and solubility. When using STIR, participants appeal to personal expertise, public interest and fear. STIR focuses on consequences of a risk and foregrounds the role of government to protect the public by minimizing security threats.

The third research question considers how experts from multiple disciplines negotiate and coordinate their different perspectives. One possible reason that user communities may have difficulty accepting the legitimacy of STIR is that they do not have a set of professional experiences with security-related issues to evaluate the inductive reasoning provided by the security specialists. Therefore, even though security specialists at the workshop made special efforts to reinforce the characterization of cesium chloride as a security threat in order to support NAS Recommendation #3, participants continued to use resources from NTIR to express disagreement through their nuanced positions. Additionally, some participants who disagreed with the characterization of cesium chloride as a security threat used STIR in an ironic manner to undercut its legitimacy.

The fourth research question considers the strategies that experts use to legitimize their particular risk understandings and justify choices that result from the risk understandings. The analysis from discursive psychology explains how accounts about the characterization of cesium chloride become established as stable constructions of the world and how NTIR or STIR are constructed to appear as facts that can undermine the other interpretative repertoire. The ability of interview participants to draw on both interpretative repertoires when providing their summary views of the cesium chloride issues demonstrates that both repertoires are legitimized by structural rules and resources. NTIR is legitimized by structures such as the U. S. medical institution, regulatory bodies, national and international legislation and policies, and belief in technology. Enactment of these structures enables participants to perform more legitimate norms

such as rationality in decision-making and procedures for sharing information and creating policies. STIR is legitimized by the security institution. However, this structure also constrains participants due to secrecy about security information. Additionally, structural constraints about politics, emotion, and legal issues tend to be attributed to participants who use STIR in order to demonstrate how those users are constrained by a limited point-of-view. Ultimately, participants' rhetorical devices to manage the paradox of using resources from both interpretative repertoires re-establishes NTIR as a more legitimate interpretative repertoire for communities who manufacture, use, and regulate cesium chloride technologies. Since I do not have any interviews with security specialists, I cannot provide insight into how that professional community uses rhetorical devices to manage the paradox of drawing on both repertoires.

Phillips and Jørgensen (2002) explain that people use interpretive repertoires flexibly which means that they can be both "identifiable entities that represent distinct ways to give the world meaning and malleable forms that undergo transformation in rhetorical use" (p. 107). Thus, it is not surprising that a year and half after the workshop, the interview participants drew on both interpretative repertoires to characterize cesium chloride both as a necessary technology and security threat. They managed this paradox with four categories of rhetorical devices that ultimately re-established the importance of NTIR: (1) colloquialisms, (2) risk logics, (3) timing and research, and (4) increased controls. Chapter VII builds on this transformative aspect of discourse and describes instances of how participants drew upon societal resources and interpretative repertoires as they go through processes of conflict and coordination.

CHAPTER VII

RESULTS: CONFLICT AND COORDINATION OF DIFFERENT VIEWS

As established in the Chapters V and VI, workshop and interview participants draw upon societal resources and interpretative repertoires to characterize cesium chloride as a security threat or necessary technology, and to resist certain characterizations of cesium chloride. Chapter VII addresses the third and fourth research questions about coordination and legitimation by using Laclau and Mouffe's discourse theory to unpack the conditions that gave rise to the particular characterizations of cesium chloride and demonstrate how meaning shifts over time were caused by creative appropriation of the societal resources and interpretative repertoires. In order to accomplish this analysis, the chapter (1) describes key signifiers that organize the relationship in the discourses, (2) describes possibilities for change in the field of discursivity and floating signifiers, (3) analyzes conflict and coordination about security, alternatives, acceptability, and benefits, and (4) discusses how the resources enabled paradigm shift for some participations.

Key Terms, Floating Signifiers, and the Field of Discursivity

Laclau and Mouffe's discourse theory focuses on abstract mapping of broader patterns of meaning in a shared context. The purpose of this analysis is to identify how key signifiers in a discourse become imbued with meaning and how different understandings of reality stand in relation to each other (Phillips & Jørgensen, 2002). This analysis allows for a coherent explanation of patterns of conflict and coordination regarding the meaning of key signifiers and floating signifiers. In essence, this analysis demonstrates what terms and concepts most shape the meanings of the discourse and how floating signifiers challenge established meanings.

Key Signifiers

Key signifiers are important terms and concepts that have a privileged status in the discourse (Phillips & Jørgensen, 2002). Discourse about the cesium chloride issue is organized around six key signifiers that fall into the three general categories of nodal points, master signifiers, and myths.

Nodal points. Nodal points are terms around which the discourse is organized. The participants' accounts are organized around their responses to the security concerns of cesium chloride (especially its dispersability) and Recommendation #3 of the NAS report to eliminate cesium chloride sources from use in the U. S.

For most participants, the security concerns about cesium chloride are the starting point for how they describe the situation. In response to the first question asking her to describe her understanding of the situation, an interview participant said "essentially there was a plan to consider eliminating the use of cesium chloride in the US and the reason for this is because of risks involved for malicious use of cesium chloride, that it could be used in some sort of weapon developed by terrorists such as a dirty bomb or a similar thing." Another participant opened his account with, "The National Academy did their study and came up with several recommendations … to see if you could phase out cesium chloride and go with some other… radioactive material with less of a potential hazard with terrorist or go to something that's totally non-radioactive." These accounts are typical of participants' responses when asked to describe their understanding of the situation. The structure of these sentences reveals that participants viewed the security concerns as being externally imposed. However, since these interviews occurred almost two years since the publication of the NAS report, the participants' use of security concerns as a starting point indicates how it is well-established in the discourse and a

concept to which they must respond when discussing this issue. Thus, the security concern functions as a nodal point that organizes the discourse about cesium chloride.

Additionally, Recommendation #3 from the NAS report organized participants' discourse. As described in Chapter V, participants used distinction shading at the workshop to articulate their views about security and alternatives in relationship to Recommendation #3. These shades of distinction are not apparent in the interviews because participants were able to be more straightforward in expressing their views. However, nearly all of their views about the cesium chloride issue were in relationship to the NAS Recommendation #3 and the subsequent NRC decision. As one interview participant summarized, "So, basically, what came later after that report was published, the NRC, I guess, took that into consideration together with other things and … they have to, make a decision or recommendation to see if this should be banned or not; the use of cesium chloride." Thus, Recommendation #3 of the NAS study functions as a nodal point that organizes the discourse about continued use of cesium chloride.

Master signifiers. Master signifiers are terms and concepts that organize identity. Concepts that organized participants' identities in relationship to the cesium chloride issue were their professional background and their beliefs about themselves as having a rational point of view about the issue.

At the workshop, participants were required to identify themselves and their affiliated organizations before making comment. In addition to this record-keeping requirement, participants often went further to explain the mission or function of their organization and the importance of cesium chloride technology. An typical example of this is, "I'm a radiation physicist with Best Theratronics and formerly NDS Nordion [and] as such we are the largest manufacturer of blood irradiators, both x-ray and cesium based, in the world." During the interviews participants used their professional backgrounds and organizational affiliations to

organize their identity in relationship to the cesium chloride issue. Thus, participants' professional background or discipline, often articulated through the mission of an organization, functioned as a master signifier to relate them to the functional uses of cesium chloride.

Participants also organized their identities around an idealization about rationality. They constructed their identities in relationship to other parties and the cesium chloride issue in terms of how they could bring better quality of information, more realistic experiences, a more holistic view of the situation, and an emotion-free disposition. For example one participant described how her experience provided a more detailed understanding of the situation: "I had actually seemed seen a lot more of these sources than some of the other people there and knew how they were used and how the radiation safety came into play and some of the security measures." Thus, rationality functioned as a master signifier that enabled participants' to consider themselves more reasonable and therefore, their views about cesium chloride to be more rational.

Myths. Myths are terms that organize a social space. In the participants' accounts, the beneficial functions of cesium chloride technologies and regulatory logic create conditions by which participants view themselves and their preferred actions in relationship to each other.

The participants' varied in their relationship to the functions of cesium irradiators and calibration equipment—some were state and federal regulators, some were manufacturers, some were representatives of professional organizations, and some used the equipment in their professional work. Regardless of their relationship to the equipment, all participants readily recognized the benefits of the technology—that cesium irradiators are responsible for saving lives. A representative of a professional organization observed that "if you don't irradiate blood properly, that is a huge patient safety risk and patient safety is really what set the forefront of folks' minds in the medical community." Additionally, another interview participant noted that "they talk about the lives of young babies or premature babies that would have died if they

couldn't have gotten the irradiator blood…What's a more noble cause than that?" With this in mind a workshop participant expressed her view that "the standard of care that exists in this country will be compromised if the use of cesium chloride is prohibited or eliminated." Participants' emphasis on the functions of cesium chloride technology was embedded in statements about (1) the importance of not eliminating this beneficial technology, and (2) the importance of ensuring that any changes should be cost-effective and supported by and supportive of the market. Thus, the function of cesium chloride technology as a myth relates the radioactive source to the public as a technology with beneficial value.

This myth of beneficial function is not possible without the myth of regulatory logic that puts the user communities in a safe relationship with the public through government agencies. Regulatory bodies fulfill the responsibility of government to ensure safe uses of radioactive material. An important element of this myth is the logic of radiation protection, by which a series of controls and barriers are established to ensure that users and the public do not get a harmful dose of radiation from the beneficial use of sources. This logic is so assumed that it barely surfaces in participants' comments; however, in the places that it does surface, it is in contrast to the thinking of terrorists who would risk a lethal dose in order to commit an act of violence. Thus, the function of the regulatory logic partly explains why user communities have a hard time fully accepting the characterization of cesium chloride as a security risk, but once they do, they simply apply the regulatory logic to increased controls in order to maintain a safe relationship between the public and cesium chloride technology via regulatory bodies.

Floating Signifiers and the Field of Discursivity

An important element of the Laclau and Mouffe's discourse theory is that there is a field of discursivity—concepts and meanings that have the potential to become important in a discursive situation, but the conditions are not right for them. The notion of "articulation"

foregrounds the relationships among "elements," which are polysemic signs whose meanings are not yet fixed within the discourse (Phillips & Jørgensen, 2002). Floating signifiers are signs to which different discourses struggle to assign meaning. In this section I describe the field of discursivity related to the cesium chloride issue based on participants' passing references but do not appear prominently throughout the accounts. Additionally, a separate section describes floating signifiers. These are concepts that have moved from the field of the discursivity and are active in the discourse about the cesium chloride issue, but, as of yet, have not become key signifiers. However, these floating signifiers challenge the meanings and functions of key signifiers as I will illustrate in the later sections of this chapter.

Field of discursivity. The field of discursivity contains possible meanings for which discursive conditions have constrained them from becoming key or floating signifiers in the cesium chloride issue. They might be remnants of important ideas related to radiation source safety and security or possibilities for the future that are not well developed or legitimate. One concept that is referred to frequently is the idea of "banning" cesium chloride or other radioactive sources. As one participant said, "I'm sure as the sun rises that some people consider that." The way participants talked about "banning" sources, they recognized it as a possibility, a hope that some people in this society may have. However, the interview participants pointed out that this possibility was constrained by current legislation that allows safe, civil uses of sources and historical precedent to not ban such materials. Therefore, the idea of "banning" sources remains in the field of discursivity even though it was mentioned frequently.

Some ideas that have historically been important for radiation source safety and security are concerns about security in other nations and non-proliferation programs. The international issues surfaced more frequently in the workshop—there was an entire session devoted to this topic. In general, participants agreed that developing nations had lower security and felt that

there was greater vulnerability for terrorists to get access to sources from these countries (in the fiction book about cesium poisoning in the water of Australia, the terrorists stole the cesium chloride from an irradiator in a developing country). This becomes especially tricky for cesium irradiators since their affordability, reliability, and low-energy consumption makes them a good medical device for developing countries. Additionally, several participants pointed out that if the U. S. eliminates cesium chloride, other nations will be pressured to follow suit, but they cannot afford alternatives like x-ray technologies for blood irradiation.

Related to international issues are non-proliferation issues, a historical effort among the U. S. and other nations to secure radioactive materials to prevent development or acquisition of nuclear weapons. This is a program rooted in the Cold War history but maintained a sense of urgency in light of credible intelligence that Al Qaeda and other terrorist groups have serious interest in getting a nuclear weapon. Cesium chloride is not a source that could be used for a nuclear weapon, but its potential for use in a radiological dispersal device provides a link for one participant to connect the cesium chloride issue with non-proliferation issues.

Finally, some ideas about alternatives to cesium chloride remain in the field of discursivity. Even though there was much talk at the workshop about the possibilities of developing an alternative form of cesium 137 (glass or ceramic), this topic rarely surfaced in the interviews and then only to point out that they would be in support of using the alternative form but they "don't see anybody creating an economic incentive proposal for the [Russian] plant to make glass forms … maybe they are, I just haven't heard about them." In addition to the possibility of an alternative form, one interview participant mentioned his expectation that pathogen technologies for removing lymphocytes in blood could replace irradiation in about twenty years. Thus, these alternatives are attractive because they would enable irradiation user communities (not calibration communities) to continue their functions. Furthermore, these

alternative have scientific basis for belief in their possible development, they just have not had enough time to fully develop into marketable products.

Floating signifiers related to security. Even though the security concerns are a nodal point in the discourse throughout the history of the cesium chloride issue, concepts about dispersability and vulnerability caused transitions in the meaning that participants attribute to security concerns. Before the workshop, several participants were not aware of the chemical properties of cesium chloride that would make its use in a terrorist act have more severe consequences than other radionuclides. This information was made available in the NAS study and at the workshop and impacted the conditions for the characterization of cesium chloride as a security threat based on its consequences. Additionally, vulnerability is a floating signifier by which participants attribute different levels of belief about whether cesium chloride can or will really be stolen. Participants' beliefs about the credibility of the characterization of cesium chloride as a security threat largely depend on the vulnerability floating signifier.

Floating signifiers related to functions of cesium chloride technologies. Throughout the workshop and partially in the interviews, participants expressed a lot of disagreement about the feasibility and possibility of using alternatives in order to achieve the beneficial functions currently provided by cesium chloride technologies. The issue about alternatives remains an important organizing element of the discourse, but the meanings and decisions about alternatives are in flux because of the continued debate about their feasibility.

Floating signifiers related to professional identity. As a violation of the norm of rationality, emotional expression is a floating signifier that challenges participants' identities. Additionally, the societal emphasis on security is a floating signifier that potentially reorganizes users' beliefs about the mission of their professional work.

The floating signifiers about security concerns, beneficial functions, and professional identity create the conditions of change for the characterizations of cesium chloride and the decision implications that result from particular characterizations. The next step of analysis with Laclau and Mouffe's discourse theory is to investigate how participants combine key signifiers with other terms with "chains of equivalence" in ways that imbue the key signifier with meaning (Phillips & Jørgensen, 2002). The following sections analyze interactions in which these floating signifiers organize participants' discourse of conflict or coordination. As participants interact with each other instances of conflict and coordination, they draw on societal resources and the interpretative repertoires in ways that reproduce certain structures and challenge other structures. These moments of reinforcement or change are explained by key signifiers that organize the discourse and floating signifiers that create conditions for change. The following sections analyze instances of conflict and coordination about (1) security concerns, (2) the feasibility of alternatives, (3) risks and benefits, and (4) possibilities leading to a paradigm shift.

Conflict and Coordination About the Nature of Security Concerns

Participants held a variety of positions regarding the nature of the security threat associated with cesium chloride (see Table 5.3). The following examples analyze instances in which participants dealt with conflict about the characterization of cesium chloride as a security threat. These examples illustrate (1) how the floating signifier of dispersability and solubility is a point of coordination between NTIR and STIR but also disrupts the current regulatory framework, (2) how participants use scientific principles to draw distinctions between the powder form of cesium chloride and the solid form of cesium-137, and (3) how participants challenge assumptions about the vulnerability of cesium chloride to theft by terrorists.

The Question of Dispersability and Solubility

The concepts of dispersability and solubility are floating signifiers that create conditions to change the characterization of cesium chloride as a security threat and the current classification system. Users of radioactive materials are familiar with the IAEA categorization that sorts materials into three categories based on the amount of danger an exposure could cause a person if the source is removed from its system of controls (International Atomic Energy Commission, 2005). However, this classification system does not currently take into account properties of dispersability and solubility—two characteristics that make cesium chloride more of a security threat than other radionuclides. Participants draw on both interpretative repertoires to try to establish them as key terms in the discourse. The principles of dispersability and solubility fit into STIR because they provide a scientific explanation for the severity of the consequences of the use of cesium chloride in a terrorist act. They fit into NTIR because these scientific principles can possibly be solved by technology and thus allow users to continue using the cesium-137.

A senior NRC manager mentioned the concepts of dispersability and solubility in the opening remarks of the workshop. He voiced these thoughts as belonging to third parties, alluding to previous conversations in which participants have been trying to establish what dispersability means in terms of existing safety and security codes and that this has not been resolved yet.

> There are those who believe that cesium chloride, because of its dispersability and solubility, deserve additional treatment, additional treatment from a security perspective, not necessarily because a certain curie amount could result in some kind of fatalities from radiation industry but from costs of cleanup, or contamination spreading. And socio-economic issues associated with any terrorist using cesium chloride. The chemical form of the material being very soluble and dispersible, in those people's minds, puts it on a different frame of reference than the traditional frame of reference in the [IAEA] Code of Conduct.

The concepts of solubility and dispersability were discussed frequently in the first panel session of the workshop that discussed alternate forms of cesium-137. Many of these comments focused on the science and the feasibility of developing a form that could minimize these concerns.

In the afternoon session of the first day a security analyst gave a memorable presentation using visual aids of capsules that would normally contain the radioactive sources.

> My role has been on the National Academies to really help inform the committee on the differences in the risk, the radiological terrorism risk, between the different radionuclides. So I brought this [holds up two capsules]…This is cesium chloride and if we filled up to about this level, that's about 1,000 curies of cesium chloride…This is about 1,000 curies of cobalt … I thought this was kind of to frame the debate between two… Now we have two very interesting accidents that have occurred with both of these types of material. The one was mentioned before was in Goiania in `87 and it involved about 1400 curies of the cesium chloride. We know from that accident that because of the solubility of the cesium when it got onto the ground it went into solution, it mixed with dust particles, the dust went onto the tops of those nice Spanish tiles and, as was mentioned before, you can't just rub it off. It actually chemically bonds with these building surfaces. So a huge expense in clean-up. A large difference between that and cobalt. Seventy grams of the cesium chloride in that teletherapy unit in Goiania produced roughly 70 tons of rad[ioactive] waste that had to be disposed. About a year later, a cobalt teletherapy machine in Juarez, again similar problem. It was abandoned and people stole the material and sold it to a junkyard for scrap metal. Now the cobalt in the teletherapy machines, it's not this slug. It's actually little BBs about a millimeter in size. Some of those also got dispersed in the city. In that case, it was a matter of the responders going around with the radiation detector, finding the pellets, picking it up, putting it in a pig and the problem was solved, a huge difference in the consequence. Not even looking at the radiological terrorism and all the different mechanisms of dispersal, we know from those two datapoints there's a very significant difference in the consequence. So that's what has driven my concern about the cesium chloride. By switching to cobalt, we don't completely solve the problem as was mentioned by others. Anything can be dispersed if you work hard enough at it. The difference with the cobalt of course is there's much more work that has to be done. I hope that that frames the debate a little bit.

This presentation demonstrated that cesium chloride is a greater risk than cobalt-60. It draws on STIR by using the risk logic that focuses on the consequences, reasons inductively from historical examples, and implies that the government has the responsibility to protect the public by removing cesium chloride technologies. Additionally, this presentation was persuasive to

several members of user communities because it also used scientific principles to explain why the consequences of a cesium chloride terrorist accident would be great.

By the time that participants were interviewed, about a year and half following the workshop, dispersability was a common explanation for the security of cesium chloride and only one interview participant expressed a view that it was not the most important dimension of the security concern. Most participants' accounts of the cesium chloride issue began with the dispersability explanation for why it was considered a security threat, and one participant even vividly recalled that the security specialist's presentation helped her understand the volume of the source inside the irradiator: "He got up there with a couple of little vials; he put up on the top of the podium…you know, that's a pretty good visual there, buddy."

For participants from the user communities, the scientific principles underlying dispersability and solubility enabled them to discuss a possible technological solution to this dimension of the security threat. With a direct reference to the presentation, a participant asked a follow-up question about benefits a new form of cesium-137 to address these scientific-based security concerns. This question draws upon NTIR by trying to deductively reason from scientific principles using a risk/benefit logic

> I would like to go back for the moment to the comment that I think [the security specialist] made regarding different forms of cesium that the pollucite or ceramic would only address part of the problem meaning the solubility, not necessarily the dispersability. Could you give us an idea or your opinion? If addressing both aspects would it fix 100 percent of our problems. Addressing the solubility problem only, how much of an improvement would that be if we only address that part with alternate forms of cesium? (3:96) … I guess the reason for that question was primarily to kind of assess the viability of the alternate form of cesium. Because if it doesn't really help us that much, then it's really maybe not worth doing. But my expectation was that addressing the solubility problems significantly and dispersability to some extent would get us quite a significant part of the way there.

In another example, a source manufacturer reframes the agenda question in terms of the security analyst's presentation. The essence of his question is giving participants an opportunity

to articulate their preference for the unique characteristics of cesium-137.

> I guess the question we ought to ask ourselves is how do you stack up the comparison between cobalt-60 as one option and a less dispersable form of cesium-137 as another option.

One participant quickly responds, “If nobody is going to answer that, I'll say the latter.” This provokes the audience to laughter because the reframed question was a leading question and the quick response provided an answer that a large part of the audience would agree with. The security analyst then responds:

> That's a very good point and I've talked a little bit with [source distributors] about the dispersability issue and whether if we were to start with pollucite form whether we could design it in such a way that it minimized certain dispersible effects. So one good thing about designing it from scratch is we could try to build some of those aspects into it…And by going to pollucite, you really do solve mainly the solubility issue and a pollucite behaves in terms of an explosive dispersal similar to ceramics and that really doesn't completely solve our dispersal problem. As we're looking through these different alternatives, again as I mentioned in the introduction, if we go to a radionuclide alternative to cesium we are reducing the risk because we're actually making it more difficult to disperse, but we're not eliminating the risk. The only way to eliminate the risk is to go to an non-radionuclide alternative like the x-ray machine. And being from my perspective, not being a user, but being a student of radiological terrorism, that would be my preferred option.

This statement initially draws upon NTIR by appealing to external sources, the belief in a technological solution, and deductive reasoning from scientific principles. However, at the end of his statement, he abruptly switches to STIR to express his professionally-based preference for non-radionuclide alternatives that will eliminate the risk.

A medical physicist attempted to summarize the comments about using technology to create a less-dispersible form of cesium-137 using NTIR.

> So it sounds like it is very, very much possible to come up with a solid, non-dispersible form of cesium, and it's -- probably with sufficient activity, in larger amounts, that would fulfill the tasks necessary… But the scientific issues, the technical challenges, sound like they're soluble. I mean, they're -- they can be resolved. (Laughter.)

His comments appeal to the others' expertise and reason from scientific principles. He acknowledges that it is not yet ready, but his main point (made with an ironic slip of the tongue) emphasizes the belief in a technical solution to the problem.

Despite a growing belief about a technical solution to the dispersability issue, source manufacturers used NTIR to also address the fact that currently, there is not any regulatory guidance or policy about standards of dispersability that they will need to consider when designing, testing, and manufacturing sources.

> When it comes to discussion about dispersability, which of course is another concern, then I don't know that there is any very clear guidelines right now. And I think part of the process of developing the technology will be to develop an understanding of what is acceptable in terms of dispersability.
>
> Unfortunately, we have not the standards for dispersability properties of these materials. We have standards for leachability, we have standards for the mechanical properties study, for fire testing, but we have not -- IAEA regulation hasn't standards for dispersability.

These statements allude to scientific principles and the belief in technology to solve a problem. Additionally, these examples have special emphasis on the lack of government standards that would guide development of the new forms. With these kinds of statements, it becomes clear that they are trying solve the security issue with technology. However, dispersability, the physical property of concern, is not yet a nodal point in regulatory discourse about cesium chloride. The regulatory logic comes from societal structures and is a myth that organizes the relationship between user communities and the public. The floating signifier of dispersability potentially disrupts the established regulatory framework and this challenges regulatory bodies to revisit their policies and guidance in light of a newly relevant concept.

Drawing Distinctions Between Cesium-137 and Cesium Chloride

During the workshop, some participants drew distinctions between cesium-137 as a radioisotope (which theoretically could be manufactured in different forms like glass and

ceramic) and the current form of cesium chloride which is a powder form. They recognize that the dispersability and solubility properties of cesium chloride make its consequences more severe than other radionuclides, but they also emphasize the functional importance and unique characteristics of the cesium-137 isotope. The strategy of drawing a distinction between cesium chloride (the powder form) and cesium-137 (potentially available in other forms) attempts to characterize cesium-137 as useful and unique and characterize the cesium chloride form as the potential security threat.

A series of interactions at the workshop shows how the distinction became an established premise. An oncologist is the first person to state the distinction in the early afternoon of the first day. He first draws the distinction in his opening comments as a panelist.

> I'll just pose a question first and it's obvious. But should we pursue safer forms of cesium-137 or technologies assuming they exist and are economically viable to the end user and I think all of you would agree that we should because if we don't the potential impact of not doing so could be substantial as already mentioned.

This first attempt at establishing this distinction as a premise, draws more on STIR with his focus on consequences. Additionally, his terminology “it’s obvious” and “I think all of you would agree” are trying to create a sense of agreement. However, this participant makes three more statements using this distinction before another participant picks up on it. His second attempt is brief and nearly verbatim of his first statement. His third attempt contains more specific information, but still relies on the risk logic of focusing on consequences. His fourth attempt uses a different set of discursive resources from NTIR.

> The mechanisms of X-rays, low energy X-rays and higher energy, for example, photons or X-rays. I just jotted down some stuff as we were talking, but the mechanism of knocking out electrons is different between low and high photon energies … But, again, I think cesium, getting back to it, cesium does have a good depth dose profile for small animals and I don't personally think we should advocate eliminating it. Just the form of cesium 137 should be changed.

The NTIR resources include deductive reasoning from scientific principles, attention on the application of the technology, and appeal to external expertise. Using this information and the risk/benefit logic, he clearly demonstrates the benefits of cesium-137 for certain applications. Finally, he reiterates the premise that they should draw a distinction between cesium-137 and cesium chloride.

After a series of comments about feasibility of x-rays irradiators as an alternative, a security analyst is the first to echo the premise about distinctions between cesium-137 and cesium chloride to express his disagreement with a previous presentation. His statement uses the distinction with STIR.

> I was very disappointed with the attitude that I heard on a couple of people's part… Nobody is actually talking necessarily about taking away your cesium gamma spectrum. We're talking about taking away cesium chloride, and let me point out that the only nuclear or -- pardon me -- radiological terrorist scenarios you can dream up that kill a lot of people use and exploit cesium chloride.

The oncologist immediately expressed agreement with the security analyst and used this as an opportunity to restate the distinction. In the next turn, a medical physicist uses the distinction premise in his own statements. He used NTIR and concluded his comment by trying to create a sense of consensus.

> If it's a question of 662 keV photons, I don't see X-ray or anything else replacing it… And I also think the issue is going to translate less into what's the alternative for cesium as to what's the alternative for the chemical, you know, physical form of how the cesium is. I mean, that's my sense of where we're going.

As illustrated, the distinction between cesium-137 and cesium chloride is established by using both interpretative repertoires. The coordination among these participants to establish the distinction premise provides a useful trope for participants to advocate a solution to a security threat while also acknowledging the unique and useful characteristics of cesium-137. By the second day, participants frequently use this distinction as an important resource in pursuing a

response to NAS Recommendation #3 as illustrated in this quotation from a university radiation safety officer.

> So I think that one thing that we should do today is to make sure that the manufacturers and the vendors come away from this meeting with a realization that the problem is cesium chloride, the problem is not cesium, and that we really need to go to a different technology but still retain cesium as the primary source of calibration, because of all of the historical background between that source.

Beliefs about Vulnerability of Theft

Once participants accepted the concept of dispersability, they understood the logic about the severity of consequences; however, several participants initially did not believe that these devices were vulnerable to theft and some still maintain this lack of belief. Interview participants remembered having the following objections when they first heard about the security concerns of possibility of theft of cesium chloride for the purposes of terrorist act: (1) the irradiators are too heavy, (2) a person would get a high dose of radiation in the act of theft, (3) it would be extremely difficult for someone to get to the irradiation area of the organization, (4) an irradiator would not be abandoned in the U. S., and (5) they do not believe that someone would really use cesium chloride in a terrorist act. Each of these reasons draws on years of professional experience working with radioactive materials and a deeply ingrained belief in the logic of radiation protection.

Weight of the irradiators. The first objection that interview participants would mention was the weight of the irradiator—they could not envision the theft because they did not know how someone could steal such a heavy machine. One participant summarized the thinking of "most of the people at the blood clinics… when you say, 'Well, a terrorist can get it,' and they say, 'They couldn't move it, it's so heavy.'" Another participant's description was more vivid.

> Most of the people in my industry, me included,… are thinking…this thing weighs a couple of tons and … a guy is not just going to break in to a blood center … hump it on his back and take off with it. And so… the mystery piece in all of this … is they say, well, they can get in there and get into the source very quickly and trust us.

This quotation not only captures the belief about the heavy machine, it also demonstrates that secrecy about security-related information was a constraint that prevented this user community from fully understanding the nature of the threat and therefore not believes that the threat was legitimate.

Another participants' description is even more vivid and demonstrates how envisioning a theft of cesium chloride is completely counter to their professional experiences servicing irradiators.

> So, the idea of stealing one of these machines - the smallest of our machines, like a blood irradiator weighs … about 3000 pounds. It's not like trying to steal an iPod or even a television. A guy can't come in on his own and jack one of these things. You think it's inconceivable. And then if they want to try and get the source, well, it would take them hours. And now that statement is based on our experience because we do occasionally have to recover these things from the field and dispose of them. And when we dispose of them, what we usually do is dismantle the device. Some of the workers I know try outside the radiation hot cell but they actually have to go into the hot cell for reasons of radiation safety. The workers then with remote manipulators-say the plug comes out from the device. The source comes out, it goes into the storage. It's quite an elaborate process and if you were to not to take any breaks from work for the whole process non-stop, it will easily take us a day. I mean like a working day, eight hours, from start to finish. And so, that's not much of a liquor store robbery kind of thing, if we're trying to envision it. But mostly the reason the process takes so long is because we have rules and procedures with respect to lifting heavy equipment and grinding and cutting into steel and lead, paints and fumes and respirators, inherent protection and then obviously, the big one is the radiation protection.

In this account, this participant draws on his professional experience working with the equipment, following regulatory guidance, and adhering to principles of radiation protection. He also makes vivid comparisons to common knowledge thefts such as a television, iPod, and liquor store. Each of these thefts must occur quickly so that the perpetrator will not get caught. However, based on the weight of the machine and experience with radiation protection, this user community cannot envision a quick theft of cesium chloride.

Increased controls and hardening. In addition to not being able to envision a quick theft of cesium chloride, participants felt that the increased controls and in-device delays made this

source less vulnerable to theft. As one participant stated “they weren't going to run away with it anyway, but [then we put] it into a cage so they couldn’t access it.” At the workshop, one participant specifically made the argument that the NAS study did not account for the increased controls which now make cesium chloride less of a threat.

> Since the National Research Council's report raising the concerns about these units, several things have changed that are not a part of that report. One is the security of the users has been enhanced through the requirement of background checks and fingerprinting, and this is in response to orders issued by NRC, increased controls and security in orders or amendments by the agreement states. The security of the facilities has been enhanced following the directives of the Nuclear Regulatory Commission. That means we've gone in and required the facility to make additional security capabilities to prevent access to these devices, and it has also been enhanced and should be enhanced through a hardening situation where we can actually go in and prevent the source from being removed from the irradiator. Following these three security enhancements, the units present little hazard for unauthorized source removal or disruption. The lack of such security was a major factor for the production of the original national academy of science report.

She uses NTIR to deductively reason from operations principles, with an acceptable risk logic and an emphasis the regulatory role of government. These elements of NTIR enable her to draw the conclusion that cesium chloride is now less vulnerable to theft and is therefore less of a security concern. Since these increased controls were not accounted for in the NAS study, then Recommendation #3 has less validity. During an interview, another participant extends this logic by arguing that “an external terrorist would have to have amazing knowledge of the technology [and] the individual center…the only conceivable event would be the disgruntled employee within the center.” By this reasoning, this participant believes that the only vulnerability threat is an internal threat, but he then enumerates the same list of background checks and access authorization processes that they have initiated to prevent internal threat.

The U.S. has better accountability for sources. Additionally, a couple of interview participants also felt that cesium chloride was not vulnerable to abandonment, like the incidents in Brazil or Mexico, because the U. S. has better regulatory controls about decommissioning

technologies with radioactive sources. When asked to address his views on the historical accident in Brazil, one interview participant responded with this differentiating argument:

> That was a case of -- there was nothing malicious, but the fact that the Brazilian government did not have the appropriate controls, or the regulation of their equipment and the machines. It was not handled properly by the owner, you know, at the end of this decommissioning of this facility... And, that's where it fell down. And then you get end users or you get the public, probably very uneducated public. I know that I can't speak to the educational background of the individuals that were harmed, but I'm certain they were uneducated in radiation and radiation protection. And obviously, they harmed themselves…So, I'm not sure if the breakdown's at the public level as opposed to a breakdown at the government level and not having the appropriate controls in place, which, we here, certainly do.

Terrorists would do something else. Finally, the most fundamental objection to the vulnerability of theft is that some users do not believe that terrorists would use cesium chloride in a violent act. The interview participants generally attributed this belief to their colleagues. As one interview participant explains, "everybody I work with is in a state of denial… they do not believe - they cannot accept the possibility that one of these things would be used for malevolent proposition." Another "very common" objection to vulnerability is "they would never do that" or "they would do something else." Another interview participant became quite detailed in developing this argument, and this was his personal belief, not attributed to other parties.

> But I've always argued that if I want to do terrorism, I wouldn't do something hi-tech… even the stupid explosive, this Detroit guy, the shoe bomber -- now, they tried twice they haven't been able to ignite it…it's so easy to do some other things… I would basically get smaller chunks of the solid stuff, put it under seats, stealthily deploy, like you did the anthrax in a number of locations; some of them lethal quantity, some of it not so lethal quantities.

A quotation like this may seem disconcerting on the surface, but this participant is not plotting a terrorist attack. Rather, he is using STIR in an ironic manner to discount the vulnerability of cesium chloride to theft by a terrorist.

The fact that some members of the user community do not fully accept the vulnerability of cesium chloride as a security threat leads to disagreement among members about how far to

implement increased controls. Clearly, user communities will follow the actions prescribed by regulatory bodies, but the question then becomes whether or not to take additional measures to ensure security of devices with cesium chloride. One participant recounted a memorable argument that he had with a colleague about whether or not to implement security measures beyond those prescribed by DHS and NRC (I have chosen to not include the details of this argument in order to obscure the identity of this participant). When he described why the positions in this argument were so important he described the contrasting values of profit and protecting the public.

> Because of our respective interests, right? … He's interested in the bottom line. And he's looking at me going, hey, … look, we got all these guys working … We have to remain profitable or we all lose our jobs… He's interested in the dollars. And I'm interested in doing what I would consider the morally responsible thing. The safe thing that's right for the public. And where we really, really differ in opinion is I think what's right for the public is to implement the security. If we are going to be responsible [users of this technology], I feel we have an obligation to make sure that it's safe and secure… Arguably, they're both valid positions but we've come out of it with completely different angles.

In this conflict, the interview participant draws on the resources of STIR which reinforces the security concern nodal point. However, the other person draws on resources of NTIR because of the implied belief that if regulatory bodies do not require the additional action then the current state of affairs is safe enough. This belief allows the other person to reinforce the master signifiers of function and regulation so that he can continue to use cesium technology for economic gain.

Coordinating Details of the Feasibility of Alternatives

Much of the content of the workshop addressed the feasibility of alternatives for using cesium chloride and most of the time participants provided comments by drawing on NTIR. Despite the fact that most participants agreed about not wanting to see a near-term elimination of cesium chloride, they expressed and coordinated different views about the exact nature of the

feasibility of alternatives (see Table 5.2). In particular, the nodal point of beneficial function organized their discourse about whether or not alternatives could perform the necessary task in a reliable and affordable way. As a floating signifier, the possibility of alternatives has the potential to change the methods and technologies by which user communities perform their functions of calibration, blood irradiation, and research. Disagreements about alternatives were common at the workshop and also recounted by interview participants. As one participant said, "most of the disagreement I saw was on … very, very technical levels of discussion … they would get into very sort of wonky technical discussions about alternatives, the cesium chloride, or irradiators, and whether or not they could be used for …very specific applications and what the benefits and cost were." Sometimes participants were able to coordinate their differences by exclusively relying on the resources of NTIR. However, if claims did not appear to convince other parties to agree to their view about alternatives, participants used inductive reasoning as a strategy to highlight the faulty reasoning and premises of the other party.

Can Alternatives Perform Necessary Function?

The issue of whether or not alternatives can perform a particular task was important because the beneficial function nodal point prioritized the necessity of gaining the benefits of cesium chloride technology. The NAS study recommended using X-ray irradiators as an alternative for blood irradiation, but this is not an option for calibration because it requires a very specific level of energy in order to ensure that dosimetry and other devices are set to the correct detection levels. The standard measurement of energy for this application is called a kilo-electron volt (keV). The following example from the workshop illustrates how a calibration physicist and x-ray equipment manufacturer managed a disagreement using resources from NTIR. Prior to this exchange, the calibration physicist had expressed his views that he prefers

cesium for several applications, especially calibration due to the fact that the unique characteristics of cesium make x-ray alternatives unsuitable.

> Calibration Physicist: Correct me if I'm wrong, but I believe the maximum voltage, the state of the art today, is around 300, 400 kilovolts for X-rays, and that translates if you filter such a spectrum to get a monochromatic spectrum, you can get maybe up to 200-something, 250 keV. So can you go higher than that? And if not, what do you think about that in the future, if that's possible or not?

The calibration physicist's initial question draws on NTIR by using deductive reasoning from scientific principles about energy, with the implication that even the new x-ray irradiators could not get to the 662 keV range of energy that cesium produces. The x-ray manufacturer responded by expressing his view that an x-ray alternative is possible with his new higher energy x-ray irradiators.

> X-ray Manufacturer: Well, hint, hint, we have written a grant request to put together a machine that will operate at 500 KeV, and at 500 KeV with this new technology we're using, you have enough photons that you can filter very, very hard and still have enough left to do something with. So, yes, we believe it's possible. Is it today? Is it tomorrow? No, it's probably in the same time range as anything else.

The manufacturer's response draws on NTIR and timing and research rhetorical device. However, as the turns become shorter, it becomes clear that the calibration physicist is forcing the manufacturer to concede that even in a few years with new technologies, the x-ray irradiators will not be able to reproduce the 662 keV energy level of cesium needed for calibration.

> Calibration Physicist: Okay, I guess, but what would be the main energy then? We would be talking around 400 tops, right, or maybe even less than that?
> X-ray Manufacturer: Yeah, if you were to go to 500, then you would probably have a distribution from maybe 275 to 380 or depending on what you were filtering with and if you could optimize that.
> Calibration Physicist: So is it correct to say then that the technology is not there today or —
> X-ray Manufacturer: Oh, no, I'm just saying it will be three to four years before you can even get to that level.
> Calibration Physicist: To that level, but not to 600 KeV.
> X-ray Manufacturer: I think that --
> Calibration Physicist: I think that it's a fair question since this morning when we were talking about the other alternative about the cesium form, right, we were asking,

> okay, if this would be available and we had an answer for that. So I think we should explore that question, too, for this other alternative.
> X-ray Manufacturer: I think it would be difficult to go much beyond 500 keV as a peak.
> Calibration Physicist: As a peak.
> X-ray Manufacturer: As a peak.
> Calibration Physicist: Yeah, okay.

Can Alternatives Achieve Similar Output and Reliability?

The issue about whether or not x-ray alternatives can achieve similar output and reliability as cesium irradiators is also organized by the beneficial function nodal point. This aspect of the issue about alternatives draws upon economic and business principles. Industries must find it profitable in order to make x-ray alternatives widely available to users. Organizations must find x-ray irradiators affordable, capable of equivalent output, and reliable. These points are discussed in great detail at the workshop and also over meals during the workshop. One participant explained why her organization and a similar organization had different views about the feasibility of changing. She said "we had the advantage having cost information. So, I think that was the difference in our approaches. We said, 'we can do it, and this is how much of a cost,' where they said, 'It's not feasible.'" And while at the workshop they discussed these differences when "we went to lunch with them… and I think it's a matter of, we had different information than they had."

The following analyses illustrate how participants were unable to use NTIR to resolve disagreements about output and reliability of x-ray irradiators. The participants probably argued about these details because the details could make a difference between the positions that "alternatives can work", "alternatives can work but…" and "alternatives are not suitable" (see Table 5.2). The first view lends partial support to NAS Recommendation #3 (given enough time), whereas the latter views treats cesium-137 as unique and irreplaceable.

Interactions About Output. The first set of exchanges focuses on the output of x-ray irradiators compared to cesium irradiators (i.e., the amount of unit of blood that can be irradiated

in a given time). A participant from a university hospital begins the numerical comparison by asking about how many x-ray irradiators he would need to match his current output.

> University Hospital Participant: We're a Level 1 trauma facility for seven counties in central-western New York. We choose to irradiate all blood products. That's 28 to 30,000 units a year. So my question for the manufacturers are: how many of your irradiators would I have to purchase to meet that 28 to 30,000 units a year, assuming a rate of 75 to 90 units a day, you know, 365 days a year?

The first response comes from a representative of a blood bank and gives an explicit logic for answering the question.

> Blood Bank Representative A: I'm not a manufacturer, but I know that the irradiation time for one of the X-ray devices is about five or six minutes, and you can fit basically three blood bags in at a time. So I'm a little bit slow at math, but I guess you can go through it yourself and sort out how many you would need for your facility.

Then the x-ray manufacturer provides an answer based on his soon-to-be approved, higher energy x-ray irradiator.

> X-Ray Manufacturer: … the device that we used to develop the unit would probably do somewhere around five, 500 mL bags of blood in the three minute range.

A few turns later, a security analyst offers an answer to the original question by calculating out the math and concluding that one x-ray irradiator could meet that person's need.

> Security Analyst: The gentleman behind me … suggested that he needed to do 30,000 units of blood a year. Thirty-six thousand five hundred would be 100 units a day. So let's take that number. One of the source manufacturers said he could do five bags in three minutes. He needs to do 20 times that to keep up with a day. Twenty times three minutes is an hour. Let's take another hour for in and out time. That means that basically between two and three hours of duty a day on the X-ray machine is perfectly adequate. I seriously doubt that you'll have to buy more than one blood irradiator to handle that load.

This statement draws upon NTIR and makes the security analyst seem that he understands the user-groups' needs. However, participants recognize that his statement implies that alternatives can work and this position implies that it would not be detrimental to phase out cesium

irradiators. A different representative of blood banks speaks immediately after the security analyst.

> Blood Bank Representative A: I'd just like to point out that lean and disaster preparedness are inimical. While we try to have as efficient systems as possible, and I cannot gainsay the elegant mathematics of our recent presenter, we do not function as a constant steady state manufacturer, but rather we need to be prepared for the bus accident and generating a lot of stuff fast. So in certain cases, but no means all, there may be reasons either for reliability or throughput that one might need additional X-ray devices. This is not a matter of feasibility. This is, however, a matter of economics.

This statement draws on NTIR to demonstrate that, based on operations principles and data about the inconsistent workload at a hospital, it would require more x-ray irradiators to produce the same output as one cesium irradiator. Thus, he counters the security specialist's calculations with professional knowledge about using irradiators and inductively reason that x-ray irradiators could work, but it would cost more because users would need to purchase back-up x-rays.

Overall, this exchange draws on NTIR by using deductive reasoning from operations principles and using numerical calculations. Statements that cesium irradiators produce more output carry the implication of the usefulness of this technology. Alternatively, statements that claim that x-ray irradiators can match the output carry the implication that alternatives can meet the needs.

Interactions About Reliability. The next set of exchanges focus on disagreements that compare the reliability of the two alternative technologies.

> Radiation Safety Officer: In the case of your machine irradiation of blood products, in the places where there's a single machine and that machine is not working and perhaps it takes a week to bring back into service, how is that problem remedied?
>
> Blood Bank Representative: I guess now is as good a time as any to talk about breakdown just for a moment. Among our 32 cesium-137 chloride irradiators, there have been 51 instances of breakdowns during the last three years. For the X-ray devices, there have been 21 occurrences of breakdowns of the Raycells in the last three years. Of course, we have fewer devices, and when you do it per device and figure out the breakdown rate, there's about a 66 percent increase in the breakdown rate when comparing the Raycell devices to the cesium devices. For the most part, in 66 percent of the breakdowns the device could be repaired within one day, usually by on-site staff or a local contractor. However, two repairs took 26 and 37 days to

> complete and probably involved off-site, non-local service. The average time for repairs that were greater than one day was 15.5 days, plus or minus 12.2 days, and this compares to 37 percent of breakdowns that could be repaired in one day for the gamma irradiators. And in addition, those irradiators took more than one day to repair, averaged 15.4 days plus or minus 12.3 days for the gamma irradiators, again, indicating probably that off-site service was necessary, and of course, this makes sense because as we know, the gamma irradiators are a regulated device with safety concerns and require specialized staff many times to fly in sometimes from other countries to repair the device.

This exchange begins with a question that is answered by drawing upon NTIR. The level of detail about operating history from the blood bank representative is compelling and ultimately concludes that cesium irradiators are subject to less down-time due to repairs. Even though it is not explicitly stated, the implication of the question and the answer is that a cesium irradiator is a more reliable machine, with less down-time, better serves the medical needs.

At this point a manufacturer speaks up to add additional information to the blood bank representative's comments. He directs attention to the age of the devices and implies that cesium irradiators have longer length of service which makes them an attractive purchase. The blood bank representative agrees with the equipment manufacturer and directs attention the fact that users know that cesium irradiators last for decades, but the length of service of x-ray irradiators is unknown. These arguments support the position that cesium is preferred due to reliability issues. Notably, the participants make several references to money, such as "if you want to make a donation to the Red Cross then we can [afford to buy an x-ray irradiator]." These kinds of comments provoke the audience to laughter because they highlight shared beliefs about the reliability and relative affordability of cesium irradiators and concern about the possible expense of having to buy x-ray irradiators as replacements.

At the conclusion of the output and reliability comparisons, a medical physicist connects these topics. He apparently disagrees with the points made about the inability of x-ray irradiators to match cesium output or the lower reliability of x-ray irradiators. He appears to disagree with

the “alternatives can work but…” position and supports a “preference for cesium” position. His opening phrase emphasizes his rationality and attempt to overcome the limited point-of-view constraint.

> I've got to add balance back to this discussion. Those of you who understand X-ray technology, some of the high output computed tomography X-ray tubes, the reproducibility and accuracy of modern medical imaging technology and output, the technology is clearly here and has been here for many, many years. So to imply that the technology is not capable to put reproducible output over a period of time is, in my opinion, just wrong. However, maintenance and quality control, if you neglect a high quality car, it's not going to last as long as a less expensive car that's maintained on a regular basis. So the issue with electronic products more so than the radioactive sources is to require long-term maintenance and calibration and so on. But to imply that the technology is not up to the task is wrong. It's the human factor, the maintenance, the calibration. So there's little doubt in my mind. Energy aside, unless you can come up with an X-ray source that can generate a 662 keV photon, that for scientific applications the non-radioactive technology is clearly… capable.

In this statement he deviates from the deductive reasoning of NTIR and introduces inductive reasoning from analogy to make a point about maintenance. This use of inductive reasoning helps to differentiate his position about feasibility of alternatives by redirecting attention away from the operations problems of x-ray irradiators and focusing on the unique energy of cesium.

After this turn, another participant uses an analogy of a light bulb to discuss reliability of x-ray irradiators. A manufacturer of high energy x-ray machines is the first to respond to the car and light bulb analogies about maintenance and advancement of technology.

> Actually we think we have hit on a relatively good solution. It's a matter of having the availability of being able to open up the tube, repair it, close it up again and reuse it. Again, this is a brand new concept. The best we've been able to do so far is somewhere less than 1,000 hours of use. We think we can get considerably higher than that, but even at 1,000 hours, if you think about the calculations that were just done here a little while ago, two hours a day or whatever they were, 1,000 hours is a year and a half before you have to do anything to the tube, and that's a huge, huge operation to irradiate that type of blood.

This statement draws on NTIR and supports an “alternatives can work” position. The facilitator observes that several participants disagree with this statement. The first person to respond is an agricultural researcher who provides considerable numerical information about the operations

and expenses of the USDA's irradiation needs. He drew on NTIR with the typical deductive reasoning from economic principles, strong appeals to the public good provided by these operations, and scientific reasons why they cannot allow long downtimes for their irradiation. The x-ray manufacturer has the next turn and he disagrees with the researcher's statement but he does not provide specific reasons for it. His use of the phrase, "I would like to remain professional about this," indicates that he probably feels upset by the previous comments but he wants to maintain norms of rationality by not expressing his emotions. After this comment, other participants, offer statements that further counter the x-ray manufacturer's estimates of usage time with operations data from their respective organizations. A participant from a blood bank concludes the comments with a statement about the reliability of x-ray irradiators with economic principles. "So they're selling, but if they were as cost efficient obviously they'd be selling more." At this point the facilitator invites further comments but no one responds, so they move to the next agenda question.

Throughout these examples of disagreements about alternatives, the beneficial function of irradiation for blood transfusion and research is a key signifier that organizes the question of the feasibility of x-ray irradiators regarding their output, reliability, and cost. Generally, participants managed the conflict with resources of NTIR and demonstrated rationality by sharing specific information about scientific or operations principles and refraining from expressing emotion (although anger was on the surface at some points). Instances of deviation from NTIR are when participants used analogic reasoning to differentiate their position in relation to Recommendation #3 from the slightly different positions about alternatives.

Coordinating Agreement About Balancing Risks and Benefits

Even though floating signifiers created potential for change in the discourse about cesium chloride the key signifiers of function and regulation were also reinforced through

participants' coordination about risk logics and benefits. The key signifier of regulation was reinforced through the fact that most participants relied on acceptable risk and risk/benefit logics. The acceptable risk logic maintains that society can bear risks of certain technologies. The risk/benefit logic adds the reasoning that this acceptability must be in proportion to the benefits the technologies provide. The risk/benefit logic also reinforces the beneficial function signifier because it attends to the benefits of a technology. Sometimes participants expressed the risk/benefit logic explicitly in statements such as "you start making a sort of risk-benefit analysis…I think the benefit is higher than the risk and I think the risk in this case is very small because NRC has been doing an excellent job making sure that all facilities operate securely." Participants also implied the risk/benefit logic contextually in statements like this: "There really is a health issue and it really is something that has to be taken care of…and whatever we do, we can't just eliminate it because of the consequences there of real health issues versus a perceived terrorist risk are outweighed because you really have …big consequences if you didn't irradiate the blood." Thus, participants used risk logics to reinforce the beneficial function and regulation key signifiers. This can be seen in an example at the workshop that began with disagreement the elimination of cesium chloride based on RDD consequences and ended with a tacit agreement about basing a decision on an acceptable risk logic. Additionally, the interview participants provided insight into how user communities built agreement about making a decision based on the beneficial functions of cesium chloride technologies.

Coordination of Risk Logics

Even though the final session of the workshop was designed to address risk analysis, in the early afternoon of the first day, participants began describing their positions using the risk logics. This session created tension and disagreement and ultimately, a senior NRC manager felt the need to step in to frame the talk about risk by drawing on the regulatory structure of the

NRC's task and mission. This exchange about risk began when a security analyst made an explicit reference to "eliminate" risk and expressed a preference for non-radionuclide alternatives. It is the use of the word "eliminate" that seems to provoke the subsequent exchanges (I have italicized the use of "eliminate" or synonyms in the quotations).

> If we go to a radionuclide alternative to cesium we are reducing the risk because we're actually making it more difficult to disperse, but we're not *eliminating* the risk. The only way to *eliminate* the risk is to go to an non-radionuclide alternative like the x-ray machine. And being from my perspective, not being a user, but being a student of radiological terrorism, that would be my preferred option… After 9/11 we got a lot of complaints that the government didn't connect the dots. So here's a case where we're really trying to connect the dots and look where the holes are in our security, where our gaps are, and trying to plug them and that's one of the reasons why we're trying to look at other options for cesium chloride.

The security analyst's set of statements draws upon STIR by using a risk logic that focuses on consequences and inductively reasons from his professional knowledge. He also draws on the security institution by referencing the terrorist attacks on 9/11 to justifying this effort as a conscientious attempt to prevent another terrorist attack. In the comment that immediately follows, a medical physicist picks up the word "eliminate" and uses the risk/benefit logic with NTIR to suggest that phasing out cesium chloride is an extreme action.

> Are you talking about *eliminating* cesium from all commerce for all calibration applications just because of its chemical and mechanistic form? I think you would be doing the scientific community a disservice by taking this specific nuclide out of the picture completely. If you're talking about terrorism and being afraid of things… when do you block yourself up in a corner with a wall and just not expose yourself to anything? The NRC has a tough task here. There are societal benefits of cesium. There are scientific benefits of cesium with its unique energy. It's used as the nuclide for many, many calibration applications. But then again, in its current form, it also raises some risks. But I think … you're going to create a hole if you *eliminate* cesium-137.

Several participants were provoked by the use of the word "eliminate" which they consider to be a violation of the precedent of using nuclear technologies for beneficial purposes. Many responded by using STIR in an ironic manner to demonstrate their view that the focus on consequences is a faulty premise for a decision. After a few attempts to keep the conversation on

the agenda, the facilitator recognizes a senior NRC manager who has been waiting a while to make a comment about risk and security. This is only the second NRC comment since the opening remarks and it occurs in the early afternoon of the first day. At this point, the audience of nearly 200 people becomes very quiet to listen to this comment.

> One of the things that the NRC has to ponder when formulating our decision making is … how far do we go as a regulator… Nothing that we're going to do is going to give *zero risk* except complete *elimination* of radionuclides. I think that's recognized. So the question becomes what is an acceptable risk and that's something we should be thinking about as we go through and formulate our comments… We don't live in a *zero risk* society. We're not going to get there as I said. So therefore … if we were to go forward and promulgate some kind of ruling-making on this activity, part of our rule-making activity requires a regulatory analysis which has to factor in cost/benefit of the actions that were taken. It's important for us to have that information so that we make informed decisions as we go forward.

After general acknowledgement of several perspectives, the NRC manager explicitly says that the only way to achieve "zero risk" is to have a complete "elimination of radionuclides." He then continues by using the acceptable risk logic to explain the NRC's intent to gather information that would support rule-making. In the course of this comment he hints at the use of a PRA logic that could help determine which alternatives do the most to minimize risk and bring it to the acceptable level. The function of this statement is to establish the acceptable risk logic as a guiding premise for the NRC's decision and perhaps the remainder of the workshop.

At least one participant focused on the statement about the elimination of radionuclides and posed a question indicating concern about this extreme action.

> Equipment Manufacturer: You said *getting rid of* radionuclides. Are you talking only about the high level or what level or --
> NRC Manager: Yes … if you were removing the risk completely of using cesium chloride or cobalt or any radionuclide, the only way you *eliminate* that risk completely is not to use it at all from a radionuclide perspective. So there's a recognition --
> Equipment Manager: But get rid of low level radionuclides as well?

> NRC Manager: That's all it's going to take. Yes, any utilization of it at all in any form is going to give some form of risk. The question becomes what's that accepted level which I think is the point that we're trying to ponder.

Apparently the participant was concerned that the NRC manager's remark was literal, when in fact the NRC manager was using it as a trope to establish the premise that such action would be extreme and therefore warranted a discussion of "acceptable risk" instead of "zero risk." In this example of coordination the two participants probably hold similar views, but the manufacturer interprets the regulator's comments in a literal fashion and perceives a disagreement.

Immediately following this exchange, a member of one of the NRC's advisory committees expresses agreement with the NRC manager's comments.

> I couldn't applaud you more for bringing up the issue of risk. On the one hand … we've [presumed that] cesium doesn't work. How about we ask the other question? What would it take to make a cesium irradiator have a *risk profile* that was acceptable by whatever metric you wanted to use? Asking the alternate question is a way to analyze how do you make it better, rather than what can we substitute. And I think when you do that in a risk-informed way and think about all the risks, the risk of a terrorist, the risk of them getting to the material, the risk of them getting it and doing something bad with it and all those things which is the event side and then thinking carefully and systematically about protections that you have or don't have now or should have or might have, we can really kind of sort it out. But I would just urge that we focus on the risks. What are the risks we're trying to mitigate and how can we systematically mitigate them and then how do we ask the questions? Instead of presuming cesium has to *go away*, we can say if we really want to keep cesium, what does it take to give it the risk profile that would be acceptable from a risk-informed regulatory view?

This statement uses the vocabulary of "risk profile" instead of "acceptable risk" and this allows him to reframe the overall workshop question from being about "the continued use of cesium chloride" to creating an acceptable risk profile for cesium chloride. He then used the term "risk-informed" which invokes the PRA logic. The use of PRA logic focuses attention on the probabilities of events (in addition to the focus on consequences) that could lead to a terrorist attack and ranks these risk contributors. Ultimately, the use of PRA logic and acceptable risk

logic functions to reframe the questions in direct response to the recommendations of NAS Recommendation #3.

Following this comment, an oncologist draws a distinction between cesium-137 and cesium chloride and focuses on the consequences of a terrorist attack. This begins coordination between these two individuals about reframing the overall question of the workshop.

> Oncologist: I haven't heard anybody including the NRC or NAS advocating *elimination* of cesium-137, but I think at least according to the NAS report they do suggest to *eliminate* of cesium-137 chloride, at least, category 1 and 2 and just one reason is just due to the solubility and that's a significant economic impact it would have on society if a terrorist event happened.
> NRC Advisory Committee Member: It is true it is soluble. I agree 100 percent. It is salt. But where is the evidence that says on a risk metric that that's the most important thing about cesium-137? If it's properly secured, properly confined, properly contained, by whatever mechanism you want to think up so that it prevents that action, that solubility may become less significant from a risk point of view and I think we're giving that up too quickly.
> Oncologist: I agree with you, but can we mitigate the risk and is it still economically viable?
> NRC Advisory Committee Member: That's exactly the question we're posing.
> Oncologist: That's our question.
> NRC Advisory Committee Member: Exactly the question. I think we need to systematically think that through before we throw it away.

This coordination drew upon distinctions between cesium-137 and cesium chloride, the issue of solubility, scientific principles, and economic principles. In the end, the participants expressed agreement about asking the same question, but it took three rounds of expressed agreement for them to believe each other. The reason is subtle, but lies in the fact that the oncologist is convinced by scientific explanations of solubility and dispersability to use a risk logic that focuses on consequences. His use of distinctions between cesium-137 and cesium chloride shows both his understanding of the uniqueness of cesium and his concern for the security threat. On the other hand, the member of the NRC advisory committee uses to PRA logic to focus on probabilities of the security threat and the acceptable risk logic to lay a foundation that allows for the continued use of cesium chloride. Therefore, they may have reached agreement about the

wording of the question, but the function of the disagreement may be rooted in their different risk logics.

This process of coordination about the risk/benefit and acceptability of risk logic reinforces the concept of regulation as a key signifier in the discourse about cesium chloride. These individual actions are reciprocally reinforced by the regulatory and legislative structures from a society that has some level of trust in government agencies to protect the public. However, these resources are not available in all countries and regulatory bodies often do not have trusting relationships with the public or their regulated communities. This process of coordination about risk logics is also an action that corrects a violation of talking about elimination of radionuclides. With this reframing of the overall purpose of the workshop, user communities can think about ways to keep cesium chloride technologies while also improving security.

Coordination About Beneficial Functions of Cesium Chloride Technologies

As interview participants reflected on their interactions about the cesium chloride issue, many of them told stories about how easy it was for them to coordinate agreement with other user communities wanting to keep cesium chloride technologies because of their beneficial functions. Their praise about the NRC decision reflects their belief that the best basis for the decision was a risk/benefit logic that accounted for its impact on user communities.

Several participants recounted how each professional group had similar views about the NAS study Recommendation #3, but for different reasons based on how they used cesium chloride. When commenting on her organization's ability to partner with other organizations, one participant said they were "able to tie sort of research uses as well as the clinical use in medical facilities and I think that was sort of a very powerful one-two punch, if you will, on this issue." This professional collaboration gave the user communities strength in the face of what

they considered a fear-based, politicized issue about banning cesium chloride. As one participant recounted, when the members of their professional organization initially heard about Recommendation #3, they protested on their chat rooms and list serv. Then, the president of the organization coordinated their responses into the official statement that they made at the workshop.

This process of coordination seemed straightforward to many of the interview participants because to them the right decision seemed apparent and according to one participant, "it was quite clear that [NRC officials] felt quite constrained on to be able to point out the obvious." The "obvious" in the eyes of the user communities was to take into consideration the impact of the decision on the beneficial functions of cesium chloride technologies. As one participant noted, "I agreed with the original panel that said that it's safest to ban Cesium. That is true. That is from a purely scientific perspective and safety perspective, too. But, then the NRC went out and said, 'What's the impact of this?' Then they listened." Another interview participant talked about his experience interacting with different disciplines on sub-committees and he said, "To see all the different aspects that you really have to try make it as safe as you can and yet not inhibit the use that is so vital until --if there's an alternate that could be used."

Coordination Leading to a Paradigm Shift

Several participants recounted how they were initially resistant to the characterization of cesium chloride as a security threat. The five main reasons for this resistance were discussed in the section about vulnerability of theft. Participants who felt that they made a paradigm shift to accepting the security risk about cesium chloride, attributed this shift to immersion in security studies and interactions with different professional groups. The participants who made the shift acknowledged that at the beginning they were constrained by their own limited point-of-view and when they got new information, this helped them change their perspective. Participants also

admitted that it took time for the information and experiences to sink in enabling them to make the shift.

Immersion

An important reason that participants did not believe the vulnerability of the security threat was the lack of information. The interview with one participant, who I refer to as Smith, went into great detail about he had adjusted his beliefs about the security threat and he recognized that "the security culture is very, very new to us" and "people haven't fully made the adjustment to the new world, the new reality that I think that we live in." In his account, Smith explained how, "[I had] developed my own sort of personal security culture" because "I spent quite a bit of time working in the area of security in recent years and I've read papers" and "from the work I've done mostly with the Department of Energy in the United States." In his own words, the participant felt like he had undergone a "paradigm shift" based on his immersion in thinking about safety and security issues related to his industry. This section uses this participants' account to demonstrate how key signifiers and floating signifiers were coordinated in a manner to enable a paradigm shift through immersion.

Smith recounted how he first received the information about the security threat of cesium chloride—a reaction that was similar to nearly all interview participants.

> I'll tell you, when I first heard about the possibility of using one of these devices to make a dirty bomb, I thought that's absolutely ridiculous. I thought that's the stupidest thing I've ever heard… So, why was it hard to believe? Just because of the fight. My experience.

Based on his experience with cesium irradiators, Smith found it difficult to envision how they could be used in a terrorist attack. However, based on his professional commitment to "read the book," he "studied the historical facts … long before 9-11 from a safety point of view …because [he] felt it was the important part of the engineering that [he] was doing [and] now

[he does] the same thing with respect to security." This immersion in security studies enabled him to adopt the 9/11 logic.

> This was something that 9-11 taught us was if you - we were using our common sense and our rational experience… You think it's inconceivable…And now that statement is based on our experience because we do occasionally have to recover these things from the field and … the reason the process takes so long is because we have rules and procedures … the big one is the radiation protection. What 9-11 taught us was all those rules go out the door… the terrorist actually is happy to die. And that breaks all the rules. All the sudden, common sense is gone out the door. It took awhile for me personally to imagine this change of perspective about those rules and think of it from that perspective.

Once Smith believed that terrorists might really want to use cesium chloride in a violent act, he began to use 9/11 logic to understand that a terrorist would not be concerned about radiation protection procedures and therefore would simply steal the source from the irradiator and get a high dose. This account demonstrates how the security threat nodal point shapes the discourse and how the radiation protection logic initially constrained Smith's ability to believe the credibility of the security scenarios. Additionally, the master signifiers of his professional identity and rationality enable Smith to justify his choices to study security scenarios and understand that point-of-view.

For Smith, the next barrier to overcome was the disbelief that anyone could steal the source from the irradiator quickly. The following excerpt demonstrates how his exposure to the "Red Team" videos changed his point-of-view about the vulnerability aspect of the security threat.

> What the big eye opener was … "Red Teams." The folks at Sandia National Lab…got their hands on some machines … and then they were allowed to study these machines and figure out how they work, reverse engineer them. And then they were put in the room with a set of tools and a video camera and they started the clock and these guys got the stuff out in a matter of minutes. And I saw the video, I watched it and I couldn't deny it, but it just defied my life's experience--what these guys did. And even then, my … first reaction was to scoff and say, do you know what kind of a dose that guy just got from a radiation dose? But even then I knew about the dose he didn't get. It wasn't lethal. It wouldn't quite the kill him immediately. And it might never have killed him. The point is, they got the source out of the machine and now it's gone…It has [entered]

> the public domain, we lost track and we don't know where it is. So, that whole process for me took a couple of years. The video itself obviously was the turning point for me to see that but it just defies our common experience.

For Smith, viewing the "Red Team" videos was a "turning point" for him, but even this information took a while to sink in because it "defied [his] life's experience" as a professional working under the logic of radiation protection. Later in the interview Smith revisited the importance of viewing the videos.

> I think it was probably a defining point of my career to see that because it really did shatter all the notions of what was conceivable. I saw what they were doing. I witnessed it. I could understand absolutely every step that they took in the process but to put it all together and to see it unfold in front of me was a really truly an eye opening experience. … Probably because it was in a matter of a half hour meeting, it changed the direction of my career and made me realize that the step is possible whereas previously… I was not concerned.

The visual image of a person stealing the source "in a matter of minutes" was a powerful piece of information that came from a credible source and therefore, it was not a violation of rationality for Smith to accept this information and use it to expand his point-of-view.

Another element of Smith's paradigm shift was his involvement with the In-Device Delay program—a DOE and DHS program that re-engineered cesium irradiators to make it physically more difficult for someone to get the source out of the machine. This new role caused him to incorporate elements of security work into his previous professional identity of working with the functional benefits associated cesium irradiators. Smith had been given permission to view the videos because of his role in the In-Device Delay ("hardening") program. Smith said, "I think I could conduct my job without having seen that, but having seen that and been exposed to that information makes my job not necessarily easier but a lot clearer."

Even though Smith articulated a belief in the security threat and recounted how his paradigm shifted through his immersion in studying the issue and the In-Device Delay program, he still firmly believed in the beneficial function of cesium irradiators. His account about the

cesium chloride issue was also organized around the beneficial function nodal point. This was illustrated in a story he shared after describing his involvement with hardening.

> When we're doing this upgrade, we strip the machines down to the skeletons and we end up rebuilding it. The machine is out of service for a good four to twenty-four hours… One of the very first machines we were doing, we had just got the machine back together and were running it. We were literally running it through its first few cycles. And a woman in the blood bank came in and she just burst into the room and she said , 'Is that machine running? … I've got a new born baby upstairs that's hemorrhaging to death.' … I told the story to somebody and I said… 'the baby was bleeding to death [and] that machine is about to save that baby's life.'

Throughout the account of his paradigm shift, Smith drew on resources in both NTIR and STIR. Smith drew on values of the benefit of the technology and the importance of protecting the public. Additionally, his account draws on the belief in technology to provide a solution to the security threat through the In-Device Delay program. Smith's involvement in the hardening program emphasizes both responsibilities of government to protect the public and oversee safe uses of technology. In an interesting reverse usage of reasoning, Smith's initial resistance to the security threat was based on inductive reasoning from professional experience and the legitimacy he attributed to the security threat was based on careful reasoning about credible evidence. Thus, Smith's account of the paradigm shift provides evidence of a potentially new repertoire that merges NTIR and STIR in an attempt to negotiate the tension of a security threat that has the potential to phase out a beneficial technology.

Interaction

Another element of participants' accounts of a paradigm shift is interaction with other professional communities. Smith's account tells of his interactions with security specialists through his involvement in the In-Device Delay program. Two other interview participants provided in-depth accounts of interactions among user communities, regulators, and security personnel. These extended interactions provided opportunities for the different communities to overcome the constraint of a limited point-of-view. In the first account, told by Jones, state

regulators created forums for interactions between themselves, the NRC, and their licensees. In the second account, told by Jackson, a university radiation safety officer created forums for researchers and security personnel to interact.

A State Regulatory Conference. Similar to other participants, Jones recognized that user communities did not feel that additional security measures were necessary for cesium chloride. He felt that it was important to impress upon them that they took this issue seriously, so they made violations of the increased controls the highest possible for this state.

> Since we felt it was something that NRC thought was important, we made our violations severity levels 1 and 2, which is the highest severity level. So, many of the blood facilities came in, had to pay a thousand, two thousand dollars penalty for not implementing quickly, and it got their attention really soon. So, we were able to learn a lot from there that they -- and them too, they almost thought, "Well, you can't remove it from the facility." And once they realize that no it's more about removing the source and I think that they came around.

This account is organized by regulatory logic, that an external agency should oversee and enforce the safe use of a technology. However, Jones recognized that some of the licensee organizations did not completely understand the extent of the requirements. For example the licensees would have access badges and background checks for blood bank personnel "but they didn't check the people in IT who control entry" which is important because "you had to make sure you checked everybody who could possibly have access to that area." In order to address these kinds of issues, the state used their bi-annual conference as a time to provide information about the increased controls.

> We had a regulatory conference…And we tried to get these folks in and what we did, after the increased controls, is we focused that conference on the whole increased control side of it … And then, we had stakeholder meetings, where we invited the individuals to come to Austin to really go through and work with them on what the issues were. And it was working so well that we involved the NRC [since] we were all kind of on a learning curve ourselves. And I think the only part that was frustrating to the users was none of us has some of the answers when we first started, and it took a while… and it kept evolving because initially it was just increased controls, then it added fingerprinting. And so the fingerprinting though was all at NRC… And so over time working through the states and the NRC, we've been able to develop a good set of questions and answers. We put them

> in our Web site so that any of our licensees can go there and see easily; track what they need to do.

Clearly, Jones' account is organized by the regulation key signifier. However, this account highlights a weakness of the regulatory logic—it requires these agencies to understand what counts as safe and secure use of materials. In the case of the cesium chloride issue, this was an evolutionary understanding. These interactions between licensees and regulators helped improve understanding of what was expected from increased controls. Additionally, Jones used the conference to emphasize the importance of the security issues.

> At that point with the workshops, we would … explain to them that there's a whole culture of change. They're going to have to really assume now that someone would want to steal those sources and they would have to protect them. And they would have multiple ways to make sure that they understood that they needed to work with local law enforcement. Because they had to make sure that if there was an attempt to break in or even a successful theft, they needed to do certain things. So, we went through all the different scenarios and all of the new requirements that they were going to be held to.

Based on this account, the state regulators used the conference as an opportunity to provide additional information to the user community. Jones believed that this approach was effective and resulted in much improved compliance with increased controls.

Meetings at a University. Much like the accounts of other interview participants, Jackson, who is a radiation safety officer at a university, recognized that "many scientists didn't believe that there was a terrorism risk." However, Jackson recounts his own experience of undergoing a paradigm shift and connects this belief with a position about whether or not alternative should be imposed on user communities.

> I kind of thought there might be but was able to prove to myself through scientific study that there was and, you know, that kind of changes some of your reality but more importantly on the other side, I was of the opinion that, you know, you can use an alternative radiation source and x-ray machine is a whole lot easier.

Even though Jackson began with this position about the feasibility of using alternatives, he sought input from the researchers about how this decision would impact their work. Jackson

recalls that "as I worked with the scientists more, I became more convinced that they needed it rather than did not, which was contrary to what I was hoping to do." Jackson recognized the constraint of his limited point-of-view and followed a rational process of gathering and testing evidence about the importance of cesium irradiators to researchers.

> I went to them and I asked them to make their case why they needed them. And then I challenged them to prove it scientifically, and then I took their literature and I went to their colleagues without referencing them and asked their colleagues if it was a valid point… And I was quite surprised to find that the scientists were supportive of this other viewpoint which I was hoping to shoot down…I was able to find that here and by making phone calls to colleagues at other institutions, they pretty much universally said when there was a technique that required, for instance, using more irradiators, it was really because they needed to do it for a scientific reason whether it was all of the data that's based there or that particular reaction is what I need.

The development of his position about alternatives was the first set of interactions that Jackson recounted. He then began to tell about how researchers and security personnel interacted with each other to form a collective view about increased controls. At first he recalls some of the scientists' initial angry reactions to the increased controls and how he responded by explaining that terrorists would be willing to take radiation doses in order to steal the cesium chloride.

> When we went around to our users, the comments that we were getting were, "You're violating my civil rights." And they would throw things at us and I've known these people for 20 years and they were throwing things at us. And we finally solved that problem by bringing some of the university police officers for this. So, it's definitely full of energy… I explained it to them is when you change your reference point to not worrying whether or not you have breakfast tomorrow morning, it really doesn't matter, does it? And then they started to think a little differently when they finally heard that message.

This type of account demonstrates how users were initial unconvinced that cesium chloride was vulnerable to theft by a terrorist. However, Jackson recognized that his user community included "some very, very smart individuals here." He acknowledged their expertise and provided forums for them to interact with each other and form their own views about this issue.

> We had some pretty spirited discussions with them about why they needed to have these sources…. and it actually took pretty clear academic discussion style where the users were arguing with themselves about whether one was right versus one was wrong, or if

> their points were valid or points were not valid. And it got to the stage where we were actually reserving lecture halls to these discussions because it better fit the forum that we wanted to have with them. And [when] they would start off … one side of the room was adamant that you could live without these sources and we shouldn't have to worry about them and just get rid of them. And the other half [felt that basically] petty rules are ridiculous, and we wound up with the consensus of the audience where these sources were valuable and that we needed to do whatever we could to secure them before the rule book changed, and then later that we come up with new security systems. And as result of that, we actually had a new security system that met the regulations before the regulations came out.

Jackson recalls that the earlier meetings were held in small classrooms and this was problematic because "they were jockeying for position which changed the dynamic in the room because when a senior faculty member stands up and starts arguing, people are going to keep quiet because they don't want to…challenge him or her in public." Jackson addressed this by moving the forum to a lecture hall [where] they can actually sit down in their chairs and then they could have a dialogue around the room because the lecture halls have slanted floor and so they could see each other…it became more of a format they were used to." The lecture hall forum gave the different groups "the opportunity to question each other and that kind of goes back to the dynamic of the room is they were more put on an equal basis rather than a hierarchy." The dynamic that caused the need for a change of forum was a result of the master signifier of professional identity that organized the researchers' relationships to each other. This constrained the flow of information and therefore violated the norm of rationality. The change of forum improved the quality of conversation and created the possibility for the researchers to overcome the constraint of the limited point-of-view by listening to each other and adapting their views.

Additionally, Jackson invited the campus police officers, the security personnel, to these forums to describe their role in the cesium chloride issue. He recalled that "some of these [scientists] are really super-animated, energetic … and when we brought the officers with us, they kind of toned it down and had them see this is not really just an entire academic discussion; this is one of the consequences." Jackson explains how the interaction between these groups

created an opportunity for dialogue that led to ways that they could help each other achieve both research with cesium irradiators and security controls.

> The police officers didn't really have an opportunity to interact with these people and … they got to experience [the researchers] and how they really were thoughtful about what they were working with and that they were trying to do something of value with it…The research on the other side… were actually able to see that these guys weren't the bad guy and they were here to help us understand how to fix this problem so they can do the science. And it was interesting dialogue watching the two different kinds of mindsets on -- interact…And so the next thing you'd see is they were actually talking about what each side wanted. And they were able to work out things that helped the -- the researchers figure out why the police officers/regulators were looking at certain things to increase security and why for certain things an approach were important to them and the same thing applied in reverse.

Ultimately, as a result of these interactions, the scientists "were relieved that the regulators were not completely without thought but they didn't like it and they turned that into regretful acceptance [of the increased controls]." Thus, the outcome of these interactions may not be a complete paradigm shift, as in the case of Smith or Jones, but rather a sense of "whatever it takes" meaning that users follow increased controls in order retain access to the cesium irradiators they need to do their research. It is a similar rhetorical device that several participants used to manage the paradox between NTIR and STIR as their view of the cesium chloride issue became more complex.

Summary

The results in this chapter complement the answers from Chapters V and VI to the overall research for this study about how experts from different disciplines communicate with each other about risk. Chapter VII has explained the conditions that gave rise to the particular characterizations of cesium chloride and demonstrate how shifts over time led to creative appropriation of the societal resources and interpretative repertoires. Key signifiers organize the discourse about cesium chloride and create conditions for characterizing it both as a beneficial technology and a security threat. The nodal points of the security concerns and Recommendation

#3 from the NAS study organize the discourse because most participants are positioning their views in relation to these key signifiers. The master signifiers of professional and organizational affiliations and rationality organize participants' identities in relationship to each other and the cesium chloride issue. The myths about beneficial functions of cesium technology and the regulatory bodies relate the user communities to public who expect safe use of beneficial but hazardous technologies. Even though these key signifiers are well established, the conditions for meaning are always in flux and this can be seen through the activity of floating signifiers. Concepts of dispersability and vulnerability keep meanings about the security threat in flux. Different beliefs about the feasibility of alternatives position participants' in relationship to Recommendation #3 and indeterminacy about this issue largely prevents the NRC from deciding to phase out cesium chloride technologies. Finally, politics, the expression of emotion, and shifting professional cultures destabilize participants' professional identities and characterization of each other as rational.

The bulk of this chapter addresses the third research question that considers how experts from multiple professions and disciplines negotiate and coordinate their different perspectives. The key signifiers and floating signifiers provide entry points to examine how participants use societal resources and interpretative repertoires, identified in Chapters V and VI, to coordinate their conflict and agreement about security issues, alternatives, and risks and benefits. Conflict about security issues demonstrates that the concept of dispersability creates a possibility for coordination because it fits within both NTIR and STIR—it explains the consequences of a cesium RDD and also creates the possibility for a technological solution to the security threat. Additionally, the distinction between cesium chloride and cesium-137 draws on NTIR to allow cesium-137 to remain characterized as a necessary and useful isotope while attributing the security concerns to the particular form of cesium chloride. Finally, participants' disbelief about

the vulnerability challenges the legitimacy of the characterization of cesium chloride as a security threat. Participants most frequently relied on NTIR by emphasizing the processes of increased controls and hardening within their organizations to justify why cesium irradiators now pose less of a threat. Additionally, participants questioned the vulnerability of theft by deviating from the NTIR and using inductive reasoning from their operational experiences to question the premise that terrorists want to use cesium chloride or could steal such a heavy machine.

Talk about alternatives was a floating signifier that had the potential to create conditions for legitimizing a decision that the NRC can phase out the use of cesium chloride because the beneficial functions could be achieved through x-ray irradiators, other radionuclides, or other forms of cesium-137. This topic was a frequent point of disagreement among users and without paying close attention to the nuances of their positions, these disagreements may seem like much ado about nothing. However, as Table 5.2 demonstrates, participants' statements about the feasibility of alternatives positioned their views in relationship to Recommendation #3. Examples of coordination about alternatives demonstrate how participants use NTIR to coordinate different views, and in these cases the use of scientific principles legitimized the beneficial functions because they are reproducing structures based on the precedence of science and technology and the norms of rationality. Additionally, participants coordinated their different views about alternatives by deviating from NTIR and using analogic reasoning to demonstrate faulty premises of other positions.

Participants coordinated agreement about a risk logic that enabled them to continue to use cesium chloride technologies for beneficial functions. Coordination about risk logics began with reactions to the norm violation of an expressed position to eliminate cesium chloride. By drawing heavily on the structure of regulatory bodies, participants coordinated agreement about the acceptable risk logic. Throughout interactions leading up to and following the NRC

workshop, participants coordinated agreement that the NRC decision should be based on its impact to users—an agreement that was legitimized by reproducing structures of the U. S. medical institution and beliefs in technology. These two processes of coordination explain why risk/benefit logic is the most common risk logic expressed among participants—a system of reasoning that assumes society will accept certain levels of risk from a technology if the benefits outweigh the risk.

Embedded in the conflict and coordination are insights to the fourth research question about strategies experts use to legitimize their particular risk characterizations and justify choices that result from the risk characterizations. Interpretative repertoires help identify how participants attempt "to establish accounts as factual and stable and deconstruct other accounts as the product of personal or group interests" (Phillips & Jørgensen, 2002, p. 113). In terms of Laclau and Mouffe's theory, the "factual and stable" accounts are key signifiers that have achieved closure, fixed taken-for-granted meanings that provide clues to shared ideologies and assumptions (Phillips & Jørgensen, 2002). These taken-for-granted meanings create a sense of objectivity that "appears given and unchangeable" and "seemingly does not derive its meaning from its difference from something else" (Phillips & Jørgensen, 2002, p. 36-37). The key signifiers that have meanings which are taken-for-granted are: (1) rationality, (2) beneficial technology, and (3) regulatory principles. The master signifier of rationality is a basis for information gathering and decision making that participants do not question as a key assumption. Indeed, rationality is one of the norms identified in Chapter V and participants often take great pains to highlight violations of rationality that they see in other expert groups such as operating from a limited point-of-view, expressing emotion, or being motivated by politics.

Participants also take for granted the myths of beneficial technology and regulatory principles. Both of these key signifiers draw on resources from NTIR and societal institutions

like the medical institution, legislation, and belief in technology. Participants repeatedly reinforce the legitimacy of these key signifiers by drawing out the certainty of harm to patients if medical providers cannot irradiate blood in comparison to the uncertainty of terrorist theft and subsequent RDD attack. Additionally, the legitimacy of these key signifiers is further bolstered by the risk/benefit logic that participants repeatedly draw on when characterizing cesium chloride as a useful and unique source. The taken-for-granted nature of the myths of beneficial technology and regulatory principles are reflected in the agreement that interview participants expressed with the NRC's "obvious" decision to allow continued use of cesium chloride with increased controls.

Finally, even though the imperative for the government to protect the U. S. from security threats has a taken-for-granted status, the application of this key signifier to cesium chloride has not yet attained a taken-for-granted status. Floating signifiers that draw on scientific principles, such as dispersability and solubility, legitimize the security concern. Additionally, Congressional interest in securing radioactive sources to prevent their use in terrorism and NAS Report legitimizes the characterization of cesium chloride as a security threat. However, some participants deconstruct the rationality accounts as politicized, emotional responses—both of which are violations identified in Chapter V.

In conclusion, all of these coordination and conflict processes create conditions for a paradigm shift to which workshop participants alluded and interview participants described in more detail. The interview participants' accounts demonstrate that the key components of the paradigm shift are immersion in security information and interaction across professional groups over extended periods of time. When recounting their stories of paradigm shifts, the participants draw on both NTIR and STIR and use the tropes identified in Chapter V to manage the tension

that seems to result when a person characterizes cesium chloride both as a necessary technology and a security threat.

CHAPTER VIII

SUMMARY AND DISCUSSION

Discursive analysis of the cesium chloride issue suggests that experts from different professional and disciplinary communities partially accept each others' risk characterizations during the workshop and the interviews. This integration of the two characterizations of cesium chloride is reflected in the NRC decision to write a policy that allows the continued use of cesium chloride but simultaneously encourages the enhancement of security programs at the organizations and encourages research for alternatives. This decision integrated divergent positions about the unique and useful character of cesium chloride as well as the expense and time required to change out irradiators with comparable alternatives while maintaining a level of concern for security threat. Participants constructed the conditions for this decision through the reciprocal use of societal resources and interpretative repertoires at an NRC-sponsored workshop and in other sites such as professional meetings, conference calls, and exchanges over the internet. This chapter revisits the answers to the research questions and then integrates those responses with Bakhtin's dialogism. It then discusses the limitations of this study, how research about expert risk communication fits in the academy, and opportunities for future investigations of this topic.

Revisiting the Research Questions

Chapter V used structuration theory to analyze the societal and discursive resources participants drew on when characterizing cesium chloride. Chapter VI used discursive psychology to explore the way participants employed resources from two interpretative repertoires to characterize cesium chloride and express their views about whether or not to eliminate it. Chapter VII used Laclau and Mouffe's discourse theory to explain the conditions

that gave rise to the particular characterizations of cesium chloride and demonstrate how shifts over time led to creative appropriation of the societal resources and interpretative repertoires.

RQ1: What are the societal resources that enable and constrain expert's talk about risk?

Structures such as the U. S. medical institution, regulatory bodies, national and international legislation and policies, and belief in technology provided rules and resources that enabled participants to legitimize norms such as rationality in decision-making and as well as particular procedures for sharing information and creating policies. Most interview participants recognized that they were constrained by a limited point of view but they balanced this constraint with their view of themselves as rational. The emerging security institution enabled participants to take action to protect the public from terrorist threats—the impetus for the concerns about cesium chloride. The structural constraints equated norm violations with decisions based on politics and emotion, distortion of information, sharing too much security-related information, and expressed desires to ban radioactive materials. These structural constraints also limited participants regarding the kind of information they could disclose due to security issues.

RQ2: What types of evidence and appeals do experts rely on to articulate their characterizations of risk?

Participants used characterizations of cesium chloride as a beneficial technology or as a security threat as an implicit way to express agreement or disagreement with Recommendation #3 of the NAS study. Through their talk about the feasibility of alternatives and security issues, they expressed nuanced positions related to the elimination of cesium chloride such as “since different applications require different technologies, there are instances when alternatives might be preferable” and “we could use an alternative technology but there are large obstacles to this possibility such as expense and reliability.” The interpretative repertoires organized participants’

use of evidence, appeals, and reasoning and highlighted that participants have predictable patterns for drawing on NTIR (Necessity of Technology Interpretive Repertoire) or STIR (Security Threat Interpretive Repertoire) depending on whether they want to characterize cesium chloride as a unique and useful isotope or as a potential security threat. NTIR was a resource that enabled participants to characterize cesium chloride as a beneficial technology by reasoning deductively from scientific principles, operational information, and economic principles. When using NTIR participants appealed to external expertise and organizational affiliation, as well as values of medical need, safe use of equipment, and quality control of a product or service. NTIR relies on risk/benefit and acceptable risk logics and foregrounds the role of government to protect the public by regulating uses of technology. STIR was a resource that enabled participants to characterize cesium chloride as a security threat by using inductive reasoning from professional knowledge, past events, and economic consequences and deductive reasoning from scientific principles about dispersability and solubility. When using STIR, participants appealed to personal expertise, public interest and fear. STIR focused on consequences of a risk and foregrounded the role of government to protect the public by minimizing security threats.

RQ3: How do experts from multiple disciplines negotiate and coordinate their different perspectives?

Answering this question focuses attention on the conditions that gave rise to particular characterizations of cesium chloride and how shifts over time led to the creative appropriation of societal resources and interpretative repertoires. The coordination and conflict processes created conditions for a paradigm shift to which some participants briefly alluded at the workshop and more fully described by several interview participants.

The analysis using discursive psychology demonstrated that even though security specialists at the workshop tried to reinforce the characterization of cesium chloride as a security

threat in order to support NAS Recommendation #3, participants from user communities drew on resources from NTIR to express disagreement by creating nuanced positions. For example, representatives of blood banks shared detailed operational and economic information to support the distinctive position that they "could use an alternative technology but there are large obstacles to this possibility such as expense and reliability." Additionally, some participants who disagreed with the characterization of cesium chloride as a security threat used STIR in an ironic manner to undercut its legitimacy. For example, one participant's hypothetical scenario about x-ray irradiators on parade floats was intentionally extreme in order to highlight his disagreement with the focus on consequences risk logic.

The analysis with Laclau and Mouffe's discourse theory illustrated how key signifiers organized the discourse about cesium chloride and created conditions for characterizing it both as a beneficial technology and as a security threat. Even though key signifiers were well established, the conditions for meaning were always in flux which can be seen through the activity of floating signifiers. The concepts of dispersability and vulnerability kept meanings about the security threat in flux by creating possibilities for coordination while also challenging the premise of the security threat. Different beliefs about the feasibility of alternatives positioned participants in relationship to Recommendation #3 and this lack of certainty about the feasibility of alternatives to replace workload of cesium irradiators and calibrators largely prevented the NRC from deciding to phase out cesium chloride technologies. Finally, politics, the expression of emotion, and shifting professional cultures destabilized participants' professional identities and characterization of each other as rational.

These key signifiers and floating signifiers provided entry points to examine how participants used societal and discursive resources to coordinate their conflict and agreement over cesium chloride. Conflict about security issues illustrated how participants used and

responded to the floating signifiers about the concepts of dispersability and solubility, the distinction between cesium-137 and cesium chloride, and disbelief about vulnerability of theft. The floating signifiers about dispersability and solubility and the distinctions between forms of cesium-137 created possibilities for coordination because they could be supported by resources from both NTIR and STIR and they legitimized both the characterization of cesium chloride as a security threat while opening up a possibility for use of another form of the necessary cesium-137. The floating signifier of user communities' disbelief about vulnerability challenged the legitimacy of the characterization of cesium chloride as a security threat by using NTIR to emphasize the processes of increased controls and hardening and also deviating from the NTIR by inductive reasoning from their operational experiences or appropriating STIR resources in an ironic manner.

Talk about alternatives was a floating signifier that had the potential to create conditions for legitimizing a decision that the NRC can phase out the use of cesium chloride because the beneficial functions could be achieved through x-ray irradiators, other radionuclides, or other forms of cesium-137. However, this topic was a frequent point of disagreement among users because participants' positions about the feasibility of alternatives positioned their views in relationship to Recommendation #3. Participants coordinated their differing views by using the NTIR resources of scientific or operations principles or deviating from NTIR by using analogic reasoning when they wanted to demonstrate the faulty premises of another position. Finally, participants coordinated agreement about a risk logic that enabled them to continue to use cesium chloride technologies for beneficial functions. The coordination processes show that participants relied on risk/benefit logic most frequently because it created a system of reasoning that assumes society will accept certain levels of risk from a technology if the benefits outweigh the risk.

RQ4: What strategies do experts use to legitimize their particular risk understandings and justify choices that result from the risk understandings?

The analysis from discursive psychology explains how accounts about the characterization of cesium chloride become established as stable constructions of the world and how NTIR or STIR were constructed to appear as facts that could undermine the other interpretative repertoire. NTIR was legitimized by structures such as the U.S. medical institution, regulatory bodies, national and international legislation and policies, and belief in technology. Enactment of these structures enabled participants to legitimate norms such as rationality in decision-making and procedures for sharing information and creating policies. STIR is legitimized by the security institution. However, this structure also constrained participants due to secrecy about security information. Additionally, structural constraints about politics, emotion, and legal issues tended to be attributed to participants who used STIR in order to demonstrate how those users were constrained by a limited point-of-view. The ability of interview participants to draw on both interpretative repertoires when providing their summary views of the cesium chloride issues demonstrated that both repertoires were legitimized by structural rules and resources. However, interview participants' use of rhetorical devices to manage the paradox of using resources from both STIR and NTIR ultimately re-established NTIR as a more legitimate interpretative repertoire for communities who manufacture, use, and regulate cesium chloride technologies. Ultimately, these coordination and conflict processes created conditions for a paradigm shift that was briefly alluded to at the workshop and more fully described by several interview participants. The interview participants' accounts demonstrate that the key components of the paradigm shift were immersion in security information and interaction across professional groups over extended periods of time.

Analysis with Laclau and Mouffe's theory revealed three key signifiers that have taken-for-granted meanings and created a sense of objectivity that "appears given and unchangeable" (Phillips and Jørgensen, 2002, p. 36-37): (1) rationality, (2) beneficial technology, and (3) regulatory principles. The master signifier of rationality was a basis for information gathering and decision making and participants often took great pains to highlight violations of rationality that they saw other expert groups exhibiting such as operating from a limited point-of-view, expressing emotion, or being motivated by politics. Participants also took for granted the myths of beneficial technology and regulatory principles. Participants repeatedly reinforced the legitimacy of these key signifiers by drawing out the certainty of harm to patients if medical providers could not irradiate blood in comparison to the uncertainty of terrorist theft and subsequent RDD attack. Additionally, the legitimacy of these key signifiers was further bolstered by the risk/benefit logic that participants repeatedly drew on when characterizing cesium chloride as a useful and unique source. Finally, even though the imperative for the government to protect the U. S. from security threats has a taken-for-granted status, the application of this key signifier to cesium chloride had not yet attained a taken-for-granted status. Floating signifiers that drew on scientific principles, such as dispersability and solubility, legitimized the security concern. Additionally, Congressional interest in securing radioactive sources to prevent their use in terrorism and the NAS Report legitimized the characterization of cesium chloride as a security threat. However, some participants deconstructed the rationality accounts as politicized, emotional responses.

Contributions of a Dialogic View on Expert Risk Communication

In Chapter III, I argued that a dialogic framework was necessary to address three main criticisms within the expert risk communication literature: (1) Risk communication research historically treats expert groups as uniform and does not consider the processes by which they

construct and legitimize risk understandings. (2) Risk communication research tends to privilege transmissive and message-centered approached to communication rather than examine the discursive management and coordination of different risk understandings, and (3) Rather than assuming the taken-for-granted position that objective scientific knowledge is the source of legitimacy for technical risk understandings, risk communication research should examine the way that expert groups legitimate their knowledge claims and emphasize the transparency of norms and values in public discourse.

The multi-perspectival framework enabled entrance into the discourse of experts' risk communication from different vantage points. Three main implications emerge from this study as seen through the lens of dialogism. (1) Expert risk communication in cross-disciplinary situations is a tension-filled process. (2) Experts who interact in cross-disciplinary situations manage the tension between discursive openness and closure through the use of shared resources between the interpretative repertoires, immersion and interaction with other perspectives, and the layering of risk logics with structural resources. (3) The emergence of security risk Discourse in a post-9/11 world involves a different set of resources and strategies that risk communication studies need to address.

Dialogical Tensions in Expert Risk Communication

Traditional approaches have tended to minimize the contradictory, paradoxical, and tension-filled qualities of risk communication. This omission is odd as the communication field generally and organizational communication studies specifically have embraced the notion that communication practices are riddled with dualities, oppositions, and contradictions (Trethewey & Ashcraft, 2004). This study takes an important first step in addressing this omission by identifying four main tensions that experts must manage in cross-disciplinary risk communication: (1) contradictions from historical layering, (2) tensions among disciplinary and

professional groups, (3) tensions within personal and professional identities, and (4) tensions among realist and constructivist ontologies.

Contradictions from historical layering. Experts demonstrated that they are socially responsive to each other through their interanimation of other voices and ability to construct utterances that respond to outward criteria for usage of words. Bakhtin (1981a) writes that, "The living utterance…cannot fail to brush up against thousands of living dialogic threads, woven by socio-ideological consciousness around the given object of an utterance" (p. 276). The object of the utterances in this study is the characterization of cesium chloride. The socio-ideological consciousness consists of the societal resources and constraints, the interpretative repertoires that create conditions to assign meaning and legitimize decisions about cesium chloride. Because of this dialogic characteristic of discourse, utterances contain "criteria for the social usage of words" that imply the views of other social actors' positions and carries meanings about responses to past positions and anticipation of future responses. The socio-ideological consciousness, with its criteria for social usage of words, is an "activating principle [that] presupposes the ground for active and engaged understanding" (Bakhtin, 1981a, p. 282). Thus, meaning lies in the interaction between the speaker and the anticipated response.

The structuration analysis in Chapter V demonstrates that the way experts related to the cesium chloride issue were responsive to a context including historical precedents, legislation, political forces, other professional groups, and beliefs in technology to address patient needs and radiation protection needs. The experts in this study were knowledgeable actors who used a diverse repertoire of strategies and information and societal resources in order to meet the "criteria for social usage of words" by adapting to the social conditions of the cesium chloride issue. However, experts were not always successful due to constraints and violations of norms. For example, participants demonstrated awareness of criteria for social usage of words in their

responses to the different but equally legitimate values that were underlying the two primary characterizations of cesium chloride: as beneficial technology or a security threat. These contradictory values represent "the co-existence of socio-ideological contradictions" (Bakhtin, 1981a, 291) because the beneficial technology characterization is legitimized by historical precedent of the civil use of radioactive materials and this ideology is becoming layered with the relatively new ideology that considers how terrorists would use technology in harmful ways. Thus, these two historical ideologies become layered in the discourse, and the social criteria for usage of words prevented participants from completely discounting either view, so they had to carefully manage the paradox through rhetorical devices. Additionally, participants' characterizations of the NRC decision as "rational" or "obvious" illustrated their awareness of criteria that a rational decision, made by following norms of information gathering and policy-making procedure, would be considered legitimate. The legitimacy of rationality arises from the historical layering of beliefs about objective decision-making of the rational-actor model in policy-making (Garvin, 2001) positioned against the participants' view of others as having fear-based or limited points of view. Given the contradictions that arise from historical layering of ideologies, this study offers insight into conditional state of characterizations of risk and strategies by which participants legitimatize or de-legitimatize characterizations.

Tensions across disciplinary and professional groups. A dialogic view of expert risk communication invites exploration of traces of value judgments and other social issues layered in the discourse that led to nuanced disagreements in expert risk communication. Analyses of conflict in Chapter VII demonstrate that participants recognized the nuanced positions in relationship to Recommendation #3 and also responded to slightly different appropriations of interpretative repertoires. For example, at the workshop, calibration physicists, representatives of blood banks, and equipment manufacturers challenged each others' nuanced positions about the

feasibility of alternatives (Table 5.3). The analysis of these exchanges in Chapter VII demonstrates that, in general they all drew on resources of NTIR, but when they could not achieve their goals, the participants used inductive or analogic reasoning to challenge the premise of the other parties' position. In another example, the user community implicitly considered that Recommendation #3 was based on the risk logic that focuses on consequences. Thus, from their point of view, Recommendation #3 violated rationality because the NTIR resource enabled a rational characterization and decision about cesium chloride based on a risk/benefit logic. In actual interactions, these risk logics rarely surfaced explicitly in the text, but were layered into the discourse and recognizable by other knowledgeable actors. Moral "accents" of risk communication exist in expert risk talk because the traces of other voices are always present (Wertsch, 2001). From a dialogic point-of-view, the nuanced disagreements have an evaluative accent and therefore are about morality, responsibility and blame—even if the surface of the language appears to consist of detailed technical, scientific, or operational data. External observers may find the source of disagreement difficult to ascertain but experts are knowledgeable actors within the context of the cesium chloride and have awareness of the nuanced distinctions. Thus, this study offers an explanation for conflict across disciplinary and professional groups because it foregrounds the complex layering of the discourse that gives rise to different positions that is readily recognizable and challenged by knowledgeable actors.

Tensions within personal and professional identities. A dialogic view of expert risk communication demonstrates that professional and personal identities are in a tensional relationship that participants manage in order to build and maintain credibility. Chapter V demonstrated that NTIR and STIR use different discursive resources for formulating credibility appeals. Of particular note, the NTIR strategy of appealing to external expertise and organizational affiliation is a response to the normative criteria of rationality. However, in some

ways this creates a constraint for the experts who may have professional, individual views. This is evident in the last session of the workshop when participants deconstructed their professional selves by "taking off their hats" and expressing their personal views. Their statements prefaced with phrases such as: "I would like to add a personal comment, not from CRCPD," and "I'm going to speak for myself since everybody else is taking hats on and off." This symbolic change in identity demonstrates participants' awareness that a change in the criteria for usage of words had occurred and they were now allowed to fully express their views about the cesium chloride issue. Additionally, the tension within professional identities is apparent in accounts of the paradigm shift, especially Smith whose security-related assignment caused a shift in his professional identity which helped him to make a paradigm shift to embrace both characterizations of cesium chloride. This suggests that it is important for expert risk communication to pay closer attention to the way personal and professional identities come into play during the negotiation of risk understanding.

Tensions between realist and constructivist ontologies. A dialogic view of expert risk communication helps understand the legitimacy of divergent characterizations of cesium chloride because one can see how threads of meaning negotiate the tensions between realist and constructivist ontologies. Most expert risk talk consists of physical cause and effect relationships about hazards—scientific and technical discourse underscored by the realist ontology. However, if the hazards have not yet manifested then the experts' talk also contributes to the social construction of the risk's meaning by making claims about priorities that are underscored by political, economic, or moral values. In this way, expert risk talk imbues the possibility of risk and its perceived causal agents with values and expectations (Douglas, 1990; Taylor & Kinsella, 2007). In the cesium chloride issue the participants frequently referenced the physical properties of material reality such as the chemical forms of cesium-137, the engineering principles of

equipment, and actions to implement increased controls in their organizations. These physical realities constrain social constructions, but social constructions have implications for what people plan to do to change the material reality, if anything.

One example of this mutual constraint can be seen in the physical properties of the chemical form of cesium chloride in its current powder form. The current form of the isotope is relatively affordable and used in reliable irradiators and is therefore a good medical technology that meets the needs for patient health. However, this same form is very soluble and dispersible which makes it a security concern that could be used in a dirty bomb to harm the public. The characterization of these "real" properties imbues the isotope with values that become a legitimate premise for a decision. In particular, user groups use the social construction of time to argue that an elimination of cesium irradiators would cause certain harm to patients whereas the actual probability of a cesium security event is less certain. The argument about certainty legitimizes a decision to allow continued use of cesium chloride. Furthermore, experts must continue to manage this ontological tension because discussion about the chemical form of cesium chloride both explains the potential security-related consequences and the basis for a technological solution. And as the physical property of cesium chloride becomes more constructed as a critical dimension of its security concern, regulators will have to revisit their current scheme of categories.

Another example of the mutual constraint of the realist and constructivist ontologies can be seen in the ways that participants talk about increased controls. Participants from user groups work in an environment of physical barriers, access authorization, and background checks. They reference this physical reality to help them socially construct sense of invulnerability to theft. Additionally, since the belief in radiation protection is based on scientific properties of exposure to radioactive sources, this physical reality makes it difficult for user communities to construct a

belief that terrorists would not be concerned with an overexposure. Alternately, security specialists refer to the real historical record of failed security controls to construct a belief that no amount of increased controls could eliminate the vulnerability risk of theft of cesium chloride. They use the "Red Team" video to make this vulnerability seem "real." However, they must rely on analogic arguments to 9/11 to help user communities believe that terrorists would do anything to carry out their plans—even risk high exposure to a radioactive source.

A final example of the mutual constraint of the realist and constructivist ontologies is how user communities talk about alternatives to cesium chloride. Some alternatives, such as a ceramic glass form of cesium-137, pathogen technologies, or high energy x-ray irradiators have scientific basis for belief in their possible development, they just have not had enough time to fully develop into marketable products. Thus, these alternatives do not physically exist, but the alternative form of cesium-137 is attractive because it would enable user communities to continue their functions. Other alternatives, such as current x-ray irradiators or cobalt-60 irradiators, have capabilities to perform the same physical function as cesium irradiators, but these alternatives are constructed as possible but not reliable or cost effective. Thus, the first set of alternatives do not physically exist but are constructed as an attractive option whereas the second set of alternative do physically exist but are constructed as a less attractive option. This complicated negotiation of the realist and constructivist ontologies can be seen in how participants labeled cesium-137 as a "workhorse," "gold standard" and "perfect isotope" based on its physical properties. Alternately, x-ray irradiators are frequently labeled as "back-up" and "unreliable." A dialogical perspective toward risk communication allows theorists and researchers to move closer toward exploration of the interconnection between realist and constructionist ontologies and tease out the ways they may simultaneously oppose and join with each other.

Managing Discursive Openness-Closure Duality in Expert Risk Communication

The previous section highlights four main tensions present in cross-disciplinary expert risk communication. This section explores how experts keep these tensions in living reflexive relationships (internally persuasive discourse) while also creating discursive closure through boundary building activities (authoritarian discourse). This tension between discursive openness and closure is not surprising as Bakhtin notes that processes to centralize or decentralize meaning are always at work within discourse. To the degree that discourse permits other voices to interact, Bakhtin writes that "language is transformed from the absolute dogma it had been within the narrow framework of a sealed-off and impermeable monoglossia into a working hypothesis for comprehending and expressing reality" (Bakhtin, 1981b, p. 61). The degree to which discourse creates boundaries to isolate meaning or expands connections among meanings, largely determines the outcomes of centripetal or centrifugal forces. Laclau and Mouffe maintain that this exploration of ideology is important to examine because it masks the contingencies of knowledge and hides alternative possibilities of meaning (Phillips & Jørgensen, 2002). The workshop and other interactions enabled these encounters across professional and disciplinary groups and the decentralization of meaning around the characterization of cesium chloride. These possibilities for internally persuasive discourse overcome strong and still-existent tendencies of authoritarian discourse and reification of cesium chloride as either a beneficial technology or as security threat. There are three main explanations for how cross-disciplinary expert risk communication manages the tension between discursive openness and closure: (1) shared resources between the interpretative repertoires create opportunities for shared meaning, (2) immersion and interaction with other perspectives create conditions for maintaining discursive openness, and (3) the layering of risk logics with structural resources reinforce discursive closures.

Shared resources create opportunities for shared meaning. In the cesium chloride issue, participants were able find opportunities for internally persuasive discourse when floating signifiers created conditions for change and resources of the interpretative repertoires overlapped. However, when key signifiers mutually reinforced each other by drawing on societal resources and interpretative repertoires did not overlap, experts maintained disagreement about characterizations of cesium chloride and the security implications of those characterizations. The analysis from Chapter VII demonstrated that floating signifiers gained some level of legitimacy, which decentralized meaning and created a tension and paradox that remain unresolved in the discourse. The root of tension is that not all participants attribute legitimacy to floating signifiers about security concerns of cesium chloride—although, very few interviewees expressed disagreement with security concerns. Rather, they attributed this disagreement to other colleagues. Chapter VI demonstrates that participants created a paradox when they drew on both interpretative repertoires in a single statement and used one of four rhetorical devices to manage the felt inconsistency. These rhetorical devices are resourced by structural resources and institutions and ultimately reaffirm legitimacy of NTIR.

The most obvious shared resource among the interpretative repertoires is the use of deductive reasoning from the physical properties of dispersability and solubility described in Chapter VII. A more nuanced shared resource is the 9/11 logic. It may be that when participants from user communities appropriate STIR in an ironic manner, they seem to be building boundaries to reinforce the risk logic of NTIR. However, using another interpretative repertoire paradoxically may open the discourse to the 9/11 logic which lends some legitimacy to the characterization of cesium chloride as a security threat. Thus a “working hypothesis” for expressing risks about cesium chloride can be seen in the paradoxes that become apparent when participants draw on both interpretative repertoires.

Immersion and interaction create conditions for discursive openings. Another "working hypothesis for comprehending and expressing reality" can be seen through interview participants' accounts of moving through a paradigm shift. A dialogic view of the three accounts of paradigm shifts in Chapter VII explains that the participants intentionally moved into different conversations about cesium chloride and in doing so created conditions for internally persuasive discourse through the immersion and interaction with different disciplines and professional groups. The activity of floating signifiers analyzed in Chapter VII decentralized the taken-for-granted values of beneficial technology that was legitimized by legislation, regulation, radiation protection logic, and precedence of civil uses of radionuclides. At the beginning of the cesium chloride issue, the characterization of cesium chloride as security concern was a completely new concept to most of the user community. The authority of the National Academy of Sciences and Congressional interest legitimized the characterization of cesium chloride as a security threat. The NRC workshop and other sites of interaction (Table 5.1) created opportunities for cross-disciplinary interaction and the internally persuasive discourse. Over time experts from the user communities appear to be incorporating security concerns into their discourse and even if they continue to disagree with aspects of security concerns, they couch their statements very carefully because of the societal sources that legitimate security concerns. The implications of the ideological struggle for the characterization of cesium chloride ultimately manifest through the construction of a security-minded culture within the user communities. Even though Chapter VII demonstrated that conditions for a paradigm shift exist, not all members of user communities have access to the requisite information, interactions, and professional work. An important question for expert risk communication is how these conditions of immersion and interaction can be developed and whether other conditions might also create the construction of a constructive tension between internally persuasive and authoritarian discourse.

Discursive closures reinforced by norms, government, and risk logics. Even though floating signifiers and shared resources from interpretative repertoires created opportunities to keep the tensions in living reflexive relationship, these opportunities for interplay of meanings were only allowed within the parameters of normative rationality, government responsibility, and the risk/benefit logic.

Initially in the cesium chloride issue, participants from user communities were very upset and reinforced their beliefs about the beneficial use of cesium chloride using resources from NTIR in an authoritarian manner that did not permit interplay with meanings and understandings from the STIR—especially the view that security concerns about cesium chloride merited the elimination of this technology. These boundaries were built because Recommendation #3 violated their norms and was not supported with resources from NTIR. Furthermore, these participants constructed the security-related view as being irrational and motivated by fear and politics. However, participants also recognized the Congressional interest about the security concerns and accounted for NRC's deliberative process as having to legitimize their decision to allow for the continued use of cesium chloride to these political forces. As demonstrated in Chapter V and Chapter VII, experts built boundaries by taking up nuanced positions. Throughout the workshop and interviews, they expressed agreement and disagreement with each other based on criteria of rationality. Participants constructed their expertise as rational, especially in the relationship to limited points-of-view and fear-based premise. Chapter VII suggested that rationality is key signifier that participants treat as taken-for-granted and, as such, objective. Since participants treated rationality as objectively given and considered their views as more rational than other views, then they acted as if they were constrained by this key signifier.

Chapter III argued that in situations that have a strong tendency toward centralized meaning statements that align with the authorities are viewed as more legitimate because the combination of ideological values with scientific discourse centralize meaning. As demonstrated in Chapter VII, this clearly happened with the layering of the key signifiers of regulatory logic and beneficial technology to legitimize the risk/benefit logic as a basis for rationality. The rationality based on risk/benefit logic acts as a screen to filter out positions based on the risk logic that focuses on consequences. The risk/benefit logic and government responsibility to regulate are resources in NTIR that are crucial to the logic of increased controls and hardening programs. These organize user communities' definition of the problem and what counts as a reasonable solution. Clearly meaning is centralized around these concepts which are fundamental to risk management (Löfstedt, 2005). Additionally, views about security concerns also centralized meaning by aligning with societal resources of the security institution, Congressional interest, and public interest to avoid terrorist attacks. However, the cesium chloride issue demonstrates that concerns about security meet resistance when they challenge technological benefits and economic values because these key signifiers are more taken-for-granted and embedded in the discourses. As a result, members of user communities can believe it is perfectly rational to, at least partially, discount security concerns and maintain current safe use of radioactive sources since they believe the benefits outweigh the risks. In the meantime, the authoritarian discourse of security that keeps information secret for important national security reasons, also constrains users from gaining access to information and cross-disciplinary interactions that could enable a paradigm shift to embrace both characterizations of cesium chloride.

Emergence of Security Discourse in Risk Communication

This study demonstrates that security risk discourse may be distinct from other Discourses that are traditionally present in the risk communication literature and has gained prominence since the terrorist attacks of September 11, 2001. Chapter II describes the historical efforts to identify patterns of risk communication among lay and expert groups and argues that more research is needed about cross-disciplinary expert interactions. Additionally, Garvin (2001) draws distinctions between policy-makers, scientists, and the public. However, the data from this study demonstrates how the communication of security concerns for the purpose of managing risk is legitimized by political institutions and have their own repertoire of patterns and strategies. The category of risk communication creates a new "other" to which experts must address and legitimize their risk characterizations. Even though, this study did not include interviews with security specialists, the security perspective is interanimated through all the respondents as they positioned their views in relation to the security concern about cesium chloride and Recommendation #3 of the NAS study.

The implication of security Discourse is that it relies on a different cultural mindset than the safety culture mindset. Members of user communities are accustomed to attending to safety, the prevention of accidental exposures, when working with radioactive material; however, security culture considers exposures from a different vantage point, that a terrorist is intentionally seeking to cause harm (Kripunov, 2005). As can be seen in the transition that user communities are making to the 9/11 logic, the mindset and values associated with a security culture are in the process of being constructed and incorporated. In conjunction with this development, traditional studies of technical and public Discourses of risk are having to respond to the security Discourse that is becoming more pervasive in society (O'Hair & Heath, 2005). As security Discourse becomes more prevalent, the public will most likely respond the to risk

logic that focuses on consequences whereas experts from different disciplines and professions will behave like the participants in this study and draw on risk/benefit and acceptable risk logics. The premise of Larsen's (2007) book *Our Own Worst Enemy*, that in order to ensure homeland security we must learn to ask the "right questions," implies that talk about these risks socially constructs our knowledge about them and the "question" trope invokes a dialogic, conversation view of these interactions. One of the workshop participants invoked this kind of thinking, "we should strive to ask the right questions to the extent that that is possible." Thus, individuals involved in risk talk about security inevitably find themselves strategically drawing on or responding to discursive resources of STIR or other security-related repertoires and this has implications for how these instances of risk communication construct knowledge about and legitimize or de-legitimize security risks (Ayotte, Bernard, & O'Hair, 2009).

Furthermore, the security discourse faces challenges due to the constraint of secrecy. The barrier building activity of the authoritarian discourse of security that keeps information secret for important national security reasons constrains users from gaining access to information and cross-disciplinary interactions that could enable a paradigm shift to embrace both characterizations of cesium chloride. Larsen (2007) calls this security constraint "the wall"—a description of "laws, policies, and cultural barriers that prevent or hinder the flow of information and other efforts in the fight against international terrorism" (p. 149). Larsen attributes the complexity of this subject to the ever-changing laws, policies, and interpretations that lead to honest mistakes or intentional misrepresentation. One interview participant explicitly describes how this constraint affected her: "That was the most frustrating part…it's been the piecemeal part to say that we're doing this to mitigate the risk. We can't tell you what the risk is. Just trust us. That's what's been hard for my industry to deal with." This participant had a background in the military and fully respected secrecy for national security, but she could not help but feel the

impact of this secrecy on how she and her industry were able to understand and mitigate security risks. One implication of the secrecy is there are probably at least two different interpretative repertoires for security threats: a public one that has been discussed here and a private one that has a different set of resources and this is inaccessible to the public.

Limitations and Future Opportunities

Limitations

Any one case study has a natural limitation—that it has only examined one instance of a particular phenomenon. As such, the case study approach is not designed to be generalized to other situations, but rather to gain local, contextual knowledge that foregrounds the particularities and tensions of the phenomenon of cross-disciplinary expert risk communication (Chen & Pearce, 1995). Additionally, the in-depth investigation of this case of cesium chloride is appropriate because this study explores the explanatory power of a dialogic theory (Titscher, Meyer, Wodak, & Vetter, 2002) and provides detailed insights that can guide future research about cross-disciplinary expert risk communication.

Another limitation of this study is that I was the only coder of the data. However, I was able obtain a form of member checks (Lindlof & Taylor, 2002) by sharing initial findings of the study with nuclear engineers and security specialists at a mid-winter meeting of the American Nuclear Society. The feedback following this presentation provided encouragement and additional insight for the analysis of that project. Additionally, as an employee of the Nuclear Regulatory Commission, a typical feature of my work involved conversations with NRC about a wide variety of nuclear risks and I became accustomed to patterns of talk in scientific, engineering, and regulatory communities.

The third limitation of this study is that I was not able to secure an interview with security specialists. As noted in the methods section, despite my insistence that I would not ask

for any security-related information, several potential participants declined to participate in interviews due to the security dimension of this project. Most refusals came with general statements about how their organizations' general counsel or public affairs office discouraged or forbade participation. The supervisor of one potential participant said they he preferred that they only communicate about this issue with individuals or groups authorized by the Federal government and referenced me to publically available information. In order to ensure my trustworthiness, another potential participant requested that my security clearance be transferred before granting an interview, but NRC refused to transfer my clearance since I was doing this work as part of my doctoral program and not for the NRC. This is a typical constraint for doing security work (Chess & Johnson, 2009)—especially about a policy issue that is still under development. Chess and Johnson (2009) argue that this constraint can be partially overcome by incorporating well-developed research in organizational communication theories into the limited available data for security-related issues. Additionally, one potential participant told me when she declined to be interviewed that she would be glad to participate in the research topic of expert risk communication given its importance and relevance to her work, but since I was studying a very specific issue under policy-development and with Congressional interest she could not participate. She suggested that I could get more interview participants if I set up my study on a more general study of cross-disciplinary expert risk communication.

Future Opportunities

Insights about how a topic, such as cesium chloride, becomes characterized largely determines the implications of risk decisions about that topic. Post-hoc analyses of every major accident discover the possibility for people to recognize the danger in time to take mitigative actions. The security concerns of the cesium chloride issue represent a case when officials are trying to characterize a danger in order to prevent an accident or attack.

Future research about cross-disciplinary expert risk communication can examine additional cases to look for shared patterns and how the idiosyncrasies of the cases shape discourse. Shared patterns across cases would have broader theoretical implications about what discursive and societal resources are layered into expert risk communication. As further research identifies the idiosyncrasies of different cases of expert risk communication, comparisons of these cases may create a vocabulary of cross-disciplinary situational categories that experts may find themselves having to coordination and legitimize different risk characterizations. For example, cases of expert risk communication within an organization may be different than cases that occur in public context. Additionally, further cases of expert risk communication could explore whether or not there are typical sets of complementary or contradictory values that are layered into expert risk discourse that must be negotiated during their interactions.

Future research can also examine the transformative learning aspect of cross-disciplinary expert risk communication. Several authors advocate how surfacing values contribute to social learning in risk communication (Funtowitz & Ravetz, 1992; Strydom, 2008; Wynne, 1992). These values can be surfaced during interactions within organizations. In this environment, a dialogic view of expert risk communication can contribute to theories of organizational knowledge and communities of practice (Iverson & McPhee, 2002). Values can also be surfaced in public spaces, such as public meetings, and for these environments a dialogic perspective can examine how the public space shapes expert interactions across disciplines and professions, with an eye toward creating a transformative learning experience (Barge, 2006; Hamilton & Wills-Toker, 2006; Peterson & Franks, 2006; Walker & Daniels, 2004).

Finally, a dialogic view of expert risk communication may provide additional explanation about the phenomenon of collective minding in high reliability organizations (Weick, 1987; Weick & Roberts, 1993). Conversely, the emphasis on maintaining active

engagement of the tensions in expert risk communication may provide insight how organizations build and maintain safety and security culture, especially organizations responsible for managing complex, high stakes risks. Finally, the tension between realist and constructivist ontologies in expert risk communication may extend the work of "materializing" organizational communication, especially related to materiality evident in organizational objects, sites, and bodies that contribute to or mitigate risks (Ashcraft, Kuhn, & Cooren, 2010).

Summary

This project demonstrates how security risks shapes organizational decisions and priorities in both policy-making and regulatory organizations and private-sector and functional organizations. In order to address these risks, both types of organizations need expertise across professional disciplines. How these experts characterize a risk largely determines policy development and the implementation of mitigation measures at the functional level. In the case of cesium chloride issue, the interaction of experts negotiated conflict about the characterization of this isotope as a security threat or as being useful and unique. Even though participants and organizations vary in their how they characterize cesium chloride, most maintained some level of balance between both characterizations—a balance that was constructed through their interactions with each other.

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APPENDIX A

INTERVIEW GUIDE

1. Please describe your understanding of the situation.
    a. What do you see as the risks and the benefits associated with the situation?
    b. What scientific and technical information do you feel is critical for understanding the situation?
    c. Are there other relevant non-technical aspects of the situation?
2. What event stands out in your mind as critical to develop your current understanding of the situation?
    a. Did the event act as a turning point in which you changed some of your thinking? If so, what aspects of the situation prompted the change?
    b. Did the event function to solidify your understanding of this issue? If so, what aspects of the situation reinforced your thinking?
3. Please describe an interaction that you have had with a colleague in which you expressed disagreement regarding this issue.
    a. How would you characterize the different points of view?
    b. How would you characterize the emotional quality of the interaction?
    c. What would you say to someone who disagreed with you for [this reason]?

APPENDIX B

QUESTIONS AT NRC WORKSHOP

Issue No. 1.1: Feasibility of the Use of Other Forms of Cs-137

Q1.1–1. Are manufacturers currently considering the use of other forms of cesium (other than CsCl)? If yes, what are such considerations?

Q1.1–2. Is the use of other forms of cesium feasible? If so, please describe desired methods and discuss any benefits or obstacles (*e.g.*, intended function of source, costs, timeframe).

Q1.1–3. (a) Would the effect of density loading with different forms of cesium preclude their use in existing devices?

(b) Would it require modification of existing devices?

Q1.1–4. Is it feasible that high-activity (*e.g.*, IAEA Category 1 and 2) cesium sources will be available in alternative material forms? If so, what is the estimated timeframe for manufacturing?

Q1.1–5. Since all the CsCl is manufactured in Mayak, Russia, is it known if the cesium source producer can modify its production process?

Q1.1–6. Would other entities (in the U.S. or worldwide) engage in manufacturing sources with alternative forms of Cs-137?

Issue No. 1.2: Feasibility of the Use of Isotopes Other Than Cs-137

Q1.2–1. (a) Can cobalt-60 (Co-60) be substituted for radioactive CsCl for any applications? (b) If so, what types of applications? (c) If not, why not?

Q1.2–2. Can the shielding challenges for Co-60 be addressed by switching from lead shields to more effective tungsten or depleted uranium shielding?

Q1.2–3. What are the attendant risks associated with Co-60 source transportation?

Issue No. 2—Use of Alternatives Technologies

Q2–1. Are X-ray generators already commercially available as substitutes for applications that do not require the gamma rays with Cs-137 and Co-60?

Q2–2. Are X-ray tubes cost-effective considering the initial cost, operating costs, and requirements for more maintenance for periodic calibration and replacement than radioactive sources?

Q2–3. Is there any indication that the performance of the alternatives will change (improve or worsen) with respect to Cs-137?

Q2–4. Regarding the availability of alternative technologies, (a) what is the timeframe of future availability of each alternative, and (b) what is the cost for each of the alternative technologies (capital costs, operation costs, cost to users)?

Issue No. 3.1: Potential Rulemaking Issues and Justification for Regulatory Change

Q3.1–1. (a) What would be the medical consequences if CsCl was to be banned for medical (*e.g.*, blood) irradiators? (b) What would be the impact to existing and future biomedical research using these devices? (c) Can alternative technologies be used for medical applications and/or biomedical research (research on animals and tissue?)

Q3.1–2. (a) What would be the consequences if CsCl was to be banned for irradiators that are used for industrial and calibration purposes? (b) What is the impact on existing American National Standards Institute (ANSI) standards and licensee conditions that require the use of Cs-137 for calibration purposes?

Q3.1–3. What would be the economic consequences to users if CsCl was to be banned?

Q3.1–4. What would be the economic consequences to vendors if CsCl was to be banned?

Q3.1–5. (a) Should the NRC discontinue all new licensing and importation of these sources and devices? (b) What is the regulatory basis? (c) Who (NRC, DHS, or jointly) should conduct the risk analysis?

Issue No. 3.2: Transportation and Storage Issues Associated With Removal of CsCl Sources From Licensee Facilities

Q3.2–1. (a) Are there transportation packages available for transportation? (a) Who should bear the transportation costs?

Q3.2–2. (a) How could the current CsCl sources be disposed given that CsCl is defined as a ''Greater Than Class C'' source and currently has no disposal mechanism in the U.S.? (b) If disposal was made available by DOE, what would be the cost of disposal?

Q3.2–3. (a) Where could the decommissioned sources be stored? (b) What disposition options are needed in the United States?

Issue No. 3.3: Consideration of Government Incentives and Voluntary Actions by Industry and Manufacturers

Q3.3–1. Should the Federal government issue incentives to implement replacements?

Q3.3–2. (a) Are there feasible incentives to shift users away from radioactive CsCl for users? (b) Manufacturers?

Q3.3–3. (a) What incentives should the Federal government provide to licensees to decommission their existing sources or devices because the devices still have use value? (b) For licensees that are defined as ''not-for-profit'' (*e.g.*, hospitals), what type of incentives could be made available to change technologies?

Q3.3–4. How can the Federal government compensate licensees when they are forced to decommission these sources? Should compensation include the cost of the replacement technology? Decommissioning?

Issue No. 3.4: Impact of Potential U.S. Changes to Regulating CsCl on the International Community

Q3.4–1. How can the U.S. prevent recovered sources from decommissioned devices (or the devices themselves) from being sold outside the U.S.?

Q3.4–2. (a) If the U.S. decides to ban the use of CsCl sources, should the U.S. have a position in denying or eliminating after-market sales of CsCl irradiators outside the U.S.? (b) Would this be potentially denying medical care to developing countries?

Q3.4–3. What should the role of the International Atomic Energy Agency (IAEA) be in assisting the U.S. in ensuring the safe and secure use of CsCl sources and devices?

Issue No. 4—Additional Requirements for Enhanced Security of CsCl Sources

Q4.1. Should the NRC and Agreement States require more stringent security measures than those currently mandated (*e.g.*, should additional requirements be implemented for IAEA Category 1 and 2 sources)?

Q4.2. Should the NRC and Agreement States require more stringent security measures for lower than Category 2 CsCl sources and devices (*e.g.*, Category 3 sources)?

Q4.3. Would additional security requirements for CsCl create a disincentive for owning them?

Issue No. 5—Role of Risk Analysis in Potential Future CsCl Requirements

Q5.1. (a) How should the NRC determine the economic and social disruptions/impacts to the public, licensees, and the environment? (b) How should these factors be measured in decision making?

VITA

Name:	Dorothy Collins Andreas
Address:	Communication Division Pepperdine University 24255 Pacific Coast Highway Malibu, CA 90263
Email Address:	dottielynn99@gmail.com

Education:	B.S., Interdisciplinary Studies, Texas A&M University, 1999 M.A., Communication Studies, Texas State University-San Marcos, 2005 Ph.D., Communication, Texas A&M University, 2010
Awards:	2010 U.S. Senator Phil Gramm Fellowship, Texas A&M University 2010 Department of Communication, Tiffany Hunnicut Award 2009 College of Liberal Arts Dissertation Fellowship, Texas A&M University