# Problem-Solving in Complex Settings: Techniques for Crossing Organizational Boundaries

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**EDITORIAL NOTE**

At their core, practitioner-doctorate programs are about developing research that can contribute to solving real-world problems. In this essay, Wolfberg addresses this fundamental challenge by focusing on particularly complex problems that require crossing of organizational boundaries. To address this challenge, he reviews relevant literature and draws on extensive experiences from cross-boundary problem solving within the Defense Intelligence Agency within the U.S. Department of Defense. As a result, he extends Carlile's (2004) theory of boundary crossing with the notion of boundary permeability, suggesting that boundaries with higher permeability are easier to cross while those with lower permeability are harder to cross. This vocabulary allows Wolfberg to add to Carlile's suggested boundary crossing techniques and to demonstrate the value of the extended repertoire using examples from the Defense Intelligence Agency. The paper offers useful techniques and interesting experiences for managers that are engaged in complex problem solving across organizational boundaries. For practitioner-researchers, the paper offers an example to follow when developing essays for EMR of the type *Research Survey*.

Lars Mathiassen

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## ABSTRACT

Solving problems in complex organizations requires managers to successfully navigate organizational boundaries. Yet, crossing boundaries can be an extremely difficult endeavor that requires sophisticated and multifaceted skills and behaviors. In this paper, we introduce boundary permeability to expand on the available boundary crossing techniques identified by Carlile (2004). Acknowledging the messiness in organizational life, we propose a set of techniques requiring that managers consider the multiplicity of boundary conditions and, in many cases, use multiple techniques simultaneously. We describe an innovative, real-world, problem-solving program within the U.S. Department of Defense to demonstrate the practical application of the proposed techniques and to recommend a three-step strategy that managers can use to apply the techniques to various problems.

## INTRODUCTION

Solving problems often involves change. When change is planned, or is thrust upon us, the existing organizational structure usually is not as accommodating as we would like it to be. Organizational structures consist of many entrenched boundaries, especially in large organizations. Each boundary protects specific missions, purposes, functions, and expertise—ostensibly created for the good of the entire organization. Hence, navigating these boundaries to accommodate new outcomes, outputs, or processes is hard even when the reason for change is commendable. One well-known reason for the difficulty is that organizational boundaries are inherently ambiguous (Akkerman & Bakker, 2011; Santos & Eisenhardt, 2005). Another reason is that change often threatens the distinctions that boundaries have created for its organizational members on either side of them. For example, a change in purpose that crosses boundaries can create conflicts because it reveals differences in unit goals (Page, 2007).

As a result, crossing boundaries has become an important leadership competency (Klein, 1996; Lifshitz-Assaf, 2017). In this paper, we offer a strategy for applying a variety of boundary-crossing techniques in complex organizational environments in response to the following research question: *How can managers select and combine boundary-crossing techniques under different boundary conditions?* Building on Carlile's (2004) categorization of organizational boundaries, which comprises three increasingly complex types of knowledge and three corresponding boundary-crossing techniques, we introduce the concept of boundary permeability. Permeability describes the varying degrees of difficulty at the interface between boundaries for each of the three type of knowledge. We argue that when managers take both boundary complexity and boundary permeability into account, they can better diagnose conditions at the interface between boundaries and more effectively implement changes from a suite of boundary-crossing options.

Our argument proceeds as follows. First, we introduce a practice-based problem taken from the author's experience as manager for a problem-solving program within an agency of the U.S. Department of Defense, called "Crossing Boundaries." Second, we discuss what the scholarly literature says about boundaries and boundary crossing. Third, the main part of the paper develops the conceptual foundation for diagnosing boundary conditions and selecting boundary crossing techniques. Fourth, we demonstrate the utility of the conceptual framing based on real-world examples from the Crossing Boundaries program. Fifth, we discuss a key theoretical issue implied by Carlile (2004) that has two practical benefits for managers. We conclude with a strategy that managers can use to apply the framework and thus to successfully cross organizational boundaries during complex problem solving.

## PRACTICE-BASED PROBLEM

In early 2006, a unique and innovative program was created in the federal government called "Crossing Boundaries" (Wolfberg, 2006, 2007). The program name reinforced that its purpose was to instill collaborative behavior and provide support for crossing organizational boundaries during complex problem solving. The program was located in the Defense Intelligence Agency (DIA), a highly complex national security organization within the U.S. Department of Defense.[1]

The program was initiated in 2005, on the basis of observations made by then incoming director of DIA, Lieutenant General (LTG) Michael D. Maples, United States Army. In an agency-wide culture climate survey, employees' responses revealed poor morale, due in part to their experiences with senior leadership. In the survey's narrative section, employees raised the concern that they had little ability or receptivity by leaders to push ideas for improvement up the chain of command. Hence, the purpose of the Crossing Boundaries program was to investigate how to improve poor employee morale while also improving senior leaders' recalcitrance to considering change initiated from below.

To address both aspects of this problem, the program involved employees, managers, and executive leaders. Once a month, employees and managers were invited to attend an assembly, chaired by LTG Maples. Maples sat in the front of the large auditorium and asked those who attended to offer solutions to problems they experienced. Moreover, employees who did so were required to own the solution process, to take an active lead in collaboration, and to shepherd their solution toward acceptance by those identified as responsible for implementation. These assemblies were not complaint sessions in which responsibility for solutions was handed off to senior leaders. As the Crossing Boundaries program developed, DIA allowed for virtual participation through teleconferencing, thus facilitating broad discussions and joint problem solving.

To illustrate, employees who served in temporary field assignments overseas might have unique and diverse experiences in the field, pick up new skills, and want to figure out how to use these learnings after returning to Washington, DC. However, back at headquarters, employees returning from temporary assignments historically had been placed right back in the positions they had served prior to their overseas tour. The approach gave no serious consideration to maximizing the employee's new learnings. This practice was widely known as the reintegration problem. Through the Crossing Boundaries program, returning employees voiced their concerns and suggested a solution, which resulted in increased problem awareness and development of a new reintegration approach.

When Crossing Boundaries ended in October 2009, of the 436 solutions that had been discussed, 214 had been implemented or were on the path toward implementation. Only 7 percent of the solutions were rejected, and the remaining fell into three categories: some were in process, some were merged with other related solutions for greater implementation efficiency, and some were withdrawn by the employee who had proposed the solution, usually because of time constraints that made devoting time to working the solution difficult. Anecdotal evidence collected over the course of Crossing Boundaries indicated that morale and performance outcomes improved and that leaders' recalcitrant views about change generally had shifted as Crossing Boundaries proved beneficial to their employees and the DIA mission.

## CROSSING ORGANIZATIONAL BOUNDARIES

Organizational boundaries arise to represent the interests of organizational members. They support stability by protecting "...the members of the system from extra-systemic influences and [by regulating] the flow of information, material, and people into or out of the system" (Leifer & Delbecq, 1978: 41). As such, boundaries are created to foster specific patterns of behavior by one set of individuals who are different from other sets of individuals (Katz & Kahn, 1966; Schein, 1971). Boundaries can be highly differentiated and multilayered and can create different identities on either side of the boundary (Kreiner, Hollensbe, & Sheep, 2006; Lifshitz-Assaf, 2017). As a result, they imply an inherent paradox that complicates boundary crossing. *Boundaries are created to separate and create stability, yet collaboration and networking require crossing boundaries to create shared spaces (Star, 2010).*

Crossing a boundary to reach a new organizational goal creates instability. Boundary crossing is defined as individual or group behavior in which those on one side of a boundary interact with and affect changes interacting with individuals or groups on the other side of the boundary (Suchman, 1994). "Boundary crossing stimulates the formation of trading zones of interaction, interlanguages, hybrid communities and professional roles, new institutional structures, and new categories of knowledge" (Klein, 1996: 2). Hence, boundary crossing feels like "...encountering difference, entering onto territory in which we are unfamiliar and, to some significant extent therefore, unqualified. For those of us who have spent a lifetime building up our competence within a domain of specialized professional practice, placing ourselves on unknown ground is a difficult thing to do..." (Suchman, 1994: 25). As a result, boundary crossing involves negotiating

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[1]  DIA was established in 1961, based on the recommendation of then Secretary of Defense, Robert S. McNamara, to centralize military intelligence. Since World War II, intelligence had originated from the three separate military departments. The problem was that these three department, at times, provided conflicting estimates to the Secretary of Defense. DIA currently employs more than 16,500 people and provides military-related intelligence to combat and non-combat military missions around the world, as well as to defense and national policymakers in Washington, DC.

differences at the interface between individuals or groups, who often represent two or more domains of knowledge. For example, in the for-profit sector, boundary crossing might occur between personnel in marketing and manufacturing, research and development, and finance, or between the chief executive office and the board of directors; in the non-profit sector, it might occur between donors and program managers; and in the public sector, it might occur between policymakers and domain experts.

In boundary crossing, the complexity of boundaries varies according to the types of knowledge that move between individuals or groups (Carlile, 2004).[2] Carlile (2004) defines the least complex type, *the syntactic boundary*, as one where individuals or groups on either side clearly understand their work-related differences and dependencies (e.g., processes and procedures). The more complex *semantic boundary* is one where individuals know that differences and dependencies exist and must be negotiated to accomplish a shared organizational goal, but they are confused about what these differences and dependencies are and, consequently, experience misinterpretations of what is expected from each other (Carlile, 2004). The most complex, a *pragmatic boundary*, is one where those with political interests or organizational agendas seek control over the processes and procedures that must be negotiated between individuals or groups on either side of the boundary (Carlile, 2004).

For each type of boundary, Carlile (2004) proposes specific boundary-crossing techniques. At syntactic boundaries, sharing of knowledge between individuals on either side of a boundary occurs fairly seamlessly, and managers can use various information systems as knowledge transfer techniques. These techniques might include common lexicons for task-related functions, shared storage design and technological systems, and shared data retrieval protocols. At semantic boundaries, knowledge is ambiguous and subject to different interpretations, so that managers must first translate knowledge, which requires use of a boundary spanner. Boundary spanners are individuals who can operate between two or more organizational groups, navigate the boundaries between them, and negotiate the meaning and usefulness of information to individuals or groups on either side of the boundary (Aldrich & Herker, 1977; Thompson, 1962; Tushman, 1977). At pragmatic boundaries, different interests and agendas collide; here, a zero-sum outcome often results or is desired. One side wants to win at the cost of the other side's losing. With this type of boundary, managers must use techniques to transform knowledge before individuals and groups can begin to focus on the processes and procedures that bind them together or separate them. Such techniques often include boundary objects, which are concrete or abstract communication-related mechanisms; these objects are stable enough to allow individuals with different views to maintain their existing identity and view of the world but are flexible enough to translate singular viewpoints into shared meaning, without disrupting organizational boundaries (Star & Griesemer, 1989). For example, content on a Power Point slide or on a whiteboard might serve as a boundary object; either can be used to achieve a shared understanding of a new idea, concept, or process among individuals or groups on either side of a boundary.

Table 1 summarizes Carlile's (2004) types of boundaries and their associated boundary-crossing techniques.

**Table 1: Carlile's Boundary-Crossing Techniques**

| Boundary Type | Type of Knowledge Moving Between Domains | Level of Boundary Complexity | Problem-Solving Approach | Boundary Crossing Technique |
|---|---|---|---|---|
| Syntactic | Clarity: Individuals on each side of the boundary know the domain specific differences and their dependencies | Least Complex | Knowledge Transfer | Information System |
| Semantic | Ambiguity: Individuals on each side of the boundary do not fully understand the domain specific differences and their dependencies | Complex | Knowledge Translation | Boundary Spanner |
| Pragmatic | Political interests and agendas: These surface as motivators for behaviors and challenges to achieving shared knowledge across boundaries | Most Complex | Knowledge Transformation | Boundary Object |

This table is adapted from Carlile (2004).

[2] Carlile (2004) characterizes complexity in two ways: as the variety of knowledge, and as the quantity of effort. In this paper, complexity pertains to the varieties of knowledge. I explain why the quantity of effort definition is not used in the Discussion section.

## BOUNDARY PERMEABILITY

Crossing boundaries involves understanding the types of knowledge exchanged between individuals or groups, as well as variances within each type of knowledge. For example, a semantic boundary can involve knowledge exchange in which the degree of ambiguity ranges between great and small. For a pragmatic boundary, knowledge exchange might involve variations in the intensity of political agendas, and these variations might create great hardships, easily allow working together, or make working together a nuisance. We capture this variance as the boundary permeability. Katz and Kahn (1966) establish boundary permeability as variable across a spectrum: at one extreme, it is sharply and rigidly defined, preventing or inhibiting boundary crossing; at the other extreme of permeability, the boundary is open to all. Permeability also can lie somewhere in between these extremes. Lifshitz-Assaf (2017) provides empirical support for the existence of simultaneous boundary permeabilities within a single organizational context, from fully permeable to almost impermeable. Accordingly, the boundary types are defined by their complexity, and they also come with varying degrees of permeability (Boland & Tenkasi, 1995; Carlile, 2004; Klein, 1996; Lifshitz-Assaf, 2017). Boundary permeability ranges from high to low and boundaries with higher permeability are easier to cross, while boundaries with lower permeability are harder to cross (Hernes, 2004; Kreiner et al., 2006; Lifshitz-Assaf, 2017).

Because the permeability of each boundary type can vary, the techniques appropriate for boundary crossing vary as well. For syntactic boundaries, the ideal situation is full clarity shared by all involved, which affords unimpeded knowledge transfer. This situation exemplifies high permeability. However, a new context, situation, or event might create difficulties in maintaining full clarity within or across shared information systems, resulting in low permeability. If clarity is not significantly disrupted, the individuals and groups can use their experiences as they share an in-formation system to modify the system, to alter the data embedded in the system, or to reconfigure how the data are used to support relevant tasks (McGrath & Argote, 2001). Through such efforts, boundary crossers can create a new syntactic boundary situation with high permeability. Depending on the types of difficulties encountered across a syntactic boundary, modifications can be made to recalibrate information system standards, including standards related to data, data processing, material and equipment that supports data and data processing, and connectivity between the people for whom the information system is used (Mathiassen & Sorensen, 2007).

For semantic boundaries, boundary spanners might effectively translate knowledge between individuals and groups. Permeability in this case is high. However, when ambiguity is severe, boundary spanners might face challenges in translating knowledge between the individuals and groups (Carlile, 2004). In this case, a new boundary might have to be created to establish a different purpose and identity. The individuals who forge this kind of boundary organizing are boundary architects (Kodama, 2018). Boundary architects transform the boundary landscape by intervening with, disrupting, or bypassing existing boundaries, thus creating new boundary conditions. The newly modified boundary has to grow and change organically if the new connection is to be sustained (Kodama, 2018). Such connections require the creation of a shared space that invites individuals and groups on either side of the modified boundary to interact (Guston, 1999; Star, 2010). This situation has low boundary permeability.

If an organizational boundary is a wall with existing doors or windows, the boundary spanner is the existing door or window, translating between those on either side of the wall, as long as permeability is high. But when permeability is low, a boundary architect has to construct new or modified boundaries so that near doors or windows provide pathways for sharing knowledge to meet organizational goals (Boland, Lyytinen, & Yoo, 2007).

For pragmatic boundaries, permeability is high when individuals and groups on either side have found common ground, despite politics and agendas (Thompson & Fine, 1999). However, permeability is low when conflicting interests obscure or destroy common ground. In such instances, boundary objects might have little effect because individual or group interests on one side of a boundary might be in stark opposition to interests on the other side, leaving little flexibility for transformation. In such a situation, managers can try to implement boundary practices (Bechky, 2003; Carlile, 2004), such as organizing regular activities, procedures, or processes that bring individuals together, even if they haven't found common ground or don't have a shared identity in place (Kellogg, Orlikowski, & Yates, 2006).

Figure 1 summarizes the techniques individuals and groups can use for boundary crossing, taking into account both boundary complexity and boundary permeability. Adding boundary permeability as a key condition doubles the number of boundary-crossing techniques, compared to Table 1. While organizational boundaries vary according to complexity—between syntactic, semantic and pragmatic boundaries—they also vary in boundary permeability—ranging from easier to harder in how difficult they are to cross. Additionally, managers may have to use multiple techniques simultaneously because boundaries may exhibit multiple complexity and permeability characteristics simultaneously (Lifshitz-Assaf, 2017).

## PRACTICAL APPLICATION

We use examples from the DIA Crossing Boundaries program to illustrate how boundary-crossing techniques apply to real-world contexts (by cells in Figure 1).

### Least Complex & Easier to Cross Boundary (Cell 1)

*Technique: Existing Common Lexicon*. Boundary spaces with the greatest ease of crossing were universally experienced, even though the workforce included people with highly differentiated expertise: analysts, collectors, technologists, logisticians, accountants, trainers, purchasers, and more. Universal problems included technology-related issues associated with desktop computers and software, human resources policies, and facilities-related concerns. (Having enough parking spaces was a common problem.) Everyone had a vested interest and was equally affected and therefore shared a common lexicon across these problems, conducive to a well-functioning information system.

### Least Complex & Harder to Cross Boundary (Cell 2)

*Technique: Novel Lexicon*. DIA has a long history of sending its personnel overseas in or near combat areas to support U.S. and coalition military forces. These short-term deployments increased dramatically after the 9/11 terrorist attacks. Civilians with many new kinds of expertise were deployed, including analysts and collectors, as well as procurement specialists, human resource professionals, administration officers, facility managers, and logisticians. Most of the civilian employees, especially the new analysts and collectors, had no experience working in a war zone, and they were not trained for it like their military colleagues were. As a result, several returned with physiological and psychological stress, and some found the Crossing Boundaries program to be a venue where they could begin talking with each other across organizational boundaries. These conversations resulted in a new common lexicon—a recalibration—and in the creation of a repatriation center to evaluate the mental and physical health of returning personnel.

### Complex & Easier to Cross Boundary (Cell 3)

*Technique: Boundary Spanners*. Crossing Boundaries had a dedicated coaching staff to track the progress of the proposed solutions. These coaches were boundary spanners who helped to create shared meaning across boundaries. When employees presented a solution, they were immediately paired with a coach. The coaches served as boundary spanners between employees who were the "solution submitters" and managers who were the "solution implementers." Thus, the coach helped the proposers who brought the problem and solution to the forum to acquire or develop the skills they needed to bring a business case forward to a process owner, who would implement the solution if it was acceptable. The most critical role for the coaches was to help employees to articulate, translate, and frame their solution in a way that could be absorbed by others in the organization who would be targeted for the implementation.

In Crossing Boundaries, the director of DIA also served as a boundary spanner when an employee recommended a solution to a problem. The director would recast the problem and the solution in real time and verbalize them back to the employee, with additional information about other places in the organization where the problem existed, where the solution was in progress, or where a related solution was under consideration. The director had the bigger picture and could communicate it to employees who often understood the problem and their proposed solution only from their particular context. Rather than changing the problem and solution, the director translated what one part of the organization knew to someone in another part, thereby increasing awareness of related problems and solutions and what was being done in unrelated parts of the organization.

**Figure 1: Techniques for Boundary Crossing**

| | Least Complex Boundary (Clarity in Knowledge Differences and Dependencies) | Complex Boundary (Ambiguity in Knowledge Differences and Dependencies) | Most Complex Boundary (Political Interests and Agendas Overlay Knowledge Differences and Dependencies) |
|---|---|---|---|
| **Easier to Cross Boundary** (High Permeability) | **Information Systems** *Cell 1* | **Boundary Spanners** *Cell 3* | **Boundary Objects** *Cell 5* |
| **Harder to Cross Boundary** (Low Permeability) | **Recalibrate Standards** *Cell 2* | **Boundary Architects** *Cell 4* | **Boundary Practices** *Cell 6* |

Multiple levels of complexity and permeability may apply in a situation, requiring use of a combination of techniques.

Parts of this figure are adapted from Carlile (2004).

### Complex & Harder to Cross Boundary (Cell 4)

*Technique: Boundary Architects*. The director of DIA was a committed sponsor of Crossing Boundaries and created a new path for communication that bypassed the normally observed chain-of-command. Acting as a boundary architect, the director constructed a way to connect employees with the leader of the organization. DIA, like other military organizations, adhered strictly to communicating through each level of the chain-of-command, whether going up the chain or down. However, through direct conversation with a solution submitter, the director gave employees permission to take the initiative and navigate across and through boundaries, bypassing the chain-of-command. For employees and managers alike, the new architecture of communication initially created confusion because it contradicted established norms: outside of Crossing Boundaries, the chain of command existed and was strictly observed, but inside it did not exist at all. The director resolved this confusion by allowing both behaviors to co-exist.

### Complex Boundary (Cells 3 and 4)

*Multiple Techniques: Boundary Spanners and Boundary Architects*. Boundary architects reinterpret the boundary landscape, whereas boundary spanners translate knowledge across existing boundaries. Crossing Boundaries involved both techniques. As more employees got involved in Crossing Boundaries, they created a new group identity that attracted the interest of other employees who were not yet involved. This group identity included a shared belief that "we can make change happen." This belief was new, in that the established norm was that "it's management's job to fix the problem." The director supported and encouraged the adoption of this new identity through his encounters with employees outside of the Crossing Boundaries venue when he visited work spaces. During these visits, the director would often ask employees—in front of their managers—what challenges they experienced in doing their job. When employees raised entrenched, unsolved problems with the director, he responded at times by asking them to bring their solutions to Crossing Boundaries. The director simultaneously played the role of a boundary spanner and a boundary architect during these visits. He was a boundary spanner because he translated a solution approach in terms that both employees and managers could understand; employees did not have to wait for management to fix entrenched problems, while managers did not feel burdened that solving an entrenched problem was necessarily their responsibility or threatened by the transfer of power to resolve problems to employees down the chain of command. He was a boundary architect because he transformed the way the organization moved solutions forward. Instead of dealing with an entrenched problem and its solution as occurring in the relationship between employee and manager, which had been the established norm, the director constructed a new pathway using Crossing Boundaries, which opened up the solution space and expanded the problem-solving strategies to include relationships throughout the organization and beyond.

### Most Complex & Easier to Cross Boundary (Cell 5)

*Technique: Boundary Objects*. DIA as an organization has highly differentiated functions, so that how employees saw a problem typically was shaped by missions and interests. As a result, creating shared interests was challenging. The Crossing Boundaries venue served as a boundary object and a means to create shared interests. When employees attended a monthly Crossing Boundaries meeting and raised their hand to present an idea, the director invited the audience members to share their perspectives on the organizational problem and solution under consideration. Others then spoke from their unique organizational perspective about how they saw the problem and solution. The director thus modeled a translation behavior that sought and valued the development of shared interests. This broader vision benefited the speakers who raised the original problem and solution because their perception and perspective often were limited to their own location in the organization, with its missions and interests. Other meeting participants, from different organizational functions, also benefited by expanding their vision, recognizing different interests, and also by learning to establish and develop a shared interest.

### Most Complex & Harder to Cross Boundary (Cell 6)

*Technique: Boundary Practices*. Because the Crossing Boundaries program was brand new, when it began, each participant submitting a new idea had to create a tailored process to move a proposed solution toward implementation. While some solutions were quickly implemented (e.g., in just a few weeks), others took up to a full year. To overcome the challenge of long-term implementations, a Crossing Boundaries Council was created in 2007 to facilitate communication about the expected involvement and progress of solutions. The Council comprised representatives from the DIA's primary lines of business. Through the Council, representatives could quickly promulgate information about proposed new solutions vertically, within their line organization, both upward and downward through established channels. They could also disseminate information horizontally, through the other Council representatives and through informal networks to other line organizations. After the Crossing Boundaries Council was formed, it improved the speed of information exchange, and implementation times were dramatically reduced. However, the functioning of the Council neither assumed nor required that every employee or manager receiving information about solutions have a shared identity or find common ground.

### Most Complex Boundary (Cells 5 and 6)

*Multiple Techniques: Boundary Objects and Boundary Practices*. Employee participation in Crossing Boundaries involved time and effort beyond the monthly Crossing Boundaries meeting. During these inter-

vening periods, solution submitters and their coach created a business case. This boundary practice became necessary because the established norm of top-down, chain-of-command communication meant that requirements for solving a problem often came from managers higher in the chain. However, when they didn't—for example, if requirements were set or recommended by someone lower in the chain of command or someone laterally—solution planners and implementers often paid less attention to them. To overcome this challenge, generating a business case became the accepted practice for exploring a new requirement. The formal organization recognized the value of business cases as a standard practice, but they had not yet been used in Crossing Boundaries. The business case was a boundary practice because its development was used to create an acceptable pathway for communicating a new idea between the solution submitter, coaches, and the solution implementers without having them to buy into the process and motivation of Crossing Boundaries. The business case itself was also a boundary object, used to communicate the logic and conclusion through a verbal briefing, visual materials (e.g., Powerpoint slides), and written documentation to establish common ground for understanding the meaning and implication of the business case.

## DISCUSSION

Carlile (2004) characterized boundary complexity in two distinct ways. First, boundary complexity is a function of knowledge types: "Creating a complex product or service often requires differences in the amount and type of knowledge. This in turn creates differences in levels of experience, terminologies, tools, and incentives that are unique to each specialized domain" (Carlile, 2004: 556). Second, boundary complexity is a function of the level of effort needed to cross the boundary. In this case, a boundary is imagined "as a vector between at least two actors. It starts at the origin where the differences and dependencies are known; as novelty increases, the vector spreads, scaling the increasing complexity and the amount of effort required to manage the boundary" (Carlile, 2004: 557).

For our purposes, we emphasized the first definition for two reasons. First, the second definition involves an implied assumption that boundary crossing techniques focuses on quantity over quality in the crossing effort; thus, it implies no variation in available strategies for boundary crossing. As a result, introducing boundary permeability and different boundary crossing techniques would have been difficult under such an assumption. Second, the second definition also implies that the boundary complexity remains static, without being affected by boundary crossing efforts. In the case of the Crossing Boundaries initiative, boundary crossing techniques can, over time, affect the boundary complexity and the required effort. This possibility would not have been conceivable using the second definition.

Defining boundary complexity in terms of knowledge variety has two practical benefits for managers. First, when boundary crossing techniques are first used in any situation that involves difficult boundary crossing, then, the managers implementing the techniques likely face new situations. At the leading edge of a learning curve, they will learn from their experience over time (Argote & Miron-Spektor, 2011).

As they acquire various skills and learn a variety of boundary crossing techniques, they can gain expertise that quickens their decision-making in boundary crossing situations. With familiarity and expertise comes a larger knowledge base, more sophisticated pattern recognition capabilities, better situation assessment and problem representation, specialized memory skills, and an ability to be highly sensitive to cues in the environment in a variety of contexts (Rosen, Salas, Lyons, & Fiore, 2008). The development of expertise makes situations that were once difficult easier to resolve. Weick's (1993) case study of the Mann Gulch disaster is an example: The most experienced fire fighter was able to assess a very chaotic and complex situation and survive; those who lacked experience and during the chaos of the fire became separated from him unfortunately perished. Learning boundary crossing techniques in conditions characterized by low boundary permeability (i.e., boundaries are harder to cross) suggests that the development of expertise may change the boundary crossing techniques to ones more appropriate for conditions characterized by high boundary permeability (i.e., boundaries that are easier to cross).

Second, managers who develop expertise in using boundary crossing techniques can change the type of boundary complexity. Actors, organizations, and processes can change – and change each other – over time (Van de Ven & Poole, 2005). Similarly, external factors can affect the direction of causality between actors, organizations, and processes (Rousseau, Manning, & Denyer, 2008). Hence, just as boundary conditions can determine the choice of boundary crossing techniques, so can boundary crossing techniques determine the boundary condition. For example, managers might want to change a complex boundary so that it becomes less complex. In this case, boundary spanners might become more effective at translating knowledge so that their clarity improves; as a result, the boundary condition might become less complex. After boundary spanners achieve greater clari-

ty, translating information might become superfluous because information systems could learn to transfer information across boundaries.

This evolution occurred in the Crossing Boundaries program, when boundary techniques changed the boundary type. The director of DIA served as a boundary spanner when employees proposed a solution to a problem. As already noted, the director recast the problem and the solution in real time and verbalized them back to the employee, providing additional information about other places in the organization where the problem existed, where a solution was in progress, or where a related solution was being considered. In this way, the director translated what one part of the organization knew to another part, thereby increasing awareness of problems and solutions across the organization. Over time, this boundary spanning behavior became an established norm and was adopted by the Crossing Boundaries coaches and by employees who participated in the program. After some time, a larger number of employees understood the Crossing Boundaries processes, as well as their interdependencies and relationships with already established procedures for solving problems. An online spreadsheet was made available for all DIA employees to access and to share perspectives and knowledge about specific Crossing Boundaries problems and solutions. Knowledge translation changed to knowledge transfer– a sign that boundary complexity shifted from complex to less complex.

Managers, whether in the public, for-profit, or non-profit sector, can implement the boundary crossing techniques framework proposed here (Figure 1) using a three-step strategy: Step 1, understand the boundary conditions; Step 2, select the problem-solving approach; and, Step 3, apply the appropriate boundary-crossing techniques. Because multiple boundary conditions can exist at the same time, managers must use this strategy dynamically and develop a competency for orchestrating multiple boundary crossing techniques simultaneously.

### Step 1: Understand the Boundary Conditions

Step 1 involves two tasks. The first task is to determine the boundary complexity based on the three varieties: the degree of clarity in knowledge differences and dependencies (Figure 1, left column); the ambiguity in knowledge differences and dependencies (Figure 1, middle column); or the political interests and agendas involved in the work interaction (Figure 1, right column). This level of complexity increases from one to the next, with syntactic being least complex, semantic being more complex, and pragmatic being most complex. The second task is to evaluate the boundary permeability: Is the boundary harder to cross (less permeable) or easier to cross (more permeable). For example, in Figure 1, left column, is the condition best described by Cell 1 or Cell 2? Are the conditions so severe that sharing knowledge across boundaries is harder, or are the conditions manageable enough that sharing knowledge is easier? Interviews or surveys could be used to gather data for both tasks.

### Step 2: Select the Problem-Solving Approach

This step involves determining where to focus resources and energies, establish priorities, and identify processes needed to achieve outcomes. Carlile's (2004) types of approaches are knowledge transfer, knowledge translation, and knowledge

transformation. These approaches can occur simultaneously, or they might overlap, because they can support different goals and different levels of complexity across related or the same boundaries. For example, assuming the least complex boundary, a replication of process, procedure, or technique requires knowledge transfer. However, this replication assumes a boundary where everyone on both sides understands any knowledge differences or dependencies. If there is any variability, a lack of shared meaning between units involved in a replication would thwart success, and knowledge translation might first be necessary to reduce confusion about the existing differences and dependencies. Knowledge translation would seek to resolve any interpretation problems. In the most complex boundary condition, different units might have divergent interests or strong political agendas, so that knowledge transformation would be needed to overcome or reduce conflicting interests or agendas.

### Step 3: Apply Boundary-Crossing Techniques

In this step, managers select the appropriate boundary-crossing techniques. Gaining access to the right techniques assumes managers have the necessary resources. If not, they might have to acquire or develop what they need. However, as Carlile (2004) warns, if specific problem-solving techniques are needed but the right ones are not used, then managers intentionally or inadvertently might defeat their chances for successful outcomes. For example, if the boundary condition is most complex and warrants the use of boundary objects (Figure 1, Cell 5) but a manager tries to use a boundary spanner (Figure 1, Cell 3) appropriate for a complex boundary instead (e.g., because of a lack of experienced personnel), the manager is using the wrong tool for the job.

### Senior Leadership Support

In the Crossing Boundaries program, the director of DIA provided much needed senior leadership buy-in, which supported the various applications of boundary

crossing techniques. However, what if senior leadership buy-in was non-existent, limited, or, inconsistent?

*If buy-in is non-existent.* In this case, managers should begin selecting techniques for boundary conditions within their own sphere of influence. They are more likely to achieve success in this sphere because they have freedom of action that is less likely to depend on senior management support.

*If buy-in is limited.* Managers should match the results of Steps 1 and 2 of the strategy with the techniques that fall in the sphere of the most senior leader's degree of buy-in. If a senior leader only supports a particular outcome, the manager should focus the boundary crossing techniques on achieving that outcome. In the case of Crossing Boundaries, one of the main desired outcomes by the director of DIA was to improve employee morale. The strategies for selecting boundary crossing techniques were all shaped to achieve this outcome.

*If buy-in is inconsistent.* In this case, managers should first assess why senior leaders' buy-in is inconsistent. Such assessments can be very challenging. The goal is to identify the problems (and the relevant techniques) for which senior leaders' buy-in is least likely to be inconsistent. Beginning with small solutions and limiting any perceptions of disruption can provide opportunities to build on success and to assess whether and where consistency of buy-in begins to improve.

## CONCLUSION

This paper gives managers a broad spectrum of boundary-crossing techniques for solving difficult organizational problems. This expanded set of boundary crossing techniques was derived by considering the interactions between the theory of boundary complexity (Carlile, 2004), and the theory of boundary permeability (Katz & Kahn, 1966). In the most complex boundary conditions, individuals have their interests or political agendas to protect, making shared understanding and mutually agreed-on goal attainment difficult. Under these conditions, when boundary permeability is high (Figure 1, Cell 5), so that boundaries are easier to cross, managers can use boundary objects to transform knowledge in the search for common ground. When permeability is low (Figure 1, Cell 6), so that boundaries are harder to cross, boundary practices are more likely to achieve objectives without the need to establish common ground. In complex boundary conditions, individuals experience ambiguity because their expertise, processes, and techniques differ, and yet they depend on each other. Under these conditions, when boundary permeability is high (Figure 1, Cell 3), managers can use boundary spanners to translate knowledge and reach a common understanding for sharing knowledge. When permeability is low (Figure 1, Cell 4), boundary architects can effectively create new boundaries and new meanings. In the least complex boundary crossing conditions, individuals have a clear understanding of how different they are and what types of shared knowledge are needed. When boundary permeability is high (Figure 1, Cell 1), managers can use information systems to transfer, store, and retrieve shared data across boundaries. When permeability is low (Figure 1, Cell 2), the recalibration of requirements for information systems can be used to realign transfer needs.

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