THE COMMUNICATIVE ACCOMPLISHMENT OF KNOWLEDGE IN COLLABORATIVE WORK: TEXTS, CONVERSATIONS AND SOCIAL MATERIAL PRACTICES

by

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scholarly work in the above mentioned discipline.
ABSTRACT

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Communicative Accomplishment of Knowledge in Collaborative Work: Configuring Texts, Conversations and Social Material Practices

Dissertation directed by Associate Professor Matthew A. Koschmann

Over the past thirty years, science research in the U.S. has faced increasing demand for collaboration across disciplinary and organizational divides, with varying success. This dissertation study traces a federal research laboratory facility through organizational changes implemented toward achieving greater cross-disciplinary collaborative capacity. The particular interest driving this study is to discern and trace the role of disciplinary expert knowledge as a potential resource and/or obstacle for situated, collaborative problem-solving. To examine the mitigating role of expert knowledge toward the achievement of problem-centered collaborative knowing, I study laboratory and building management meetings involving a committee of scientists and building workers representing a number of research units and building systems workers. Through participant-observation during these collaborative management meetings, and by asking follow-up questions during interviews with those involved, I document the collaborative communication and resulting texts produced by the committee as they raise, discuss and resolve the building and laboratory issues experienced during these organizational changes. Key findings center on the way that collaborative talk became encoded into organizing texts that provided a common vision of the organization and collaborative work, by linking together and configuring organized meanings, narratives, practices, material (spatial and object) understandings and, in the process, specifying worker relationships. Together, these configurations resulted in a new type of expert knowledge: a textual compilation of building
knowledge that replaced prior “silo-ed” laboratory-specific expert knowledge/practice combinations.
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CHAPTER ONE

INTRODUCTION

In June of 2008, at a research laboratory on the Boulder campus of the National Institute of Standards and Technology (NIST), two scientists are conducting research for a collaborative project with the Los Alamos National Laboratory. The project involves developing improved sensors capable of measuring alpha and gamma radiation released from radioactive materials in “dirty bombs”. To conduct the experiment, the scientists have acquired three small samples (.05 mL each) of a plutonium isotope under the direction of a project leader. The plutonium samples, which have the appearance of a brown powder, were protected within two containers: most immediately, a glass vial, which was then contained within a second, more protective metal can.

In order to gauge the sensitivity of the sensors being developed, however, one of the two scientists (now working alone) opens the metal can and handles the glass vial of plutonium directly with his bare hands, maneuvering the vial around the test sensor for data collection. Shortly after, the scientist notices something wrong: a crack in the glass vial. He puts the vial into a plastic bag, then back into the metal can, and returns it to a storage cabinet. He turns the test sensor off, leaves the immediate experiment area, washes his hands in the laboratory sink, and casually heads for his office to discuss data analysis with his colleague. On the way, he stops briefly at the project leader’s office to tell him that “there might be a crack in the glass bottle” of plutonium. Ten minutes later, the project leader inspects the plutonium source and finds not just a crack in the vial, but that the entire bottom had broken out; the plutonium was no longer in the vial, and traces of brown powder are evident in the plastic bag. With this discovery, the project leader recognizes the seriousness of the situation, and calls for an evacuation of the laboratory. However, the alarm has come too late: radiation sensors show a high reading around the lab,
including the sink area and the path leading out of the lab and into the hallway. The brown plutonium isotope powder had been spread on the scientist’s hands, his clothes, and on the bottom of his shoes, contaminating not only the space in and around the lab, but also the sink where he washed his hands, and more significantly, the water pipes leading to the Boulder city sewer system. The plutonium spill soon made local and national news. The ensuing investigation revealed that at least 22 NIST workers tested positive for traces of plutonium on their body or clothes. At least two had inhaled or ingested the airborne plutonium powder. The city of Boulder began monitoring the sewer lines through the city for radioactivity. The U.S. Nuclear Regulatory Committee (NRC) revoked NIST-Boulder’s permission to handle radioactive materials, and NIST’s safety procedures came under intense scrutiny.

On July 30, 2008, an internal review committee published a 62-page report detailing the findings of their investigation into the incident. Surprisingly, despite the obvious carelessness of the individual scientist who handled the plutonium, the blame for the accident is placed primarily on NIST as an organization. In sum, the committee found that NIST-Boulder had poor safety procedures in place for handling hazardous materials, poor safety training for scientists who handle the materials, and cluttered and cramped laboratory space that led to unsafe work plans and practices during experiments. In response, the administrators at NIST-Boulder promised a complete revamping of their safety protocols and training program for scientists.

By all measures, the plutonium spill was a shock for everyone, both inside and outside of NIST. Yet, the full weight of that shock can only be understood by considering the paradox that the spill seemed to represent. In the years and months leading up to the incident, NIST-Boulder maintained a world-class reputation for precision measurement research. As of 2008, NIST-Boulder was home to one of the world’s most accurate atomic clocks, two Nobel laureates (soon
to add a third in 2012), a National Medal of Science, and two MacArthur Fellowship "genius grants." By the merit of their productivity alone, NIST-Boulder appeared to be an exemplar of innovative, collaborative research. As the primary scientific research organization under the U.S. Department of Commerce, NIST is responsible for “promot[ing] U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life” (NIST, 2015a). At NIST-Boulder, scientists from five separate research divisions work in neighboring labs to “produce high-quality products for electronics, communications, optics, nanotechnology, public safety, biosciences, forensics, defense, and environmental applications” (NIST, 2015b). The high level of technicality, precision and productivity of the research conducted at NIST, in combination with the emphasis on innovation and collaboration, had by all appearances placed NIST on a very short list of high functioning, world class research facilities in 2008.

A closer examination of the circumstances leading up to the spill, however, reveals a paradoxically dysfunctional collaborative research environment. Before 2008, the primary facility that housed laboratories at NIST-Boulder (“Building 1”) had already become in some respects a tenuous place to conduct scientific research. The conditions in the laboratories were generally neither environmentally stable nor clean, with significant fluctuations in air purity, temperature and humidity, any of which could threaten the integrity of experiment results. Talking with the scientists now, they widely agree that the heart of the problem behind those conditions were the building management practices that had become commonplace in Building 1. The building had come to resemble, in the words of scientists, a “wild west” culture, characterized by adversarial, fend-for-yourself relationships among and between scientists and facilities personnel. Frustrated by bureaucratic delays, poor communication with building
workers and a string of building failures, scientists had typically resorted to fixing their own laboratory problems, sometimes at the expense of the conditions or safety of neighboring labs. They might, for instance, store dangerous chemicals in galleys where other scientists might unknowingly work near them. Or, at times scientists altered building functions such as ventilation systems to suit their own needs, but those alterations often impacted the systems of neighboring labs. Thus, by time of the plutonium spill in 2008, friction among and between scientists and facilities workers had led to commonplace maintenance practices that had the effect of isolating and alienating labs and scientists from each other, despite their close proximity. In a laboratory facility where collaborative work is prioritized, Building 1 had fallen into practices that can only be described as *dysfunctional* toward collaborative purposes.

This growing paradox between their productivity and their dysfunctional work environment was not lost on NIST administrators. In 2006 they had secured funds from the American Recovery and Reinvestment Act to construct a new state-of-the-art building on the Boulder campus: the Precision Measurement Laboratory (PML). Although plans for the building had been drawn up before the 2008 plutonium spill, the accident compelled administrators to not only reform the safety training and protocols as promised, but also to improve the problematic building management practices that had in part led to the unsafe work conditions implicated in incident. Toward that end, PML administrators changed the way that the building would be managed. Instead of relying on bureaucratic policies and procedures, like work-orders and chain-of-command communication, administrators instead created an ad hoc committee as the centerpiece of a new collaborative management model in the PML building.

The building management committee, called the PML Operations Group, is comprised of scientist representatives from each of the five research divisions at NIST-Boulder, as well as
facilities personnel (such as the building manager), and on occasion, visitors from the safety office or from division chiefs. The driving idea behind the PML Operations Group has been to reform building management practices to reflect the collaborative ideals that drive science research at NIST. To do so, administrators restructured the way that information is circulated around the PML building: the scientist representatives would become liaisons for relaying the needs and concerns for the scientists who typically work privately in the labs and thus are not generally a part of discussions over building management. As those needs and concerns are brought forward, the PML Operations Group members meet to discuss them, make decisions toward resolving them, and then develop plans for implementing and announcing those resolutions. By placing building management more in the hands of scientist representatives, who in turn provided communication channels where concerns could be voiced, PML administrators were hopeful that this collaborative model of building management could spark the type of “buy in” necessary from scientists to transform the unsafe practices of the “wild west” culture into one more conducive to collaboration.

Of all the organizational changes implemented at NIST in the wake of the plutonium incident, the creation of the PML Operations Group is particularly significant organizationally on at least two levels. First, the formation of the group entails an experiment – the first of its kind at NIST – which, importantly, confirms the underlying problems, in administrators’ eyes, that contributed to the building conditions leading up to the incident. The cluttered laboratory space and the lack of communication between scientists and building facilities in large part contributed to the deteriorating building and laboratory conditions that led to the spill. Second, and most importantly, the formation of the PML Operations Group highlights the centrality of knowledge and information sharing within collaborative work. Specifically, the PML administrators’
decision to move towards a collaborative model of organizing and building management surfaces important issues involving the way that knowledge-intensive organizations approach their work. As the changes at NIST suggest, successfully and safely constructing an organizational environment that enables collaboration as an enduring structured practice requires careful consideration of how shared knowledge is important not just as an outcome of collaboration, but also in support of collaborative work. No longer is it safe to assume that isolated researchers can produce innovative knowledge that can in turn be disseminated across organizational boundaries.

To accomplish their mission of fostering innovative collaborative research, NIST administrators have recognized that their work lies not only knowing the science behind their research, but also learning and improving the practice of collaboration. As the plutonium spill illustrates, how they organize their work in pursuit of innovation has important implications not just for their own safety and functionality, but also for increasing the likelihood of fostering collaborative projects. The focus of this dissertation project is to examine the role of knowledge and knowledge sharing in accomplishing collaborative work. More specifically, the seemingly paradoxical circumstances surrounding the plutonium spill demonstrate an interesting tension between two distinct ways of viewing knowledge in collaborative work. On one hand, knowledge is frequently approached as an outcome. Based on their track record of producing world class innovation through collaboration, NIST-Boulder is highly regarded as collaborative organization. On the other hand, focusing on knowledge as an end-product can obscure or dismiss the importance of the processual aspects of collaboration. That an organization as highly regarded as NIST can have a breakdown as basic and yet as monumental as the plutonium spill attests to the potential tendency for knowledge workers to overlook the communicative practices that constitute collaboration. To tease out this tension between knowledge-as-product and
knowledge-as-process, I take a communication-centered approach to understand both how knowledge comes to be viewed in collaborations, as well as how those views are accomplished. In so doing, I aim to explicate the relationship between the practice and outcome of collaborative knowledge accomplishment.

**The Rise of Organizational Collaboration**

Over the last thirty years, collaboration has become a central interest of organizational practitioners and scholars alike. Particularly in the growth of today’s ‘knowledge economy’ (Thrift, 2005), collaboration has increasingly become a hallmark of organizing in the 21st century. Organizations have long recognized that collaborative relationships can be a source of innovation and competitive advantage (Huxham, 1993; Dess & Picken, 2000; Huxham & Vangen, 2005), but recently the trend has particularly impacted workers in the knowledge sector. Scholars across a wide variety of disciplines have turned towards participating in collaborative research projects, from biological sciences (Larson, Nerlich, & Wallis, 2005; McMahan, Martin, & Hugenholtz, 2007; Aagaard-Hansen, 2007) to the environmental sciences (Daily & Ehrlich, 1999; Freudenburg & Alario, 1999; Naiman, 1999). Broadly, such research is premised on the notion that innovative solutions to complex organizational problems require collaborative work that connects knowledge workers across a number of sectors (Ketl, 2006; Weber & Khadamian, 2008; Brown, Harris & Russell, 2010). That such collaborative connections offer new possibilities for research and innovation has become a popular and widely accepted cultural narrative. In his biography of Bell Laboratories, for instance, Jon Gertner (2012) argues that the cross-disciplinary collaborative research environment at Bell – sometimes by design and sometimes by accident – led to its remarkable success as the most prolific science and technology incubator of the 20th century. As such, Gertner asserted, Bell Laboratories provided
an early prototype for imagining “the possibilities of what large human organizations might accomplish” (p. 5)

Gertner’s look at Bell Laboratories, and the cultural narrative in which it participates, is noteworthy because it highlights the way that collaboration and innovation have become especially intertwined within the institutional practice of science and technology research. Particularly during and after World War II, science research has become increasingly enlisted into business and government efforts to produce innovative products towards commerce, energy, and war technologies, resulting in a new era of massive collaborative research projects, collectively termed “big science” (Galison & Hevly, 1992). Much of the push for big science projects has resulted from the recognition that adaptive solutions for large scale organizational problems involve bringing together specialized expertise from various groups of scientists and practitioners spanning a broad array of organizational sectors. For example, the prospect of quickly responding to worldwide pandemic outbreaks have led health officials to recognize the need to bring together experts in medicine, epidemiology, public administration, and communication (Webby & Webster, 2003; Lai, 2012). This and many other examples of collaborative problem-focused scientific research projects has contributed to the linkage of collaboration and innovation towards broad and tacit cultural acceptance as “god terms, expressed as desirable, modern, progressive, and improvement” (Lewis, 2014). The cultural linkages and embeddedness of collaboration and innovation are further evidenced by the National Science Foundation’s 2014 strategic plan, which characterizes its overarching responsibility as cultivating the nation’s “innovation ecosystem,” a concept that highlights not only the implicit cultural prioritization of innovation, but that also forwards a vision of the integrative process of its growth.
While the “innovation ecosystem” metaphor provides a broad basis for envisioning the benefits of cultivating new, transformative knowledge, it has not been as successful at prescribing collaborative methods towards achieving it. In practice, the pursuit of innovation through collaboration has proven to be an especially problematic endeavor. Not only have scholars who study collaboration noted the substantial list of difficulties that often derail collaboration (for summaries, see Gray, 1989; Eisenberg, 1995; Huxham & Vangen, 2005), but researchers themselves from various disciplines have often elected to summarize their own collaborative struggles in disciplinary journals in attempt to help colleagues on their future collaborations. This grassroots approach to collaboration has arisen in fields such as nursing (Bradford, 1989), biology (Lele & Norgaard, 2005), environmental planning (Margerum & Whitall, 2006), environmental ecology (Naiman, 1999; Wear, 1999), education (Milbourne, Macrae, & Maguire, 2003), and clinical psychology (Rose, 2003), to name a few. While these summaries generally highlight the need and potential of collaborative research, they also describe an array of problems that can derail collaborative efforts. One frequently-cited set of problems revolve around the difficulty of knowledge sharing and knowledge management. For instance, Selin & Chevez (1995) argue that imbalances of power between collaborating organizations can hinder the sharing of knowledge between them. Further, relationships between organizations can be problematic if one or both is reliant on bureaucratic policies that can hinder flexibility towards knowledge sharing practices (Sink, 1996). Problems in collaboration have also been identified in the translation necessary between the values and assumptions held by the partnering organizations, which is often labelled as ‘culture clashes’ (Siegel, Waldman, Atwater, & Link, 2003). Focusing more on the micro level, some scholars point to the importance of having (or lacking) key organizational members who can serve as knowledge brokers as they can
connect individuals between the organizations by knowing ‘who knows what’ (Gray, 2007). The idea of brokering knowledge has also been identified as a particular concern for geographically dispersed collaborations, where “mutual knowledge” is difficult to establish due to an inability to share a common context (Cramton, 2001).

**Collaboration toward Organizational Knowledge**

The common thread in all of these approaches to collaboration is the emphasis on a ‘commodity’ view of knowledge (Kuhn, 2014a). More specifically, organizations who participate in collaborations often hold the view that the incentive of collaboration is to gain access to the resources and/or expertise that other organizations can offer. According to this perspective, the goal of collaboration is to expand the knowledge base of the organization by drawing on the expertise offered by partnering organizations. Knowledge, then, is understood as a valuable commodity that is held cognitively by particular individuals or groups, but can be made sharable through communication, as the means through which it can be “freed” across organizational sectors (Maier, Prange, & von Rosenstiel, 2001). Following this line of thought, the imperative for the collaborative organization becomes knowledge management, which involves controlling and facilitating the flow and application of knowledge throughout the organization (Jackson & Williamson, 2011), and for collaborative purposes, across organizational boundaries. If knowledge sharing is successfully managed, then organizational knowledge takes on the characteristics of a network, where knowledge is not just stored within individual nodes (persons, groups, or units), but also takes on a new dimension where ‘meta-knowledge’, or knowledge about knowledge, becomes a type of organizational consciousness that enables value-generation and value-assessment through new knowledge and innovation (Kogut, 2000).
With these perspectives in mind, it comes as no surprise that much of the popular collaboration literature revolves around developing strategies that facilitate the “network” communication processes that enable knowledge sharing throughout and between organizations (e.g., Huxham & Vangen, 2005; Kaats & Opheij, 2013; Morgan, 2012). The extent of problem-solving in this model is typically limited to examining particular groups or individuals, if they prove to be problematic nodes that hinder the flow of knowledge across the organizational network lines surrounding them (Contractor & Grant, 1996; Rice & Aydin, 1991). While this approach to collaboration-building has at times included a consideration of how social structures within and across the organization might influence cognitive practices at the individual or group level (e.g., Carley, 1986), it generally stops short of considering in more depth the micro-level influences on the organizational knowledge construction process. Innovation, in this view, is an emergent capability made possible by healthy networks of knowledge exchange.

However, the consequence of looking at organization-level linkages and networks for the production of new knowledge and innovation is that this view may overlook or fail to recognize the constitutive role of communication at the community level in the accomplishment of knowledge. More specifically, scholars have argued that knowledge is accomplished through group processes where social dynamics, such as shared meanings (Wenger, 1998), informal understandings (Brown & Duguid, 1991; Orr, 1996), trust (Adler, 2001), identity (Iverson & McPhee, 2002; Iverson, 2011, and legitimacy (Alvesson, 1994) are coordinated along with, and interwoven into knowledge. That is, if we accept the popular view that knowledge is a network-level commodity, then we may lose the ability to differentiate how specific notions of knowledge are premised on community-produced frames of meaning and legitimacy (Kuhn, 2014a). This point is highlighted in the ‘translation’ problems that practitioners of collaboration often point
out; while they only see ‘translation’ as another obstacle to overcome, communication scholars have more specifically recognized that these problems are rooted in the way that expertise and legitimacy is evaluated differently across communities (Alvesson, 1994; Brown & Duguid, 1991). In this way, collaborators in knowledge-intensive organizations may be hindering their own attempts at collaboration insofar as they hold assumptions about knowledge that it is a network-level commodity, while reducing communication to only a means of transmitting it.

More to the point with collaborative work, organizational communication scholars have recognized that successful collaborations require attention to group processes where a sense of collective identity can be fostered among collaborators (Hardy, Lawrence, & Grant, 2005; Koschmann, 2013). These insights suggest that group communication may also provide possibilities for the accomplishment of community-based knowledge, where shared meanings, trust, informal understandings, and common evaluations of expertise can develop situationally and organically among collaborators. Yet, these perspectives and insights are overlooked in the network view of knowledge that pervades practitioner approaches to collaboration.

In sum then, recent organizational scholarship provides a view of collaboration that highlights the prevalence of a commodity approach to knowledge, particularly among those who participate in collaborative projects. Generally, these practitioner approaches rely on network understandings of knowledge generation, which conceptualize innovation as a particularly valuable type of integrative knowledge. Yet, the success of this commodity approach in modeling and motivating the achievement of collaborative knowledge, particularly at the intersections of industry and science research, may also have the effect of steering collaborators away from recognizing collaborative knowledge as a local, situated community achievement. As a result, this overview of organizational scholarship provides reason to question whether
collaborators may neglect to grasp the degree to which knowledge and innovation must be emergently negotiated through communication on the collaborative level.

**Accomplishing Knowledge in a Collaborative Management Group**

In the context of this established tension between a commodity versus communicative view of knowledge accomplishment, I now return to the developments at NIST-Boulder in the aftermath of the plutonium spill. To review, the 2008 plutonium incident was, in the recognition of scientists and administrators at NIST, a manifestation of underlying organizational problems in the months and years leading up to the spill. In the words of scientists, the “wild west culture” at NIST, involving adversarial relationships amongst and between scientists and building facilities personnel, had resulted in competitive work practices that hindered and precluded cooperation between them, contributing to circumstances leading up to the incident. In response, NIST-Boulder administrators assembled the PML Operations Group in attempt to reorganize the building management practices towards improved information and knowledge sharing between and among scientists and facilities personnel.

The particularly interesting aspect of the formation of the PML Operations Group is the experimental attempt to redirect building management practices toward a focus on collaborative communication. Such an experiment would seem to indicate that the PML Operations Group defies prevalent approaches within the institution of ‘big science.’ Given the entrenched nature of the knowledge-as-commodity model for conceptualizing the production of innovation, the question remains whether the group can succeed in overcoming the tendency for scientists to manage their laboratories and experiments in accordance to those commonly accepted ways of approaching knowledge.
This dissertation traces the work of the PML Operations Group as it aims to engage and change the way that scientists in the PML building approach their work. Based on the recent scholarship examining common approaches to knowledge in collaborative science research, the group will need to overcome obstacles represented by their own entrenched approach and practice of knowledge as an assumed product. That is, if the scientists at NIST follow trends documented in knowledge management research, they may overemphasize knowledge present among a network of capable scientists while underestimating knowledge as a communicative accomplishment. While such logo-centric thinking is useful to scientists because it can index innovation and discovery as a systemic feature of existing knowledge, it can also marginalize or invalidate alternative means of resolving problems that fall outside traditionally accepted sources of expertise. Consequently, while scientists on the one hand seek out innovation according to accepted institutional views of where to find it, in so doing they may also resist re/negotiations or re/locations of expertise outside of these network view conceptions. Thus, to explore the tensions between these two ways of approaching collaborative knowledge accomplishment, this study examines how scientists navigate significant organizational changes, during which they are forced to reconfigure their work and the practical knowledge they had established in their previous labs. In so doing, they recognize the possibility of reconfiguring the problematic building management practices that have hindered their attempts at constructing a more collaborative work environment at NIST.

This dissertation report unfolds in the following steps. Next, in chapter two, I draw on recent organizational communication scholarship to establish a theoretical framework for exploring the accomplishment of collaborative knowledge from a communication-centered approach, and through which I craft research questions involving organizational texts,
conversations and knowledge practices. In the third chapter, I describe the methodological design of this study, including an explanation of NIST as a research site, a sketch of the important participants of this study, and the processes I employed toward data production and analysis. In the fourth chapter, I summarize and then detail the findings of this study, particularly involving the way that Operations Group Scientists conversationally reconfigure their work by authoring new building texts and across them, practical building knowledge. In the fifth chapter, I propose implication of this study, centering on the ways in contributes to existing organizational knowledge practices. Finally, I conclude this dissertation with an explanation of the study design limitations, and a brief summary that offers reflections on this study.

**Chapter 2: Review of Literature**

On a broad level, one of the aims of this dissertation project is to better understand the varying ways that knowledge in organizations has been conceived, by both practitioners and scholars, and the resulting implications of such conceptions. As the opening plutonium spill vignette illustrates, organizational knowledge is widely understood by modern organizations as a commodity or substance that is possessed and managed by the organization via organizational members. But the assumptions entailed by this view may be problematic for the collaborative, knowledge-intensive organizations that are a hallmark of 21st century organizing.

In this review of literature, I begin by summarizing this prevalent ‘cognitive/commodity’ approach to organizational knowledge. In so doing, I highlight the functionalist purposes that such a view holds for organizational practitioners, including the current reliance on concepts such as *knowledge base, transactive knowledge*, and *organizational networks of knowledge*. Second, I draw attention to the limitations of this approach, and in particular, the way that cognitive/commodity assumptions tend to overestimate the stability and objectivity of knowledge
and underestimate the role of communication in process of knowledge construction. Third, I explore the theoretical bases for approaching organizational knowledge. To do so, I articulate a three dimensional approach to knowledge. I present the first two dimensions together (synoptic and cultural) because they coincide with a cognitive/commodity view of knowledge. I then introduce the third dimension (improvisational) and demonstrate how it critiques and problematizes the cognitive/commodity view. I also highlight an important effect that is encompassed by organizational knowledge: the tacit nature of organizational knowing.

Continuing with this line of argument, in the fourth section of this literature review, I identify a more specific communication-based theoretical model of organizing that provides a conceptual framework for recognizing the constitutive role of communication (CCO) in organizational knowledge accomplishment and draws together the three dimensions of knowledge, as well as the tacit effect of organizational knowledge. Particularly useful is the ability of a CCO model to draw links between the interactional bases of knowledge accomplishment on the one hand, and the continued modern reliance on a static/commodity view of organizational knowledge on the other. Fifth, I provide a background for the way that CCO theorizing provides unique approaches to materiality and agency. Finally, I summarize this literature review by proposing the current study as an investigation of the tensions between entitative (synoptic/cultural) and enactive (improvisational) approaches to organizational knowledge through a communication-as-organizing lens, with implications involving the co-constitution of discourse, materiality, and agency. Last, I culminate the literature review section by proposing research questions that will guide this investigation.

1.0 Functionalist Approaches to Organizational Knowledge
One consequence of the relative youth of organizational communication as a field is our tendency to draw on related disciplines to inform our theoretical work (Craig, 1993). An example of this tendency is the way that organization studies and organizational scholars have provided an enduring legacy of functionalist approaches to studying organizations and organizational knowledge (Bullis, 2005), which has proven difficult to shed. More specifically, only in the early 1980s did organizational communication scholars begin in earnest to step away from “positivist or empiricist approaches to organizational science… which was then considered the norm in our field” (Ashcraft, Kuhn, & Cooren, 2009, p. 8). By and large, the norm we began to break from at that time was an alignment with managerial interests, marked by an emphasis on improving the operational efficiency of organizations and organizational processes (Canary & McPhee, 2011; Easterby-Smith & Lyles, 2003). The prevalent tendency generally included the appropriation of available theoretical constructs towards exploring the ways that they could be operationalized towards manipulating organizational outcomes. Much like the concept of culture, which in the 1970s had been adopted from anthropology and employed by organizational pragmatists as a variable that could be manipulated and managed within organizations (Trujillo, 1992), organizational knowledge had been similarly conceptualized as a distinguishing variable possessed and managed by organizations (Grant, 1996). Given the increase in the importance of intellectual capital in modern knowledge-intensive organizations, scholars have come to argue that the knowledge and innovation sought, generated, and offered by an organization is the primary means of characterizing it and analyzing its competitive capability (Spender, 1996; Spender & Grant, 1996).

1.1 Knowledge Management. Given this practical utility of linking organizational knowledge, innovation, and competitive advantage, organizational scholarship involving the
management of knowledge bases has quickly grown to be the dominate approach to studying knowledge. In a recent study, Serenko & Bontis (2009) identified and ranked 20 academic journals that focus solely on knowledge management in organizations, which they determined by surveying 233 active researchers in the area. The need for knowledge management arises out of pragmatic concerns involving the division of labor and areas of expertise (Tsoukas, 2011).

Insofar as organizations encompass an array of interdependent divisions and specialists, a primary challenge they face is ensuring that information and expertise is made available across the organization to members in need (Jackson & Williamson, 2011). The imperative of knowledge management revolves around viewing knowledge as an asset that can make or break the success of an organization (Ghalib, 2004). As a result, knowledge management scholars have worked to articulate explanations for how the knowledge and expertise of individual workers can be interfaced with the composite accumulation of organizational knowledge, which has resulted in at least three related domains of knowledge management research: transactive memory, organizational networks of knowledge, and technological systems for knowledge management (Kuhn, 2014a).

1.2 Transactive Memory. For practitioners, transactive memory involves the need for creating an organizational repository for knowledge that may otherwise remain isolated within individuals. In this sense, scholars and practitioners have recognized the need to create systems for documenting “who knows what” within the organization. The goal then of transactive memory systems is inventorying the types of knowledge and expertise the organization holds and where to find it, in the process providing the organization the capacity to reflect on its own body of knowledge (Walsh & Ungson, 1991). If an organization has developed and maintained an
effective transactive memory system, then they are more likely to achieve greater functional efficiency.

1.3 Network View of Organizational Knowledge. Implicit in transactive memory efforts is the tendency for knowledge management scholars and practitioners to approach the organization as a network of linked individuals who are simultaneously nodes in the organizational network and storages of specialized knowledge. As a whole, a network is understood as overall capacity for an organization to draw on knowledge or expertise from members (Shumate & Contractor, 2014). In this sense, an organization’s network is a manifestation of its overall knowledge capacity: “A network serves as a locus of innovation because it provides timely access to knowledge and resources that are otherwise unavailable, while also testing internal expertise and learning capabilities (Powell, Koput, & Smith-Doerr, 1999, p. 119). Not only is an organizational network the manifestation of the organization’s overall capacity to generate and inventory knowledge, but it also has ecological effects on members. Participation in organizational networks is understood to influence individual member knowledge through the exposure to other groups and individuals who serve as a “contagion mechanism” for each other (Burkhardt, 1994). As a result, a number of knowledge management scholars have taken to theorizing organizational networks as manifestations of its knowledge (e.g., Borgatti & Foster, 2003; Dhanaraj & Parkhe, 2006; Kogut, 2000).

1.4 Technological Systems. Finally, knowledge management scholarship has also undertaken an examination of the way that technological systems become integrated into organizational knowledge. Frequently, sharing knowledge across networks and between separate groups of expertise requires translation and encoding that is constituted by various technologies. For instance, expertise databases intended to index transactive memory become infused with the
affordances and limitations of those technologies (Flanagin, 2002; Monge & Fulk, 1999; Taylor, Groleau, Heaton, & Van Every, 2001). As a result, Leonardi (2011) points out how such technologies can become reified or made tacit by the assumptions that practitioners make towards their objectivity. The overall effect is that knowledge management technologies draw into question how or whether knowledge can be indexed and stored.

In sum, the thriving research agenda of organizational knowledge management has come to be seen as imperative towards nurturing the intellectual capital that characterizes an organization. In the pursuit of such research, knowledge management practice has come to rely on approaches to knowledge that focus on knowledge as a commodity, which importantly, can be compiled and stored for the purpose of building transactive memory. To the degree that organizations can connect groups of expertise to share their knowledge, they gain the capacity to reflect on the “what” and “who” of their organizational knowledge base. Fostering such capacity has been recognized as the means to gaining competitive advantage in markets of intellectual capital.

2.0 Limitations of the Cognitive/Commodity View.

With these strengths of knowledge management established, however, it is important to recognize some problematic underlying assumptions about knowledge and communication at work in the knowledge-as-commodity approach. Recent reviews of scholarship on organizational knowledge have identified at least three interrelated problems of approaching knowledge from a commodity view: (1) that the stability and objectivity of knowledge tends to be overestimated; (2) that communication is regulated to a subordinate role of mere transmission; and (3) that such a conception of knowledge fails to provide a mechanism that explains how knowledge is emergently involved in human organizing, rather than serving merely as the basis of organizing.
That is, accepting the organizational “knowledge base” at face value runs the risk of reifying the notion of social reality it represents, while denying the complex social and political underpinnings of its adoption.

### 2.1 Over-reliance on Object/Subject Dualism

First, not only does knowledge tend to be viewed as commodity or substance that flows within the organization (and potentially across organizational boundaries), but it is also by extension understood as something akin to an object that can be carried by an individual or shared within a group (Kuhn, 2014a). That is, the commodity view provides the visualization of knowledge being possessed, stored, and passed along in the minds or bodies of organizational members, cognitively (Kuhn, 2014a, p. 482). Given the expectation that knowledge can be possessed and shared within the organization, this commodity view would further assume that knowledge is relatively static and robust, due to its objectivity, such that it “speaks for itself.” For organizational communication scholars, the problem with this approach is that it tends to ossify our reliance on the object/subject dualism for understanding social reality (Chia & Holt, 2008; Kuhn, 2012). Understanding knowledge-as-object would suggest that it is passed along organizational members already preformed, and that we are merely subject to its self-evident truths (Rorty, 1981). Yet, this approach prioritizing knowledge as the objective source of organizing contradicts the disciplinary foundation built on the linguistic turn of the early 1980s, which “proceeds upon the claim that communication does not merely express but also creates social realities (Searle, 1995, as cited in Ashcraft, Kuhn, & Cooren, 2009, p. 4). Thus, while some organizational communication scholars in the last 20 years have taken to task the deconstruction of the object-subject dualism (e.g., Kuhn, 2012; Mumby, 2011), the knowledge-as-commodity approach remains stubbornly opposed to this work.
2.2 Limited View of Communication. The object/subject legacy of organizational knowledge also connects to a second problem with the knowledge-as-cognitive/commodity view: its narrow conceptualization of communication. The knowledge management and associated organizational network approach conceptualize communication as merely the means to transfer or transport knowledge. “Communication, then, is rendered epiphenomenal: it becomes the mere surface, rather than the substance, of organizing” (Kuhn & Porter, 2011, p. 18, italics in original).

Prioritizing the self-efficacy of knowledge while reducing the role of communication to mere transmission, however, runs the risk of reproducing credibility criteria through which knowledge is recognized (Deetz, 1992). Such a view reproduces notions of locating knowledge in bodies or minds rather than in organizational practices (Rennstam & Ashcraft, 2013). Furthermore, according to Kuhn (2008), a transmission model of communication imposes artificial limits on our notions of organization, in that it “tends to assume cultural integration, valorize the speed of messaging, ignore ambiguity, isolate responsibility for action (and agency) in message senders, oversimplify change processes, and believe in the adequacy of expression rather than emergence in dialogue” (Kuhn, 2008, p. 1231). Overall, regulating communication to the mere reflection and transmission of pre-formed objective knowledge leaves unanswered questions of organizational becoming (Tsoukas & Chia, 2002).

Given these weaknesses of the cognitive/commodity approach to knowledge that underlies knowledge management and network views of organizational knowledge, the question remains of why organizational practitioners and scholars remain firmly committed to these views. I address this question in the next section by first identifying the theoretical bases for approaching organizational knowledge, and second, by examining the conceptual links between cognitive-commodity views of knowledge and organizing processes and purposes.
3.0 Theoretical Bases of Organizational Knowledge

In the 20th century, scholars increasingly recognized the complexities involved in organizational knowledge and knowing. Generally, our current understanding of knowledge revolves around three facets or dimensions: (1) synoptic/representational knowledge (to “know of”); (2) contextual/cultural knowledge (to “know how”); and (3) improvisational (or experiential) knowledge (to “know by acquaintance”). I proceed here by first describing synoptic and cultural knowledge, because together they provide a basis for the commodity/cognitive approach to organizational knowledge. Then I later discuss the third dimension, improvisational knowledge, and the pivotal role it plays in highlighting the constitutive role of communication in organizational knowing.

3.1 Synoptic and Cultural Dimensions of Knowledge. Synoptic knowledge, or expertise, has roots in a positivist ontology in that it holds that the reality of nature can be truly represented (or, mirrored: Rorty, 1981) through symbols: language, diagrams, and artifacts such as maps. In this sense, synoptic knowledge is premised on the idea that it is possible to gain expertise over phenomena by accumulating representational mastery of it, particularly through compiling and categorizing a comprehensive understanding within a “body of knowledge” or “knowledge base”. However, recently scholars have increasingly drawn into question the plausibility and adequacy of synoptic/representational knowledge alone. For instance, in an often-cited study, Orr (1996) noted how copier repairmen rarely relied on repair manuals – the official knowledge base of their profession – for their work, instead experimenting on problems or asking each other for help. Similarly, Brown and Duguid (1991) revealed how managers’ over-emphasis on the “canonical” organizational documents for worker evaluation actually hindered the learning and innovation that take place in the informal work processes of small work groups. Building on this
insight, Alvesson (2001) points out the inherent ambiguity that plagues the application of “official” knowledge and expertise, which opens space for discretion in judging what knowledge is relevant in a given situation. As a result, issues of context and social identity become implicated in how that discretion is exercised (Alvesson, 2001, p. 866).

Synoptic knowledge, then, must be accompanied by the second dimension of knowledge – cultural knowledge – involving the ability to contextualize its value and application. Tsoukas (2011) explains:

“Representations can be used insofar as organizational members know how to use them. That knowledge is obtained through individuals’ immersion in socio-material practices, in which they have learnt how to make competent use of relevant categories and their associations. Organizations, therefore, as well as being carriers of synoptic knowledge, are the sites of cultural knowledge: collective meanings that provide an organized system with a distinct identity and enable its members to act in coordinated ways” (p. xiii, italics in original).

It is this cultural ‘know-how’ that enables organizational actors to recognize the significance of their synoptic knowledge and thus to competently apply their expertise in relevant organizational contexts. For this reason, the interplay of synoptic and cultural knowledge has informed popular definitions of organizational knowledge as “the ability to make meaningful distinctions in a given context” (Nonaka & Takeuchi, 1995, as cited in Kuhn, 2014a; Tsoukas & Vladimirou, 2001). In other words, common approaches to knowledge stress that, to be knowledgeable is to not only possess information (data, objective facts, etc.) about phenomena, but also to be able to assess the significance and applicability of that information within particular cultural frames. Through this cultural dimension of knowledge, personal expertise becomes social; for knowledge
to be shared and coordinated, practitioners must form a *sensus communis* around common interpretations of relevant knowledge in particular contexts (Myers, 2011, p. 286; Tsoukas, 2011, p. xiii).

### 3.2 Synoptic/Cultural Knowledge as Cognitive/Commodity

At this point, before moving on to the third type of knowledge – experiential or improvisational knowledge – it is important to pause to draw linkages between the first two facets of knowledge, synoptic and cultural, and a cognitive/commodity approach to organizational knowledge. Together, synoptic and cultural knowledge theoretically coincide with an *entitative* approach of viewing organizational knowledge as a cognitive commodity (Tsoukas, 2011). More specifically, the “expert systems” that typify and characterize organizational knowledge management rely on a combination of representational systems of “know-of” knowledge, along with the indexical, transactive memory capabilities of “know-how” knowledge (Giddens, 1990; Tsoukas, 2011). In other words, these two theoretical dimensions provide an explanation for how an organizational body of knowledge is created, maintained, and distributed culturally, and in so doing, they together validate the theoretical bases upon which knowledge management scholarship is premised. However, continuing the exploration of the theoretical approaches to knowledge opens space for addressing the limitations of the knowledge-as-commodity approach. I turn next to the third theoretical facet of knowledge – improvisational knowledge – in order to articulate ways that recent theoretical work bridges the divide between organizational knowledge-as-commodity and the emergent, situated nature of knowledge-in-action.

### 3.3 Improvisational Knowledge: Situated in Action

The third facet or dimension of organizational knowledge, improvisational knowledge, has roots in a process philosophy approach to organizing, as articulated in recent work by Haridimos Tsoukas (2011). Adequately
describing improvisational knowledge requires explaining in some depth the links that Tsoukas
draws between a process philosophy of organizing and organizational knowledge as a form of
control. Though he has an extensive research agenda involving organizational knowledge (e.g.,
Tsoukas, 2000; Tsoukas, 2001; Tsoukas, 2005; Tsoukas & Chia, 2002; Tsoukas & Hatch, 2001;
Tsoukas & Vladimirou, 2001), in his prologue to Canary & McPhee’s (2011) edited volume,
Tsoukas outlines his theoretical approach linking knowledge to organizational control via
situated action. Drawing on Giddens (1990), Tsoukas posits that modern organizing
encompasses the process of drawing together disparate organizational contexts through a
dialectical process of disembedding and re-combining social relations across time and space. To
organize is to foster cooperation through the assumption of a composite organizational
knowledge base. Tsoukas (2011) explains:

“What distinguishes the modern purposeful organization is the relentless process
of disembedding (de-contextualizing): the lifting of social relations out of their
spontaneously occurring local contexts of interaction and their re-combination in
abstract space and time. Through the process of disembedding, social systems
extend their reach beyond the here and now of interaction in conditions of co-
presence…. Purposeful organization is a process of abstraction… Action becomes
organized insofar as it can be instantiated across different contexts.” (p. xi)

The key connection here between organizing and knowledge is the abstraction-instantiation
dialectic that links together concrete, situated organizational action with the “fiction” of acting
organizationally. Through technical control systems (symbolic tokens and expert systems)
organizations foster a sense of trust in organizational members that they inhabit an ontologically
secure reality presented by the organizational narrative (Giddens, 1990). So while on one side,
ontological security is provided by the system of representations (synoptic knowledge) that characterizes the organization, there is on the other side, however, a concrete, imperfect process of attempting to apply that knowledge to complex and chaotic situations in organizational life. According to Tsoukas (2011), organizational “representations (syntax) and meanings (semantics) are applied by concrete people in a concrete world, which is infinitely more complex than any representations. There is always a phronetic gap between representations and the world, which is filled in through actors improvising in situ. Representations and meanings are instantiated through the pragmatics of human action” (p. xiv). As organizational actors work to solve organizational problems, they necessarily attempt to apply their synoptic and cultural organizational knowledge, yet are inevitably confronted the imperfect match between the “shoulds” of representation and the world encountered. “The more indeterminate the situation, the greater the need to fill the phronetic gap… by imaginatively extending a category beyond prototypical cases to peripheral ones. The effort to close the phronetic gap leads inescapably to improvisation and, thus, the development of improvisational knowledge” (p. xiv, italics in original).

Improvisational knowledge, then, is the third dimension of knowledge. It involves the creative application and evaluation of abstract synoptic knowledge systems towards complex instances of the encountered world. Given the imperfect match between synoptic knowledge and the encountered world, improvisational knowledge necessarily requires interpretive and creative consideration for which synoptic knowledge systems are applicable in a given situation, resulting in a trial-and-error process. For this reason, improvisational knowledge is unavoidably personal, as it always entails arbitrary personal judgements that are limited by the synoptic knowledge systems available to the actor/s (Polanyi, 1962).
3.4 Critiquing the Cognitive/Commodity View with Improvisation. So, while synoptic knowledge is a dimension of organizational knowledge that entails an abstract, composite, and robust system of representations and categories that attempt to describe the world, improvisational knowledge is a co-existent dimension that is creative, emergent and inherently unstable. Synoptic knowledge by necessity attempts to extract and de-contextualize general principles out of concrete situations. Improvisational knowledge, however, defies synopsis. It is this improvisational dimension of knowledge that the cognitive-commodity view of organizational knowledge fails to recognize. That is, while organizational knowledge involves the intertwined processes of all three types of knowledge (synoptic, cultural, and improvisational), organizational practitioners and scholars who focus on the entitative aspects of knowledge fail to account for the enactive aspects of knowledge. In so doing, they are apt to artificially assume the objectivity and adequacy of synoptic/cultural knowledge alone.

In sum, the tension between entitative and enactive approaches to organizational knowledge provide the theoretical basis for this dissertation project. On one side, organizational knowledge requires the creation of static, robust entities in the form of representations and using them in open-ended contexts (Tsoukas, 2011). While the entitative approach necessitates a systemic & network view of organizational knowledge, the neglected enactive view emphasizes the messy use of those representations in practice, which implicates communication in a more constitutive role towards organizational knowledge accomplishment. Yet, because the entitative approach maintains a view of knowledge as objective and impersonal, the scholars who employ this view are apt to overlook the constitutive role of communication. As Tsoukas (2011) attests, “the reach of any organization’s knowledge always exceeds its final grasp” (p. xvii). That is, the entitative “reach” (i.e., conceptual mapping) of organizational knowledge systems typically fail
to fully “grasp” (i.e., attend to) the complexity of organizational enactment and problems arising in it.

In the next section, I identify a theoretical framework that can bridge these two approaches to knowledge by repositioning communication as not merely the representation of reality, but rather as the basis of organizing it; by constructing an organizational ontology. This repositioning provides the possibility of conceptualizing knowledge and knowledge achievement as simultaneously conversational resource, communicative practice and organized product.

4.0 Communication as Constitutive of Knowledge and Knowing

To briefly summarize thus far, scholars have widely recognized the need for entitative knowledge systems in organizational life, such that managing these knowledge systems is often viewed as synonymous with proprietary value-generation (Kuhn, 2014a), giving rise to a vast array of studies on knowledge management (for a review, see Barley, Treem, & Kuhn, 2017). Obscured within this trend, however, are the ontological and epistemological assumptions premised in such a view; namely, that entitative knowledge, or to “know-of” particular objects or phenomena assumes the existence of those material objects or phenomena as discrete entities. By extension, an entitative, representational approach to knowledge begins with the a priori acceptance of the physical world as a collection of objective, static objects and properties that together provide a self-evident reality to inhabit. As parsimoniously appealing as this mechanistic worldview may be, scholars have nevertheless levied a number of criticisms against this “realist material determinism” (Dale, 2005, p. 652). Most prominently, critics’ attacks have centered on the essentialism embedded in material realism and, by extension, how it fails to account for change, emergence or the becoming of organization (Dale, 2005; Kuhn & Porter, 2011). Such an essentialized world renders communication as mere transmission; in a purely
entitative view of knowledge, communication is understood to only describe material phenomena and not participate in its constitution or becoming. Lost in this view, then, is the possibility of analyzing the ways in which the “social” and “material” may not be separate or separable at all, but rather how they may be mutually entangled and constituted in organizing processes. Bridging entitative knowledge and improvisational knowing thus requires a theoretical approach that can explain both how entitative knowledge functions to successfully presuppose and represent a realist world, but also how that world can alternatively (or even simultaneously) be subject to improvisation and negotiation that can contradict or disrupt entitative knowledge.

In this section, I introduce a communication-centered approach to organizing that offers just such a capacity: to explain how entitative knowledge can be both functionally assumed as a resource to organizing, but also potentially emergent in enactive organizing practices, despite the ontological contradiction between the two.

4.1 Communication as Constitutive of Organization (CCO) Theorizing. One potential way to draw connections between the abstract, synoptic modes of organizational knowledge and situated, improvisational knowledge (or, knowing) claims is offered by recent theoretical work on the communicative constitution of organization (CCO). Theorists who aim to articulate a CCO framework explore the communication basis for emergent organizing through iterative processes involving discourse, text production and situated organizational sensemaking (Brummans, Cooren, Robichaud, & Taylor, 2014). Rather than accepting an organization as a given and deductively tracing its evolution over time, a CCO approach seeks to inductively explore how an organization is continually re/emergent (or re/achieved) in potentially nonlinear ways (Brummans, et. al., 2014). In this endeavor, the CCO theoretical project is a useful means of articulating how our social and organizational reality is constituted within and through
communication and, furthermore, it explores the premise that to communicate is to organize—such that communication is a defining feature of organizing. Such a lens is an appropriate tool for exploring the role of organizational knowledge and knowing during these organizational changes at NIST because it offers a means of examining the communicative basis for knowledge constitution while inviting suspicion toward taken-for-granted notions of organizational knowledge; for instance, about the ontological status of entitative knowledge systems, and who may possess or assert them. In the following section, I expand on the CCO basis of my theoretical framework, by identifying key components of the approach involving: (a) worldview co-orientation via a text/conversation dialectic, (b) organizational distanciation across space/time via ventriloquism, (c) the engagement of materiality and agency via networks of practices, and (d) the emergence of authoritative texts.

**4.2 Worldview co-orientation via text/conversation dialectic.** Although there are generally three strands of CCO scholarship, including Montreal School (Taylor et al., 1996), “four flows” (McPhee & Zaug, 2009), and Luhmann’s (1995) autopoietic systems approach, it has been the Montreal School view that has received the most attention from communication scholars (Brummanns et al., 2014). The Montreal School (CCO/MS) view posits that organization is a phenomenon that emerges out of a dialectical relationship between texts and conversations. As organizational actors engage in conversation, they draw upon available texts (e.g., documents, policies, speeches) as resources for their local, situated meaning construction and sensemaking—a process Taylor, Cooren, Giroux, and Robichaud (1996) refer to as “worldview co-orientation.” In the process of conversing, participants negotiate common frames for conceiving reality, which has the effect of labeling and ‘ordering’ the material world, as well as fostering shared commitments, and defining social relations (Taylor et al. 1996). By drawing together textual
resources into a co-orientation frame, organizational conversationalists in turn re/produce their own texts, which effectively become resources for later coordinative conversations – an iterative process which has the effect of imbricating organizational texts as though they were roof tiles layered one on top of the other (Cooren, 2006). Across repeated cycles, the text/conversation dialect offers a means of understanding how everyday talk (i.e., language and discourse) have performative functions insofar as they invoke contextual frames for meaningful interpretation and production of organizational life (Cooren, Brummans, & Charrieras, 2008).

4.3 Organizational distanciation across space/time via ventriloquism. Conversations are productive and performative then, because they can creatively draw on and combine textual resources toward re-establishing the relevance of past organizational understandings or by potentially providing new notions or visions. That is, everyday organizational talk “translates” established textual resources into the “here and now” of a situated conversation. In this sense, new contextual frames can emerge for understanding organizational reality which may or may not provide linear reproduction of those past texts (Brummans et al., 2014). As Brummans et al. explain: “Translation involves more than a change from one position to another (flow). It implies transformation both in medium and in form, one that becomes a new lexicon” (p. 146).

Imbrication of organizational texts, then, offers a means of instantiating images of the organization across time and space, while it also reconfigures those images and meanings toward coherence within and among the situated practices, narratives, and knowledge required for carrying out organizational work (Faure, Brummans, Giroux, & Taylor, 2011; Goffman, 1974).

Importantly, CCO/MS places this text-conversation dialectic as the constitutive process through which social reality is constructed, and specifically, as the means through which “organizations” as entities come into being, and thus become readable and understood (Taylor,
Insofar as common understandings of the organization are produced and imbricated in texts, they become sources of authority for further organizational conversations across time and space. That is, as local, situated interactions “scale up” (Cooren & Fairhurst, 2009), they gain distance from their immediate circumstances and become decontextualized, or *distanciated* (Ricoeur, 1981, 1991), and are available to be drawn upon as resources for subsequent conversations in other situated contexts. According to Cooren (2006), this distanciation is achieved by conversational ventriloquism: the ability to speak on behalf of both present and non-present entities (e.g., ideas, values, persons, objects, effects, etc.: Cooren, 2006; Cooren & Sandler, 2014). By referencing an entity, idea, or figure conversationally, an organizational actor asserts the relevance of that figure toward constructed organizational purposes at hand. In other words, conversationalists have the ability to raise and enlist figures that become involved in the performance of the broad vision and/or narrative that meaningfully frames the ‘who, what, why, and how’ of the situation. Insofar as figures raised contribute to the direction and outcome of the conversation and any potential outcomes (e.g., resolutions, authored texts) then the figure acquires agency attributed to it by participants. A conversation, in this way, encompasses the invocation of a “plenum of agencies” (Cooren, 2006) that form a polyphony articulating both the “why” and the “how” of organizational action (Cooren & Sandler, 2014). In turn, the plenum of agencies constituted in conversation are encoded into texts which provide the means of distanciating them across organized time and space (Cooren, Matte, Taylor, & Vazquez, 2007; Cooren & Fairhurst, 2009).

Important for this dissertation study is that this plenum of agencies can also be understood as providing a basis for organizational knowledge and knowing. In particular, agencies constituted in conversation populate a context that provides “worldview co-orientation”
(Taylor, 1993) for participants, enabling them to coordinate mutual meanings, practices, and purposes. Such co-orientation can reproduce past combinations of agencies as specified in available texts, or it can specify a new combination of agencies that together transcend prior texts. In the case of the former, entitative knowledge can be translated relatively intact; for the latter, enactive knowing is centered. In either case, whether such knowledge or knowing is carried forward into further conversations depends on the relative authority that emerging texts are attributed (Kuhn, 2008).

4.4 The emergence of authoritative texts. As texts become distanciated and imbricated across organizing efforts, they necessarily become abstracted and shed the specificity of the conditions of their authoring. This includes any indications of individual authorship; instead, texts portray a collective representation that becomes, in its use, accepted organizationally as legitimate and ordering (Benoit-Barne & Cooren, 2009). It is this ‘vanishing’ (Taylor & Van Every, 2011) of situated specificity that enables abstractions to develop authority. Insofar as a particular text becomes successful in organizational representation, it survives across a number of imbrications and the authority attributed to it increases – it becomes, in Kuhn’s (2008) terms, an authoritative text. Concomitant with gaining authority across imbrications, an authoritative text serves a number of functions organizationally. Among them, an authoritative text: represents the intentions of organizational actors; mediates their conversations; directs attention towards particular phenomena; disciplines actors by discerning and labeling appropriate action; and links and contextualizes disparate practices across the organization (Kuhn, 2008, p. 1236). As an authoritative text serves these functions, it provides a composite characterization of the organization, tying together organizational roles, duties, values, activities, and outcomes into an abstract narrative. Insofar as these functions entail organizational action, they also enlist material
resources into the social frames they order, and in this sense, the authoritative text is not merely social; rather, it is “social material” (Orlikowski, 2005). Thus, authoritative texts serve as the recognizable surface of organizations, but importantly, the conversations that re/produce authoritative texts are also the sites where the tension and contest that underlie text production can be observed (Koschmann & Burk, 2016; Kuhn, 2008).

4.5 The engagement of materiality via networks of practices. Thus far, I have described the constitutive processes of the text/conversation dialectic underpinning CCO theory. Texts authored during situated organizational sensemaking can be understood as providing an overarching narrative that frames a vision of the organization, which then can ‘scale up’ as it is invoked and gains authority across organizational space and time. While this explanation provides a basis for understanding how we come to recognize an organization narratively, it does not offer a robust explanation that links social and material facets of organizations. A noted challenge for CCO theorists has been to more thoroughly account for the enmeshment of materiality in organizational processes (Ashcraft, Kuhn, & Cooren, 2009). In a CCO view, conversational agents exhibit the capacity to ventriloquize non-present or abstract figures toward constructing coherent conversational frames of action, but those frames alone are not enough to accomplish organizing. Another component of a CCO/MS approach is an emphasis on a network of organizational practices that reference and reinforce each other, creating interdependence between organizational actors (read: agents/figures) across multiple situated conversations (Brummans et al., 2014; Taylor & Van Every, 2000). Increasingly, organizational scholars draw on a practice approach to theorize organizational status (Brummans et al., 2014; Taylor, 2011), knowledge (Barley, Treem, & Kuhn, 2017; Kuhn, 2014a; Kuhn & Jackson, 2008; Rennstam & Ashcraft, 2013), and change (Spee & Jarzabkowski, 2011). These scholars emphasize how
organizational practices (repeated or routinized work processes and procedures) are nexuses where not only the ‘work’ of the organization is accomplished, but also where roles, relationships, narratives, and knowledge become interwoven, embodied, and performative. In this view, organizational practices are rational articulations of organizational values, priorities, and purposes, and thus they are configured to carry out the broad-level organizational understandings that gain authority via text/conversation cycles. But more than just connecting to abstract levels of shared organizational meanings, practices also encompass an ecological engagement with the material milieu of organizing (Contu & Wilmott, 2006). Practices are commonly performed via, and thus inseparable from, technology, artifacts, space, infrastructure, bodies, etc., entailing an enmeshment that scholars have referred to as “social material” (Orlikowski, 2005).

Within a CCO framework, studying practices therefore offers the possibility of examining knowledge and knowing from the perspective of their involvement in work activities. Whereas text/conversation cycles provide interpretive frames for making sense of, rationalizing, and configuring work practices, the carrying out of those practices calls forth a social material complexity that has the potential to defy or contradict organizational narratives, beliefs, and assumptions. In this sense, practices are often sites of recalcitrance, resulting when outcomes from situated organizational practices do not match expectations prescribed by the text/conversation dialectic that configures them. Examples of such recalcitrant discrepancies in organizational scholarship are numerous. Orr’s (1996) study of copier technicians found that copier breakdowns often defied common understandings provided by service manuals due to idiosyncratic combinations of user input, mechanical breakdown and programming insufficiency, giving rise to the need for continual improvisational problem-solving among technicians.
Leonardi’s (2012) study of car crash simulations found that iterative versions of the software programs written to simulate the crashes introduced new unforeseen programming and modeling problems that continually necessitated later, updated versions. Rennstam (2013) traces engineers’ work in developing a new generation of power amplifiers for cell phones, only to find that required elements of the amplifier, when combined into a model, rendered it impractical. Ewenstein and Whyte (2009) studied the development of architectural plans for an herbarium addition to a London botanical garden and found that inventorying the various demands on the herbarium gave rise to an unfolding problem-based process, “embodying a lack, raising a question, begging an answer, unfolding, developing a lack elsewhere, raising new questions, and so on” (p. 27). In all of these examples, social material practices and processes of organizing involved “material” engagements that resulted in recalcitrance that redirected organizing work. Linking CCO with an emphasis on practices, then, is one way to theorize connections between abstract levels of meaning-based organizing with situated, practical processes in a way that holds potential to better ‘materialize’ the study of organizational communication.

4.6 Social materiality and notions of organizational space. A pause here is warranted to more squarely articulate my approach to the “material world” in context to recent work aimed at materializing organizational communication (Ashcraft, Kuhn, & Cooren, 2009). Thus far, I have situated my theoretical framework in response to the deterministic realism implicated in entitative approaches to knowledge – a view I reject because it neglects the constitutive role of communication toward making meaning matter (Ashcraft, Kuhn, & Cooren, 2009; Cooren & Sandler, 2014; Kuhn, 2014) and by extension, its failure to recognize the inseparability of communication and organizational knowledge (Rennstam & Ashcraft, 2015). The danger of such a move, however, is to swing too far into the nominalism of collapsing any notion of “the
material” into talk, for instance, by claiming that the physical world will only ever be what we claim it is (Alvesson & Kärreman, 2011; Iedema, 2007; Reed, 2010). In response to the “Scylla and Charybdis” of these two extremes (Dale, 2005), I take a middle-ground social constructionist stance that acknowledges, on the one hand, that the “social” and “material” are mutually constitutive (Dale, 2005; Orlikowski, 2002; Orlikowski, 2007; Orlikowski & Scott, 2008), yet on the other hand, that current theory has yet to fully articulate how (Ashcraft, Kuhn & Cooren, 2009). While a number of scholars have taken up the challenge of exploring notions of “socio/materiality” from a communication standpoint (e.g., Dale, 2005; Nyberg, 2009; Kuhn & Burk, 2014), with recent work emphasizing a process/practice-based, relational ontology approach (Iedema, 2007; Kuhn, Ashcraft & Cooren, 2017), or bridging discourse analysis to scholarship in new materialism (Cederstrom & Spicer, 2014; Coole & Frost, 2010), nevertheless, offering a clear and succinct theoretical explanation of matter remains elusive because, as Coole and Frost (2010) recognize, “there is an apparent paradox in thinking about matter: as soon as we do so, we seem to distance ourselves from it” (p. 2-3). That is, we inevitably infuse any concept of matter with our own social devices to make it comprehensible. As a result, any notion of the material *qua material* remains hidden in a “black box” of the unknowable.

I start with a social constructionist approach in part because of this paradox, but also because of the overarching focus of this study. I aim to examine processes of organizational knowledge and knowing, which are inevitably discursive (van Dijk, 2003). Scientists by practice develop entitative knowledge systems involving what they deem to be physical phenomena, and thus they have existing notions of matter embedded in their work practices. From a CCO approach, such entitative notions of matter are thus likely to be salient resources for conversations about their work, and important to trace for this study.
This is not to say, however, that matter does not have agency in its own right. While a social constructionist approach begins with the acknowledgment that we in part construct the world we inhabit, it can also acknowledge that the performance of that world can depart from such constructions. As noted above, science laboratories can, for instance, perform in ways that defy the intended design of the experiments conducted there. Within a practice-focused social constructionist frame, this harkens to insights provided by Lefebvre’s (1991) theory of the production of space, in which he identifies three simultaneous sources (or dimensions) for meaning construction of organizational space: conceived space, perceived space, and lived space. While conceived and perceived space entail aspects of our experience that result from purposeful designs and constructions of space, his notion of lived space acknowledges that routine practices can engage unintended aspects of space and thus provide resources for meaning that defy or transcend those constructions. That is to say, from a social constructionist lens, matter can be understood to always/already participate in the performance of space, and in so doing, may introduce recalcitrance that interferes with the purposes of those performances. The problem is that we observe the performance of space through our constructions of it, and thus cannot definitively attribute any particular agency to materiality qua materiality, separate from those constructions.

As a result, for the purpose of this dissertation study, I view organizational space as a discursive construction that simultaneously conceives and is enmeshed with matter, and is thus inseparable from it. Organizing laboratory space, in this way, involves social material constructions that provide the possibility (and limits) of tracing the practical accomplishment of knowledge and knowing. A CCO framework is useful toward that end because it locates this
accomplishment in communicative negotiation (via conversation) and textual documentation of those constructions, insofar as they order and configure networks of social material practices.

4.7 CCO and authoritative texts in organizational scholarship. The ability to trace the emergence of organization through the text/conversation dialectic has inspired a number of scholars to utilize a CCO/authoritative text lens for studying organizing processes. Generally, these studies focus on documenting text-conversation dialectics across organizational time and space, and tracing the social material underpinnings of those organizing processes. For example, Spee and Jarzabkowski (2011) trace the development of a British university’s strategic plan through a series of text/”talk” cycles. They are able to document the way that the strategic plan becomes imbricated across a number of planning sessions, where it is shaped by both the talk of organizational members as well as social material artifacts (such as PowerPoints and emails) where previous organizational texts had become inscribed. In another study, Koschmann & McDonald (2015) document the way that actor performances are inscribed into an authoritative text as they examine organizational rituals at an AIDS advocacy NGO. More specifically, Koschmann and McDonald (2015) show how rituals “presentify” organizational power insofar as those rituals invoke organizational meanings that are connected in its authoritative text. Authoritative texts have also provided a lens towards better understanding interorganizational collaboration. By studying a collaborative organization that focuses on creating health and education partnerships, Koschmann (2013) demonstrated the central importance of authoritative texts towards creating a sense of collective identity among collaborators – a step previously identified as key for successful collaborations (Hardy, Lawrence, & Grant, 2005). Koschmann and Burk (2016) similarly establish the importance of authoritative texts toward organizational collaboration. By studying an organizational change aimed at fostering a more collaborative
environment, the authors demonstrated how an outdated, non-collaborative authoritative text had to be de-authorized before a new, collaborative authoritative text could be authored in its place.

Together, these studies demonstrate ways that organizational meanings and member relations are tied together in powerful ways by authoritative texts. In particular, these studies have provided evidence of how an authoritative text is the constitutive centerpiece of organizational control, as it orders and disciplines member performances and relationships. What is left uncertain, however, is the role that synoptic knowledge (or, expert systems) serve in the meaning construction of authoritative texts. We know that authoritative texts gain authority because they provide a meaningful organizational narrative that links actors, contextualizes their performances, represents their intentions, and mediates their conversations (Kuhn, 2008). However, just how that integrative meaning is constructed from among pre-existing meaning resources (e.g., existing organizational texts) remains uncertain. In particular, the relationship between entitative knowledge and authoritative texts has yet to be explored. According to the CCO/authoritative text approach, we can assume that synoptic knowledge is a conversational resource that can be invoked during the text construction process. We can further assume that the accomplishment of knowing is an overarching aim of problem-solving conversations, such as those that take place during organizational committee meetings. But what remains uncertain are the relationships between the “system-ness” of synoptic knowledge, the narrative highlighted by the authoritative text, and the social material practices legitimated and ordered by the authoritative text. These are the underlying questions that this dissertation project aims to explore. In the next section, I introduce the impact that these questions have on the way that CCO theorists approach social materiality and agency in the study of organizational communication.
5.0 Study Summary: Exploring the Communicative Constitution of Knowledge, Agency and Materiality at NIST

Thus far, I have raised questions involving potential tension between entitative and enactive approaches to organizational knowledge, and I introduced a communication-as-constitutive theoretical approach with which to explore this tension in organizing processes. A key strength of a CCO/authoritative text view of organizing is that it enables the possibility of tracing through time organizational *becoming*; rather than taking for granted the pre-existence or naturalized status of organizations-as-entities, knowledge, institutions, or material objects, a CCO approach instead leaves such issues as open questions ripe for investigation. In this way, a CCO approach turns an analytical lens towards the communicative re/production of organizational reality, assuming rather that the existence and status of the social material world is constituted (made real) via communication. Implicated in this shift away from essentialism are

Having established this communication-constitutive-of-organizing theoretical framework, and considered its implications towards agency and materiality, I return in the next section to the collaborative challenges at NIST in order to explicate specific research questions that will provide focus for this study.

As recent trends in scholarship on organizational knowledge demonstrate, practitioners and theorists alike commonly highlight the synoptic, representational qualities of organizational knowledge. Doing so serves functionalist needs: if managers emphasize the accumulation and management of a common organizational knowledge base, then they also simultaneously provide a control mechanism that disciplines and rationalizes member decision making while projecting a clear organizational identity for members and stakeholders alike. However, if we take seriously a three-dimensional view of knowledge, including both entitative and enactive aspects of
knowledge, then we must also recognize the way that all knowledge – even synoptic knowledge – is evoked by members through improvisation during situated interactions (Brown & Duguid, 2001; Kuhn & Jackson, 2008). Insofar as knowledge is organizational, it is born of practicality, which also makes it inherently social. As Kuhn and Jackson (2008) argue, “knowledge in a given context is simply that which enables and sustains problem solving and not necessarily that which can be independently justified as true” (p. 456, italics in original).

Out of this tension between entitative and enactive approaches to knowledge, more exploration is needed to examine how synoptic representation systems are encoded within organizational texts via communicative processes, and in particular, how representational (i.e., synoptic/cultural) knowledge impacts the potential construction of an authoritative text. From a CCO/Montreal School perspective, the question remains of how entitative knowledge is “made real” and carried forward communicatively through organizational imbrication. Accordingly, my first research question is:

**RQ1: How is synoptic/cultural knowledge encoded into organizational practices and/or authoritative texts?**

Second, this study offers the opportunity to explore connections between the abstract, narrative aspects of organizing and the concrete, enactive situations involving actors, materiality, and agency. In response to recent calls to “materialize” organizational communication (Ashcraft, Kuhn, & Cooren, 2009), this study endeavors an answer by documenting the way that situated, problem-based organizing can reflexively influence or impact organizing narratives. Thus, the second research question driving this study is:
RQ2: What is the relationship between the organizational narrative of the authoritative text and the appropriation/performance of agency and materiality in collaborative management conversations?

Answering these questions can provide inroads into better theorizing the communicative basis for knowledge construction while also potentially making communication-knowledge links more visible to organizational practitioners.
Chapter 2: Methodology

This study examines an organizational change at NIST Boulder. The change involves efforts to increase cross-sector collaboration among a number of groups, including scientists from five different research divisions, campus administrators, and building maintenance workers. A particularly important facet of this change is the role that specialized knowledge plays in cross-sector collaboration, given that such knowledge commonly distinguishes organizational sectors via both abstract and practical work orientations. At question is whether and how cross-sector collaborators can negotiate shared authority across these practical knowledge barriers as they meet to discuss building management policy and practices. In this regard, the move toward such a collaborative management model is a novel step for an otherwise siloed federal research facility, and cross-sector organizational authority must be newly negotiated and sanctioned during these building management discussions, particularly as new laboratory management practices are enacted. Accordingly, this dissertation study examines those conversations to explore how expert and practical knowledge are invoked (and re/produced) toward achieving cross-sector collaborative authority.

Premised in a CCO framework is that the ontological status and emergence of abstract organizational qualities like knowledge and authority are manifest and thus traceable in discourse (Cooren, 2015). For Montreal School CCO theorists, conversations evidence discourse as both the textual structuring resources that inform it, as well as the micro-level performative capacities that accomplish situated meanings and outcomes (Alvesson & Kärreman, 2000; Taylor & Van Every, 2000). The latter function – the way that discourse is performative toward organizing processes (that is, frames a particular image and narrative of the organization and organizational action; Fauré et al., 2010) – is especially important for this study, given the focus here on the
conversational accomplishment of knowledge and authority. Together, the emergence of these qualities highlight how conversation is more than merely the exchange of information; rather, it also functions to construct the context of its use, from a myriad of possibilities (Austin, 1962, as cited in Cooren, 2015, p. 28-9; Faure et al., 2010). This study is particularly concerned with the way that conversations invoke and negotiate contextual organizational frames that make possible coherent, meaningful action.

As such, this study methodology is rooted in a social constructionist tradition, highlighting the interrelated processes of how interactional resources are made meaningful and as such, provide a shared sense of reality within and across groups of people. The underlying basis of this view is that symbolic resources such as language, artefacts, and figures (e.g., metaphors, ideologies, etc.) are made present in conversation and together provide the symbolic basis for constituting a knowable and functional organized reality. In this way, the communicative construction of co-oriented reality makes possible shared meaning systems that guide and coordinate action, and which in turn can be textually stored for later reference and meaning-making.

While this emphasis on discourse as the site and surface of organizing places Montreal School within the Social Constructionist tradition, such a categorization is not a clear-cut fit and has invoked debate. In particular, the Montreal School has faced criticism that its ontological rejection of “deep structure” runs counter to recent Social Constructionist (more specifically, Interpretivist) methodological work toward better accounting for researcher reflexivity and considerations of power (Bisel, 2010; Lindlof & Taylor, 2017; Reed, 2010; Taylor, McDonald, & Fortney, 2013). For methodology in particular, the challenge Montreal School scholars face is how to collect discursive data that can evidence (and thus better account for) power and
researcher involvement in the text/conversation dialectic (Putnum & Nicotera, 2010). To be sure, these are difficult endeavors, due to questions involving whether and how such complexities are discursively encoded in text/conversation dialectics. While Montreal School scholars have begun to acknowledge these challenges, particularly targeting ways to recognize the involvement of sites, objects and bodies in a flattened ontology (Ashcraft, Kuhn, & Cooren, 2009), progress toward addressing these concerns remains in process. Toward that end, this dissertation study joins Kuhn’s (2008) emphasis on tracing textual authority as a locus of (and constitutive of) organizing power, and thus as a potential way to better theorize links between text/conversation, social materiality, and power.

In sum, my study methodology is crafted to produce data that enable the tracing of collaborative management conversations at NIST insofar as they constitute emergent organizational meanings, practices and authority toward fulfilling the target narrative of becoming a more collaborative research facility. Doing so provides an avenue toward better understanding links between organizational knowledge, conversational knowing, and the re/emergent authoritative narratives through which conversations, understandings, and practices are coordinated.

In this Methods section, I document the process through which this study was carried out, including a description of my research site and participants, as well as my data collection tools and procedures for data analysis. To begin, I offer background information about NIST as an organization, in order to contextualize my subsequent explanation of the particular participants involved in data collection. Next, I describe my field work toward data production, and finally, I conclude this chapter by explaining my aims and techniques for data analyses.

**Research Site Overview**
The National Institute of Standards and Technology (NIST) is a federal research laboratory complex under the Department of Commerce, responsible for measurement technology ("metrology") research aimed at both standardization and innovation. The research conducted at NIST has direct influence on the regulation of industry in the U.S. as well as the development of military technologies. In the opening vignette of this study proposal, for instance, scientists were at work on a project aimed at improving the radiation-sensing capabilities of portable devices deployable to ground troops in Iraq and Afghanistan. In the wake of 9/11, NIST also conducted experiments to test the reliability and integrity of building materials under the stress of extreme heat and pressure, the results of which had immediate impact on the building standards of the new One World Trade Center. Further, NIST has also been home to a series of atomic clocks dating back to 1949, continuously serving as the official time source of the U.S., and earning respect as a worldwide authority on time measurement precision. Research conducted at NIST also has relevance to “pure” science; four NIST scientists have won Nobel Prizes in the past fifteen years, involving advances in quantum measuring techniques (Dave Wineland in 2012), laser frequency measuring techniques (John L. Hall in 2005), and quantum physics (Carl Wieman and Eric Cornell in 2001).

All four of those Nobel Prize laureates conducted their research at the Boulder branch campus of NIST, a notable feat given that three-quarters of the scientists employed by NIST conduct their research at the main campus of NIST in Maryland. Since its formation in 1901, NIST (formerly National Bureau of Standards) has been headquartered in Gaithersburg, Maryland. The NIST-Boulder campus was built in the early 1950’s (dedicated in 1954) as the second (and at the time, only) branch-campus of NIST. The Boulder site was chosen with the intention of taking advantage of the relative quiet of the Rocky Mountain foothills to conduct
radio (i.e., electromagnetic) wave research. Through the 1960s, 70s and 80s, however, NIST-Boulder grew to accommodate the relocation and expansion of other research areas. At the time of data collection, NIST-Boulder was home to five distinct organizational “research divisions,” including (1) Applied Chemicals and Materials, (2) Communications Technology Laboratory (now encompassing the aforementioned radio wave research), (3) Applied Physics, (4) Quantum Electromagnetics, and (5) Time & Frequency. In the 1990s and 2000s, these five research divisions were housed among three buildings on the NIST-Boulder campus, producing a degree of interdependence under shared building policies, yet they had little cooperation or collaboration. During this time, cross-division relationships became somewhat strained and communication suffered. Under these conditions, the plutonium spill occurred, which inspired changes: both in adding and designing new building space, but also in adopting new building management practices.

In 2008, with funding from the American Recovery and Reinvestment Act, NIST-Boulder began construction of a new facility, the “Precision Management Laboratory” (PML) in order to provide a much-needed expansion of laboratory space – 68 new laboratories in all. Included in the building plan was a centerpiece, state-of-the-art “clean room” laboratory, to be furnished with rows of multi-million dollar research equipment that would be shared among scientists from all five of the research divisions at NIST-Boulder. Requiring scientists to share equipment was not incidental: the design of the new PML building coincided with a strategic restructuring at NIST, flattening the bureaucratic organizational structure, in attempt to encourage the increased bilateral coordination and collaboration between and among scientists, administrators, and building workers. The PML building floorplan represented a definitive step away from the previous isolation between research divisions: most centrally, it established an
integration of the five research divisions, setting them up with neighboring laboratories that shared access hallways, forcing the scientists to “rub elbows” more frequently. Furthermore, PML design included an integration of support space: meeting rooms, office space, and common areas were placed in locations so as to include scientist and administrator visibility, with hopes of inspiring impromptu conversations between them. To entice scientists to move into the new building space, the PML was equipped to accommodate the next generation of precision scientific equipment and resources, with not only multi-million dollar quantum-level research tools, but also with unprecedented environmental controls, including pinpoint specification of laboratory temperature (+/- .5 degrees Fahrenheit), humidity (+/- 5 percent), air quality, and vibration reduction (velocity amplitude of 3 micrometers per second at 20 Hz to 100 Hz). Furthermore, the laboratories were constructed to provide continuous supply lines of nitrogen, helium, ultra-purified water, clean dry air (CDA), and temperature-controlled compressed air.

All in all, the clean room and laboratories in the PML building provided the opportunity to improve the way that scientists conducted their research, both individually, and in teams.

Administrators, however, anticipated that organizing the move to new facilities would prove challenging, given the number of scientists, their varying needs, and the sophistication of the equipment and building systems involved. For context, when NIST-Gaithersburg constructed and opened a similar building with their own clean room facility (the “Center for Nanoscale Science and Technology”) in 2007, administrators reported that it took over three years before “all of the kinks were worked out.”

Complicating the move-in was the coordination required between two co-present, but otherwise very isolated organizational units at NIST-Boulder: (1) Laboratory Programs, encompassing scientists and administrators, and (2) Management Resources, encompassing
organizational support services. Historically, the relative isolation between these two overarching units resulted in both sides experiencing a growing tension between them. This tension is significant enough to warrant some explanation. While Laboratory Programs at NIST-Boulder are further broken down into the five research divisions listed above, Management Programs are broken down into six sub-units: (a) Office of Acquisition and Agreements Management (“purchasing”); (b) Office of Safety, Health and Environment (“OSHE”; i.e., specialized review boards); (c) Office of Information Systems Management (“I.T.”); (d) Engineering, Maintenance and Support Services (EMSS, or “plant”); (e) Office of Financial Resource Management (“budgeting”); and (f) Office of Human Resources Management (“HR”).

A key distinction between these two major organizational units are differences in structure. Briefly, Management Programs were more strictly bureaucratic, in both their more disciplined adherence to standardized operational procedures, but also in their chain of command. While scientists generally enjoyed more autonomy within a relatively flattened hierarchy, those on the Management side of the divide had more direct supervision, more paperwork, and broadly had to concern themselves with navigating the “corporate ladder.” These differences commonly produced tensions as each side of this major organizational divide operated at different paces, and had different orientations to their responsibilities.

Of the six subunits under Management Programs at NIST-Boulder, one is particularly important for this study: EMSS. “Plant” personnel were building workers who were responsible for maintenance and service work on building systems. Accordingly, EMSS workers tended to specialize in a particular building system, such as HVAC or electrical systems. Compared to scientists, there were relatively few EMSS workers on hand in a building, typically 4-8, all of whom worked under the supervision of the “building manager.” The building manager was
ultimately responsible administratively for handling service requests and in turn, coordinating and delegating maintenance in one particular building. The building manager during most of my field work was an HVAC specialist who had risen through the ranks by taking training courses in management and purchasing in order to become qualified as a building manager.

Beyond EMSS workers, only one other subunit under Management Programs makes an appearance in the findings of this study: OSHE. This subunit included safety and environmental specialists who were occasionally invited to management meetings in order to provide supplemental information or analysis for particular building problems requiring resolution.

**Formation of the PML Operations Group.** Recognizing the difficulties ahead in opening the new PML building for research, administrators sought to overcome these overarching divisional divides by forming a collaborative building management committee composed of both scientists and building workers. The basic model of the PML Operations Group was that it would serve as a channel for soliciting concerns and problems among scientists throughout the building, such that those concerns could be addressed and resolved by a committee of scientists and building workers with interdisciplinary, cross-divisional consideration. By selecting scientist representatives from each division who would meet frequently alongside the building manager and other building workers, administrators wagered that integrative resolutions to building problems could be implemented in a way that sufficed interests across both organizational unit divisions and scientific research divisions. Because the PML Operations Group was assembled for the purpose of discussing and resolving building problems, representatives on this group became ideal participants for this study. In the next section, I introduce these participants in more detail.

**Study Participants**
While the initial participants in this study were those involved in the PML Operations Group, the number grew as the collaborative building management model expanded. Specifically, the collaborative model developed into three distinct, but connected management groups. First, the PML Operations Group is the original group created as the PML building opened in April of 2012. Membership was primarily composed of scientists from each research division who served as liaisons between scientists working in the PML building laboratories and the policies and decision-making that governed the day-to-day management of their work environment. If resident scientists had problems or concerns that hindered or threatened their research, the idea was that they had a PML Operations Group representative who could listen to those concerns, and bring them before the group so that they could be addressed and resolved. Soon after the formation of this group, however, the need was recognized for a Galley Safety Representative group, who became responsible for safety code development and enforcement in particular areas of the building: the shared service galley space area running between, and connecting neighboring laboratories. Finally, the PML Oversight Committee was formed out of the need to gather administrators – Gaithersberg-appointed “division chiefs” – who possessed the organizational and budgetary authority necessary to implement the building management resolutions that PML Operations Group members had determined.

**PML Operations Group.** The centerpiece of the collaborative management model is the PML Operations Group, which was assembled with dual purposes in mind: to both represent the needs of scientists in the building, and to resolve the issues in way that reflected the needs of all building residents. Towards the first purpose – representation – the PML Operations Group would be comprised of scientists from each of the five research divisions occupying labs the PML building, to serve as points of contact for other scientists to report building issues or
problems that required attention; in turn, the PML Operations Group member would raise that issue for discussion during PML Operations Group meetings. The number and selection of scientists from each division is somewhat complicated, and requires an understanding of the physical layout of laboratories in the PML building. Spatially, the PML building is comprised of the shared “clean room” on one side of the building, next to which are five side-by-side “blocks” (imagine a city block with an alley) of interconnected laboratories (see appendix 1 for a floor plan map of the PML Building). Each block has a service galley running the length of the block (like an alley), which effectively separates the block into two rows of labs. The PML building was designed so that multiple research divisions could occupy each block, ensuring more exposure and interaction between divisions. The PML Operations Group members were generally selected such that each division occupying a block would have one representative. If a block has three research divisions occupying it, then three PML Operations Group members would be recruited to represent it – one from each division. As a result, some divisions had more representatives, because they occupied more blocks than other divisions. The purpose behind this representative selection scheme was to ensure both division- and spatial-representation, such that scientists from each division in each lab block had a familiar PML Operations Group member who could hear and represent their concerns.

Beyond representation of their fellow scientists, PML Operations Group members were also responsible for meeting to discuss the building issues raised, with an expectation of coming to a consensus for sufficiently resolving those issues. Toward that end, they typically met for 1 to 1.5 hours, during which they brainstormed for possible solutions, discussed the merits of solutions identified, selected one resolution, and compiled a summary list of resolution-based “action items” at the end of their meetings. One member would then present that action item list
to the PML Oversight Committee meetings with “higher-up” division chiefs, who had the authority to implement the resolutions, including making large purchases, if necessary.

On its formation, the PML Operations Group was composed of: one clean room representative (a scientist: the “clean room manager’’); two representatives from Applied Chemicals and Materials division; one representative from the Communications Technology Lab division; four representatives from the Applied Physics division; three representatives from the Quantum Electromagnetics division; and two members from the Time and Frequency division.

Finally, importantly, the EMSS building manager also attended PML Operations Group meetings. During PML Operations Group meetings, the building manager provided status updates for building systems, particularly those that had been experiencing problems, and was often called upon for explanations of problems and a timeframe for completing required building repairs. The building manager also had building maintenance staff under him, who occasionally attended PML Operations Group meetings.

In all, there were 15 regular PML Operations Group members during data collection. Two were female; thirteen were male. When the building first opened, the group met biweekly to handle the high number of complaints/requests from new occupants. Approximately 18 months after the building opened, however, they reduced their meeting frequency to once per month due to a reduced number of problems requiring resolution.

**Galley Safety Representatives.** Soon after opening the PML building, the members of the PML Operations Group began to recognize recurrent problems in a particular area of the building: the service galleys between labs. The service galleys were areas where scientists had long grown accustomed in the old building to storing excess supplies for their experiments, yet they lacked explicit regulation of items that could be stored there. As a result, it became clear
that the galleys were dangerous places, and required closer monitoring (this recognition will be discussed in more detail in the findings of this study). Out of this recognition, the PML Operations Group members elected to create a sub-committee, the Galley Safety Representatives, to monitor the galley space and make policy recommendations to the PML Operations Group. The Galley Safety Representative (GSR) Committee was composed of five members – one for each lab block/galley. The GSRs met monthly to discuss any incidents or issues they or other scientists may have encountered in the galleys, with the purpose of determining whether the issues should be relayed to the Operations Group. The GSRs also conducted more thorough quarterly “walk-throughs” of their respective galleys, in order to compile a more thorough inventory and assessment of the items found there. Because of the need to report their work to the Operations Group, GSRs also became regular attendees of the PML Operations Group meetings. Of the five total GSRs, three were female and two were male.

**PML Oversight Committee.** Finally, the PML Oversight Committee was assembled as a support and advisory committee to the Operations Group. The Oversight Committee was composed of the “division chiefs” for each of the five research divisions, as well as the “Boulder Lab Director” who occupied a position above the division chiefs (the Lab Director is ultimately responsible for all of the research conducted at the Boulder campus of NIST). Given their status as high-level administrators at NIST-Boulder, the Oversight Committee had ultimate authority to follow through on the resolutions determined by the Operations Group. In addition to these administrators, one or more Operations Group members attended Oversight Committee meetings in order to provide reports and updates on their activities and resolutions. In order to follow through on their resolutions in a timely manner, the Oversight Committee generally scheduled their meetings to follow the Operations Group meetings within a day; thus, their meetings were
scheduled for once a month. However, division chiefs were often absent, and during data collection, Oversight Committee meetings were increasingly postponed and/or canceled as a result. Of the six members of the Oversight Committee, five were male and one was female.

In sum, among the PML Operations Group, GSRs, and Oversight Committee, a total of 26 participants were involved in the regular meetings that I attended during field work. Beyond these regular members, specialists from Management Programs were occasionally invited to Operations Group meetings in order to offer information or analyses about particular problems that group members faced. In total, six such experts visited Operations Group meetings during field work, some of them multiple times. These specialists are noted in study findings when they contribute to the decisions or resolutions determined by the Operations Group. With this introduction of participants established, I now turn to describing my processes and tools of data collection, starting with an explanation of my emerging status and role at NIST.

Data Production

In this section, I detail the process of data production, beginning with an account of how my access into NIST was negotiated, and how it developed over time. By providing an explanation of my evolving access and identity at NIST, I aim to establish the capability of accounting for the ways in which my presence became involved in data collection tools I employed. Given my target of documenting problem-solving conversations in the PML building at NIST, I developed a focus on the PML Operations Group centrally, and the GSRs and Oversight Committee peripherally, with the overarching goal of identifying and tracing building issues longitudinally across meetings, and specifically, within the text-conversation dialectics through which such issues were re/established.
Site Access. In April of 2012, just as the PML building opened, my access into NIST was provided and navigated by a scientist – an Operations Group member – who had a particular interest in the collaborative management model. This scientist, an acquaintance of my academic advisor, became my “gatekeeper,” escorting me around NIST-Boulder during my first days on campus, and introducing me to important administrators. I had the good fortune of enjoying this type of warm welcome from most of the scientists and building workers I encountered at NIST. In part, I had indications that my cordial reception resulted from my status at a graduate student researcher; a number of scientists offered stories of their time as graduate students. In this respect, aspects of my social identity apparent in my appearance worked in my favor toward tacit acceptance at NIST: I am a white, male academic, which demographically put me on common ground with the vast majority of those I encountered at NIST. Furthermore, as highly-educated scholars and PhDs, the scientists expressed a “big brotherly” regard for me, showing concern for helping me finish my “thesis.” As this misconception involving my “thesis” work implies, the disciplinary differences between us also provided me with some helpful insulation from the discursive commitments that scientists themselves practiced. That is, I took advantage of my status as merely a “communications” expert to excuse myself from engaging in the scientists’ technical talk before and after meetings, even on the occasions when I had the aptitude to engage. This type of cross-disciplinary respect allowed for ideal levels of being present, but silent. I maintained this respectful/respected distance by occasionally sharing insights from communication theory when those insights were relevant and therefore appreciated.

As I will explain, this “fellow (but disciplinarily-foreign) researcher-in-training” identity provided me with ample levels of access without encroaching on the process or content of scientists’ Operations Group work. In what follows, I describe particular tools of data collection,
including field work, semi-structured interviews, and artifact collection, which were constituted via the access and identity I embodied at NIST.

**Protecting participant rights and privacy.** Consistent with University of Colorado Boulder’s IRB guidelines, at the onset of data collection, I obtained verbal consent from all of my participants, and provided them with a written consent form that outlined their rights, the risks of this study, as well as potential benefits. I also offered anonymity to the degree that it is possible in a high-status organization with such distinctive positions and relatively few study participants. Along these lines, I told them I would nevertheless use pseudonyms in place of their names in this study report. Finally, my participants were made aware of their right to abstain from participating in the study; none of them chose to exert this right. For interviews, I explicitly requested and received permission to audio record the interview discussions toward the purpose of transcribing them. All interviewees agreed to be audio recorded.

**Field work and participant-observations.** The majority of data produced during this study was accomplished via participant observations and writing field notes. These field notes were hand-written during meetings and subsequently reproduced digitally for purposes of data analyses. At the time of my first Operations Group meeting at NIST, I made a key decision not to request permission to audio record meetings (including Operations Group, GSRs, and Oversight Committee meetings). I made this decision after raising the possibility in a conversation with my gatekeeper scientist, who recommended that I not seek permission to record. He reported that such a request would need to be cleared by the Human Subjects review board at NIST headquarters in Gaithersburg, MD; approval of which was not assured. We also discussed what was, at the time, my uncertain status and acceptance at NIST. He expressed concern that some scientists would not welcome the sight of an audio recorder at a newly formed cross-divisional
building management meeting, where trust between divisions was tentative at best. As a result of this discussion, I elected not to pursue the ability to audio record meetings. This decision, of course, had important consequences, as it prevented my data from including micro-level discourse. Data produced during meetings are limited to the field notes I was able to write during them. At times, particularly early in the process of data production, this practical challenge meant that data was limited by that which I could inscribe in notes and, by extension, that which I could evaluate as important to inscribe. Thus, the lack of transcribed dialogue did create a filter in what became data and, by some measures, this prevents the project from being a micro-discourse study that typifies CCO research (Brummans et al., 2014; Cooren et al., 2013). This risk was mitigated, however, by the recognition early in data collection that problematic building issues were the important units of analysis: Ops Group meetings were issue-centered. In this respect, field notes were sufficient to record problematic issues and the arguments made toward resolving them, because those issues were recurrent. While early field work did run the risk of failing to grasp the significance of off-hand remarks that foreshadowed eventually important issues, it is safe to say that meaningful issues for the Ops Group were spread across a number of meetings and thus were notable and traceable over time.

Field notes were produced in the following manner. Whenever possible, I arrived at meetings early. Often helpful conversations took place before the actual meeting started, during which scientists tended to speak more informally, particularly after they became comfortable with my presence. My early arrival also enabled me to identify and write the names of committee members as they arrived. Early in field work, meetings were frequently attended by new participants. In these cases, those who led the meetings generally asked for introductions from each person around the table. For these occasions, which happened about eight times in all, I
simply introduced myself as a “communication graduate student who is studying collaboration,”
and I only elaborated when pressed with follow-up questions. I also recognized that emphasizing
my appreciation for this “ground-breaking experiment” of such cross-divisional collaborative
building management tended to ingratiate myself among the important administrators who had
advocated for the Operations Group management model. Once meetings began, I spent nearly
every minute recording all relevant aspects of the meeting space (seating arrangements,
whiteboard drawings, etc.) and conversation, including nonverbal qualities and performances.
My goal was to produce rich field records that were sensitive to the variation in how discursive
meanings are re/produced (Van Maanen, 1979). As a result, I simultaneously wrote in shorthand
while also visually observing social material qualities that surfaced as important or meaningful
during discussions. Furthermore, I also bracketed reflections that occurred to me during meetings
that warranted later consideration and/or research memos. At the end of meetings, I recorded the
time of finish (rarely did meetings finish right on time), and I typically stayed around as
scientists left the meeting in order to observe any noteworthy post-meeting conversations.

In sum, during field work for this study, I observed 58 meetings over 36 months, totaling
86 hours and resulting in 242 pages of single-spaced text in typed field notes. These field notes
are interlaced with actual quotes when possible, summaries of claims or utterances when full
quotes were not possible, as well as particularly noteworthy nonverbal reactions when they were
meaningful, and a documentation of particularly attention-garnering performances (jokes,
sarcasm, etc.). They also document which group members contributed to each discussion topic.

**Semi-structured interviews.** During this study, I also conducted in-depth interviews
with 16 key members of the PML Operations Group, GSRs, and Oversight Committee
administrators. During interviews, I targeted a few types of information from interviewees. First,
I used the opportunity to ask them about their background; for instance, their “home” division, research projects, tenure at NIST, and experiences working in the “old building.” Furthermore, I asked about their perspective on how their respective committee involvement was going, whether they had frustrations or success stories, and generally whether they thought it was a successful model. Last, I prepared and followed a semi-structured interview guide in order to identify follow up questions that would provide occasions for them to offer examples or stories that illustrated their committee or research experiences at NIST. Interviews averaged 40 minutes in length and were digitally recorded (with written consent) for transcription and analyses, resulting in 157 pages of single-spaced text.

It is worth noting that the 16 interviews do not include two individuals who had been among the participants I targeted for interviews, but that instead became key informants with whom I periodically met informally outside of the NIST campus (typically over lunch or coffee). On these occasions, conversations with these two scientists provided the possibility of raising sensitive issues that I would not have otherwise felt license to ask, such as about the plutonium spill and who was involved/responsible, and about the history of tensions between EMSS and scientists. In other words, these two informants provided reports of aspects of NIST that might otherwise have only been spoken in whispers around the PML building.

**Collection of Artifacts.** NIST is an organization ripe with artifacts, and many were collected during this study. Examples of artifacts include meeting agendas, meeting summaries (with “action items”), prepared reports, operating procedure manuals, building maps, event flyers, and research posters. For the purposes of this study, artifacts are understood as texts that can be drawn upon as resources during situated conversations, and they can potentially presentify people, principles, standards, the PML building, or NIST as an organization. Artifacts were
particularly important for my purposes because tracing the episodic meaning attributed to them across a number of meetings and contexts is involved in the overarching aim of this study. Artifacts were often distributed at meetings or emailed following meetings (reports, PowerPoints, maps, etc.). When I collected artifacts, I also recorded the manner of their use into field notes, in order to capture the conversational context wherein they became meaningful. Doing so enabled me to trace their emergent participation in organizing conversations, including the ways that they became key figures in decision-making.

**Analysis Strategy**

Qualitative data analysis is not always linear, nor clear-cut. Given my time in the field (over three years), and given that this is a doctoral dissertation project, the data I produced have been analyzed from a number of different theoretical perspectives during graduate coursework, each at various stages of data production. This is important to note, because examining the data from a cultural or rhetorical framework, for instance, though not directly applicable to a CCO approach, still nonetheless influenced my familiarity and relationship with the data. For instance, previous ethnographic thematic analysis familiarized me with relationships between the discursive/symbolic references made by scientists and their particular research division and agenda, providing me with the capability of readily recognizing terminology shared by subgroups of scientists. As a result, I could draw connections between conversations and textual resources that were not otherwise easily made or recognized (not to mention difficult to document after deciding on a CCO framework!). This pluralistic theoretical pre-analysis complicates my timeline of data analysis, because at times it obscured or hid important steps that contributed to insights and connections I drew in my findings. Still, notwithstanding this nonlinear process of analysis, I identify three layers of analysis that were instrumental in
surfacing the connections between cross-sector organizational knowledge and authoritative texts, toward answering my research questions. All three steps were aimed at making visible the text/conversation dialectic that occurred across Ops Group meetings: (a) conversation-to-text analysis; (b) text-to-conversation analysis; and (c) trans-dialectic analysis.

**Conversation to text.** First, to document the conversation-to-text process, I examined the relationship of fieldnotes with texts that resulted from Ops Group meetings, written by Ops Group members. Here, I was primarily interested in tracing the building issues raised during Ops Group meetings (via fieldnotes), and how those issues became encoded (or not) into organizational texts. That is, I inventoried the conversation topics raised during meetings, so that I could trace whether the topics became episodic, and if so, how they were translated (and thus emergently understood) from meeting to meeting. To aid in this process, I used NVIVO qualitative analysis software, and digitally transcribed my fieldnotes so that they could be coded, indexed, and searchable. Using an adapted version of Glaser & Strauss’ (1967) constant comparison method, I inductively developed a coding system that resulted in 19 categories of discussion topics found across Ops Group meetings. Among those 19 categories, 14 were building issues that scientists identified as problematic, and in need of resolution. For example, many of the issues described later in the study findings were among the 14 building problem categories experienced by a number of scientists/labs, including: air temperature, nitrogen supply lines, helium generator/supply lines, and electromagnetic interference, to name a few. The remaining five categories could be characterized as one of two types: they were either meta-conversations the group had about their own process, or they were non-episodic (i.e., discussed only once, and determined to be either irrelevant or trivial). Examples of these types of topics were the Ops Group’s discussions about their own group responsibilities, discussions about
funding that involved fiscal/budget questions or speculating about what sort of resolutions were likely (and unlikely) to be funded, and brief one-time events like planned power outages.

A primary benefit of this conversation-to-text analysis is that it provided the capability of tracing building issues from the first time they were discussed, until they were deemed to be resolved. Each time an issue was raised, I documented in fieldnotes the way in which the issue was depicted by Ops Group members, including any related sub-aspect discussed, and the arguments made advocating one avenue of resolution over another. This type of description captured emergent differences in the way that a topic was discussed from meeting to meeting, and thus how it was made conversationally meaningful across various contexts.

A second benefit of this conversation-to-text analysis is that it provided the possibility of indexing issues with conversational participants. In my fieldnotes, I noted which Ops Groups members contributed to conversations involving each topic. As a result, I could conduct analyses that associated each Ops Group member with a set of issues that particularly interested them. Further, I could identify the number and types of viewpoints that contributed to the “worldview co-orientation” through which issues became defined, described, and understood (Taylor, 1993). This step of analysis helped to discern divisional and lab-based interests, but connectedly, it helped to gauge the degree to which scientists participated in discussions involving issues not immediately relevant to their own research.

Finally, a third benefit of conducting conversation-to-text analysis is that it offered the possibility of noting any differences between the scientists’ representations of their discussions with fieldnote documentations of those discussions. In other words, I could trace how textual representations of issues selected some aspects of the conversation to represent, while potentially obscuring or dismissing others. This type of analysis could surface any discrepancies between
how an issue was discussed and how it became textually organized – an important distinction for CCO scholars who are interested in questions of how and why organization emerges in particular ways instead of others. For example, on occasion during analysis, fieldnotes documented discussions about some issues that scientists had agreed to deprioritize, yet those issues were often listed and described in meeting summaries alongside or even above other issues that were deemed to be higher priority. In turn, those meeting summaries became the basis for the next meeting’s agenda, and the de-prioritization seemed to be irrelevant and/or forgotten. As a result, comparing fieldnotes to meeting summary texts proved to be a useful way to surface aspects of conversation that were disorganized in the text/conversation dialectic (Cooper, 1986; Kuhn & Burk, 2014).

**Text to conversation.** A second key component of the text/conversation dialectic is the way in which prior texts provide discursive resources invoked by conversation participants (Taylor & Van Every, 2000; Cooren, 2015). Recognizing the textual resources that interlocutors reference is important because it surfaces a priori forms through which the present is made recognizable (Taylor & Van Every, 2000, p. 72). In this sense, texts provide “pre-packaged” constructions of reality that heuristically frame possible ways of seeing and interpreting conversational experience. Tracing organizational texts that may be used as sense-making resources, particularly while addressing technical cross-sector collaborative conversations can be a challenging task. Often Ops Group members referenced texts they previously authored in prior meetings, for instance, prior meeting notes. But at other times, they referenced discursive meaning systems that were not readily apparent. Placing scientists’ comments in context to these prior texts therefore required investigation.
To recognize these a priori forms referenced in the text-to-conversation process, I used interviews and artifacts to create background profiles for each of the Ops Group members, as well as to learn more about the research conducted in each research division (and even in each lab). I anticipated that compiling these profiles would point to the textual resources that constituted the scientists’ viewpoints and comments during Ops Group conversations. For instance, at times during Ops Group meetings, particular scientists expressed concern about the presence of electromagnetic waves in his/her lab. The reasons for their concern were not always apparent to me during meetings, yet other Ops Group members indicated their acceptance of the concern at face value. By asking about the scientists’ research during interviews, I found that they would describe for me the source of their viewpoint – for instance, texts on the qualities and behaviors of lasers, etc.

Analysis of text-to-conversation therefore provided the possibility of tracing particular textual resources referenced during Ops Group meetings, for the purpose of recognizing when those texts were accepted a priori, without contestation, and likewise, when particular texts were challenged. In this way, I could identify the relative authority that these texts carried for scientists, administrators, and building workers.

**Trans-dialectic analysis.** While the above two strategies of analysis were instrumental in revealing the way in which particular discussion topics became significant in contributing to the Ops Groups’ negotiation of their new “collaborative” reality, in time I recognized that connecting those topics to organizational narratives required another layer of analysis. Specifically, it became evident that tracing organizational knowledge and narratives involving what it means to be a “collaborative science organization” necessitated examining emergent texts across a number of meetings and text/conversation dialectics. In other words, identifying the way
that knowledge practices constituted the group’s emergent understandings of collaborative science required that I look across all of the issues raised and resolved by the group, to assess whether they collectively evidenced potential emergent narratives that placed their work in context.

At this point, I began to recognize patterns across the Ops Group’s meetings and building topics that spurred a third phase of analysis: a consideration for how they worked together toward “constructing” a particular quality and character of the Ops Group’s work – especially how that work differed from building management practices that had been in place in the “old” building. I considered the possibility that Ops Group members were assembling building problems and issues toward a particular type of knowledge: practical understandings of the building itself. With an eye toward recognizing how organizational knowledge may be manifesting through and across building issues, I returned to the data with the purpose of searching for evidence that new conceptions of practical building knowledge was becoming integrated. In this search, I found evidence that the Operations Group had been authoring building texts via their problem-solving work on building issues. As a result, I pieced together building issue vignettes into a narrative that connected the Ops Group’s text/conversation dialectic with emergent notions of knowledge that addressed my research questions.

In sum, my analysis approach involving these three phases – conversation to text, text to conversation, and trans-dialectic analysis – provided in-depth, issue-centered vignettes that surfaced links between collaborative conversations, problematic building issues and the authoring of texts that effectively systematized practical organizational knowledge. In the following chapter, I present the findings of this dissertation project.
Chapter 4: Findings

To review, this dissertation study examines an organizational change at the Boulder campus of the National Institute of Standards and Technology (NIST). With the opening of a new research building (the “PML”) in the spring of 2012, NIST administrators sought to build a more collaborative research environment in which scientists could develop better cooperative relationships between research divisions and with building management workers. To do so, they designed the building with an integrative laboratory scheme, such that the five research divisions would share “lab blocks” and interact more frequently. To facilitate this change, they also gathered together scientist representatives from each research division inhabiting each lab block, to create a building management committee called the “PML Operations group.” One of the primary challenges of the PML Operations Group was to encourage scientists to turn away from the “old” way of managing their labs in the previous building, which they had titled “wild west” and embrace a new collaborative model of lab management.

These changes at NIST-Boulder highlight questions involving links between authoritative organizational narratives and the organizational practices and knowledge they rationalize and order. While the prevalent functionalist approach to organizational knowledge management views knowledge as synoptic representations that systematize work-related information, it lacks an explanation for the role of enactive knowing in organizational processes and practices. This dissertation endeavors to explore the role of synoptic knowledge and enactive knowing during these organizational changes at NIST-Boulder.

A communication-based theoretical model holds the potential to draw and explain these connections. Specifically, the CCO approach of “worldview co-orientation” via the text-conversation dialectic provides a means to document the process through which organizing and,
by extension, any requisite organizational knowledge, are emergent through the production and consumption of texts. Key to the explanatory power of CCO is that the conversational invoking and re/production of texts induces commitments among participants toward common conceptions of “the organization,” including an associated organizational ontology (i.e., objects, space), participant roles and relationships, and a narrative (e.g., “authoritative text”) that ties them together. This dissertation provides an opportunity to explore how notions of organizational knowledge are similarly invoked in conversation with the potential of being re/inscribed into the texts that emerge or are reproduced though those conversations. Employing such a model toward cross-divisional collaboration offers the possibility of exploring the issue of whether and how entitative knowledge, as a discursive (or inter-discursive) resource, may or may not be carried forward into pursuant organizing texts, and concomitantly, how emergent achievements of knowing become organizational within the shared context of produced texts.

The two research questions guiding my findings are:

RQ1: How is entitative knowledge encoded into organizational practices and/or authoritative texts?

RQ2: What is the relationship between the organizational narrative of the authoritative text and the appropriation/performance of agency and materiality in collaborative management conversations?

Toward answering these questions, these findings are organized into five sections. In the first, I document an important first step of the organizational change, when Ops Group scientists were confronted with specific insufficiencies of the “wild west” practices and approach in the new PML building. In the second section, I demonstrate how these insufficiencies are attributed by
the group as a lack of understanding of the building itself, which inspires them, in section three, to hail the building as a conversational figure and attribute it with qualities, conditions, and performances to produce understanding of it. In section four, I document how the “con/figuring” of the building is compiled into texts that constitute an entitative system of building knowledge, fulfilling and resolving the problematic lack of understanding that hindered scientists’ work. Finally, in section five, I examine how qualities of the Ops Group’s discussion became inscribed into the texts they produced. Specifically, I illustrate how the group’s conversations and eventual decisions became influential in defining what exactly should be represented by the synoptic texts, including a social material documentation of building objects, space, and relationships, all of which participated in political organizational currents.

Section 1: The insufficiency of the “wild west” approach

As the PML Operations Group (“Ops Group”) was assembled in March and April of 2012, the recruited members shared and discussed one basic recognition: the old “wild west” way of laboratory management was no longer sufficient in the new PML building. A key to understanding the ensuing work of the Ops Group is to document what exactly had been identified as broken. “Wild west” had become a frequently referenced phrase that elicited common understandings among Ops Group members, as well as among administrators and other resident scientists in the PML building. Across a number of Ops Group meetings, the layers of meaning invoked by the phrase gradually became apparent: “wild west” was used to indicate an alignment of lab management practices that corresponded to a rough collection of practical organizational knowledge (or “know how”), drawn together by a metaphorical “maverick” scientist approach to problem-solving. At various points, scientists referenced the “wild west” in the following ways:
We’re so used to doing things our own way, the – you know, then – then we started being called the “wild, wild west” [by administrators at NIST headquarters in Gaithersburg, MD] and everything, because we were rebelling, and we still are, you know, we still rebel against all the rules and the – the methodologies and the [paperwork]…oh man, there’s 15 times more paperwork for everything now.

One place [where] we are the wild, wild west… there’s a lotta handy people who will take things upon themselves.

It’s involved in our own professional practice. There are some aspects of the wild west that I never want to go away. I’m a big fan of pushing bureaucratic boundaries where I can, in a smart, intelligent way and still keep my job. Because I wanna get things done… There’s a bit of a maverick, sort of always floating around in there.

These quotes identify a general orientation for scientists as “maverick” problem-solvers for the issues they encountered in their labs. Key to this approach was the autonomy they enjoyed to rely on their own work, their own understanding, and their own resourcefulness for resolving issues. In this respect, “wild west” entailed a confluence of an organizing narrative and metaphor, as well as a set of laboratory management practices which together encompassed a sensibility that scientists at NIST-Boulder shared toward trusting only their own work.

What had broken, then, was the authoritative text associated with the old building: “wild west” had served as an unofficial yet powerful narrative that described an associated set of practices broadly recognized as how scientists “get things done.” On one level, then, the Ops Group was assembled to help reconstruct a new set of acceptable practices for lab management.

A key first finding, however, is that while scientists recognized they had to change the way they managed their labs, they resisted letting go of the “maverick” sensibility. As the above quote indicates, NIST scientists were physicists who identified strongly with a “professional practice” oriented toward “pushing boundaries… in a smart, intelligent way.” This orientation did not change during data collection. Rather, as I will document in the sections that follow, what motivated scientists to change the “wild west” was that they were forced to acknowledge that
they lacked the information required to manage their labs in the PML building in a “smart, intelligent” way. In short, scientists no longer had the collective, practical understanding necessary for working within and managing their labs, and were unable to restore it without the help of others. The Ops Group’s work began with the recognition that they and their experiments were made vulnerable by their lack of understanding about the building and the qualities, conditions, and performances they expected of it.

The trajectory of the Ops Group work became one of conquering this lack of understanding about the PML building. In the following section, I document the ways in which the Ops Group discovered and confronted the insufficiency of their understanding and practical knowledge of the PML building. Later, I document how the Ops Group simultaneously produced the required building knowledge while they also discussed, decided, and implemented an accompanying set of policies and practices to replace the “wild west.”

**Section 2: Insufficiency of understanding the PML building**

In the PML building, Ops Group members quickly recognized the insufficiency of the practical organizational knowledge they had established within the "wild west" approach to lab management in the old building. The practical knowledge they had relied on for managing and problem-solving in their old labs became no longer sufficient in the PML building. In this section, I document ways that the Ops Group scientists were quickly forced to confront how their previous familiarity with their lab space in the old building was no longer possible nor relevant in the PML. The following cases illustrate ways in which the group acknowledged that their previous knowledge and understanding of their lab became inapplicable toward managing their new lab facilities in the PML. First and foremost, the group was confronted with the discovery of safety risks within the service galleys shared between neighboring labs. Fully understanding and
assessing those safety risks was found to be beyond the capability of any single research division or lab. Second, the close proximity of scientists from other divisions in neighboring labs created problems with accessing and policing the building resources required for their work.

**Service galley safety concerns.** One distinguishing feature of the PML building was the presence of service galleys running behind rows of labs, similar to alleyways on city blocks. Service galleys provided access to the backdoor, service entryway of labs. In the PML building, service galleys became important for scientists as supplemental storage options for lab supplies. Lab storage was particularly important in the PML building because laboratories were designed significantly smaller than in the old buildings, which created a widespread shortage of storage space. Scientists could no longer store as much in their labs, a problem they commonly resolved by storing items outside of their labs, in the shared service galley hallways. The result was that service galleys soon became filled with surplus lab supplies -- for instance, cabinets filled with vials of chemicals, tanks (or “dewers”) filled with gases or cryogens, or equipment like uninterruptible power supply (UPS) units, heat exchangers, ladders, mobile storage carts or refrigerators for bio-samples. In the old building, items such as these were typically stored in the laboratories, but also, on the rare occasions when scientists ran out of space in laboratories, they sometimes stored the items along the hallways immediately outside of their labs. However, this practice was unproblematic because labs were isolated sufficiently such that scientists from other divisions rarely ventured close enough to encounter unfamiliar items. As a result, scientists had acquired the habit of freely storing items in and around their labs, which represented a very practical arrangement.

Carrying this practice over into the PML, however, presented problems. Ops Group scientists soon recognized that walking through service galleys was a potentially hazardous
prospect. The galleys became lined with supplies that no individual fully knew; scientists knew their own objects, but not those stored by others from unfamiliar labs. Within a month of the PML Ops Group formation, the Ops Groups representatives discussed service galleys as highly problematic areas:

Brendan: Do we have a utility [service] corridor access policy? Should there be one, if we don’t have one already?

Pete: I see a very good reason to have one: the expensive equipment we have there.

Steve: A more important issue is having SOP’s [standard operating procedure documentation] for people to follow. If we do not have an SOP, then people will quickly resort to “wild west” and we’ll have chaos in those corridors.

Brendan: Does service corridor qualify as “lab space”? And therefore require SOPs?

Jack: I’ll report our discussion/questions to Oversight. Safety is a primary concern. Should we have a lab safety coordinator assigned to the service galleys? Should we suggest that a DSR (Division Safety Representative] to fill this role?

Brendan: They fought hard to make those public corridors.

Steve: Maybe our recommendation should be that they revisit it on their hazard review walkthrough.

Jack: there are certainly hazards that need to be known and recognized.

Steve: Frame report to Oversight as questions/concerns. Ie, “should the service corridor be treated as a lab space?” (fieldnotes, 5/23/2012)

In this, their first discussion of the service galleys, the Ops Group quickly identifies them as problem areas for safety (“there are certainly hazards that need to be known…”). This point attests that the service galleys were already becoming storage locations for an array of dangerous chemicals, cryogens, and gases, less than a month after the building opened and even before the labs were fully occupied. This recognition led to the group’s concerns that service galleys could quickly mark a return to the “wild west” culture of the old building.

From this point, service galleys became the most frequently raised issue at Ops Group meetings, as well as the areas most central to the group’s work. A pivotal decision, introduced in
the exchange above, was the consideration of whether the service galleys should be officially defined as “laboratory space.” Although some scientists opposed this label because they preferred that the service galley doors remain unlocked for easy lab access, arguments of safety and equipment costs quickly prevailed. The group consulted a NIST Safety office representative, who agreed with their assessment: “Glen, it seems like one of your basic recommendations is something we whole-heartedly agree with, that the service galleys are probably the most dangerous places in the building” (fieldnotes, 6/6/2012). At the very next Oversight Committee meeting (on 6/20/2012), administrators determined that service galleys would officially be recognized as “lab space” in the PML building, which mandated that the galley doors remain locked, and that special safety attention was warranted in them.

While the label allowed administrators and the Ops Group to more effectively manage and police the service corridors, it also marked a significant new paradox for scientists: it was now lab space that none of them fully knew. In contrast to previously knowing their labs so well that they acquired practical knowledge and mastery of them, the service galleys represented shared lab space that defied any one scientist’s understanding. When interviewed, a scientist described the conundrum:

“In the old building, we shared some space …main hallways… but [we] didn’t have to interact that much. And so there wasn’t stuff in the [main] halls that you know could be hazardous that nobody knew about, that was all kept in their labs. And here with the service galleys, we’ve got that possibility where you’ve got one division that’s doing something, and another one right next door, and if they both put stuff out in the hall – in the service galley that could interact with each other in a bad way, you know so we’ve got to pay attention to that now and coordinate a lot more across divisions.”
This explanation of the danger of service galleys highlights the newfound fallibility of scientists’ knowledge of their now-expanded and shared lab space. As a result, they were forced to recognize the need to “pay attention… and coordinate a lot more across divisions.”

The key paradox, however, is that none of the scientists who shared a service galley were in position to know and assess the objects that were being stored by their cross-division neighbors in the service galleys. Defining the service galleys as shared lab space, then, provoked the resident scientists to encounter and recognize, within their own extended labs, objects beyond those that were previously defined and utilized within their established practical arrangements. Scientists were now confronted with objects not immediately understood in the context of their own experiments; these objects were not included in the practical knowledge previously required for their work. That is, scientists did not already know the dangers presented by these objects via the routine of their established “wild west” lab practices.

**Inadequacy of Shared Resource Policy.** The close proximity of cross-divisional lab neighbors also disrupted the way that scientists accessed the resources required for managing their lab and experiments. The design and construction of the PML building aimed to consolidate the provision of lab resources by making them “standard issue” for all labs. Whereas in the old building, scientists were in large part left to their own devices to secure the resources needed for their research (especially insofar as the old building had aged), the new PML building was constructed to centrally provide and manage them. Building resources in the PML included the environmental controls that made it a world-class research environment: precision control of air temperature, humidity, cleanliness, acoustic noise and three separate types of water supplies (ranging from regular “tap” water to ultra clean). In addition, the laboratories were designed with
continuous supply lines for gases that many, though not all, laboratories needed for experiments: nitrogen, helium, and “clean dry air” (CDA).

What designers did not anticipate, however, was the degree to which the resource needs of scientists in neighboring labs varied and thus had to be negotiated and configured across research divisions. As the PML building opened, Ops Group scientists recognized that the prior practice of scientists securing their own needs would be problematic insofar as it would interfere with the needs of neighboring labs. To better illustrate how lab problems were solved in the old building, one scientist described how he and his lab mates confronted problems with temperature stability:

“…there's a lot of dust, there's a lot of temperature fluctuation, so you know somebody leaves the loading dock open in the sun, and it's hot outside of the corridor. So for our experiment, or for my experiment, I need, you know, dust free, no vibrations, super temperature controlled, like all the laser people need that. I mean if you want to run an experiment for weeks, then you know the temperature has to be just absolutely stable. Whenever the temperature changes, you can see that from the measurement. You know it depends on the experiment, how much temperature fluctuation you can have. So… we had a lot of problems with temperature fluctuations, and especially in the summer, it – you know an experiment would be set up, I would start running it, in the afternoon the temperature would climb by 10 degrees Fahrenheit, 5 degrees Celsius, and so the whole line was lost. And so we checked into this, and we saw that there was a reverse flow in the air conditioning unit, so basically we didn't have enough – when it comes down to it, didn't have enough pressure, and the return line was pressurized. So we came up with a solution to actually put a booster on them, and get our lab temperature really stable, and the specs then at that time was .1 Fahrenheit, and that was the standard deviation, I mean it was super stable. And so I could run experiments from then on, and that was great.”

The noteworthy aspect of this scientist’s explanation is that, when he and his fellow lab mates’ experiments are threatened by a large temperature fluctuations in their lab, they troubleshoot the problem on their own. They recognize the underlying cause (reverse air flow through the air conditioning unit) and then they successfully resolve it themselves. The entire process of
problem discovery and resolution is handled only within the lab, and no other scientists, nor administrators, or building maintenance workers (EMSS) ever become involved.

In the PML, however, this type of private problem-solving became problematic due to the way that building resources and conditions were shared. Securing the needs of one’s lab could jeopardize the provision of needs for neighboring labs, and problems encountered in one lab could impact others. For example, during one Ops Group meeting a few months after the building opened, the group discussed various complaints from scientists about temperature fluctuations:

Pete: we did make a discovery with air temperature – someone [a lab user] called and said that the air temp was varying significantly. So, while investigating it, we turned off Johnson Control’s “Prac-tuning” [an electronic building control program] which handled the air adjustments. Once it was off, everything was fine – the temperature leveled out completely. Which means we need to do the same for the entire building. [Pete pulls out a chart on a sheet of paper, and shows everyone the trending graph.]

Steve: “So this [program] is causing measurable problems with this data.”

Pete shows another page of trending data in graph form – points out that when humidifying the air – that is, when the air is too dry and the humidifier kicks on or off, the temperature becomes unstable.

Pete: as of right now/ this time of year, we are humidifying multiple times a day, and so the temperature is unstable as a result. So, we’re moderating the system manually right now, until we can get Johnson Controls back out here – they claim it’s an easy fix, but when we had them on the phone, we couldn’t simulate/replicate the situation well enough, so they need to be here during a humidifying time.

Pete: So, these are some interesting clues/developments, but it’s still just gonna take time.

This segment of field notes illustrates the interdependency and interconnectedness of building conditions. After the problem with air temperature is first reported, the building manager (Pete) raises the issue with the Ops Group, showing them data tracing the temperature and humidity readings throughout the building. The group then discusses the potential reasons for the fluctuations, and decides that the building-wide computer program is the culprit. Importantly, the
temperature problem of one lab is immediately recognized in connection with the temperature and humidity performance around the building.

This fundamental shift drew attention to the way that managing and policing the building and lab resources required a consideration for not just scientists in one lab, but rather for all scientists throughout the building. Discouraging and replacing “wild west” practices in the PML necessitated a calibration of scientist needs among and between labs. Another more pointed illustration of this shift is provided by the following discussion regarding the “Process Chilled Water” (PCW) system, provided for all labs in the PML. PCW is a closed, circulatory water system that is dedicated for laboratory tools and equipment that require the water for either cooling or for basic functioning. In this exchange, the Ops Group discusses a problem with the PCW being too dirty:

Pete. Process Chilled Water. In order to get existing particles out of system, we need to flush it – once per lab.

Jack: [There are] 100+ systems in the C.R [Clean Room]….

Pete: it may be possible that old equipment have dirt and grime already in them, and they introduce the dirt into the system when they are hooked up.

Brendan: very possible. Any place we can hook up a big filter?

Pete: We’re looking into that.

Steve: we need to recommend scientists to flush their equipment before hooking into system.

Jack: Recommend that we flush machines and put filter on input/output (20 microbe; 5 microbe is too small). Flushing should be scheduled on a particular day and closing drops [spigot valves] in labs is mandatory.

Jack: an equally important water issue is that pumps are set to 25 psi when our equipment (in the Clean Room) needs 45psi. The pressure differential should be set as high as is reasonable and if you need lower then use an interceptor [i.e., intervention mechanism].
The pump does vibrate at some PSI. Someone asked for 25psi – that person needs to be found, to discuss the increase to 45psi.

Tim: What psi do you want, ideally?
Brendan: 50-ish.

Tim: There are also 1-inch bypass loops that are killing the differential (ie, pressure level)

Jack: [reads the recommendation he’s writing out loud:] “when vibration is fixed, then psi should be set to highest value that will work – i.e., keep pressure at minimum for equipment needs.”

Tim: people should also install flow meters with all values into equipment (in addition to filters)

Jack: People are probably going to complain.

Steve: we should also recommend that Oversight Committee send out emails mandating these changes.

Steve/Brendan: So, anything hooked up to the PCW Return System needs to be flushed first.

In this exchange, the Ops Group identifies a number of ways that they need scientists in all labs to cooperate in helping to cleanse the PCW supply, and to keep it clean. They first decide to ask scientists to flush their machines before hooking them into the PCW lines. Second, they recognize that they need to ask the scientists to help close off lines in their lab to prepare for a system flushing. Furthermore, Jack raises the issues of filtering and system pressure. He proposes that the group should ask scientists to install 20-microbe filters on the PCW lines in their lab, to help keep the water clean. Finally, Jack also proposes that the system be set to 45 or 50 psi – reasoning that it’s easier to lower pressure in each lab by installing “interceptors,” than to raise it. Overall, this discussion documents the various ways that the PCW system, as a building-wide resource, requires a common policy and procedure for coordinated management,
which disrupts and makes obsolete the “fend for yourself” practice in the old building (Jack: “People are probably going to complain”).

**Summary of section 2: Insufficiency of understanding the PML building.** Together, these two examples demonstrate how the interdependence of building conditions and shared resources forced the Ops Group and other resident scientists to recognize the insufficiency of their prior lab-specific practical knowledge and focus. This insufficiency highlighted first, the inability of scientists to rely on information and practices specific only to one (i.e., their own) lab in the PML. Second and relatedly, it demonstrated the need for building-wide coordination and cooperation toward developing policy that would collectively serve all scientist needs. The key recognition that grew out of these issues and others addressed by the Ops Group was that they needed to determine and author building resource policies that could facilitate the integration of needs, practices, and understanding among scientists across all labs in the building. This type of policy had been unnecessary in the old building, yet was central to shifting the locus of lab management from a per-lab basis (“wild west”) to building-wide coordination.

**Section 3: Producing and configuring a well-understood building**

Following the trend documented above, the early meetings of the Ops Group centered on identifying the practical and policy deficiencies that hindered the work of resident scientists. The group members were problem-oriented: they aimed to collaboratively manage the PML building in a way that could satisfy scientists with an array of needs, particularly those who were potentially in conflict with one another. From the perspective of Ops Group members, they were helping to re-channel the problem-solving practices of scientists, to help ensure that resolutions to problems were suitable for their cross-division neighbors. While the group proceeded with this
practical goal in mind, they raised, discussed, and resolved a growing list of issues over time, two of which I documented above, and more of which I will describe in the following sections.

Important for this study, however, is the way that their work accumulated thematically around producing practical organizational knowledge. Though they did not overtly recognize it, the Ops Group developed a conversational metaphor that characterized their purpose: the key figure of their work was the building itself. During their discussions, the group began to “presentify” the building by establishing it as a conversational figure. In the process, they ascribed it with qualities, conditions, and performances. Doing so provided the possibility of framing their work as a response to the fundamental challenge to understand the building. Achieving this purpose would in turn provide a synoptic knowledge base that represented the building while also “con/figuring” its performance. Implicated in this view is that the availability of a synoptic knowledge base describing the building and its qualities, conditions and performance provides scientists with the stability and consistency required to accomplish their work.

Underlying this process was a relocation of the locus of management practices: from the lab-level in the old building to building-wide in the PML. More specifically, whereas in the old building, individual laboratories served as the nexus where practices, roles, and commitments were organized, the Ops Group’s work broadened that nexus building-wide in the PML, through conversations in which they weaved together management practices and policies across labs and divisions, while constituting commitments and relationships through them.

Here, the figure of the building and the qualities attributed to it provide the meaningful distinction between the disrepair and insufficiency of the “wild west” and the pristine capability of the PML building. The PML is a valued figure for the qualities attributed to it, which the Ops
Group had been directed to optimize and protect. In what follows, I document evidence that illustrates this process: first in the way the PML was consistently raised as a figure across Ops Groups conversations; second in the way the PML is attributed key qualities that juxtaposition it from the “wild west;” and finally, in the way that the Ops Group aims to configure the building toward a system of representation that link building discourse and performance.

**Attributing the building as conversational figure.** In the first introductory meeting of the Ops Group, the PML building itself became an important conversational resource, particularly as it was situated as the inspiration and purpose behind the group’s formation. The meeting was attended by a collection of twelve administrators and Ops Group members, and was led by an administrator – a division chief at the time of the meeting, but who also oversaw the PML building development, from conception through design and construction. His PowerPoint identified two primary goals of the Ops Group, both of which centered on the building itself: “1. Ensure the most effective, efficient and productive use of PML for NIST Boulder research and metrology. 2. Protect PML as a crucial resource for decades to come.” (fieldnotes, Ops Group meeting, 4/11/2012). The first goal marks the building as a prized resource, insofar as it enables scientists to do their work (“research and metrology”), particularly when used well (“most effective, efficient, and productive use”). The second goal emphasizes the ongoing protection of the building as a resource “for decades to come.” In this sense, the building provides resources and receives care from the Ops Group and resident scientists, with the overarching aim to maximize the relationship between them.

In addition to establishing the building as an important figure, the introductory PowerPoint presentation also began a process of attributing the building with particular qualities. The PML was identified as potentially uncertain and unstable, and therefore in need of
modification and experimentation. In the following slide, used near the end of the presentation, the presenter anticipates the process ahead for the Ops Group:

<table>
<thead>
<tr>
<th>PML Operations Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>• This is an experiment.</td>
</tr>
<tr>
<td>• We all hope and expect this approach can succeed.</td>
</tr>
<tr>
<td>• We will make small or large modifications in the approach as needed.</td>
</tr>
<tr>
<td>• Longer-term plans.</td>
</tr>
<tr>
<td>• Initial PML Operations phase.</td>
</tr>
<tr>
<td>• Building completion and testing, moving to PML, stabilizing building and operations, etc.</td>
</tr>
<tr>
<td>• Hectic, uncertain, we are all learning.</td>
</tr>
<tr>
<td>• 6 months to one year??</td>
</tr>
<tr>
<td>• Expect need for full PML Operations Group.</td>
</tr>
<tr>
<td>• Stable, on-going PML Operations phase.</td>
</tr>
<tr>
<td>• Building is well-understood, fully occupied, generally stable.</td>
</tr>
<tr>
<td>• One year???</td>
</tr>
<tr>
<td>• Different Operations Model, to be determined.</td>
</tr>
<tr>
<td>• Perhaps Facility Manager and One or Two Lab Reps.</td>
</tr>
<tr>
<td>• For example, Clean Room Rep plus Instrument Labs Rep.</td>
</tr>
</tbody>
</table>

Key to this slide is the way that managing the PML building is presented as “an experiment” for the scientists on the Ops Group. The building itself is identified as the phenomenon in need of “testing” and “stabilizing.” To accomplish this testing, the Ops Group can “make small or large modifications.” In this metaphor, the projected end goal is that the group will overcome the “hectic, uncertain” learning period, after which the building will be full of occupants, stable in its performance, and “well-understood.” As a result of this framing of the Ops Group’s work, the building is summarily constructed as both a crucial resource and an uncertain challenge; one that can provide for the high precision needs of scientists, but that is not fully understood, controlled, or optimized as of yet.

Concomitant with this figuration of the building, the Ops Group members often drew on this image in their discussions, particularly as they aimed to “con/figure” the building toward stability, control, and understanding. Ops Group members often invoked the building as a figure in their “con/figuring” discussions:
Brendan: So, higher-ups want us to *re-prioritize what the building needs*. They feel that we have been using this meeting time to discuss and decide on issues that are not high on the priority list. (fieldnotes, Ops Group meeting, 6/6/2012, italics added)

As Brendan points out here, one way to describe the Ops Group’s work is that they must determine the building’s needs in order to ensure that it stabilizes and performs as anticipated. Toward that end, the group repeatedly invoked the building itself as a conversational *figure* during and across their meetings. In this way, the building became the central figure around which the group oriented their work, particularly insofar they negotiated and determined its preferred qualities, conditions and performances. Not long after their formation, the Ops Group began the routine of addressing the building at the start of their meetings, toward identifying its most up-to-date status and aspects in need of attention. For the Ops Group, this resulted in the building repeatedly being ventriloquized as a figure early in their meetings:

Jeff: *building door access* is an issue – some scientists cannot unlock lab doors (fieldnotes, Ops Group meeting, 4/18/2012, italics added)

... Ethan presented a graph charting “PID gain/change” - spikes in air temp levels… “*When will the building be in spec?*” (fieldnotes, Ops Group meeting, 4/25/2012, italics added)

... Brendan: first item- there’s a disagreement brewing over *building EMI* [electromagnetic wave interference] & cellphone use. (fieldnotes, Ops Group meeting, 5/2/2012, italics added)

In all of these examples, the building and its conditions and attributes become the focus of the group early in their meetings. Within three months of their formation, the group explicitly determined to address the building first in their meetings as a matter of practice:

Brendan: Why don’t we get into the habit of starting with building updates from Pete [the building manager]? (fieldnotes, Ops Group meeting, 7/11/2012)

With this, the group routinized the process of conversationally “figure-izing” the building at the start of meetings by agreeing that it would always be the first agenda item. In effect, the group wanted to recognize what had changed, or what the building had done since the last time they
met. To be sure, nearly all of the Ops Group’s work was aimed at identifying whether the building was performing as expected (or, “optimally”), and if not, to determine what it needs in order to do so. The group commonly sought to measure building performance against its anticipated design specifications:

Brendan: “I’ve asked the Oversight to set temperature building-wide to 70.7 degrees Fahrenheit, fixed for all labs. Is that a problem for anyone? If we set it at this, then we can enforce building-level spec.” (fieldnotes, Ops Group meeting, 9/12/2012, italics added)

If the building was not measured to be performing “in spec,” then the group generally aimed to document the cause, by identifying any harm, malfunction or breakage to the building. Again, this typically led group members to invoke the image of the building as a central figure in their ensuing conversations:

Jack: [addressing others present besides Pete, seeming to indicate that this was previously an issue primarily discussed between him and Pete] – “So, we lost one pure water pump, which only hurts the building very little, but it really affects the clean room’” (fieldnotes, Ops Group meeting, 8/29/2012, italics added)

... Brendan: Pete, anything break in the building last week? Pete: no, only fixed a problem with the temperature spikes. (fieldnotes, Ops Group meeting, 5/16/2012, italics added)

These brief exchanges during Ops Groups meetings are just two examples out of many that illustrate the group’s practice of referencing the building as a figure in their meetings – one that has a status or condition tied to its ability to perform. In this way, the building became a repeatedly invoked figure by Ops Group members, a practice through which it was attributed conditions and qualities of performance, around which the scientists oriented their work.

**Fostering trust and faith in the building.** Given the centrality of con/figuring the building in the Ops Group’s work, and the importance of the building performing within
expected measurements, a key aim for group members was to foster an image of the building as reliable and trustworthy. When the figure of the building was threatened in meetings by doubts over its ability to perform with specification measurements, group members often emphasized the need to re-establish faith and trust in its capability to eventually do so. If scientists reported a lack of trust regarding some condition or performance of the building, then Ops Group members viewed such a report as a call to action:

Brendan: Scientists want proof that the CDA is truly “clean dry air” so as not to damage equipment, and to ensure that experiments are successful. Operations group can figure out & design a test to gauge fitness of CDA; reiterated that scientists habitually don’t trust that the building provides what is claimed, that they typically take matters into their own hands.

Tom: Operations group should formulate test for CDA in a couple of different locations [around the PML]. (fieldnotes, Oversight Committee meeting, 4/18/2012)

…

Tim: Also, building sensors are not trusted by all – because it’s questionable whether the sensors are up to NIST standards.

Tom called his administrative person to investigate. (fieldnotes, Oversight meeting, 5/16/2012)

In these brief exchanges, when issues are raised regarding the lack of trust in building systems or conditions, the resolution immediately follows to investigate the identified problems toward reinstating that trust. Similarly, when experiments on building systems are in progress or completed, the group often translated results with phrasing that reflected on the status of the building as a figure:

Brendan leads – “Let’s start with the temperature/humidity update. So, the basic news is that the building will work, it’s just a matter of ‘PID tuning’, which is going to take money and time. The problem is on the interstitial layer, and particularly involves the humidification system. (fieldnotes, Ops Group meeting, 9/12/2012)
As a result, it becomes clear that not only is the building a key figure that is attributed status in Ops Group and Oversight Committee meetings, but also that reliability and trustworthiness are defended, important qualities associated with it.

**The ‘building’ against ‘wild west’**. Thus far I have documented the ways that Ops Group members consistently invoked the building as an agentic figure in their meetings by attributing it conditions and qualities that associated it with a measurable performance. Further, through their conversations and resolutions, the Ops Group members centered their work on maintaining the conditions and performance of the building such that it would meet “specification” expectations and thus foster trust among resident scientists.

Recall from the start of this section that, upon its opening and the formation of the Ops Group, the PML building was simultaneously described as both a crucial resource and an uncertain challenge. The “experiment” of the Ops Group was to overcome the “hectic, uncertain” learning period of moving in and getting the building fully operational, after which it would be full of occupants, stable in its performance, and “well-understood.” Through this process, the Ops Group members raised, discussed and resolved a number of issues. Across all of these issues, the Ops Group members consistently anticipated an important tension which they aimed to address in the timeliness and scope of their resolutions: that scientists might continue their “old building” practice of resolving their problems privately and without consulting neighboring labs. To indicate this concern, they commonly invoked “wild west” as a warning label that invoked the set of practices that worked against their purpose of optimizing the building as a resource and “protecting it for years to come.”

As the Ops Group met toward preventing a return to the “wild west” practices, their means of doing so was to maintain scientists’ trust that the building would provide for their
needs. That is, it became clear that the building itself, if maintained as a stable and trusted figure, was the antidote to “wild west” practices. As the Ops Group members relayed the concerns of scientists on their lab blocks, the group collectively recognized that their work involved timely responses to problematic building conditions that hindered its specification performance. Doing so would re-establish, in the months following its opening, the relationship between the scientists and the building they occupy, which was missing in the old building. The following is an exchange I had with one scientist during an interview, in which I asked him to reflect on his experience in the Ops Group, both positive and negative:

MW: The thing that’s been frustrating but not totally surprising is just that the whole thing is so relentless. You know I mean we’ve been talking about certain issues since the doors opened. And you know, they can be very frustrating. It’s frustrating that they weren’t right in the first place, it’s frustrating that they don’t seem to be getting better, and that’s you know there’s some people who have kind of lost all patience for it. Not necessarily in our group, but inside building 81 [another name for the PML building].

NB: Do you think there are people therefore who would not move into building 81 because of that?

MW: I don’t know for sure, but I think the clock people have some pretty strict standards, and that’s – they’re one of the big ticket tenants, if they don’t have faith in the building, that’s a huge deal.

NB: And so you mentioned there may be people who lost faith in the PML operations group process?

MW: I think it’s more that the way the building fit out was done, we were as future tenants allowed to go in there and see what we wanted. And drawings were made and things, and in many cases, what people perceived as a promise didn’t get kept. And sometimes it was specific things like well, there’s supposed to be a helium recovery drop in my lab, and it’s not even here. But sometimes it’s something more like well you know, the temperature spec’s supposed to be this degrees, and it’s not. And that – you know these are scientists right, I mean they’re very much into you know measurable compliance with promises.

This exchange reinforces the notion anticipated by Ops Group members, that the building must perform according to the expectation of scientists, or else they risk losing the good faith of those
scientists (“if they don’t have faith in the building, that’s a big deal. That’s a huge deal”). When viewed this way, it becomes clear why this particular Ops Group scientist describes their work as “relentless” – being the group responsible for addressing all of the ways that the building condition or performance might fail to meet expectations is a difficult endeavor.

So the building is a figure that scientists hold accountable to “measurable compliance with promises,” and thus the trustworthiness of its performance is a key pivot point toward discouraging a return to “wild west” practices. The building must deliver as promised. But interview data also reveal another way that the building influences the lab management practices of scientists. In the following exchange, I asked an Ops Group member whether the group was successful in preventing a return to the “wild west” in the PML:

NB: So, one thing I’m wondering about… since most of the experiment of the Ops Group was created in the name of turning the corner from the wild west. Has anything like that resurfaced?

JN: Hmm, that’s interesting… So there are lots of facets in that. I think a simple answer is that there’s still a wild west contingent. Umm… I think we’re evolving in our wild-west’ness. The, uh… and I think it has to do with the arc of safety here, you know, the apex, or the low spot being the plutonium spill, and as we’ve come out of that, and tried to tackle these safety questions, I think a fair number of the more egregious wild west stuff is sort of going…. is really not happening… I mean, for instance, just this morning… so I’m a group leader now, I have a responsibility for the safety of not only the clean room as a laboratory but also the offices for my team, and um, so we had a safety walkthrough of our offices, and we had a DSR there, a division safety rep, and Tim Drapela, the PML-level safety rep (GSR), we had a guy from the safety office here, and so we walked through everyone’s office, to make sure that they seemed like they were safe. And, you know, looking for outlets, looking for heavy things up too high, looking for stuff. And I thought, I don’t know if that ever would’ve happened before the plutonium spill.

NB: Hmmm, yeah…

JN: And so is that killing the wild west nature? Not really. Is it making us safer? Yeah, probably. Um, you know, are there things that still go on where people go, ‘yeah, well… let’s just try and do it this way’… I mean, yeah, that happens all of the time, but that’s just because we’re usually just trying to solve hard problems, and we’re looking for any way to do it. So… but uh… yeah, has the wild west changed? Yeah, it’s…. it’s also a little hard from a NIST sort of, site-level culture perspective. I perhaps was not exposed
as much as others, because I’m in building 81 and not really… you know, I’m in my fancy sort of office, and you know I don’t have to deal with this old stuff where if people needed to solve a problem they just drilled a hole in the wall. You know, whereas I don’t want to drill a hole in my wall, because… you know… there’s no need to.

NB: Interesting. So that actually raises a really fascinating point, that it’s the building itself that might inspire particular practices?

JN: Yeah. Totally.

NB: The niceness and the pristineness and the overall sort of performance of the building that discourages that, you know, that taking matters into your own hands and just… doing whatever you wanted to the building….?

JN: Right. Yeah. I think that’s probably true. I mean granted the clean room is different and unique space for a variety of reasons, but, I mean… one of my… I have lots of big-picture goals, and one of them is: I want the clean room to look like it looked when we first moved in. I want it to look clean and the things we’ve put in have been put in smartly and professionally and done well and done safe. And it doesn’t just look like a, you know, like other clean rooms where you’re just like, “ew, wow, well that’s interesting…” You know, and so part of it is just like… one of my goals is, I want to hand off a clean room that someone says, ‘this is 15-years old? What are you talking about? This is old?’

NB: Yeah.. and it almost demands the respect because it’s so well maintained and it speaks for itself, you know…

JN: Exactly.

While this scientist admits that the “wild west” mentality and approach are still alive among scientists in the PML building, he also points out that “we’re evolving in our wild-west’ness.” To further explain, he claims that the approach is still alive because it entails a type of problem-solving that is unique to scientists (“we’re usually just trying to solve hard problems, and we’re looking for any way to do it”). But the key idea raised in this passage is that, despite this “maverick” way of thinking (a word he uses later in the interview), scientists are likely changing their problem-solving when moving in to the PML *because of the building itself*. He claims, “I’m in my fancy sort of office… I don’t have to deal with this old stuff … *I don’t want to drill a hole in my wall.*” When I follow up by asking if he means that the building itself influences his choice, he responds “Yeah. Totally.” His assessment and description of the quality of the
building influences him to not fully resort to the old wild west practices. He later reinforces this view when he emphasizes that when he moves on from NIST, he wants his clean room laboratory to look as good as the day he moved in. When the building is a valued and respected figure, it becomes a factor – an agential figure – in scientist decision-making and problem solving. And, more to the point: agency attributed to the building signifies an important reason for ending and evolving the “wild west” practices. Scientists are still mavericks. However, the presence of the building as a pristine, stable and trustworthy figure is the difference that dissuades the old “wild west” practices.

**Summary of Section 3: Producing and configuring a well-understood building.** On the whole, it may not be surprising that the new PML building became central to the work of the Ops Group: the occasion of their formation was, after all, the opening of the building itself. However, the key insight provided here is the way that the PML building became an important figure in the ongoing meetings and discussions of the group. From their inception, the Ops Group was presented with attributions of the building that established it as both a prized resource and an uncertain challenge. The high stakes and uncertainty of that challenge provided the exigency and rationale for the Ops Group to carry out an ongoing experiment to ‘con/figure’ the building by determining its optimal condition(s), its array of qualities/resources, and its measured/measurable performances. By carrying out this experiment and articulating a stable ontological status of the building, the Ops Group mediated the relationship between resident scientists and the building. The group ascertained its goal was to foster trust in the building among scientists by succeeding in their work to stabilize it by defining qualities and conditions that provided consistency between its performances and specification measurables. Fostering trust would encourage scientists’ faith that the building could serve their needs and thus
discourage a return to the “wild west” practice of prioritizing the maintenance of one’s own lab at price of neighboring labs and the building as a whole. This key shift expands the organizational space from a per-lab basis to building-wide.

Section 4: Authoring texts with building knowledge

Thus far I have documented the way that the building became the key figure that participated in the Ops Group meetings, insofar as “presentifying” it and attributing it with qualities and conditions (“con/figuring it”) became their central ongoing work. The Ops Group’s ability to con/figure the building toward stabilizing its performances within specification became emblematic of preventing a return to “wild west” practices. In this section, I focus on another aspect of the Ops Groups work: the way that it accumulated toward a collection of building knowledge that achieved the group’s purpose. The group collected their output in texts that documented and articulated a system of practical building knowledge that represented a “well-understood” building worthy of trust.

Part of stabilizing the building meant not only documenting the measurable qualities, conditions and performances of the building, but also producing and sharing that information with resident scientists. Particularly at move-in, scientists needed to be informed about the status of the building systems and resources, so as to help to mitigate expectations for building performance and therefore buffer from the possibility that scientists may lose trust in it. Although the PML was equipped with the MetaSys building system control program, which had built-in monitoring of building conditions like temperature and humidity, that system was closed, proprietary and carefully guarded against security risk (more on this later). As a result, resident scientists did not have access to it. Soon after the group’s formation, however, as they began to discuss building issues and determine policies, Ops Group members were confronted with the
question of how the building information they produced could be provided to scientists building-wide. The solution to this question was to produce and circulate texts where building knowledge could be collected and shared. Insofar as they outlined policies and authorized practices, these texts became the documented output of the group, but importantly, they also provided the means for compiling a systemic, synoptic building knowledge. These texts became resources that represented a well-understood and trustworthy building.

Within the first month of Ops Group and Oversight Committee meetings, the group began to author and compile two building texts: a Sharepoint Wiki intranet website, and a PML User Guideline printed manual (eventually titled the “PML User’s Manual”). Although these two texts had some overlap in purpose between them, they evolved toward holding unique roles: the Wiki site, developed by scientists, became collaborative space for sharing status updates on building systems and conditions, while the PML User’s Manual, written by both scientists and EMSS workers, became the documentation of policies, rules and procedures for accessing and protecting building and laboratory resources.

Wiki site. The Wiki site idea developed between two scientists and grew to be used by the Ops Group and subsequently, nearly all of the scientists in the building. A Sharepoint Wiki site is a technology developed by Microsoft that allows collaborative content to be edited in Microsoft Office programs (such as Word) and dynamically written to an intranet (or internet) website, so that others may immediately view updates. The following exchange, in which a scientist explains the idea to the building manager, is the first indication that the Wiki idea may serve long-term purposes:

Jack: any [building] issues from you?
Pete: Humidity control system is still under construction.
Jack: sounds like something Brendan and I should announce on intranet Wiki.
Pete: you and Brendan have a Wiki? What is a Wiki?
Jack explains Wiki, how it works, “one stop shop” to house info on tools, the move, hazards, chemicals, tool use schedules, ordering info; validated users can edit/update info, permissions-based; some general access provided; general knowledge-sharing is encouraged; people need also to be able to ask for additional Wiki’s that might aid their work.

Jack: we’re starting by focusing on Clean Room Wiki for now.
Pete: What is the number of people who will modify Wiki content?
Jack: 80-90. (fieldnotes, Clean Room Management meeting, 4/11/2012)

In this exchange, “Jack” is a scientist who, when he hears that the building humidity control system is not operational, wants to relay that news to other scientists on a Wiki site that he and “Brendan” have been developing. “Pete” is the building manager – on the EMSS side of the division – who had never used a Wiki and therefore asked for an explanation. Following this example, Ops Group scientists began to suggest that updates from their discussions be relayed to other scientists in the building via the Wiki site. Two weeks after the above conversation, when the group raises an issue about knowing which scientists occupy particular labs and having contact information for them, the group again decides to use the Wiki site to provide and maintain such information:

Jeff: we need to map [the building] with names & emails.
Jack: yes, occupant map & contact list is needed.
Brendan: Need Alan in Telecom to give us a list of phone ports active to associate people w/ those ports & phone numbers.
Jack: should Cindy put together the list on the NIST website? Or Wiki? Or [an Excel] spreadsheet?
Ethan and Lisa: I liked the Wiki.
Jack: Okay, I’ll ask her to start [it] on the Wiki. (fieldnotes, Ops Group meeting, 4/25/2012)
With the Wiki site already serving as an interface between scientists for key updates on building condition and systems status, in this conversation Ops Group members decide to expand on the way it is used – to now include an updated list of lab occupants and contact information for them. Not only is this information deemed a necessary mapping that is uniquely important to the PML building, but it also contributes to the growing “repository” of practical knowledge about the PML building that is necessary for occupying and working there. In other words, the Wiki site is becoming a technology of the expanding building ontology as it is emergently defined and articulated by the Ops Group.

In the following months, as the Ops Group raised and discussed more building issues, the Wiki continued to grow in scope. For example, when the group later identified the particular safety challenges presented by the service galleys between labs, they met with a NIST fire safety specialist who recommended a supplemental lab label system that warned of the particular hazards presented by each lab:

Jack: So what to call our supplemental sign? “Expanded Laboratory Hazard Sign”?  
Alan: Yeah, so the supplemental signs are not required. The additional information they provide is also stored in the Metasys database; the printed sheets just condense and summarize the myriad of chemicals that are in labs.  
Jeff: Maybe we could have a policy where “3”s or “4”s [elevated levels of toxicity/danger] need to be identified on the sheet?  
Jack: That’s what I was leaning towards.  
Jeff: A big long list is counter-productive… it needs to be intuitive  
Pete: Who knows what a first-responder would want to see?  
Alan: They’d want the most basic info first, immediately, and then more details following.  
Jeff: I think we’re doing this already, just not in a simple format.
Pete: Need something like a “triangle” system that is standardized, but also contains important details.

Brendan: Okay, so our recommendation is to have the additional [supplemental] sign and then to put the information on the Wiki. (fieldnotes, Ops Group meeting, 5/30/2012)

Through this discussion, the Ops Group decides to adopt the supplemental label system, but then also, as a way of preparing fellow scientists to recognize and understand the laboratory sign changes, they decide to share information about the supplemental labels on the Wiki. In this way, the Wiki continues to grow in providing necessary developments and contextual information about building resources, conditions and changes.

**PML User’s Manual.** While the Wiki was developed by scientists to serve as an immediate, shared interface for building status updates, the PML User’s Guide became a more permanent documentation of building systems, protocols and scientist responsibilities. The Wiki site was functional and frequently used in the early days of the building opening; the User’s Guide, on the other hand, was compiled gradually and not finalized until well over two years after opening. This was largely due to the Ops Group work, as they decided how (and whether) particular building resources and systems would function, and as a result, how those resources would be configured, managed and policed. The end product was an exhaustive documentation of all building systems, resources, and procedures that scientists may need in order to work in the PML building. One scientist, who served as the leader of the Ops Group, passed around an early version of the User’s Guide, describing it as “a combination of Spec Guide, User Safety Guidelines, and Building Facts” (fieldnotes, Ops Group meeting, 7/11/2012). As the Ops Group resolved issues and broadcast them on the Wiki, and as that information “stabilized” and appeared not to need any further changes, it was added to the “PML User’s Guide.”
The final version of the PML User’s Guide (as of the end of data collection) spans 91 pages, and was distributed to resident scientists in early January, 2015 – two and a half years after the building opened. As written, the vast majority of the User’s Guide represents the decision-making of the Ops Group. Following is a snapshot of the table of contents for the PML User’s Guide; I have highlighted the items that were decided and/or configured by the Ops Group:

Given the prominence of the Ops Group’s work in this finished product, it in many ways represents the output or results of the experiment they were assembled to carry out. The PML User’s Guide is a collaborative text that collects and provides the practical building information
necessary for scientists to conduct their work. Further, it is an agreement: note the signature pages provide at the end of the manual (pages 83-85), which all scientists are required to sign and return to their Ops Group representative. Therefore, not only does the manual serve as documentation of a completed experiment to produce and configure a building that is stable and “well-understood,” but it is also written to ensure that the textually represented building ontology acquires authority to be recognized as scientists’ shared organizational context. The PML building had been specified, and scientists could only acknowledge their assent. For this reason, the PML User’s Guide can be understood as an integrative text of synoptic knowledge produced about, and thus constituting, the building itself. It provides a description of building space that has been brought to order by mapping, negotiating, defining, measuring, and specifying (in some cases, updating) an expected performance. Further, producing the text entailed a commitment – among Ops Group members and resident scientists alike.

**Summary of Section 4: Authoring texts with building knowledge.** Together, the Wiki site and the PML User’s Guide became the means that Ops Group members chose to inscribe in texts their work as they determined, defined and configured the building conditions and resources that constituted the PML. As such, these texts offer representations of the group’s experimental work toward documenting a stabilized and well-understood building. While the Wiki site provided collaborative technology through which the Ops Group and other scientists could quickly share updates on building conditions and system changes or breakdowns, the PML User’s Guide was aimed more toward producing a stable and long-term description of those systems, resources, and policies, invoking a commitment among resident scientists. Both, however, effectively provide the Ops Group with an avenue for collaboratively negotiating, configuring and documenting a shared context for knowing the PML building. In this way, the
“hectic uncertainty” of the building could be deemed resolved if the resident scientists had common textual resources for describing and/or referencing the qualities, conditions, and resources of the building and thus measuring its performance against that description.

Section 5: Social Materiality—Configuring building texts and knowledge

Thus far, I have described the Ops Group work as the process of conversationally determining and con/figuring the PML building toward producing and textually representing a stable and well-understood building. Insofar as the group could compile (a) an integrative (i.e., cross-divisional) inventory of objects, along with (b) mappings of the building that ordered access and defined spatial qualities, and finally, if they could (c) determine and implement policies and practices that collectively induced common commitments toward maintaining this ontology of building space, then they would complete their assigned experiment of producing a stable and well-understood building. Now that I have established and illustrated this frame for characterizing the process (problem-solving discussions) and product (texts) of Ops Group meetings, I want to return to illustrating examples of the types of issues raised, discussed and resolved by Ops Group members. I do so with a specific aim: to further document the way that the group’s discussions and decision-making articulated a particular building ontology that encompassed a unique social material alignment of defined objects, spatial qualities, and corresponding policies and practices.

Following are three subsections, each with extended examples of building issues that the Ops Group raised, discussed, resolved, and inscribed into building texts. Each subsection illustrates unique aspects of the social material ontology constituted by the Ops Group’s work in configuring the building. The first subsection, Practicing and defining new roles and objects, documents the new organizational roles and relationships created as a response to the discovery
of vulnerabilities entailed by not knowing items stored in service galleys; further, how these roles and relationships made possible a new, integrative way of seeing and monitoring service galleys.

The second subsection, *Defining and policing space*, demonstrates how the close integration of labs inspired the Ops Group to map the building space along boundaries of preferred qualities (e.g., the presence/absence of electromagnetic waves) and access policies (e.g., building security and door locks).

Finally, the third subsection, *Political tensions in building ontology*, takes on the task of collecting together issues that are particularly “messy” due to political and economic complexities along division lines. Here, I document the way that resolving issues toward “stabilizing” the building sometimes involved prioritizing particular lab or division interests above others, because they provoked the Ops Group to at once acknowledge tensions yet still subsequently configure the building with some qualities and conditions instead of others. Toward that end, I demonstrate how Ops Group members anticipated tensions in negotiating their role (“apolitical positioning”) before and while they defined and configured a building that favored some scientists and labs over others (encompassed by issues involving power outlets, continuous nitrogen supply, and building digital information).

**Subsection 1: Practicing and defining new roles and objects.** Recall from section two of these findings, that among the first decisions the Ops Group made was that the service galleys were hazardous due to the collection of unknown objects stored in them. The Ops Group’s response to this newfound vulnerability was to begin the process of documenting the service galley spaces and the objects stored in them; to construct, implement and systematize shared knowledge of those objects.
Defining Roles: Galley Safety Representatives. To do so, they first created a new position, Galley Safety Representatives (GSRs), assigned one or two per lab block, which would carry the responsibility of monitoring service galleys and to inventory the various objects located in them. In an email introducing the GSRs to all scientists in the PML building, the justification for their appointment was explained:

Service Galleys are a very useful space, but they pose some unique and interesting challenges. Since some of these galleys are shared over a number of different Divisions there had to be a way of ensuring that safety rules and regulations were being adhered to and that incompatible activities were not being conducted in this shared space. There are also the “overall” safety issues that might arise such as the emergency lighting and showers—things that are not unique to any one group of people but would affect all the users in any particular galley. The solution to these problems was to create the PML Galley Safety Representatives (GSRs).

The emphasis here is increasing the awareness of the objects and activities in the galleys, which were “not unique to any one group of people, but would affect all users.” Soon after the creation of their position, the GSRs became responsible for quarterly walk-throughs in the service galleys, and would fill out “Hazard Review” reports and pass them onto the Ops Group to address any necessary action or policy adjustments. In this sense, the GSRs became the “eyes” of the service galleys, as they would monitor the accumulation of objects there, and investigate the dangers they posed.

Defining Objects: Galley Labelling. The Ops Group’s second step to addressing safety concerns involved mandating a new labelling system for the galleys, to identify and make visible important information for all objects/items stored in them. The labeling system served two purposes: (a) to help make objects recognizable outside of their “home” labs, and (b) to initiate a consideration for the relationality and interaction of the items stored in the galleys. One GSR explained:
“the thing that they realized… is that if you have all these individual things in the galley, nobody necessarily knows how they’re interacting, or that they’re all there, so the idea of the galley safety reps you know is just someone who – I may go to a lab space that belongs to a different division and have no authority over it, but I can see how it mixes with everything else in the hall and talk to the right people.”

One example of this newfound concern for the “interaction” of galley objects is an issue raised by the GSRs involving the accumulation of dewers in the service galleys. After their initial galley walkthrough, the GSRs became worried that the growing number of dewers in the service galley resulted in the presence of an array of gases and cryogens that together could unknowingly produce added dangers that no single lab had reason to fear before. Shared service galleys meant that the practice of storing two or three full dewers in the hall outside of the lab in the old building now resulted in up to 20-25 dewers in the galleys of the PML building. If any combination of these dewers began to leak (leaking valves are not uncommon), they could reduce the oxygen present to unsafe levels and suffocate or poison unknowing persons in the area – a concern not present in the old building. This calculation was specifically addressed by the Ops Group, as they attempted to assess the danger presented by the accumulation of dewers. In the following email, an OHSE specialist enlisted to assess the potential danger of oxygen deprivation in the service galleys reports on his findings:

From: [Name Redacted]
Sent: Wednesday, August 07, 2013 9:22 AM
To: [Name Redacted]
Subject: PML Galley ODH

Hi Tim. I’ve got some info for you regarding the oxygen deficiency hazard in Galley 15 in the PML.

Room size: 140’ x 9’ x 14.5’
Ventilation supply: 1100 – 1200 cfm

Room Contents:
Compressed Gas Cylinders:

- 7 He cylinder, standard size
- 4 He3 mix Horiz. Tanks on cabinets, one vertical
- 5 N2 cylinder, standard size
- 2 Ar cylinder, standard size
- 1 SF6 cylinder, ¾ size, in cabinet, vent turned off
- 1 CHF3 cylinder, tiny (2x lecture bottle), in cabinet, vent on
- 1 CF4 cylinder, ½ size, in cabinet, vent turned on
- 1 O2 cylinder, small

Cryogens:

- 1 N2 200L (?)dewar
- 2 N2 ~250 L dewar

Other:

- 1 He Compressor

Now we just have to decide what scenario we want to evaluate. I’ve attached a 5-sheet spreadsheet for calculating air contaminants and ODH. The first tab, “Single Release” calculates O2 % if all 5 N2 gas cylinders release at once. There would be a slight O2 deficiency for 4 minutes.

Assumptions: Instantaneous release, 100% mixing – not very realistic.

Tab 4, “Continuous Cryogen Release”, looks at the release of one entire 250L dewar of N2 over 10 minutes. This results in a serious O2 deficiency. (The spreadsheet doesn’t seem to be working correctly over periods of time greater than the release time. I need to work on that.)

Where do you want to go with this? -M

[Name Redacted], CIH
Industrial Hygienist
National Institute of Standards and Technology

In this exchange, the specialist inventories the dewers in one particular service galley – Galley 15 – and produces an analysis of the dangers they present, in a number of scenarios. As a result of this investigation, the Ops Group decided to install oxygen sensors in all service galleys, which would trigger alarms if the oxygen level fell below critical points. Important here is that, in this example, the GSRs served the purpose of viewing the service galleys from an integrative perspective not specific to any one division (“we’ve got to pay attention… and coordinate a lot
more across divisions”). Creating a label system for the items stored in the service galleys provided the capability of conducting this analysis.

On a quarterly basis, the GSRs conducted walkthroughs in the service galleys and produced a “galley hazard report.” These hazard reports routinized the label system and provided the possibility of anticipating the interactions of the service galley object ecology. The following is a portion of their second hazard review, produced three months after the GSRs were created:

Quarterly Inspection Report
PML Service Galleys
1st Quarter, FY2014
December 6, 2013

Miscellaneous Information
The four Galley Safety Representatives (GSRs) conducted the quarterly walk-through of all the Service Galleys in the PML Building (Building 81) of the NIST Boulder site on November 12, 2013. The GSRs were accompanied by Alan Brass and Sonja Ringen of OSHE.

- It was noted for ALL the Service Galleys that many of the signs need to be updated to be brought into compliance with NIST policies, both on the individual lab doors as well as the Galley exits/entrances.
  - Action item for all GSRs: Speak to LSCs, Group Leaders, or Division Chiefs to ensure that all signs on lab doorways have been reviewed for accuracy. Alternatively the GSRs can look in the Door Sign Manager tool to ensure that the dates are current for each sign. In addition, the NFPA diamond signs should be checked for accuracy at the ends of each Service Galley.

- All Service Galleys continue to lack shower curtains around the Emergency Showers, and the drain pipes that are located under each Emergency Shower represent a serious potential to cause injury to someone’s feet in the event that they must use the Emergency Shower.
  - Action item for Chris McKinney, GSRs, and possible others: Install shower curtains as well as coat the sharp edges of the pipes with silicone (or place a Tygon tube over the end of the pipe) to protect people’s feet.

Service Galley 15
- There is a black hose coiled up immediately adjacent to the east exit of the Galley, underneath the fire extinguisher which may interfere with the fire extinguisher or cause a tripping hazard.
• Action Item: Find the owner of the hose and ask that it be stored elsewhere.

• Outside of room 1D104 there is a gas cylinder on a cart with the regulator attached.
  o Action Item: Contact the owner of the gas cylinder and have them secure the cylinder appropriately to the wall. This may require restraints to be installed.

• Outside of room 1D112 there is a leak detector that is blocking the egress path. There are often cryogen dewars present that are blocking the egress path. In addition, there was a good deal of ice buildup on the cryogen transfer line, but the dewar was still venting appropriately.
  o Action Item: Contact the LSCs that use the leak detector and cryogens and inform them that leaving items in the egress path constitute a safety hazard and must be moved to the side of the corridor. Ask them to check the ice buildup and to determine if there is a potential risk of creating an ice dam that would block the venting.

• Near room 1D120 there is a tall helium type tank being stored on a cart. Although it is capped, storing a cylinder on a cart is not “best practice”.
  o Action Item: Contact the owner of the cylinder and request that it be removed from the cart and secured to the wall. This may require restraints to be installed.

• Room 1D120 has no door signs in the sign holders.
  o Action Item: Contact the LSC and request that door signs be generated.

• There is a helium gas cylinder that has no labeling whatsoever.
  o Action Item: Contact the owner of the cylinder and request that it be labeled with contents and the owner’s name.

• There is a shelving unit on wheels outside of room 1D124 with equipment being stored on them. We have concerns regarding the load limit specifications on these shelves and the possibility that these limits have been exceeded. The wheels make it possible for someone to inadvertently or deliberately move the shelves while still loaded, and that would definitely present a tipping hazard.
  o Action Item: Provide funding for “standard” shelves to be installed where needed, with clear load specifications. The shelving installed in Service Galleys 18 and 19 seem to be the preferred method. Alternatively, please provide recommendations and structural guidelines for shelving units purchased by individuals if standard shelving will not be installed. At the discretion of the GSR responsible for this Galley, a note may be sent to the owner of the shelf expressing our concern and requesting information regarding load ratings, etc.

  o Additional possible Action Item: Install additional gas cylinder restraints where needed all along the “D” side of the galley.
In this Hazard Review Report, the specificity of the GSR role is made clear. They are concerned with both enforcement of item labeling standards (“There is a helium gas cylinder that has no labeling whatsoever”) as well as the performance of the galley space in anticipation of typical traffic and work practices: “the drain pipes that are located under each Emergency Shower represent a serious potential to cause injury to someone’s feet in the event that they must use the Emergency Shower.” As a result of these reports, the service galleys are carefully scrutinized, defined via labelling, and described in their anticipated performances. This explicit depiction of items and galley space illustrates a layer of practical management of service galley space and objects that is new to the PML building.

**Subsection 2: Defining and policing space.** In their old laboratories before moving into the PML, scientists worked in relative isolation. Entire wings of the old building were occupied by a single research division, which had the effect of spatially insulating them from each other. As a result, the building space within and surrounding their labs was determined and managed according to their own discretion. The PML building, however, was deliberately designed to avoid such “silo’ed” laboratories. One result of this integrated lab design was that the qualities and boundaries of the building space had to be reconsidered and redefined. As scientists began moving into the PML building and setting up their experiments, they raised issues involving the co-orientation of spatial qualities and boundaries between and across neighboring cross-divisional labs. As a result, Ops Group scientists acquired the responsibility to address, discuss and determine how to configure the PML building space according to newly salient qualities that would need to serve cross-divisional interests. Here, I provide two examples of issues that mapped the PML in new ways, and which imbued the building space with newly policed qualities.
**Building access and door locks.** One unforeseen consequence of this integrative design was that building security had to be reconsidered and renegotiated. In the old building, entrance doors required ID-badge access, but once inside, building wings, offices, and labs either remained unlocked or were often propped open to ensure access. Security tended to be assumed based on familiarity. Only a limited number of individuals who conducted research in the labs in each wing would typically be seen there. As a result, those individuals became familiar with each other, and their encounters became routine. For this reason, security was not a concern, and doors leading into the laboratory wings and laboratories themselves were generally accessible during working hours.

As scientists moved into the PML Building, door access and locked doors quickly became a concern. Early during the second Ops Group meeting, the issue was raised by a scientist who reported that some scientists in his lab block could not open the door locks to their labs (fieldnotes, 4/18/2012). In response, the building manager was quick to point out that “all doors in the PML have KABA [electronic] locks, which require an ID-badge for access, and not just the entrance doors.” This led to a broader group discussion about the door access policy throughout the PML building. As Ops Group members pointed out, the issue was complicated due to a few factors. First, all doors were locked by default, and the process for gaining access had to be requested per door. A scientist would often need access through a number of door-enclosed sections of the building: office suites, an individual office, the service galleys, the pedestrian corridor, and finally, the lab doors, front and back. The scientists’ ID badge access would need to be reprogrammed with each individual door access – an arduous process prone to error. Furthermore, access was complicated by the steady flow of “part-time” scientists; some graduate students or research assistants needed to check on experiments after hours. With the
first reported instance on 4/18/2012, the group decided to request a policy that office suites and pedestrian corridors into labs have an 8am-5pm “First Authorized” policy, meaning after the first person unlocked a door after 8am, that door would remain unlocked until 5pm. While this policy was considered “good not great” (fieldnotes, 5/16/2012), the group had no particular plan to improve it. Soon after, however, on 6/6/2012, the assistant building manager reported to the group that the door latches on the “front doors” of labs (accessible via the pedestrian corridor) were showing signs of abuse, due to objects being jammed into them to subvert the lock system. This practice needed to stop. The group’s resolution here was to purchase and install flip-down door stops for those that requested them.

As a result of this decision, the PML door lock policy stabilized around the entire building. The policy included: the main entrance doors (always locked; badge-entry), office suites (First Authorized), individual offices (always locked; badge-entry), pedestrian corridor (First Authorized), and lab front doors (First Authorized, but door props acceptable after hours). The only remaining building areas not addressed by this policy were the service galleys, which acquired greater significance and attention for other reasons, which I relate in a later section.

Overall, the differences between the door lock policy and practices between Building 1 and the PML highlights a how the Ops Group raised and recognized the need for a more narrowly articulated delineation of security access. Furthermore, the door lock practice emphasized the requirement for those present in the building to always carry their ID badges, which heightened the visibility of security practices in the building. As a result, spatially-regulated security access around the building became woven into building management practices.
Electromagnetic Wave Interference. Another issue involving building space that quickly warranted the Ops Group’s attention was electromagnetic, or radio wave, interference (EMI). EMI was among the earliest issues raised by an Ops Group member, during their very first meeting on 4/11/2012. The Clean Room manager posed a question about installing a cell phone repeater – a device that picks up cell phone signals and rebroadcasts them on a limited range into otherwise blocked areas of the building. Cell phone repeaters were common in some wings of Building 1, and the Clean Room manager wanted to set his up. The ensuing discussion, spanning multiple meetings and email threads, demonstrated that nearly everyone in the building had a stake in the matter, and EMI proved to be among the most difficult issues the Ops Group handled.

The EMI policy discussion pitted various groups of scientists and EMSS workers in opposition over whether electromagnetic signals should be allowed in the PML building. This opposition arose out of competing needs; some scientists had come to rely on wireless signals to conduct their experiments, while others ran experiments that demanded “EM silence.” Building 1 had been big enough and “siloe-d” enough that scientists could manage the EMI levels in their own labs; if they needed silence, they had it because while immediate neighbors shared their needs, more distant neighbors from other divisions were too far out of range to interfere.

The EMI issue also had relevance to safety. The Clean Room manager, who first raised the question, wanted to install a cell signal repeater for safety reasons. When interviewed, he explained that the Clean Room holds the highest concentration in the building of potentially lethal equipment, chemicals, and cryogens (gases used to reduce temperature). Clean Room accidents have the potential of quickly immobilizing scientists, turning a dangerous situation deadly, and cell phones offer an immediate line of defense. EMSS workers were quick to lend
their support for this line of argument, since they often entered labs or areas of the building alone, and without always knowing the various dangers they might encounter. Thus, for some PML users, cell phones were seen as a necessity, and as a result, they argued that the PML building could not be totally EM silent.

The issue was complicated further by the intangible and ephemeral nature of EM waves. The presence of EMI is difficult to detect, and requires special equipment. But even testing has limitations because of the wide array of potential EMI sources and frequencies that may suddenly broadcast into a lab or building area. Potential EMI sources include not only cell phones, but also wireless network routers, Bluetooth devices, handheld “walkie-talkies”, local radio or television broadcasts, or even remote key locks for cars. As one administrator put it during an Oversight Committee meeting, “Just because you can buy it at Walmart doesn’t mean you should broadcast it in on site” (fieldnotes, 5/16/2012). All of these potential sources broadcast at various electromagnetic frequencies, and not only must a scanner “look” pointedly at a particular frequency to “see” the signal, but the signal may also go in and out of range. In other words, measurements taken one minute may change significantly the next. The fear for some scientists, then, is that the first indication of EMI might come when they “directly see the effects of EM Interference on their measurements” (email memo: “Electromagnetic Interference Issues in Building 81”, 4/16/2013). In that case, days or weeks of experiment data could be rendered invalid.

Finally, another layer of complexity lies in the potential use of wireless network routers for lab or building management needs. Many groups who worked in the PML building had their own reasons for relying on private networks. To begin, the construction company for the PML building had installed its own temperature and humidity sensors in an ongoing effort to test and
troubleshoot building HVAC [air circulation] systems. These sensors were each set up with their own wireless routers and placed throughout the building in locations not made public. As far as anyone knew, there could be dozens of these sensors, and finding and removing them would be difficult. Second, many scientists viewed private wireless networks as a means to “get around draconian IT policies” (fieldnotes, 5/16/2012). As a federal laboratory, NIST computer networks were managed under heavily bureaucratic mandates for IT system security, and getting approval for tracing laboratory data (lab temperature, humidity, experiment results, etc.) and providing it to selected computers, both onsite and off, was very difficult. As a result, many scientists overcame this hindrance by setting up their own private wireless networks, which ported lab data onto private web sites. These private wireless networks, they argued, served very functional purposes of providing remote lab monitoring capabilities.

Given these complexities, the EMI situation in the PML was viewed early on as a mess, the extent of which nobody fully knew. As a result, the Ops Group avoided drafting any initial EMI policy for the PML building and instead urged administrators on the Oversight Committee to decide the issue. Despite EMI being raised as an issue repeatedly during the first summer of Ops Group meetings (4/18, 4/25, 5/16, 6/6, 6/20, 6/27, 7/11, 7/18, 8/15), the only conclusions drawn were simply: “this issue will not be decided today.”

In the absence of a building-wide decision or policy, there were indications that scientists were moving forward with providing for their own needs. The scientists in lab block six, for instance, quickly put signs up in the pedestrian corridor outside their labs, indicating “No cell phones allowed” (fieldnotes, 4/18/2012), although a later reported suggested that “people violate it every day” (fieldnotes, 5/16/2012). The Clean Room manager went ahead with installing his cell phone repeater. During the rest of the summer and fall of 2012, no other scientists on the
Ops Group provided updates on whether they or their lab block neighbors installed wireless devices. However, a memo devoted only to the EMI issue in April 2013 reported that “The mentality regarding EM interference in the building to date has been akin the ‘Wild West’” (EMI memo, 4/16/2013), suggesting that scientists were using wireless devices without permission.

For their part, the Oversight Committee began taking steps to assess the EMI situation. In July 2012 they tested the PML building at various locations and frequencies to gauge the extent of the EM noise problem. Although they found a range of problematic frequencies between 4 - 6 GHz, most of the noise centered on wireless network routers: “2.4 GHz frequency is a real issue” (fieldnotes, 7/18/2012). They also heard arguments from Ops Group representatives on both sides of the debate, who recognized that “world experts will argue on both sides” (fieldnotes, 5/16/2012). Eventually, despite NIST Boulder being historically established as an “RF-quiet” campus, the committee determined that “there is no true ‘radio quiet’ space in [the PML]” (“Electromagnetic Interference Guidelines”, 12/17/2014).

The Oversight Committee worked with an Ops Group representative to draft an official EMI policy for the PML. After a series of drafts and edits, the final 5th edition policy had two basic guidelines: (1) “Be a good neighbor” Guideline: if anyone is found to be broadcasting RF signals that are problematic for neighboring labs, they will work with those labs with “a collegial and professional approach”; and (2) Cellular/Wireless Guideline: while cell phones cannot be regulated, for wireless networks and cell repeaters, the building will be divided into acceptable wireless areas (offices, conference area, and the clean room), and unacceptable areas (lab blocks) where special approval is required. Beyond those two basic guidelines, the official policy established that any requests outside of those guidelines would go through a proposal process that required approval in the following steps: (a) the PML Ops Group, (b) the Oversight
Committee, and (c) the NIST/NOAA/NTIA Site-wide Interference Committee. Outside of those guidelines, labs that continue to experience problems are “advised that shielding their experiments is the most reliable, and in some cases perhaps only, way to guarantee an environment free from interference.”

In sum, through the process of contending with the complex problems that EMI posed for the PML building, the eventual resolution attempted to map out the PML building with regards to where EMI noise could be broadcast. While the EMI levels were important to some scientists in the old building, the attention, monitoring/measuring levels, and visibility of the policy became an important characteristic of the new collaborative building space, and management practice.

**Subsection 3: Political tensions in building ontology.** Thus far, I have documented the process through which the close quarters of integrated laboratories led the PML Ops Group to create a new set of lab management practices that mapped the shared spaces in the PML building and defined and labeled the objects stored within them. While those examples highlighted the way that the Ops Group developed policy aimed at ensuring cross-divisional “buy-in” toward integrative management of shared space, not all issues encountered by the Ops Group could be resolved with such integration. Some aspects of constructing a shared building ontology defied such integration. This resulted in political tension over whether the Ops Group work was sufficient and binding for all building occupants, or opposingly, whether some individuals or lab groups would need to secure their own needs in private, potentially in violation of policy. In this section, I document cases where this type of divisional or lab partisanship created tension in how building spaces and objects were managed in the PML building, with example cases that include:
(a) power outlets, (b) liquid nitrogen supply lines, and (c) information-sharing via the “MetaSys” building systems digital management program.

To address political tensions, however, also requires a consideration for how the Ops Group was in part constituted by and through these tensions, insofar as they participated in them. For this reason, I address the way that the Ops Group members recognized and responded to the inevitable political element present in their work. I do so in two ways. First, I open the section with a prelude highlighting the way that Ops Group members anticipated cross-divisional tensions and, as a result, postured their work by rejecting their own authority and authorship. Second, I offer a postscript to this section by documenting the way that Ops Group members described their role as potentially stigmatized, due to its status as “collateral” to actual scientific research. As a result, while Ops Group members did produce decisions and texts which became partisan to particular political interests, they generally dis-identified with such responsibility.

**Prelude: Apolitical positioning of the Ops Group.** Within the first few months of their formation, the Ops Group began to infuse their discussions with consideration for the establishment of their roles and responsibilities. Among their concerns was that the group might evolve into the “police” of the PML building – a role that group members uniformly wanted to avoid. As the group encountered issues that they anticipated would be difficult to resolve, they began to delay decisions and carefully word those they did make. Their discussions started to include questions of how their decisions or emails should “look” from the viewpoint of other PML scientists, and how to maintain the appearance of impartiality. This facet of their work first appeared in a few brief exchanges on issues they deemed contentious:

Brendan: [While reporting on the Oversight Committee meeting held earlier in the day] There is a disagreement brewing over EMI & cellphone use…
Pete: To Brendan’s credit, he said in the Oversight meeting that it’s not the decision of the PML Operations group. (fieldnotes, Ops Group meeting, 5/16/2012, italics added)

…

Tim: people [scientists] should also install flow meters with all values into equipment (in addition to filters)

Jack: People are probably going to complain.

Steve: We should also recommend that Oversight C[ommittee] send out emails mandating these changes.

Jack: Should we hold off on this & discuss more before submitting rec? (fieldnotes, Ops Group meeting, 5/23/2012)

…

Brendan: How long before we get back to a stable [building] temperature? Maybe you can send out an announcement of when that happens?

Pete: Can do.

Brendan: Also, when emails of building announcement nature are written, should our names be on them? Could potentially give people a reason to bug us.

Jeff: Should be anonymous – “Operations Group” (fieldnotes, Ops Group meeting, 6/27/2012)

Together, these examples indicate the increasing sensitivity and concern the group had for how their work and decisions could be viewed by other scientists. Over time, they positioned their work as “advisory” and as ultimately not responsible for decisions or policies. They held that such responsibilities should remain with administrators on the Oversight Committee and specifically, division chiefs. When interviewed, one Ops Group member explained:

In the beginning, [the Oversight Committee] had this concept… you [The Ops Group] will implement policy, and you will be safety group, and will be responsible for all information transfer… and you know the implementation of policy. And right off the bat, I was – I made my opinion known that no, we’re an advisory committee, and when it comes to implementing policy, we will help advise you on how to do that…and you
know the emails will come from you … I mean I don’t want to be responsible for informing people, especially if it’s a safety issue or something like that.

The attitude and approach expressed here – that the Ops Group should remain free from the burden of responsibility entailed in the publicizing and “policing/politicizing” of the issues they addressed – became woven into the way that the group crafted their decisions and recommendations. Such an approach indicates their anticipation for the likelihood that building-related decisions would on some occasions be political in nature. This demonstrates that Ops Group members were sensitive to the way that those decisions would participate in the tensions between divisions in the management of the PML building, potentially in ways that favored one division over another. The following three cases, involving (a) power outlets, (b) liquid nitrogen supply lines, and (c) the MetaSys building control program, illustrate how divisional politics remained interwoven into the shared spaces and resources of the PML building.

**a. Power Outlets.** This brief example involving power outlets documents the way that the design and management of shared space contained elements that invited divisional partisanship into the PML building and its management. The PML building was equipped with an extensive assortment of power outlets for a number of purposes, involving such complexity as to require a special training visit to the Ops Group by an electrical specialist (email “Ops Group Notes”, 3/20/2013). The outlets are distinguished by a color coding system indicating their capacity for emergency back up by either battery or generator or both:

*Normal branch power:* white outlets running in grey or white conduits. This is the typical power in a lab that comes on site from the two city power substations. There is no backup for normal branch power.

Backup generator power: various outlets running green, orange, or yellow conduit. Systems on this power have the main backup generator (on the northwest corner of the building) as backup. [Colors indicate the various types of equipment they are intended to power, based on their relative importance during emergencies and/or power outages]
**Ups battery power**: black outlets running black conduit. Systems that are on this power are connected to the UPS battery bank. When normal branch power is lost the UPS battery bank will run until the batteries run out. There is no additional backup to the UPS, when it runs dry there is no more power. The battery capacity for the building was designed to provide 22 minutes of UPS power if ALL 50 Amp panels in the building are completely subscribed to it.

**Generator-backed UPS power**: red outlets with black conduit. When a power outage occurs systems connected to this power will use the UPS battery power until the batteries die and then be switched over to the Time and Frequency backup generator (with a 120 hour run-time on a tank of diesel). There is expected to be a 10 second lag between when the UPS dies and the Time and Frequency generator turns on. This can be negated by connecting any equipment on red outlet power to a UPS in the lab. There are only 8 labs that have this red outlet power. (email “Ops Group Notes”, 3/20/2013)

This elaborate power outlet system, involving seven separate types of power-color outlets, not only requires training in order to understand and use appropriately, but it also implicates a subtle but important political dimension to the use of particular outlets. The red outlets, backed seamlessly by both battery and generator power, are made possible by their connection to the “Time and Frequency backup generator.” The Time and Frequency division purchased and maintains their own generator because they house and maintain the Atomic clock (which provides the official time for the nation). The red outlets were initially created in anticipation of relocating the Atomic clock into the PML building. During a routine walkthrough of the service galleys, Trudi, a Time and Frequency scientist, pointed out the red outlets to me:

“And when that [move-in] starts, we’re going to be putting a lot more stuff out here [in the service galley], like these UPS’s, those are ours, uninterruptable power supplies to keep everything running in the event of a power outage, we do have our own private generator for the timescale [Atomic clock], but of course you always have to have something to carry you through that gap [of power loss].

Although they were clearly originally intended for scientists in the Time and Frequency division, the appearance of red outlets in shared galley spaces outside of labs creates the possibility that
scientists from other divisions may view them as part of the shared building and plug equipment into them.

The problem presented by the red outlets then, is that they are a privately-funded resource that has the appearance of being a shared building resource. When scientists learn about the various color-coded outlets, they discover that there may be building resources that, when used, create political problems between divisions. Although the PML Ops Group never had to resolve any conflicts over the unauthorized use of red power outlets (at least not during data collection), the problem of private versus shared building resources did create more visible tensions in the next issue, nitrogen supply lines.

b. Nitrogen continuous supply lines. Part of the excitement of moving into the PML building for scientists was the array of laboratory resources that the new building could offer. Among that list of resources was the potential for a continuous supply of nitrogen to be piped into all labs. Having a continuous supply of nitrogen offered the benefit of not having to purchase and handle it on a per-tank basis. In the old building, if they needed nitrogen, scientists were responsible for maintaining and filling their own “Dewer” tanks, which not only made the nitrogen more expensive in smaller quantities, but also required that they manually transport the heavy Dewers back and forth from the fill station in the building. With cost and convenience in mind, the PML building was designed for all labs to potentially have access to nitrogen at the turn of a spigot, piped into labs from a 6000-gallon supply tank.

When scientists began moving in to the PML, however, they found the nitrogen spigots in their labs to be inoperable. As a result, the issue of nitrogen supply was raised at the very first PML Ops Group meeting on 4/11/2012:
Brendan – Nitrogen issue… well, no one knows what the issue is, or how Nitrogen will be used. I.e., who needs it?...[no immediate answers here]

Steve – Along those lines, regarding [both] nitrogen and CDA (clean dry air) – [we] need a survey put out to find out who will actually need a continuous flow. [Discussion ensued about how to manage continuous flow vs. portable tanks of N2. Generally, the concern was how to account for usage and cost per labs, which are all on separate budgets – no one wants to over-pay for other labs’ usage.]

Jack – The CR’s cost for nitrogen supply is $100k per year…

Pete – well, I will also need to know if anyone on the science side needs to run CDA through nitrogen lines.

Brendan – flow from tank won’t be a problem – actual problem might be political, in determining who will pay how much for continuous flow – I’m not sure we have the capability right now to figure out who has used how much. (fieldnotes, 4/11/2012)

In this preliminary discussion, the reason for the inoperable nitrogen lines is identified: no one has stepped up to fund the supply tank being filled and turned on, since there is no way to clearly divide costs among research divisions.

The questions of cost and funding sources led the group to begin assessing the building-wide need for continuous nitrogen, which delayed the opening of the supply lines. The issue was raised the following week, at the Oversight Committee meeting on 4/18/2012:

Nitrogen supply discussed – could CDA (clean dry air) replace in many cases? Trying to reduce use of N2 in clean room; economic cost will be political issues for N2 usage (and figuring out who uses how much, and owes how much); CDA might be used in place of N2 and is not necessary to monitor; Will need to revisit issue in 4 to 5 months (in late summer), when all are moved in and N2 needs are better assessed/known. Further discussed: how much N2 did we use in old building? CDA wasn’t really available there, so people got into the habit of using N2 instead, and we need to convert them back to using CDA in place of N2. (fieldnotes, 4/18/2012)

In this field note summary of the nitrogen discussion, the group raises the possibility that nitrogen demand may not be as high in the PML as it was in the old building. CDA was not available in the old building and thus scientists had acquired the habit of using nitrogen instead.
Determining the actual nitrogen needs of scientists would have to be assessed after they moved in and put the CDA to use. As a result, the group decides to wait four or five months before conducting a more complete assessment of needs.

Within two months, however, the issue resurfaced as a result of more scientists moving in to the PML and asking about the nitrogen spigots. By this time, the Ops Group discussed the possibility that the nitrogen tank would never become operable:

Kavita: Is there a list of [building] orders that have yet to be fulfilled?

(Group discussion turns to nitrogen and the piping required for it; this discussion is followed by a reiteration of the politics of who (i.e., what division) is going to pay for nitrogen supply, when not all use it equally. One person suggests that the Oversight committee has already decided to not use the nitrogen supply lines that are installed in the PML, but rather to let individuals who need nitrogen to fill up their own tanks, at their own cost.)

Ethan: This is ridiculous – we have a building that has been built to cut across sectors, and we can’t figure out a way to get around the politics of paying for nitrogen and other shared resources.

There is nodding of heads, general agreement around the room.

Brendan and Jeff point out that filling the 6000-gallon nitrogen tank that feeds the lines would actually be cheaper overall than making individuals fill their smaller tanks separately – they do the math out loud.

Ethan: we have a building that provides resources that we need access to – it’s ridiculous that a spreadsheet is preventing it. (People around the table seem to agree but mostly just shrug their shoulders at this). (fieldnotes, 7/11/2012)

Here, the Ops Group members begin to express frustration at the unresolved question of whether they will have access to continuous nitrogen. The prospect of not utilizing the supply lines or nitrogen tank designed into the building particularly frustrates them, as expressed by Ethan:

“This is ridiculous – we have a building that has been built to cut across sectors, and we can’t figure out a way to get around the politics of paying for nitrogen and other shared resources.”
By the following fall, the group’s concerns seemed to be confirmed, as there were still no plans in development to open the supply lines. Partly this was due to the higher priority placed on other building issues, which resulted in nitrogen getting deprioritized by default. Despite this de-prioritization, there were indications that many scientists did highly value it, but they also wanted liquid nitrogen instead of gaseous nitrogen, requiring further alternations to the piping. This placed nitrogen in a unique and difficult position. During a meeting on 9/12/2012, the Ops Group was asked to create a priority ranking for all remaining unresolved building issues. Nitrogen was initially ranked 10th out of 11 issues, which prompted the following discussion:

Brendan: Nitrogen – the issue with that is whether it will be needed as a continuous supply to each lab. And in what form: liquid or gas? (The group immediately says liquid).

Jack: A gaseous nitrogen generator is already ordered and on the way, but it’s just for the Clean Room. So, nitrogen needs in the Clean Room are taken care of, the issue is the rest of the building.

(At this point, the group discusses how much it would cost to equip the building [e.g., insulate pipes] for a continuous flow of liquid Nitrogen – Steve reminds everyone that Tom O’Alan said that it’s not their job to figure costs – only to prioritize the building needs.)

…. (A final prioritization order is discussed and decided, which places nitrogen 8th, the lowest item with a label of “medium priority,” despite the preceding discussion.)

Brendan (speaking directly to Jeff): “But how we’re gonna take care of you is another question” – specifically was addressing the medium-low priority level of liquid nitrogen. Jeff is in Electromagnetics – he doesn’t use the Clean Room, and he has continually expressed that he wants a continuous flow of liquid nitrogen – so, this new priority grouping order does not benefit him individually.

This conversation starts to make clear the bind that the Ops Group faces with opening the nitrogen supply lines –that to do so will require alterations to the pipes, to insulate them and to add metering capabilities, yet a number of other issues will receive funding before nitrogen. In the absence of building-level funding, no division will fund the alterations. One Ops Group
member – Jeff – particularly needs liquid nitrogen, and the group recognizes that his needs are not being met.

The full complexity of the political situation surrounding nitrogen became clear in the following month’s Ops Group meeting, on 10/12/2012. One Ops Group member, who had been absent from prior meetings, asked for an update, believing that the supply lines were in the process of being opened:

Lisa: Laboratories now have access to continuous supply lines of liquid nitrogen? The pipes were always there, but just not in use.

Brendan: yes, the lines are all in place, but the valves remain closed for political/economic reasons. The supply tank of liquid N2 is ‘owned’ by MBE [Molecular Beam Epitaxy facility, which is in the Quantum Electronics and Photonics Division] and they don’t want to share, i.e., fund every else’s nitrogen use. In the old building [building 1], the MBE had a “handshake” agreement with the Clean Room to split the costs of refilling the tank, but now in the PML building, the Clean Room is 4-times the size, and so that handshake agreement is null and void. Right now, the liquid Nitrogen supply lines are only going to the Clean Room, my [Brendan’s] galley (the PIF), and the MBE (it’s unclear by this who exactly has an ‘open valve’ to the nitrogen supply). (fieldnotes, Ops Group meeting, 10/3/2012)

This information, about the private ownership of the supply tank by the Quantum Electronics and Photonics division and MBE lab, had never been offered in Ops Groups meetings, but it did explain why many scientists were tolerating the “closed” supply lines. The nitrogen supply tank was, despite previous reports, operational, but the valves were only open to particular parts of the building: to the PIF (Precision Imaging Facility), to Quantum Electronics and Photonics division scientists, and temporarily, to the Clean Room (which would soon have its own nitrogen generator up and running). As a result, scientists in these sections of the building had their needs met. Everyone else had to fill their own Dewers.
On the whole then, the complexity surrounding the nitrogen tank and supply lines was that, what appeared to be an available building resource by the presence of lab spigots was actually only a politically mitigated option – if a scientist knew who to ask. Jeff, the biggest advocate on the Ops Group for prioritizing nitrogen, summarized the resulting conundrum: “The problem though is when the message doesn’t get around that it’s [liquid nitrogen] available if someone really needs it. As the system stands, divisions who need nitrogen will buy their own tanks and pay more than they should have to, even though the building is capable of providing it” (fieldnotes, 6/6/2012). This quote emphasizes the difficulties that are introduced into the PML when a “building resource” is privately funded by one particular division. The process for accessing continuous nitrogen became one of somehow being made aware that it was actually available despite the official status of “closed,” and asking the right person (and convincing them) to open the valve for your lab block and individual lab.

In sum, the Oversight Committee’s decision to delay and deprioritize funds toward altering the building nitrogen supply pipes to insulate them and install meters had the overall effect of revisiting “wild west” politics. It also complicated the Ops Group’s work. While typically, the Ops Group focused on encouraging scientists to have faith in the building to provide the environmental conditions and resources they need, here a decision was made to deliberately remove a resource that the building was capable of providing. As a result, this nitrogen supply issue ran counter to their work in fostering integrative building management practices, which created frustration among scientists.

c. Building information-sharing and MetaSys. Thus far in this section, I have documented a number of building resources and environmental conditions in the PML that became problematic for scientists and therefore important for the PML Ops Group to discuss and
resolve. Depending on the type of experiments they conducted, scientists in PML labs needed to secure an array of resources and lab conditions, the combination of which was unique to that lab. As a result, individual PML Ops Group members each raised and followed up on the particular set of issues that interested the scientists on their lab block, whom they represented. The implication of this system of representation was that each building issue had a subset of Ops Groups members for whom the issue was relevant, and rarely were all members directly impacted. One exception to this was the issue of building monitoring and information access for the data produced by that monitoring. In the PML building, that monitoring was accomplished via a digital program: Metasys.

The PML building was the first on the NIST-Boulder campus to offer a flexible, integrative electronic system for building-wide monitoring. As the building opened in April 2012 and the Ops Group began to assemble, the MetaSys building control system was still in the process of being programmed, first by the contracting company hired to create it, and then by NIST programmers who would maintain it. By May 2012, when the Ops Group began to meet and discuss building issues, they started raising questions about Metasys and its capability for monitoring various systems. Accessing the MetaSys system was particularly important for scientists and Ops Group members as they began to troubleshoot building systems that were not performing within spec (including temperature, humidity, various water systems or CDA). To that point in time, however, MetaSys was not connected to the NIST computer network, and it was unclear whether or how scientists would be able to access the continuous (“trending”) data collected by it. When the temperature and humidity in labs fluctuated wildly out of spec in early May 2012, Ops Group members created an agenda item for the next Oversight meeting, to ask administrators for permission to access MetaSys from their office workstations:
[Oversight Meeting] Agenda #6: Humidity Control
From our understanding the humidity system is not functioning properly, especially when the temperature is low. Since EMSS has very limited resources to manage the building we suggest that both the ability to read data and have alerts for severe environmental swings from the Metasys system. (Email: Oversight Meeting Agenda, 5/15/2012)

This request was simultaneously motivated by growing concern among scientists that their equipment and experiments were vulnerable to water leaks from the “interstitial” floor above their labs (the 2nd-floor machinery level of the PML building). The MetaSys monitoring capabilities became an important component of the Ops Group’s solution to mitigate the “catastrophic” threat of water leaks:

[Oversight Meeting] Agenda #7: Leaks
The prospect of a catastrophic leak exists. The Operations group and Building manager suggest that some sort of leak detection is employed directly tied to the Metasys system. (Email: Oversight Meeting Agenda, 5/15/2012)

For both of these issues, scientists wanted the ability to be alerted by MetaSys when their labs or experiments were threatened by out of spec building conditions or breakdowns. These requests prompted the following discussion during the Oversight Meeting on 5/16/2012, between Brendan (Scientist and Ops Group member), Steve (EMSS administrator overseeing MetaSys), Tom (Division Chief and Oversight Committee Chair), Mike (Division Chief), Pete (building manager), and Tim (EMSS staff):

Brendan: Item #2, Temp/Humidity control – [we’re still seeing] occasional spikes…. Also we had a temperature spike in my lab last weekend, [and as a result] equipment needed servicing; Scientists need MetaSys read-only access, so as to know when things are going wrong.

Steve: I have no problem giving read access but securities are in transition / in-limbo. So at some point in the near future that access can be granted, but not immediately. Clean Room personnel have it already.

Tom: So, question: when temperature goes out of spec, do alarms go off?
Tim: No, only when systems are in danger. But alarm can be set up.

Tom: Okay, Steve, just as you gave individual CR personnel read-only access, can you do it for Instrument Lab people?

Steve: Well, the problem is that people want to put it on the public network.

Brendan: can we have limited access for one person?

Pete: (reiterates) read-only, right?

Steve: We need less people involved. Too many people have to approve such a move right now; I know what you want, but some things are bigger than me.

Tom: We need two things: 1) short-term ASAP, one member w/ read access; and 2) longterm systemic set up for all to have read-only.

Mike Kelly: can we have continuous flow of temp/humidity data that is public?

Tom: I assume that data in Metasys is in proprietary format?

Tim: Yes

Tom: So it might not be a trivial matter of making that data flow public.

Tim: Also, building sensors are not trusted by all – because it’s questionable whether the sensors are up to NIST standards.

Jack: Two additional issues: 1) data logs, not being recorded as trending log – need to get that started. “Start getting our hands around what’s going on at a smaller time scale.”

Jack: Second issue, need automated email when temp/humidity is out of spec. Ie, some sort of communication structure to help prevent loss.

Tom: Ideally, we’re heading towards a model where trend logs are available to everyone.

Brendan: Along those lines: no leak monitoring in building is currently available. We (PML Ops group) suggest that in the future, Oversight committee needs to look at monitoring – potentially millions of $ at stake if a major leak were to occur.

Tom: Yes, agreed.

The key tension revealed here is in the exchange between Ops Group member Brendan and EMSS representatives Steve and Pete, who express reservations over granting scientists the
MetaSys data access that Brendan has requested. Steve initially claims that, although such access is “no problem,” permissions were still in limbo and could only be granted “at some point in the near future.” When pressed by Tom, however, Steve elaborates on his concern: “the problem is that people want to put it on the public network… we need less people involved. Too many people have to approve such a move right now; I know what you want, but some things are bigger than me.” By this it becomes clear that Steve is attempting to mitigate what he recognizes will be a barrier presented by EMSS administrators (“too many people have to approve such a move… some things are bigger than me”); namely, that the MetaSys data cannot be placed in the hands of scientists because they will “want to put it on the public network.” In short, Steve knows that not everyone in EMSS will sign off on relinquishing control of the MetaSys data. As a result, Tom begins to negotiate ways to connect MetaSys data to one person who could in turn trigger necessary alarms, in lieu of attempting to eventually grant read-only access on a wider basis. Overall, however, the message has been made clear in this exchange, that scientists should not count on having free access to the MetaSys data stream measuring the environmental conditions in their labs and throughout the PML building. That data is controlled by EMSS.

In the aftermath of this discussion, with no clear resolution in place, the Ops Group members were confronted with the need to adjust to the lack of building data on two levels. As Tom had alluded in the exchange above, they first and foremost needed immediate access to trending building data in order to troubleshoot problems involving lab conditions – in particular, temperature and humidity. Second, they needed to keep pursuing their own “read access” to MetaSys as a long-term solution. Both of these needs resulted in the Ops Group members relying more heavily on EMSS for MetaSys access. For example, soon after the Oversight Committee meeting in which the above discussion took place, Ops Group members changed how they
conducted their meetings, by starting the meetings with a “building report” from Pete, the Building Manager (fieldnotes, 7/11/2012). These reports often began with Pete providing building performance reports that included trending data:

Pete: we did make a discovery with air temperature… the air temp was varying significantly. So, while investigating it, we turned off this Prac-Tuning program [a MetaSys plug-in program] which handled the air adjustments. Once it was off, everything was fine – the temperature leveled out completely. Which means we need to do the same for the entire building. (Pete pulls out a chart on a sheet of paper, and shows everyone the trending graph).

Steve: “this [Prac-Tuning program] is causing measurable problems with this data.”

Pete shows another page of trending data in graph form – points out that when humidifying the air – that is, when the air is too dry and the humidifier kicks on or off, the temperature becomes unstable. (fieldnotes, 8/29/2012)

The MetaSys trending data that Pete provides in this meeting updates the Ops Group and begins a discussion in which Ops Group members discuss the potential reasons why the humidity control was destabilizing the building temperature.

In addition to relying more heavily on the building manager for building condition trending data, the Ops Group also began to take an interest in other EMSS personnel who they could sequester toward providing the building data they needed for troubleshooting sessions. In the following exchange, Brendan asks the building manager for an update on plans to hire new building technicians:

Brendan: What’s the status of the two new building technician hires?

Pete: Yes, still two new hires; one will not be under my jurisdiction; both are opened and closed, but yet to officially start (still in transition/negotiation time). One additional hire beyond those two will be an electrician.

Ethan asked for clarification of job classes and roles.

Pete: they are fulltime government positions…
Brendan: so all employees will be EMSS and will have read/write to Metasys?

Pete: yes, full access.

Brendan expresses concern over low number (i.e., availability) of individuals in PML who have the access and power to actually fix problems. [As it stands, when there’s a problem that requires Metasys intervention, only Pete, Tim, and few others can change anything.] (fieldnotes, Ops Group meeting, 6/27/2012)

In this exchange, Brendan asks about the status of the new hires because more EMSS personnel with read/write access to MetaSys increases the likelihood that scientists would be able to find help in their quest to debug problematic building systems. This evidences, again, that scientists recognized that their lack of access to MetaSys data prevented them from resolving building systems that relied on MetaSys for control.

Over the fall of 2012, however, even having additional EMSS personnel did not suffice for the needs of scientists. The Ops Group made another attempt to raise the issue of MetaSys access in an Oversight Committee meeting, on 11/28/2012:

Jack: One issue that needs addressed: Metasys. Need to bring together EMSS and IT security people with the PML Ops group. We hope to have access to Metasys for read/write; we propose that it only be available via hard-wired network stations, not wireless. Also, the logfile for building trending data – we would like read-only, so that we can see the past week for particular building systems information. Scientists need to see the past conditions of their lab remotely, to validate experiments.

At this point, the discussion moves towards network security vulnerabilities and a virus called “stucksnet” – [I need to get the background of this story – sounds like the virus caused some problems for the time and frequency division]. (fieldnotes, 11/28/2012)

Once again, despite Jack’s request for granting scientists read/write access to MetaSys, the discussion quickly moves to the networking vulnerabilities that would result from connecting MetaSys to scientists’ workstation computers. After this attempt, the issue was not raised in the
Oversight Committee meetings again. By the end of the following summer, in 2013, the MetaSys access issue was classified as “resolved” with the following summary:

Metasys access: The metasys system used to control the building needs secure access for those people allowed to change parameters (Jay Koch, Rick Kirk, and the Central Utility Plant) and read only access within the NIST LAN. Currently there is a terminal in the “A” Office block. By 9/9/2013: Resolved

Particularly noteworthy for this resolution is that read/write access was only granted for two particular individuals: one of them (Jay Koch) is a technician for the Clean Room, and the other (Rick Kirk) is the EMSS technician hired to maintain the MetaSys program. Additionally, a computer workstation in the “A” office block had been configured to “read” MetaSys data, which in turn was used to log trending data and broadcast alarms.

In sum, then, the MetaSys access issue resulted in a compromise in the level of control that Ops Group scientists had over the building systems they relied on in the PML. Whereas in the old building, scientists could monitor, produce and broadcast their own data about the conditions and resources in their own lab, now in the PML building they were forced to work more closely with EMSS to accomplish this same level of monitoring.

Postscript: Stigmatization of the Ops Group role. Despite the administrative framing of the PML Ops Group as an experiment with the building as the phenomena of study, serving on the committee had limited appeal for scientists. As described above, the experiment of the Ops Group represented a significant shift in the way that scientists organized their labs. Whereas in the old building, they made lab management decisions with respect to only the spatial boundaries of their lab, now the in the PML building, the Ops Group was assembled to ensure that those decisions were made with the context of the entire building in mind. During the time of data collection, however, it became clear that many scientists, including Ops Group members, had
reservations about the extra work entailed by establishing and maintaining this building-wide shared context. Specifically, the added responsibilities of Ops Group work carried with them repercussions for the professional status of those who served.

In talking with scientists during interviews and in the minutes before and after Ops Groups meetings, it became clear that the responsibilities of managing the collaborative aspects of the building had come to be viewed by many scientists as merely supportive and technical and thus not “real” science. One scientist, when interviewed, used the words “collateral duty” when describing how his role in the Ops Group was viewed by other scientists. He explained that some scientists resist being bogged down by this support-type work, which pulls them away from the lab and experiments:

This is one of the tricks of the safety [Ops Group] role, I was sitting in a meeting once… and I heard a researcher talking about their Division Safety Rep, and said wow, wait, he’s a Ph.D. doing research, what’s he doing [safety] work for? And that made me think wait a minute all of this we’re doing is a collateral duty.

The implication he draws from the researcher’s comment is that Ph.D.’s would rather be doing research, not serving on a committee to ensure building or lab safety. Thus, work outside of scientific research is merely “collateral duty,” and scientists who serve in this role may be compromising their time for research.

While this is may seem to be the conclusion that one scientist drew out of one exchange, the interpretation of “collateral duty” does coincide with the difficulties that the Ops Group had with finding and keeping willing members. During an interview, I asked one Ops Group member how he came to be a member: “I was volunteered by my boss… [and] it’s just you know a responsibility… I mean if they want – if they told me that was what this committee was all about, then I would have not – I would have declined.” What this response makes clear is that
this scientist only served because he was either misled or not informed fully about the purpose of
the group – and that he would rather not had taken on the added responsibility. I asked another
Ops Group member about the process through which scientists were recruited for the group, and
her response confirmed that many scientists would rather not serve if given the choice:

[Administrators approached group leaders] … and asked them hey, could you nominate a
person who you think would be good in this liaison role? And you know, it has to be
someone who knows – well preferably knows a lot of people who they work with, wants
to you know do this type of communication… someone who has time to take on this extra
role, because that’s the thing, most of the scientists, although they’re very communicative
and outgoing, would probably say “I’m too busy to take on another role.”

Again, this scientist recognizes that the Ops Group entails an “extra role,” which is a burden
because scientists are already busy with research projects – and she’s also careful to point out
that it’s not the extra communication or engagement with others that would scare scientists away,
as most are “very communicative and outgoing.” That is, she distinguishes that it is not the
prospect of extra interaction that burdens an otherwise “silo’ed” scientist; rather, it is the
responsibility entailed by this “extra role.” All of these comments point to the likelihood that
scientists, as a general rule, would rather invest their time in their own research.

This likelihood is further confirmed by looking at group membership. Those who served
long-term on the committee were not lead scientists or project leaders. When viewing the status
of those who served on the Ops Group, it becomes clear that the more time spent in the
laboratory, the less likely scientists were to serve on the Ops Group. Rather, long-term members
tended to be less-established scientists who agreed to serve because of their own practical
reasons. During data collection, only one lead scientist (i.e., a scientist who supervised others
and was ultimately responsible for experiments) was a member of the Ops Group. That lead
scientist was the one quoted above, about being misled or not fully informed. While he was fairly
engaged and outspoken during meetings, his attendance was inconsistent. Furthermore, it became clear that his attendance corresponded with meetings in which specific building issues that concerned him were discussed. This Ops Group member – “Jeff” – was a lead scientist in magnetic imaging, and had two primary building issues that concerned his work: excessive acoustic noise and EMI. Once a solution was determined for the acoustic noise, and once it became clear that EMI would not be resolved to his liking, he stopped attending meetings and recruited two new members to take his place on the committee. Once he recognized the “collateral duty” required of the group, his willingness to serve centered on advocating for the issues relevant to his lab. After nine months with spotty attendance, he was able to find a replacement for the second of his two corridor responsibilities, and left the group.

While high-status scientists, such as group leaders and lead scientists, were able to avoid Ops Group duty, the lower-status scientists generally agreed to serve in the group because it offered a means of solidifying their status at NIST. The majority of the Ops Group fit this categorization: they were relatively new scientists or they were caught in transition between labs and thus their future at NIST was to some degree unresolved. Serving on the Ops Group presented the opportunity to increase their exposure at NIST and, along with that, it raised their odds of finding more permanent, internal funding (e.g., being written into a grant by a lead scientist). Many younger scientists fit this description because they are commonly hired out of a post-doc position with partial funding from an outside grant (typically from the National Academy of Sciences or the National Research Council) and as the grant ends, they aim to get fully funded at NIST by getting work in the lab of a lead scientist or under a project leader. One of the younger Ops Group members describes the process through which he agreed to join the group:
“There was mainly an orientation meeting I think, and Tom came up with the packet of slides, and that was the first time I really understood what I was getting into. I mean I’m at a point in my career where I really don’t say no when senior people ask me to do stuff, so. Yeah, I just kind of jumped in.”

This scientist’s approach is that he agrees to serve out of the recognition that he’s at or nearing a vulnerable point in his career, during which ingratiating himself with a “senior” person is worth the extra work. The actual purpose behind the group was an afterthought. Another young Ops Group scientist told me the story of how she came to NIST on a National Research Council grant that was awarded based on her proposal to work with a specific lab/research group at NIST-Boulder. But then when she arrived, the lab was not even close to being ready, so for months she networked around the building to search for other ways to occupy her time. She eventually found another lab who needed her help, and in time, they asked her to serve on the Ops Group, which she accepted in the hope that she has found a permanent “home” lab. So as a group, then, these younger, less established scientists tended to serve on the Ops Group because it fit with their status at NIST, and not because they felt strongly about the collaborative experiment itself.

In sum, the core group of scientists most committed to the PML Ops Group work, with the highest attendance rates, were all younger and not well established in any particular lab. Outside of that group, there was one scientist who defied these prior categories: the Clean Room manager. He was one of the leading advocates for the formation of the PML Ops Group, and made clear in his conversations with me that he was motivated by the inherent collaborative nature of his job responsibilities: he routinely had to work with scientists from various labs who rented time in the clean room, as well as EMSS personnel, safety office technicians, and administrators.
Summary of Section 5: Social Materiality-Configuring building texts and knowledge. In this section, I documented cases where the political and economic complexities constituting some building resources, and the information about those resources, hindered the Ops Group from fostering buy-in toward their integrative building management model. In both the power outlets case and the continuous nitrogen supply case, the transferal of a private resource from the old building into the shared space of the PML created tensions for the Ops Group, because it challenged the integrative model of shared resources. Complicating the issue was that these resources were commonly viewed by scientists as part of the building, and the privatization of some building resources introduced political issues over which division’s and lab’s needs would be prioritized by available resources. Adding to the complexity over shared versus private resources was the MetaSys data access issue, which highlighted that EMSS controlled the monitoring information produced for the building resources that scientists relied on for their experiments. Consequently, the practices of using particular power outlets, activating nitrogen supply spigots in labs, or accessing building data became politically complex issues that confused and frustrated scientists, because using those resources required them to engage in “wild west” partisan practices, such as behind the scenes “handshake” deals. These cases illustrate the tensions that scientists carried with them into the PML as they worked to ensure that their research needs would be met.

Summary of Findings: Configuring social material practices, texts and knowledge

These findings have provided explanations and descriptions of the work of the Ops Group pursuant to the ways that their processual achievement of collaborative, conversational knowing is relational to the textual product of organizational knowledge as a synoptic system that represents a shared, stable context necessary for scientific work. I have offered case studies
involving building issues that were addressed and resolved by the Ops Group, through which group members were able to determine and implement lab management practices that constituted, in concert with building texts, a social material ontology of the building. Through such configuration, the Ops Group emergently configured the building with attributed qualities, conditions, and performances through a trial and error process.

This process unfolded via the Ops Group members invoking the building itself as a central figure in collaborative conversations during their meetings, and the trajectory of their work can be understood in terms of the ongoing “con/figuring” of the building toward desired stability and understanding. This included inventorying and defining objects that occupied shared space in a way that spanned divisional boundaries and prior lab-specific understandings. It also included identifying ways to monitor, measure, and anticipate performances in specified locations throughout the building.

The resulting product of these conversations were compiled texts that provided a shared context for ordering and rationalizing a new set of management practices that together articulated a stable, knowable building. The authoring of this new synoptic system of practical building knowledge invoked commitments among resident scientists insofar as it successfully represented a consistent alignment of building objects, spatial markers, lab management practices, and measured building performances.

**Revisiting Research Questions.** The research questions driving this study targeted an exploration of the relationships among key organizational facets from separate bodies of literature: entitative (or representational) knowledge, organizational practices that transcend socio/material divisions, and the authoritative text that is anticipated to narratively connect them. The specific research questions for this study are the following:
RQ1: How is entitative knowledge encoded into organizational practices and/or authoritative texts?

RQ2: What is the relationship between the organizational narrative of the authoritative text and the appropriation/performance of agency and materiality in collaborative management conversations?

In the following sections, I summarize responses to these research questions.

**RQ1: Entitative knowledge and organizational practices.** Addressing my first research question, this study highlights the way that the Ops Group’s work simultaneously entailed the co-authoring of organizational practices and entitative knowledge. Specifically, study findings have shown how the Ops Group’s communication about the building (via problems identified within it) constituted an emergent assemblage that linked representations of the building (i.e., its qualities, conditions, and performances) with organizational policies and practices. In turn, the trajectory of the group’s work demonstrates how these representations, policies and practices together provided the basis for developing and textually documenting a particular kind of entitative knowledge. That is, rather than providing an explanation for how entitative knowledge is “encoded into organizational practices,” these study findings suggest that both are emergent features of the group’s conversational aim of producing a stable and well-understood building (i.e., building ontology). Insofar as the Ops Group was able to specify, define, and configure aspects of the building they deemed important for their work, they also coordinated practices through which those aspects could be maintained and verified as ‘known’. Thus, while the building texts they produced – the Wiki site and PML User’s Manual – served as compilations of the ‘known’ building, those texts were nevertheless constituted within the alignment of building qualities, conditions, performances, policies, and practices through which they were deemed
“knowable.” This would suggest, then, that entitative knowledge, rather than being a self-contained or self-evident resource, is instead inseparable from conversational assemblages through which it can be practically coordinated and articulated.

A noted absence from the above RQ1 answer – and from these study results on the whole – is a clear documentation of an authoritative text in the PML building. While the Ops Group and other resident scientists acknowledged the insufficiencies of the “wild west” authoritative text from their old building, data collection did not provide any clear evidence that they authored a new one. This is not to claim that a new narrative was not being developed. But it does suggest that scientists were primarily concerned with the practical challenge of achieving the stable, predictable building context required for their work.

**RQ2: Agency and materiality in Ops Group conversations.** While this study did not provide a basis for making claims about a clear authoritative text emerging during the Ops Group’s work, it did provide a means of exploring the group’s work in producing and organizing a social material building. In this respect, Ops Group members configured the building as an assemblage of objects, resources, measured conditions, spatial markers, and policies, the combination of which produced unique relations of agencies specific to the particular kind of building they organized. Further, the building emerged through the Ops Group’s work, and actively participated in this process by defying particular configurations. This process demonstrates the way that emergent building configurations were social material in how they transcended any particular social/material dualities; that is, performative agencies cannot be reduced to one or the other.

Two examples from these findings illustrate this emergent process of specifying a unique combination of agencies, and the varying – often unscripted – performances that result. First,
recall the example of the building temperature and humidity; the variability of the air temperature in labs throughout the building resulted in considerable frustration among scientists. Although stable temperatures were vital for the experiments that many scientists conducted, the building temperature remained wildly out of spec for over six months after opening, causing many scientists to postpone moving into the building. In the early days and weeks after the building opened, this unacceptable variation in building temperature was attributed to faulty programming in the MetaSys program that monitored temperature readings throughout the building and adjusted air controllers as a result. However, reprogramming the MetaSys controls did not fix the problem, and the Ops Group repeatedly returned to brainstorming the issue. Eventually the group determined that the building temperature was influenced by mechanical limitations in the clean steam generators, but even with this decision, they could not fully anticipate or simulate the way that the weather and building equipment would affect their performance. As a result, scientists were forced to recognize the way that building temperature readings were not merely reducible to their textual representations and/or simulations of it. Rather, temperature readings were an expression of the unique assemblage of equipment, resources, policies, and demands that had been organized together in a particular building configuration. If the reading was within spec, trust was fostered in that particular configuration of the “building”; if not, then the assemblage was flagged as problematic and raised for discussion at the next Ops Group meeting.

Another example was provided in the way the Ops Group identified and addressed safety concerns in the service galleys. Early in their work, Ops Group members recognized how service galleys were locations that defied any one scientist’s ability to recognize and gauge safety threats. In response, they created a new position – Galley Safety Representatives – in order to
document and resolve hazards that resulted from the integration of cross-division objects. These GSRs were responsible for quarterly walkthroughs, during which they identified new safety hazards that had developed via scientists’ storage practices since their last walkthrough. In this, Ops Group scientists and GSRs were forced to recognize how safety could not be prescribed or simulated – rather, it is a manifestation of the unique, emergent combination of objects and conditions present in the service galleys. GSRs would always be necessary to reassess the risks associated with the unfolding combinations found in the galleys. The agency attributed to galley objects, and the way they performed during the daily practices of scientists were each measured and discussed in terms of anticipated interactions with other agents in the galleys -- thereby becoming involved in both texts that prescribed (simulated) assemblage-level agencies, but also the practices through which action is coordinated.

These two examples illustrate how agencies – more specifically, combinations of agencies – at work in the PML building defied any textually-conceived design, policy or simulation the Ops Groups members could determine and document. In this way, the performance of assemblage-level agency was not fully predetermined or specified by the Ops Group. In response, they could only develop practices that involved the ongoing assessment of emergent agency and resulting building performance.

This suggests that, in response to my second research question, the Ops Group’s work entailed a particular social material engagement in their configuration(s) of the building. Their efforts to document, define, and combine particular elements (qualities, conditions, etc.) of the building into an assemblage produced results that were not fully predictable and could not be fully simulated. Their work involved developing practices through which building performances could be detected, measured, assessed and addressed. In response, they configured iterations of
the “building” until its various measured performances matched prescribed textual representations. Only through this process did assemblage-level agency become manifest and knowable. Following Barad’s (2003) conceptualization, I have in these findings provided the apparatus of observation to document, through field notes, artifacts, and interviews, the way that these agencies were constitutive of the organizing process. In the following Discussion section, I consider implications of these study findings, in context to prior research on organizational knowledge.
Chapter 5: Discussion

This dissertation study has implications for a number of current theoretical discussions among organizational communication scholars, particularly those concerned with articulating and extending CCO theory toward understanding conversational knowing, and how it relates to practice-based approaches to organizational knowledge. In this discussion chapter, I propose contributions to these discussions that are highlighted by my study findings at NIST. Specifically, I provide six ways, organized as subsections, in which this study contributes to current theoretical conversations involving both CCO theory and a practice-inspired approach to organizing, organizational knowledge and representational texts. First, I connect the Ops Group’s production of building knowledge inscribed into texts with the achievement of a shared organizational context. That is, I argue that while organizational actors at NIST would claim to possess relevant building knowledge, organizational scholars can understand this as the achievement of a common basis for recognizing and asserting aspects of a shared context. Second, I propose that this study articulates and extends current thinking on the links between representational knowledge and organizational practices. In this, I document how practices implemented by the Ops Group function to both expand textual understandings across time and space, but they also prescribe points at which building recalcitrance can be discovered. Third, I place this study in context to current discussions involving knowledge trajectories in organizational literature, and in particular, I document how these study findings may illustrate a balance of integration and differentiation. Fourth, I relate findings of this study to previous scholarship on organizational knowledge versus the achievement of organizational knowing. I particularly argue that these findings suggest a bimodal engagement with knowledge and knowing, such that Ops Group scientists at NIST tended to be engaged in one, but not the other.
Fifth, I explore how this study previews potential avenues toward tracing the re/production of power across the flattened ontology of the text-conversation dialectic. Sixth, I revisit the absence of an emerging authoritative text during the Ops Group work, and offer potential explanations for this absence while exploring possible locations of textual authority. Finally, I conclude this discussion section by identifying limitations of this project. While this study had limitations in site selection and methodological tools that narrowed its scope, I nevertheless argue that it articulates important links between organizational texts, practices, and communication that configure technical and scientific work.

Organizational knowledge as constitutive of shared (inter)textual context

This study suggests that organizational actor “knowledge” may be usefully understood as having a basis in the communicative constitution of a shared organizational context. More specifically, communication can be viewed as the means through which a shared context is produced ontologically by collecting together figures and voices that populate a particular kind of organizational reality. Cooren and Sandler (2014) argue that conversations are always dialogic in the sense that communication raises a number of voices (or ‘figures’) – a polyphony – and that each figure is not self-determined in its agency. Rather, each gains its definition, meaning and agency from its positionality and relations among the other figures within the collective reality being communicatively constructed. Agents, voices, and figures are called together conversationally, and thus form an assemblage, the collectivity of which represents the construction and articulation of a communicative ontology.

Viewed across a number of text-conversation dialectics, we might see this assemblage carried forward if it is inscribed into texts that become imbricated over time and space (Cooren & Fairhurst, 2009). While scholars have already argued that knowledge is discursive (Foucault,
1980; van Dijk, 2003), this study suggests that organizational knowledge may be manifested via imbricated texts that represent and articulate a practical (or, practice-based) organizational ontology. Together, the PML User’s Manual and the Wiki site were authored during data collection toward stabilizing reliable representations of a building ontology. They offered current (updated) plausible understandings of the building that made work possible by identifying and locating resources, policies, and practices. These texts were the means through which scientists could reorient and expand their work context from just their lab in the old building, to the entire building in the PML, because they provided an integrative representation describing the building space as a recognizable, documented assemblage. In this sense, the PML User’s Manual and Wiki site provided a collection of practical knowledge that brought together related understandings making it possible to plausibly “know” and predict the performance of the building space.

An important contribution of this study, then, is the way that organizational space, as a shared working environment, became a central meaningful process and site of organizing. Ops Group scientists and administrators identified building instability and uncertainty as the driving impetus of their work, such that defining, describing, labeling, mapping, measuring, and policing the building became synonymous with problem-based emergent organizing (Kuhn & Jackson, 2008; Rennstam & Ashcraft, 2012). Put another way, the spatial dimension of the PML building became knowable only insofar as it became configured via combinations of text and practical performance. In this sense, Ops Group members re/wrote organizational scripts that became important resources for resident scientists to distinguish this new building from the old one. For this reason, the imbricated texts produced during this process became the primary means of both coordinating action and of understanding that action organizationally. Because they authored
these texts and implemented associated practices, the Ops Group work can accordingly be understood as constituting the building spatially, and by extension, as providing the recognizable shared context of what is distinctive about working and conducting research in the PML building.

I argue that this unique feature of collaborative management at NIST provides at least two contributions to CCO literature. First, it offers a special case in which organizing spatial characteristics of work became a key text that served a number of simultaneous purposes: it (a) invoked collective, coordinated notions of accomplishing research in the PML building by (b) specifying important qualities and measurements of the building space toward the practical accomplishment of that work, while also (c) compiling an integrative set of understandings that in turn specified criteria for judging conversational credibility and persuasiveness. The first contribution, then, is how organizing building space, in the case of physicists at NIST, provides a unique way to organize their work on both practical and symbolic levels because it resonated with their professional identity.

The second contribution involves the third facet (listed above) of the Ops Group’s work in organizing the building: namely, that it compiled practical organizational knowledge that became a basis for ordering communicative knowing (Barley et al., 2017; Rennstam & Ashcraft, 2012). Insofar as the group authored texts that specified attributes of the shared organizational space, they also provided an important resource for assessing claims about how to manage that space. That is, to make credible claims regarding the management of labs or building-wide policies (EMI, door locks, process chilled water, etc.) required a demonstrated orientation to the shared and compiled contextual building knowledge that the Ops Group was in the process of determining and documenting. An appeal for a policy or resource change was not persuasive
until it could be considered in context to how the building space was currently understood. In this sense, the findings of this study suggest that practical knowledge, when compiled textually toward spatial organizing, prescribed at least one basis for credible communicative knowing.

**Practical Knowledge: Linking knowledge with practices**

Implied in the above explanation is that this study articulates a practice-based approach to organizational knowledge. Study findings show how practices encompassed a number of situated and simultaneous ways of knowing (e.g., “embrained” and “embodied”: Blackler, 1995), beyond merely those prescribed by synoptic (or “encoded”) knowledge. An important implication of this study is that it documents tension that results from practices that are both synoptically prescribed and situationally embodied. Importantly, this tension drives organizing via assemblage-level recalcitrance.

Although the Ops Group met regularly – typically biweekly – nearly all of the issues they raised and discussed were inspired by reports of events that happened *between* their meetings. This surfaces the way that the Ops Group’s work in providing textual resources articulating a building ontology did not suffice in merely its authoring: it *did something* beyond Ops Group meetings.

Specifically, while the Ops Group members compiled those texts, they simultaneously scripted the appropriate organizational (lab management) practices via policies and procedures that coincided with the building ontology they documented. Their “configuring” of the building can be understood as producing a practice-based building ontology. For instance, recall the PCW (“process chilled water”) system. Within one discussion, Ops Group members not only determined the optimal qualities around which to organize and stabilize the system, but they also
prescribed a list of associated practices they required of resident scientists to implement such a system. The order provided by organizational texts was spread spatially via the practices they prescribed.

This interweaving of a practice-based ontology is key because of the way that it orders and scripts encounters with a represented building, but with varying outcomes. More specifically, scholars have recognized how practices provide encounters between, on one hand, representational organizational scripts and, on the other, situated complexity beyond that which is script-able (Cooper, 1976, 1986; Kuhn & Burk, 2014). Along these lines, Charles Taylor (1993) posits that practices provide an important avenue of inquiry toward understanding the social material underpinnings of organizing processes. A practice-based approach to understanding and knowledge highlights their lived, embodied nature, as well as their inherently social and distributed nature. Taylor (1993) terms any potential differences between the two as a “phronetic gap.” This study contributes to this line of theorizing by documenting how building recalcitrance resulted from the misalignment of organizational scripts and building performance as prescribed within those scripts. An example of this is in the Ops Group’s discovery that building systems controlling humidity – the “clean steam” generators – were interfering with air temperature in particular labs. On days when Boulder experienced either an increase or decrease in general humidity (due to rain, for instance), the clean steam generators kicked on or off and, in turn, disrupted building temperature. This type of interaction between building systems in tightly integrated space could not have been anticipated via scripts, but only through actual encounters via practice. Another brief example was provided by the door lock policy in the PML. A policy was determined in theory (labs and offices always locked), and subsequently programmed into
the digital building control system, but actual scientist practices highlighted the need to provide access for those who, for various reasons, did not have ID access cards on them.

Both of these examples illustrate the way that this study highlights and extends research that explores recalcitrance that emerges from the tension between representational, synoptic understandings and the complexity of lived experience. Importantly, this study documented how such encounters provided instances where these tensions became a part of Ops Group conversations that in turn became inscribed into organizational texts. This process highlights practices as interfacing the “phronetic gap” between representational knowledge and the encounter of the ‘unscript-able,’ which becomes a focal point of organizational problem-solving (Tsoukas, 2011).

**Balancing integration and differentiation in building knowledge practices**

This dissertation project raises important questions about the usefulness of the collaborative management experiment at NIST. Specifically, the building design in the PML and the accompanying Ops Group model of building management both exemplify prevalent trends in organizational knowledge management that prioritizes the integration of expertise and specialized knowledge above the differentiation (or narrowing) of such expertise (for a review of this trend, see Barley, Treem, & Kuhn, 2017). Specifically, administrators and designers of the PML building viewed the integration and relative close proximity of laboratories among the five research divisions at NIST to be a response to past problems involving safety lapses and adversarial relationships between scientists and building workers. While these practical concerns were foregrounded in the collaborative building design efforts, administrators also envisioned that increasing scientist interactions could also provide research collaboration opportunities as an added background benefit. The findings of this study, however, draw into question whether these
were safe assumptions. In particular, the reluctance of scientists to serve on the Ops Group, as well as the “collateral” label assigned to such service, highlights the potential that this experimental push toward building knowledge integration may be experienced by scientists as taxing them beyond their preferred levels of otherwise differentiated (specialized) expertise. In this sense, the “wild west” approach may remain more appealing to scientists in that it allows them to remain experts of their own labs.

In their thematic review of research highlighting trajectories of organizational knowledge management (KM), Barley et al. (2017) argue that the recent bias toward knowledge integration may entail an underestimation of the importance of differentiated organizational knowledge. More to the point, they argue that “recognizing the important role of uncommon ground in KM requires us to ask less about how organizational units integrate knowledge and more about which knowledge should be integrated across units” (p. 29, italics in original). Organizational action, they point out, requires both differentiation and integration, particularly insofar as they together enable a broad sensitivity to the environment, as well as the ability to share and coordinate around that sensitivity.

The trajectory of the Ops Group’s work can be understood to illustrate this need for striking a balance between integration and differentiation. The Ops Group scientists not only spent considerable effort in identifying building problems, exploring them, and soliciting the input of outside experts, but they also authored and implement lab management practices that required resident scientists to be more aware and considerate of their neighboring scientists. Importantly, these practices were auxiliary and not essential to their own experiments. In short, the collaborative PML building design and management required extra work via the knowledge practices required for the management of safety and shared resources. Thus, conducting their
research in the PML carried a tax in the form of these additional knowledge practice requirements. The question becomes whether the extra work is worth it for scientists. In his knowledge-based theory of the firm, Grant (1996) translates knowledge production, management, and especially, knowledge transfer into cost-benefit decisions for organization members. Important in this view is finding a means of coordinating across units or divisions in a way that is efficient by minimizing the need for information transfer. That is, if it is not clear how collaborative knowledge-sharing and coordination is relevant to their work, scientists may avoid it. Such avoidance is apparent in data for this study.

These study findings, however, also suggest a means of striking a balance between differentiation and integration that could mitigate this avoidance. Two outcomes of the Ops Group’s work can be understood as routinizing the collateral work necessary for working and coordinating within the collaborative building space in the PML, and thus making such work more efficient. One is the standardized safety hazard label system for service galleys, and the second is the PML User’s Manual. Both were authored and implemented by the Ops Group to be quick reference guides for understanding systems or hazards beyond the scope of one’s own laboratory. In this way, they each provide integrative understandings that are easy to implement/use and understand, and thus they efficiently enable scientists to spend more time on their differentiated work. The production of the label system and the PML User’s Manual therefore provide illustrations of how knowledge integration and differentiation might be effectively balanced. These examples follow a precedent identified in prior organizational knowledge research. For example, in an ethnography of aircraft carriers, Hutchins (1995) demonstrated how organizational routines that used artifacts provided efficient cross-unit coordination by minimizing the depth of knowledge required for such coordination. Similarly,
Bechky (2003) showed how artifacts like design plans and silicon wafer etching machines mediated coordination among engineers and thus prevented the need for “deep dialogue” wherein deeper expertise is shared. More recently, Rennstam (2012) documented how a power amplifier solicited coordination among a number of specialty groups who provided expertise in an abbreviated way that avoided full integration of that expertise. In all of these examples, balancing knowledge integration and differentiation was achieved in a way that reduced tension between the two, because it minimized the collateral costs of sharing.

In sum, then, the Ops Group’s work provided an illustration of this need to balance integration and differentiation because, in their view, it offered a means of evolving the “wild west” approach toward improved cross-divisional coordination. This study contributes to this literature by responding to Barley et al.’s (2017) call to explore ways that organizations can negotiate such a balance between integration and differentiation. The Ops Group positioned their work toward producing texts that encoded a combination of expert knowledge systems that were required for lab management practices. In so doing, they also provided quick-reference artifacts that helped to level the balance for scientists more toward the knowledge differentiation they had become accustomed to in the old building.

**Organizational change and knowing versus knowledge: bimodal?**

For scientists in the PML building, a stable organizational ontology – one in which a system of representation matched measurable performances of the building – was deemed imperative to their work. As scientists moved in, they widely acknowledged that the building was apt to perform in ways beyond the specifications underlying its intended design, resulting in recalcitrance reflective of the tension between design-simulated performance versus actual performance (Cooper, 1976, 1986; Kuhn & Burk, 2014). While the building was actively
recalcitrant, the Ops Group met frequently in order to identify the sources and locations of it, to assess the risks it presented, and to consider resolutions that, when implemented, would bring the building into compliance. In this, they engaged in problem-solving communication during their meetings, aimed at resolving any noted recalcitrance by achieving the capability of discursively explaining it. Resolving recalcitrance restored the building environmental stability and predictability required for the scientists’ work. Once the Ops Group achieved a plausible synoptic representational system that restored a sense of building environmental consistency, the inadequacy of their organizational knowledge had been resolved, and the group members were less motivated to participate in the PML Ops Group. The mystery/challenge that had inspired the formation of the group had largely been resolved/fulfilled.

This trajectory of the group’s work over the duration of data collection highlights a potentially important distinction between the organizational status of achieving knowing versus having adequate organizational knowledge. On one side, problem-solving can be understood as a conversational mode directed at producing or restoring a stable organizational ontology. On the other side, having organizational knowledge is indicated by the availability of texts inscribed with practical synoptic knowledge that represents consistency between the qualities and performances of organizational space. This description of the Ops Group’s work can be related to Kuhn and Jackson’s (2008) notions of determinate and indeterminate organizational problems; the former typifying situations in which problem-solving resources are already available, while the latter indicating problems for which no readymade solutions exist, meaning they would have to be creatively constructed. The findings of this study challenge and extend this framework by suggesting that the extensive presence of indeterminant problems at NIST threatened the credibility and trustworthiness of readymade solutions for determinant situations. In this sense,
then, the Ops Group members aimed to restore the trustworthiness and integrity of the synoptic organizational knowledge toward re-establishing knowledge-transmission and information requests as possible resources symbolized by the presence of the PML User’s Manual and Wiki site. Consequently, Kuhn and Jackson’s (2008) framework suggests that Ops Group members were stuck in improvisation for the entirety of data collection. Key here, however, is that scientists preferred the “normalized” problem-solving of routine, determinate situations. That is, for laboratory management, they wanted the availability of a textual synoptic knowledge base that made this type of normalized problem-solving possible and systemic. To draw on sociology of science literature, this possibility harkens back to Thomas Kuhn’s (1970) distinction of “normal” science research that describes work aimed at articulating an established and trusted scientific paradigm. The scientists at NIST, however, were experiencing a paradigm shift that necessitated the reconstruction and re-articulation of the practical building knowledge required for work.

This suggests that: (a) achieving knowing and (b) having an adequate entitative knowledge system may entail different modes of organizational work, particularly in times of organizational change that disrupts routines: normal (i.e., consult the manual), or knowledge-pursuit (write the manual). The latter is about stabilizing the organizational ontology toward providing “normal,” determinate work practices, scripts and routines. Put in terms of organization theory scholarship, this “bi-modal” possibility follows in line with Latour’s (2013) distinction between “below the script” and “above the script.” More specifically, Latour draws this distinction by arguing that speaking organizationally is fundamentally different than speaking about organizations; the former is akin to following (“below”) established organizational scripts that already provide meaningful performances for organizational actors,
while the latter are occasions when meta-discursive space is opened ("above") to reflect on those scripts toward potentially rewriting them. Taken together, these two modes explain how organizational reality can be both embodied/practiced, yet also disrupted and held in question in the span of one conversation among organizational actors. According to Latour (2013), “Organizations, in other words, remain immanent to the instrumentarium that bring them to existence… [which are the] organizational scripts [that] circulate through a set of actors that are either attributed some tasks or are in a momentary state of crisis to re-instruct the scripts with new instructions for themselves or for others” (p. 9). This view stresses that organizational ontology is flattened into these two conversational modes, and it explains how such an ontology is not continuous, but rather has the potential to be disrupted.

Following this theoretical line of thinking, the Ops Group members experienced the type of bi-modal conversations that Latour described. They enacted organizational scripts by representing their own research interests, and representing the interests of others. Yet, amidst tensions and conflicts during which it became apparent that not all scientists’ needs could be served, they were also asked to develop new policies and scripts that disrupted old ones. The contribution of this study is to suggest that organizational actors, like the Ops Group members, may prefer not to go “above script.” Their reluctance to serve on the Ops Group, as well as their drive to document a stable and understandable building suggests they prefer that a stable script is already in place.

**Tracing attributed figures and power across text/conversation**

A fifth implication of this study is the way it has offered a preview of the possibility of tracing the way that power is constituted and re/produced in a CCO approach. Specifically, CCO theorists have not yet offered a full explanation of how power can appear durable within a
flattened ontology view (Brummans, et al., 2014; Kuhn, 2014b). Drawing on Cooren and Sandler (2014), however, Kuhn (2014b), argues that organizational analysts “can start by investigating how a particular reality emerged… and then, acknowledging the distinction-making involved in his/her own positioning, consider how that reality might have been constituted otherwise, and infer the role that particular interests, as not-yet-unfolded voices, played in process of constitution he/she observed” (p. 247). Doing so, Kuhn (2014b) posited, would provide insight into the contingencies shaping dialogue, and further, it would enable analysts to locate the process and outcome of conflict and tension.

This study offers a preview of Kuhn’s vision, albeit on a preliminary level. Because Ops Groups meetings could not be recorded, data produced during these meetings were limited to field notes. This prevented analyses on a micro-discursive level. Kuhn’s (2014b) vision of tracing the “contingencies shaping dialogue” (p. 247) were consequently limited in this study to larger issues addressed by the Ops Group; I recorded issues raised and main ideas exchanged about them, but I could not trace every discursive reference and resource. As a result, data provide some indications and glimpses of the way that tensions produced commitments and the “on-going re-emergence” (Kuhn, 2014b, p. 247) of power.

A useful example is the Electromagnetic Interference (EMI) issue, which was among the most difficult addressed by the Ops Group. The difficulty resulted from the wide variation of interests brought to the table during discussions. Some scientists were vocal about their need to have “radio quiet” around their labs, arguing that EMI invalidated experiment results. These scientists posted signs reading “No Cellphones” in the hallways around their labs. Other scientists wanted to use wireless network routers in order to monitor and relay important data from their experiments, enabling remote supervision. Still, others – including EMSS building
workers and some scientists – argued that they needed cellphones as a safety outlet, particularly in service galleys were oxygen deficiency had been a noted hazard. In fieldnotes, I also recorded important contextual resources that informed the debate: for instance, Boulder had been selected as a site for a NIST branch campus particularly because of its relative lack of radio and other electromagnetic waves. All of these interests and resources were invoked in varying ways as persuasive figures in conversations during this debate, and it becomes possible to explore the way that some interests were elected to be inscribed into the PML User’s Manual, while others were not. Fieldnotes suggest that safety priorities became the most valued because they resonated with division chiefs. However, the possibility remains that I did not record in all fieldnotes all conversational utterances that would have been captured in recordings, and thus I may not have captured all relevant references and figures. Still, it is fair to say that this study offers a preliminary glimpse into the possibility of documenting and tracing all contingencies that are both selected, and not.

**Locating authority among building texts**

A sixth and final noteworthy finding of this study is that the Ops Group and other scientists at NIST roundly understood the insufficiencies of the “wild west” authoritative text from the old building, yet did not author a clear replacement that matched its symbolic authority. Midway through data collection, I recognized the importance of the “wild west” metaphor in the old building, and how it characterized and ordered an alignment of organizational narrative, metaphor, and practices toward emphasizing the “maverick” role of scientists in problem-solving in their own labs. Recognizing this deficiency in the “wild west” authoritative text was accompanied by my resolve to keep a watchful eye toward whether administrators, Ops Group scientists and other resident scientists began to author another text that gained authority toward
replacing it. As of the end of data collection, however, I did not identify any new narratives or metaphors on par with the authority evident in the “wild west.” Rather, when asked what had replaced the “wild west,” scientists generally responded by referencing how the building itself rendered the “wild west” obsolete. In the absence of a clear authoritative text, a final important implication for this dissertation study extends CCO authoritative text theory toward considering sources of authority during organizational change (Koschmann & Burk, 2013; Kuhn, 2008). Along these lines, I offer two potential explanations for locating the authority necessary for coordinating scientist practices in the PML building in the absence of a unifying narrative text.

One explanation is that the “wild west” text still had some authority, given that the metaphor of scientists as “mavericks” still had appeal to them in their desire to see themselves as smart, autonomous decision-makers (recall from the findings above a scientist’s interview quote saying as much). In this case, the “wild west” text may be undergoing an intertextual re-writing. Underscoring this point is that texts entail networks of meaning that draw on, and form intertextual links (Corman, Kuhn, McPhee, & Dooley, 2002; Fairclough 2001) that can shift over time. While the safety hazards were an unacceptable component of the old notion of “wild west,” it could be the case that scientists were crafting an explanation for themselves and their work that entailed a safer, smarter outlaw who only breaks rules with better discretion. This possibility may explain the conflicting ways that scientists seemed to reject and warn against the “wild west” in some ways, while defending it in others (i.e., scientist prestige). On the whole, this idea would suggest ways in which authoritative texts can undergo significant rewritings during times of organizational change.

A second potential explanation is that the Ops Group’s efforts to construct a new authoritative text aligning disparate laboratory practices with a new metaphorical narrative in the
PML building failed to adequately characterize and accommodate the relations of obligations among resident scientists (Kuhn, 2008). Specifically, given the interdependence entailed in the new PML building, and compromise that such interdependence requires in re-routing their lab management decision making through the Ops Group, it may be the case that the resulting inefficiencies have prevented scientists fully fully “buying in” to the collaborative management model. In this case, PML scientists may be orienting their work according to authority present in other meaningful professional texts. That is, they may see themselves and their work more in line with what it means to be a physicist or a metrology scientist, laser scientist, etc. In this case, the authoritative text may rather be dispersed according to the practical commitments of individual scientists or labs of scientists. This may also explain the symbolic importance of the pristine nature of the building itself: it resonated with conceptions of their professional status and capability as physicists. As a result, given this potential alignment between the building space that reflects their achievement and their professional identity as physicists, it may be possible that an authoritative text can operate as a dispersed collection of texts unique to sets of individuals in an organization.

**Study Limitations**

This study is most saliently limited by two choices I made in the development of this research project, one involving site selection and the other a methodological choice involving tools of data collection. First, for a study that centers organizational knowledge and knowing, the site of this study – a large federal scientific research organization – places limitations on the potential scope of my findings. Specifically, this study seeks to document knowledge in a place that is broadly prescribed by organizational knowledge literature as “where knowledge is produced,” and therefore it reproduces the contemporary archetype of a “knowledge worker”
(e.g., male technicians and scientists). In so doing, this study does not provide an opportunity to challenge the a priori assumptions provided by gender/class scripts that prioritize such an archetype (Rennstam & Ashcraft, 2013). That is, this study runs the risk of further entrenching these assumptions by finding knowledge-production only where it was “supposed to be”: in a science laboratory. This study does, however, take a practice-based approach to organizational knowing, which locates knowing within the situated practices that emphasize embodied and embedded knowledge (Blackler, 1995) and thus in analysis, practices became important units of analysis. Nevertheless, this practice-based approach alone does not deconstruct the likely gendered scripts that inform science research practices. As a result, problematizing assumptions of who can produce knowledge will have to be pursued in later studies.

Second, this study is limited by the lack of transcribed audio recordings of Ops Group meetings. Early in data collection, after an informal conversation with a “gatekeeper” scientist at NIST, I decided against pushing for permission to record meetings. Doing so would have created too many ripple effects of requiring approval from an assortment of administrators while also potentially alienating scientists who were not yet familiar with me. As a result, data collected during meetings are limited to the field notes I wrote and artifacts I collected while sitting in on those meetings. At times, particularly early in the process of data collection, this practical challenge meant that data was limited by that which I could record and, by extension, that which I could evaluate as important to record. Thus, the lack of transcribed dialogue did create a filter in what became data and, by some measures, this prevents the project from being a micro-discourse study that typifies CCO research (Brummans et al., 2014; Cooren et al., 2013). This risk was mitigated, however, by the recognition early in data collection that building issues were the important focal points of this study: Ops Group meetings were issue-centered. In this respect,
field notes were sufficient to record problematic issues and the arguments made toward resolving them. While early field work did run the risk of failing to grasp the significance of off-hand remarks that foreshadowed eventually important issues, it is safe to say that meaningful issues for the Ops Group were recurrent and thus traceable over time.

While these limitations are important to recognize, particularly insofar as they may limit the scope of my claims regarding gender/class bias, still the links established between texts, practices, and organizing communication do provide important insights into technical and scientific work, which are nevertheless prominent locations where such links are visible.
Conclusion

In many ways, this dissertation study took root by accident. In June of 2008, a scientist in Building 1 on the Boulder campus of NIST mishandled a vial of plutonium, breaking it, and spreading the radioactive powder around the lab and surrounding hallways and offices with impressive haste. To the credit of administrators at NIST, they investigated the circumstances of the accident with all due concern and thoroughness, implementing broad safety reform aimed at improving the integration of cross-divisional expertise regarding the hazards of research materials and equipment. These safety reforms happened to coincide with plans in development to construct a new research building next door to Building 1, which had been already designed to foster such integrative knowledge sharing among scientists and building workers. The possibility of this dissertation project surfaced when key scientists and administrators recognized, at the prospect of moving into the new building, that they were no experts in collaboration.

During my time at NIST, the plutonium spill was still discussed and referenced from time to time among scientists, particularly as it offered a narrative anchor for how their work had evolved in the new PML building. This dissertation study has provided the opportunity to explore the role(s) of knowledge in how scientists managed and practiced their work. Through this study, I have documented the ways that knowledge is interwoven and manifest in the particular dynamic configurations of practices, texts, and conversations through which scientists organized coherent conceptions and performances of themselves, their work, and important for these scientists, their work space.

A subtle but important irony implicated in these findings is the way that Ops Group scientists largely viewed their committee work as a trajectory toward the production of an explanatory building text. Such a compiled text documenting practical building knowledge and
policy was understood to offer an assurance that a recalcitrant building had been stabilized and made to behave predictably. This assurance fostered trust and commitment among resident scientists, who above all merely wanted to get back to their research. The larger lesson, however, was that the scientist at fault in the plutonium spill likely had a similar commitment and confidence in the relative security of his own practical knowledge. Commitment to encoded knowledge has the effect of hiding the communicative contingencies underlying its authoring.

How does one convince a building full of scientists that the parsimonious product of their work is not as reliable as the messy, situated conversations through which it was produced?
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