"You meant *what*?!"

Socially constructing meaning with ongoing interactions

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Abstract

Begun as a consulting project to resolve "disconnects" within large aerospace programs, this research effort asserts that we can gain new perspectives on innovative knowledge-work through simulations that represent the causal relations suggested by George Mead's foundational theory of how we create shared meaning. In Mead's interactionism we find principles and assumptions that underlie comprehensive social theories of structuration and practice as well as many studies on knowledge work, cognition, sense-making, and decision-making. In earlier work, we produced a formal theory represented in a simulation model of what exacerbates and reduces "disconnects" among four organizations interdependent in their innovative work. Here we describe how we collected and analyzed qualitative data in which the model was grounded; identified constructs in the data and literature relevant to the presenting problem; and proceeded with model-building and analysis, particularly detailing how we "traversed" from rich, qualitative empirical data to themes and higher-level abstractions useful as constructs in a theoretically informed simulation model. We now carry theory-building a step further by revisiting sociological theories of meaning-creation and knowledge-construction to probe how they inform and re-form our understanding and provide new insights about managing knowledge-work.

Keywords: Social construction; theory-building; interactionism; iteration; knowledge; innovation.

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Prologue

This research began as a consulting project in which the primary objective was to demonstrate that system dynamics can be a useful tool for understanding the complex behavior of large aerospace programs to develop new capabilities. At the start of the consulting engagement it was necessary to gain a specific problem statement from which to direct and frame the work to be done. As it turned out, this first question was not a simple one. Gaining authorization to work with a specific program took significant time and effort, since these very large, very long-term programs operate in a "scorched earth" environment resulting from a constant stream of consultants engaged to try to solve many ongoing issues with little perceived success. We were engaged by members of the System Program Office (SPO), which carries responsibility for ensuring that the prime contractor delivers the specified deliverables on time and on budget. The client hoped that system dynamics approaches to analysis could provide new insights into reducing the increasingly common large gaps in achieving program specifications, within-budget, and within-schedule.

Given the understandable cynicism toward problem solving efforts within these large programs, and given the general environment of over-commitment of SPO members, program executives were reluctant to allow new consultants access to the SPO staff. In spite of this operating environment, we were able to gain access to a significant program's SPO personnel and began a series of meetings to define and gain agreement on the presenting problem for our proof-of-concept effort. Two lieutenant colonels, who worked with each other on a regular basis, and were often the target of blame for many problems throughout the program, struggled with each other trying to define the most critical problem we should address. Ultimately, they agreed that the problem of "disconnects" within the program was the problem to address. The colonels stated this as: "How does system engineering identify a 'disconnect,' and what do we do when we find one?" An elaborated definition of a disconnect is a latent difference in understanding of the work to be done among program participants, at the team, group, or organizational level, that when recognized can cause significant rework, schedule slips, reputation damage, and cost overruns. The presenting problem of disconnects within large aerospace programs to develop innovative capabilities frames the empirical setting for the discussion that follows.

Introduction

In the aerospace program serving as the empirical context for this research, the focus was primarily on, not "make-to-order" demands, but rather "research-to-order" and "engineer-to-order" work. This meant that the organizations involved had to integrate knowledge from multiple disciplines, often crossing organizational, geographic, and even societal sector boundaries, in order to accomplish large-scale implementation of innovative technologies.

Therefore the empirical and modeling research led us to engage more deeply literature on knowledge, knowing, and doing novel knowledge-work across boundaries.

In this paper we claim that we can gain new perspectives on interactionism through simulations that represent the causal relations suggested by Mead's (1934a, 1934b) foundational assertions on how we create shared meaning. Because interactionism underlies theories of practice (Bourdieu 1977, 1990; Giddens 1984) and theories of knowledge (Polanyi 1966; Nonaka 1994, 1995; Brown and Duguid 2001; Brown and Duguid 2002, Carlile 2004), this effort can enrich our understanding and use of these theories as well. To enrich and complement theories grounded in and generated from qualitative data collection and analyses, Strauss and Corbin (1990) advocated for developing formal (or general) theories from previously domain-specific or "substantive" analyses. To that end, we produced the formal theory represented in the simulation model of what exacerbates and reduces "disconnects" among four organizations interdependent in their innovative work (Greer Black Adams 2006) from extensive qualitative analyses of data from multiple interviews (described further below). We now carry theory-building a step further by revisiting rich textual sociological theories of meaning-creation and knowledge-construction to probe how they might inform and re-form our formal theory of "disconnects" in shared understanding represented in the model.

Social theories about meaning, knowing, and knowledge

In Mead's interactionism we find principles and assumptions that underlie comprehensive social theories such as structuration (Giddens 1984) and praxis or practice (Bourdieu 1977, 1990), now considered pivotal in organization theory. We believe that these assumptions also form the foundation of many topical research efforts during the last 40 years focusing on knowledge work, cognition, and sense-making and decision-making. Below we summarize key premises of interactionism and then briefly discuss how they inform these other areas, all of which entered into our research efforts to understand the sources of "disconnects." While we necessarily provide a cursory treatment of these rich theories, we identify critical linkages among them in order to bring them into play as we re-examine the dynamics of organizational interactions in innovative work.

Interactionism and meaning

Sociologist Anselm Strauss has articulated critical assumptions underlying interactionism, a branch of social theory in which theories of structuration and practice, and methods of ethnography and symbolic interactionism, have their intellectual roots. Interactionism derives from the school of American pragmatism particularly through the lectures of George Mead and his students' efforts to compile his unpublished thoughts (1934a, 1934b), and the work of Herbert Blumer (1969), who distilled how Mead's assertions could inform sociological methods for empirical research.

Blumer (1969) stated that Mead's theory of interactionism was based on three premises:

- A person acts toward/with/on a thing based on the meaning s/he ascribes to the thing.

- People gain the meanings they ascribe to things from their interactions with others with regard to the thing. Meanings are, therefore, "social products" (Blumer1969: 5).
- A person gains and modifies meanings through a process of interpretation that includes, first, an indication or focus on the thing, and, second, a process of communication with oneself based on an internalized social process. "Interpretation becomes a matter of handling meanings" as a person "selects, checks, suspends, regroups, and transforms the meanings in the light of the situation" in which s/he stands and the goal of his/her action (Blumer 1969: 5).

Strauss, whose research often focused on trajectories of work that crossed boundaries of occupation, experience, duration, or discipline summarized assumptions underlying years of sociological research using the principles of interactionism in these ways (1993):

- Actions are embedded in interactions—and so carry meanings.
- Interactions generate new meanings as well as maintain old ones.
- Actors' interpretations of a situation's temporal character may differ according to perspectives.
- Contingencies arising during a course of action may affect its duration, pace, or intent.
- Interaction implies an intersection of actions, implying differences among actors' perspectives.
- Many participants in interaction necessitate alignment or "articulation" of respective actions.
- Memberships in social worlds and sub-worlds condition actors' perspectives (and interactions).
- Interacting (accumulating) social processes create, maintain, and reinvent social structures.

According to interactionism, meaning is situated—always. It is informed by an accumulation of experiences, according to Mead (1934a), shaped by the meanings gained through previous interactions with others. We also note that there is no assumption of goodness in interactions or of progress or "forward" movement in the theory of interactionism. One may interact with very detrimental results on oneself or others, and one may reverse oneself and negate or undermine previous actions.

Interactionism and theories of practice and structuration

Structuration theory, prominently articulated by Giddens (1984), distinguishes between agency and structure, or individuals' actions and enduring social patterns, and describes the interplay between these over time. Structuration asserts that social interactions among individuals can be repeated over time to establish and maintain institutions, which in turn enable and constrain individuals' actions. While individual actions can certainly transform institutions, more frequently individuals act within the opportunities and constraints that existing institutions provide (consider, for example, enduring social structures such as governments, educational systems from preschool through university, and longstanding racial, ethnic, and national customs and the ways that we adapt ourselves to these) and so perpetuate the institutions and their "meaning" in society.

We can see roots of structuration's emphasis on social processes in the premises of interactionism. We perceive institutions and their significance from our interactions with others in regard to those institutions. We internalize those interactions and so communicate with ourselves as we engage in activities that lead us to new experiences in which we interpret institutions' influence on us first as we indicate them to ourselves and then as we interpret the meanings they hold for us and for others. Depending on our situation, we may present ourselves (to ourselves and to others) as conforming to, complying with, chafing against, or outright rebelling against, these institutions. One of structuration's primary contributions to social theorizing is its clear identification of the *role of repetition and duration of certain interactions*, which give some social processes more structural influence on subsequent interactions than others.

Closely linked to structuration is practice theory, prominently articulated by Bourdieu (1977, 1990; Bourdieu and Wacquant 1992). Practice theory distinguishes between capital and habitus, or accumulated resources and the predisposition to act using those resources, and how these influence one another over time. Practice theory asserts that individuals choose to engage in specific practices, through which they gain and demonstrate competence, and which in turn predisposes them to act in ways consistent with the practices to which they have subscribed. While structuration theory may speak of the institutionalization of medical education and the structure of doctors holding hierarchical authority over other medically trained personnel, practice theory speaks of the "practice" of becoming a doctor, which includes obtaining formal medical education and obtaining organizationally sanctioned positions in hospitals but also includes many interactions with individuals in which one learns how to "behave" and "speak" like a doctor, or how to respond to people who do not recognize one as a doctor.

Clearly present in Bourdieu's theory of practice is the notion that we accumulate "capital," sometimes interpreted as competence, knowledge, or credibility in a practice as we engage it. One accumulates the capital of a practice primarily through interacting with people who already subscribed to that practice. Here we recognize the premise that people attribute meaning to a thing only through their interactions with other people with regard to that thing. Part of becoming competent in a certain practice, whether chef or teacher or parent, is internalizing experienced social processes of interpreting things in certain ways, to the point that these interpretations are automatic and one can speak as an "expert" without recognizing one's own interpretive processes. One of practice theory's most significant contributions is elucidating that our *experiences accumulate* in ways that then influence our predispositions to act, and our actions in turn influence our experiences.

We note that, according to Strauss (and practice theorist Bourdieu (1990; Bourdieu and Wacquant 1992), "memberships" to different social worlds may be complex, overlapping, and even contrasting or conflicting, and not always visible to others with whom one is interacting. When people of different practices, or expertise, interact, they often must slow down to "articulate" their work (Strauss 1991), in order to gain alignment for joint action (Blumer 1969). We also note that interacting social processes can change oneself, as well as social relations, in surprising ways. One may surprise oneself, as the "I" is not completely predictable, and we may find ourselves unexpectedly exhibiting the convictions of one practice when we intend to draw

on the capital of another practice. For example, a teacher, in the midst of instruction, may be moved to tears by an interaction with a student and respond not as an instructor but instead as fellow-parent or other commiserating role. The different practices and social worlds in which we exercise competence may manifest themselves in surprising ways particularly in stressful or high-stakes interactions.

As with structuration theory, we see recursion in social processes of practice theory. Individuals are influenced through interactions, which they internalize, and as they accumulate experiences in a given practice, they draw on them to gain more capital in that practice and, with repeated interactions, to influence the practice itself. As certain practices endure, they come to be perceived as institutions, as if imbued with life of their own. But institutions are ultimately "social products," to recall Blumer's (1969) term, generated by a society's accumulation of meanings, created through individuals' interactions.

Stacey (2001) points out that one of the valuable attributes of Mead's theory of interactionism is its scalability. The same principles of interactions apply to multiple levels of social processes—interactions between you and me, communications between the "I" and the "me" internal to an individual, and exchanges among groups, organizations, and institutions. It affords explanation of why autonomous, reflexive selves may choose to make "objects" of some sensory experiences while ignoring others and accommodates social influences without surrendering individual volition and interpretive choicefulness to social determinism. Most scientists agree that a theory that can explain more phenomena with fewer qualifications is stronger or better than a theory which requires more qualifications to explain more phenomena. Psychologists, sociologists, and organization researchers who have sifted proliferations of different theories for individuals' internal processes, individual one-on-one interactions, group processes, institutional processes, and more recently "meso-level" theories seeking to bridge "micro" and "macro" understandings, may especially appreciate the parsimony and power of revisiting Mead's interactionism.

Knowledge and cross-boundary knowledge-work

Some of the most compelling theoretical and empirical work on organizations has proceeded on the premise of the social construction of knowledge. Berger and Luckmann's 1967 treatise brought to light social interactions that influence how we perceive "knowledge" and how we internalize that we "know" a thing, a person, or an abstraction. Berger and Luckmann state that their notion of knowing is "greatly influenced by the work of George Herbert Mead and some developments of his work by the so-called symbolic-interactionist school of American sociology" (1967, p. 17). Many other scholars have taken as given assertions made by Mead, that interactions are between selves, that autonomous and reflexive selves choose to focus on and make "objects" of some sensory experiences and ignore others, and that meaning is always situated. Briefly, influential examples of these scholars include Goffman (1959) and Garfinkel (1967), who studied individuals' efforts to interact in "reasonable" ways and do "reasonable" things, given changing situations, and to bring their accumulated experiences to bear in their self-presentation to others; Latour and Woolgar (1986), who chronicled in meticulous detail the role of iterative efforts to represent experimental findings in socially constructing among scientists what they might agree is a scientific "fact"; and Weick (1979), whose theory of sensemaking

underscored the necessity of retrospective conversations in creating shared understanding of "something happened" and "why it happened" in organizational life.

While many kinds of knowing are explicit and codified, others are embedded in our physical beings and in the tools we use to exercise what we know in mundane ways. Whether called tacit (Polanyi, 1966) or embodied (Nonaka, 1994), knowledge includes a component of understanding that is demonstrable only in the context of using it. Here we see again the interactionism premise that meaning is always situated. Therefore the exercise of knowledge is difficult to separate from its content and even from the specific situation in which the content is viewed as relevant. Accordingly, many researchers have asserted that situated practices and social interactions prove a valid object of study not only because they reveal the social order in which those activities have meaning, but also because through social interactions people come to agree on what is "knowable" and "known" (Garfinkel 1967; Weick 1979; Nonaka and Takeuchi1995; Nonaka 1994; Brown and Duguid 2001, 2002).

Some scholars studying knowledge-work emphasize the importance of representations. How people perceive their work and the activities of others is shaped by the physical and non-physical ways they represent—literally, re-present—their understandings. Lave's (1988) research on cognition led her to conclude that cognition (or understanding or knowledge) is not "all in our heads" but distributed across our minds and bodies and the activities in which we exercise our knowledge, as well as the locations in which we customarily exercise our competence. Her ethnographic studies on how people "do math" emphasized that different locations held objects and tools that allowed people to represent to themselves what they know and how to calculate what they needed, given their goals. For example, people who could perform algebraic calculations in one setting, such as an office, seemed to not recognize opportunities to do the exact same algebraic calculations in another setting, such as a grocery store, but they created other approaches to calculation appropriate to the specific situation with the materials at hand in that location (Lave 1988). Studies of communities of practice (e.g. Wenger 1988, Brown and Duguid 1991), or groups of people who work within the same knowledge domain, have often focused on specialized language and tools, often location-specific, that embed assumptions about what is valued within a particular area of expertise. In these studies of individual and within-domain knowledge, we recognize the interactionism premises that individuals select some of their sensory perceptions to indicate to themselves and or imbue with meanings and that selections, significations, and re-interpretations of these social objects are created and shaped through interactions with others and the situation at hand.

Through studies of cognition and communities of practice, we can easily recognize how the items valued *within* an area of expertise are socially constructed and then reinforced by the tools for exercising competence in that area that reinforce certain things as important social objects and imbue them with richer and richer meanings. But innovative work often necessitates working *across* occupational or disciplinary practices, in order to synthesize multiple kinds of expertise to create something unachievable within any one knowledge domain. When we turn to the knowledge-work that crosses areas of expertise, we confront challenges in creating shared perspectives among various "thought worlds" (Dougherty 1992; Carlile 2002, 2004). Because capital has value only within the situated practices in which it takes shape (Bourdieu 1990), different kinds of knowledge can become problematic as people become invested (Taylor, 1995)

in their respective practices. In fact, as a person gains more expertise in her chosen field, her ability to demonstrate her competence often depends more heavily on the assumptions, methods, tools, and values of that field.

For example, engineering values precision in measurements and power in performance. Sales values achieving balance among promised volumes and revenues, given estimated costs and margins. Marketing values name recognition and brand equity. Manufacturing values constant pacing, the right tool at the right moment, and physical layouts and scheduling systems that keep unions silent if not happy. While these values are easily recognized and even taken for granted as inhering in particular groups and roles, they often remain unacknowledged and undiscussed, until confusion at the boundaries brings them to the fore. Language, carrying the weight of embedded practices (Nonaka and Takeuchi 1995) and individuals' investment in them (Taylor 1995), becomes problematic as people realize words thought to be understood by all mean different things to different departments. Even seemingly simple words can cause confusion: "This new product is going to be big!" leads marketing to interpret high revenue, manufacturing to interpret high volume, and design to interpret high performance. Unless these areas create methods to resolve their different assumptions about "big," they will probably inadvertently work at cross-purposes undermining each other's use of scarce organizational resources.

Again, because practical know-how (Bourdieu 1990) incorporates the ability to wield certain methods and tools, which in turn embed values and assumptions about the work, creating representations or social objects meaningful to multiple practices poses challenges. For this reason, some scholars have studied "boundary objects," or objects useful in helping people with differing expertise communicate about their interdependences. The term "boundary object" was first coined by Star (Star and Griesemer, 1989), who defined it as an object "adaptable" enough to be interpreted differently by people with distinct expertise without losing a coherent identity across the social worlds it is spanning. Star was studying how amateur biologists, professional biologists, and administrators worked together to create well documented museum exhibits from rather amorphous collections donated by people with more enthusiasm and political power (with the museum) than education. Star and Griesemer (1989) suggested that boundary objects are useful because they aid in negotiations when "each social world has partial jurisdiction over the resources represented by th[e] object" but those jurisdictions overlap or are mismatched or in conflict.

Henderson (1991, 1998) elaborated on the notion of "adaptable" objects, emphasizing the important role that many kinds of artifacts, tools, and technologies play in the situated (Suchman, 1987), practical (Bourdieu, 1977; Lave, 1988) exercise of knowledge and competence. Henderson and Carlile (2002) both studied artifacts used to communicate across functional boundaries (primarily sales, design engineering, and manufacturing) in the context of product development. Carlile (2002) summarized a robust boundary object as relatively concrete and representative of dependencies among the players. In her research, Henderson (1991) noted that, because boundary objects leave out information, they can also be used to "conscript" or narrow the realm of choices in cross-boundary conversations, rather than to explore broadly the consequences of interdependencies. Carlile (2002) therefore emphasizes that, to be a useful boundary object, rather than a tool used to conscript others to a single point of view, an artifact must be transformable by all players, meaning that anyone involved has the ability to manipulate

and alter the object in order to represent better the consequences s/he perceives in the dependencies.

Here again we see premises of Mead's foundational work taken as given, that social interactions shape the meaning we attribute to things and even shape the sensory perceptions we select and identify as "things." We recognize reliance on an interpretive process that first selects and then signifies (imbues with meanings) certain objects—and then proceeds with these objects as taken-for-granted elements of the world at hand. Only when we begin interacting with people who hold differing taken-for-granted assumptions about what important social "objects" are and what meanings they hold, do we reconsider the social processes by which we accumulated the capital to make use of the social structures with which we carry out day-to-day work. As Strauss (1993) points out, increasing the number of participants in a given interaction often requires "articulation" of respective actions and why they are "reasonable" because membership in various social worlds creates "intersections" of meaning. Tools that serve as boundary objects help people engaged in knowledge-work that crosses boundaries (disciplinary, organizational, cultural, or other) to explicitly represent some of their assumptions and then engage in new social processes to transform the meanings they attribute to certain things or even alter the things to which they pay attention.

Attention, sense-making and decision-making

Simon's (1945) theory of bounded rationality and satisficing has shaped studies of decision-making for decades. Limits to cognition (Miller 1956) and heuristics for "good enough" decisions based on limited information (Simon 1945; Cyert and March 1992) have been recognized in both individual and organizational decision-making research. While many of the bounded-rationality studies have assumed the limits of cognition are based in "computing power"—and there are limits to mental capacity—a social-process perspective complements and enhances the limited-cognition view. Weick's (1979) work on sense-making asserts that sifting events and observations for "what matters" and "what's going on here" is inherently a social process and often retrospective, in that people often revise their beliefs about what really happened at a particular point in time long after the event has passed. Ocasio's (1997) research emphasized that, not only is managerial cognition limited, but also that limited attention is socially constructed; we pay attention to those "objects" selected by and reinforced by our social interactions, and we often do not perceive "objects" consistently omitted from these interactions. We see again in the social-construction of attention and sense-making Mead's foundational premises, taken as given: people ascribe meanings to things based on their interactions with others with regard to that thing, and the interaction process includes, first, focus on the thing and, second, interpretation based on previously internalized social interactions.

In considering the decision-making literature, we gravitated to the Observe-Orient-Decide-Act (OODA) cycle popularized by Boyd (1992) because it affords room for cognition and sense-making, as well as actual decision-making. We cannot make a decision on a matter we have not yet made sense of, or oriented on, and we cannot make sense of anything we have not observed. What we do observe often results from the actions consequent to our own decisions, and so the cycle forms a closed loop. While Boyd did not use terms from interactionism (or social science generally) to describe his understanding of decision-making, we see in this simple loop construct room to explore the rich theories cursorily addressed above. Accumulated experiences influence

the lenses with which we observe, the things we attend to and indicate to ourselves; we make social objects of these things as we interact with others with regard to them. Orientation affords conversation about sense-making, choiceful interpretation processes that include both communication internal to the self and communication with others about "having observed this, therefore what do we believe is going on here?" Furthermore, making sense of social objects often involves representing one's understanding to oneself and/or to others. Decision-making affords discussion of the how an individual or group or organization can respond to the situation, given the sense derived from it, and we note that Mead (1934) asserted that an individual will dismiss (not orient on) any object for which he lacks a capacity to respond. And action is always imbued with the situated meanings we bring to bear, which generates new information with which we interact in order to interpret.

Moreover, Boyd's OODA construct makes explicit the issue of pacing, or the rate at which one cycles through these interactions, and few of the social theories summarized above explicitly deals with implications of slowing or accelerating the cycle of observing, orienting, deciding, and acting. Finally, the OODA construct is scalable, as is Mead's theory of interactionism, and can be useful in identifying and understanding interactions between the "I" and the "me" internal to individuals, between individuals, or between groups, organizations, or institutions.

Methods for connecting qualitative data with system dynamic models

In this section we describe how we collected and analyzed qualitative data; identified constructs in the data and literature relevant to the presenting problem of "how to reduce disconnects" and proceeded with model-building and analysis. We elaborate particularly how we "traversed" from rich, qualitative empirical data to themes and higher-level abstractions useful as constructs in a theoretically informed simulation model. While many system dynamics research efforts make excellent use of qualitative data, seldom is the method to move from an operational model to a theoretical model made explicit. We hope that the excerpts of details provided in this section broaden the discussion of how to systematically move up and down levels of abstraction to build parsimonious models consistent with social theories and whose constructs can be traced back to the empirical richness in which they are grounded.

Interviews

To begin the model building process, the research team conducted 20 semi-structured interviews of individuals from 12 groups within the System Program Office (SPO) involved at various levels of technical and organizational responsibility for ensuring adequate-quality and timely progress on the program by the prime contractor (and indirectly the contractor's subcontractors and vendors). Interviewees were employed by various commercial, military, and Federally Funded Research and Development organizations yet worked together within the SPO. Interviewees' years of experience in the SPO ranged from one to more than 20 years, and interviews lasted from 45 minutes to two and one-quarter hours. As analyses of the data proceeded iteratively, discussions of research-in-progress with individuals and small groups in the SPO stimulated individuals' providing additional data, which were then used to check, corroborate, disconfirm, and/or add depth to the emerging picture from our interview notes.

Affinity (KJ analysis)

The research notes then provided the source data for the construction of an affinity diagram (or KJ analysis) (Brassard 1989) that yielded 103 areas of interest related to disconnects. While constructing the affinity diagram, the team modified the usual method for defining "header cards" for the card groupings. While using the customary process of grouping cards, the team named each header card using a "How to…" or "I wish I knew…" prefix (abbreviated as H2 or IWIK respectively). This allowed us to distill the issues as either an action/process gap or information gap. By framing the issues this way, we sought to more enable action (by the team and by the client) on what we were discovering from the process of upward abstraction of the resultant header cards from rich interview data. Figure 1 below summarizes some of the header cards distilled from interview data analyses, grouped into topical categories emerging from the interviews.

Pacing

- H2 speed up to prevent being overcome by events
- H2 process changes quickly AND do a quality job
- H2 free the contractor from needing to work at risk
- H2 synchronize organizational pacing
- IWIK the correct pacing for the change processes

Contracts

- H2 reduce paperwork processing time
- H2 manage contracting work loads

Communication

- H2 increase the information circulation rates in a huge organization
- H2 bring informal communication into the formal channels
- IWIK if the Interface Configuration Working Groups (ICWGs) are meeting often enough
- IWIK if the ICWGs are using effective meeting management techniques
- H2 create transformable graphical forms that enable collaboration

People

- H2 establish the right skill mix and staffing level in the SPO
- H2 retain organizational knowledge and skill
- H2 increase the pool of technically competent candidates
- H2 ensure the contractor has the right mix and staffing levels
- H2 establish the right skill mix and SPO support staffing levels
- H2 reduce impact of high contractor turnover rates

Stakeholders

- H2 balance the constituency needs and contractual constraints when a change is proposed
- H2 make explicit tradeoffs among constituencies

Process and Systems

- H2 develop a comprehensive change management process
- H2 include the right reviewers at the right time
- H2 improve alignment between contractor processes and formats
- H2 create explicit and clear stage gate exit criteria at all levels
- H2 determine the best evaluation scope
- H2 clarify the Engineering Review Board (ERB) intent and processes
- H2 improve the contractor's performance

Management

- IWIK why the requirements and integration functions are considered "dysfunctional for a long time"
- IWIK why the workflow tools "failed" several years ago

Requirements

- H2 increase the clarity of requirements before executing on a contract
- H2 explicitly link Needs to Requirements to Specifications to Product

Disconnects

- H2 align contractor's contractual and technical baselines
- H2 avoid overlooking changes with classified parts until there's a gotcha
- H2 avoid problems found in 2002 that trace back to the1997 Request for Proposal (RFP)

Integration

- H2 integrate more than 25 programs with differing stages of maturity
- H2 increase people's understanding of the bigger picture
- H2 increase the utility of the integration database (DB)
- IWIK if integration meetings were effective

Policy & Strategy

- H2 operate in the new policy environment
- H2 decrease goal conflicts
- H2 fix eroding quality: "...from mil spec to whatever you think works"

Culture

- H2 develop effective relationships with the contractors
- H2 adjust perceptions of how work gets done in a huge organization
- H2 develop a culture of open communication

Knowledge, Skill, & Experience

- H2 build competence by doing
- H2 improve context evaluation skills
- H2 build competence via training
- H2 build contractor competence
- H2 effectively transfer management initiatives
- H2 effectively transfer technical knowledge
- H2 encourage asking educated questions

Infrastructure

- IWIK where the Information System (IS) function is in this organization--few tools
- H2 update the facilities
- H2 increase classified capable phones
- H2 gain visibility of the aging chain of what is in the pipeline

Roles & Responsibilities

- H2 clarify Configuration Management's (CM's) function, roles, and responsibilities
- H2 reduce the inadvertent evolutionary role of System Engineering Technical Assistance (SETA) contractors
- IWIK if there were a better way to structure responsibility for product requirements
- H2 increase the visibility of who is accountable and responsible for every outstanding issue
- H2 define explicit Responsible, Accountable, Consult, and Inform (RACI) assignments for process steps and deliverables

Figure 1

The team then distilled from these header cards, which we came to call “areas of interest,” to 62 measurable variables that we believed would be key to gaining leverage on the disconnect issue. Figure 2 shows the affinity model detail for the Pacing category. On the right are the “data

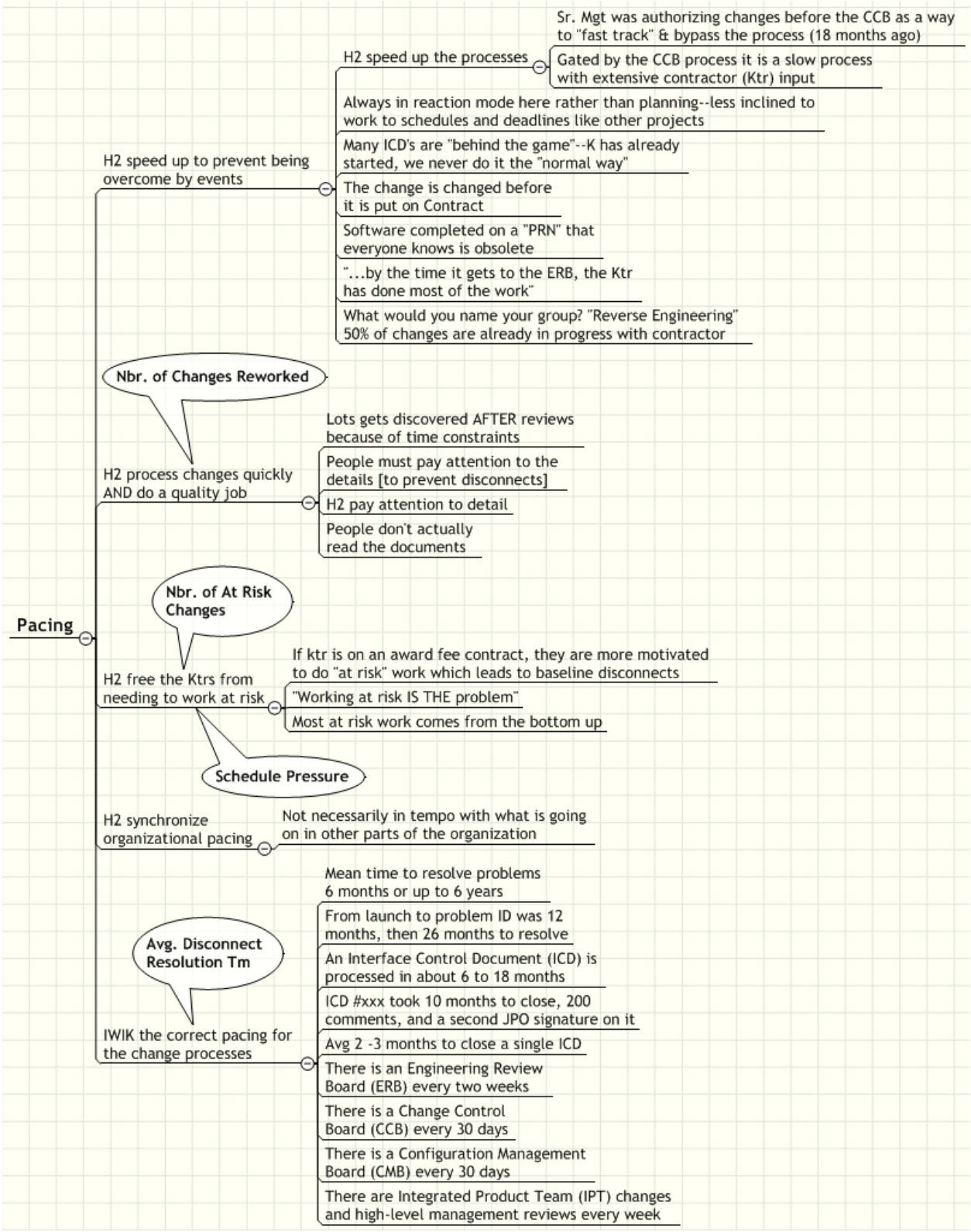

Figure 2

cards" created from interview notes, the "header cards" summarizing the issues as a "How to…" or "I wish I knew…" format, and the measurable variable, specified in the call-out balloon, that would give us insight into the problem. From all of the categories there were a total of 62 measurable variables identified. These variables were then aggregated to 11 higher-level variables and mapped to Boyd's (1992) Observe-Orient-Decide-Act loop (OODA, "ooh-duh" loop), which we had identified as a useful theoretical construct (for reasons discussed further, below). Where we did not see a direct mapping of our variables to the OODA framework, we retained the variable as its own category (here, expertise level and clarity of communication). The mapping of these elements is presented in Figure 3.

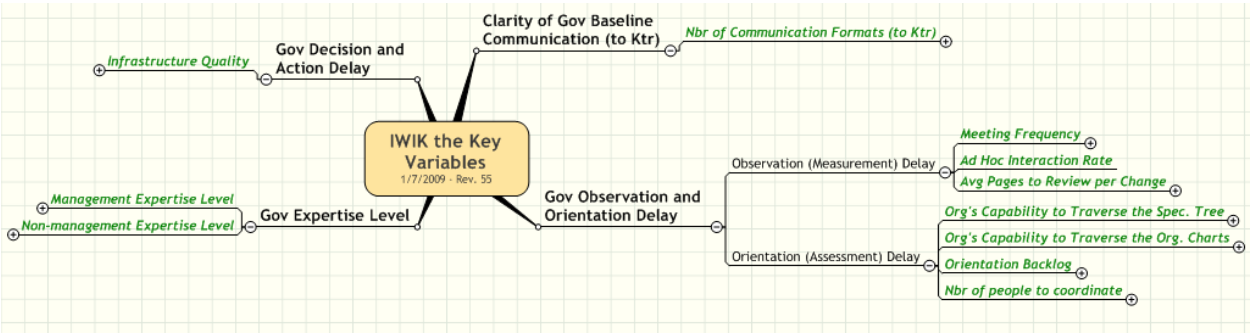

Figure 3

From 10 individuals interviewed a second time, a behavior-over-time graph for each of these 11 variables was elicited. The team found drastic discrepancies among individuals' perceptions of the behaviors-over-time of these key variables. This underscored the absence of shared understandings, even about variables that all participants agreed were critical to their success. Additionally, from interviews emerged themes of discrepant understandings in language critical to tracing issues across the organizations working on the program. The research team then developed a high-level semantic model representing the key language and traceability issues identified in transforming users' needs to program requirements, to specifications and to delivered products. Because of the wide discrepancies in individuals' perceptions of variables' behaviors and even language central to recognizing and resolving disconnect issues across the development life cycle, the research team chose to adopt a process for exploring the dynamics of creating and resolving disconnects that would build shared understanding of the complex baseline change process as the research progressed. Specifically, we used the discrepant behavior-over-time graphs and language differences in three ways: we sensitized client members to the absence of shared understanding; we focused the modeling on creating shared understanding of the program work-to-be-done over time; and we staged discussions about the model and its constructs and simulated behaviors.

Simulation model—two players

In constructing the first iteration of the simulation model, the team summarized the disconnect issue facing the SPO as one of seeking to reach the goal as defined by the baseline, of which there were three—technical, financial, and schedule. A baseline is a formal document(s) representing agreement about what is to be accomplished. During the interview process we received many questions about the baselines such as: "Which baseline do you care about?" In

many cases, getting SPO members to agree about which baseline was relevant was problematic. Our approach, therefore, in generating the first model was to remain ambiguous about which baseline we were concerned about. This would allow us to discuss the aggregation of all baselines which is simply the work-to-be-done in total. The team's analysis focus was on the organization and how they conceptualized the work to be accomplished (as the Lt. Colonel's original problem statement had indicated) without regard to how that work would be partitioned for execution.

Another aspect of reaching the goal (baseline) is that the goal was a moving target. The goal was moving because the other organizations were requesting and gaining approval to change the baselines. Conceptually, the modeling team recognized that each organization had a goal-gap structure with a time to adjust but that the goal was changing by the action of another organization. In this case, the contractor was learning, requesting a change to the baseline, and acting on the change (even before it was formally approved). The situation that one player in the interaction was acting on their proposed change before approval was the clue that triggered the team's understanding of the continuous flow of understanding developing in the interaction between the SPO and the prime contractor. The act of instantiating the baseline at any given time in document(s) was incidental to the continuous flow of understanding that was driving action which changed daily via the organization's diverse interactions. In other words, people were acting on the understanding of the baseline that was in their heads, not necessarily what was written in the baseline documents. What the team sought to represent in the first simulation model was an interlocking floating goal structure as represented in Figure 4. The stocks of KTR (contractor) Baseline and SPO (System Program Office) Baseline represent the organizations' collective understanding of the work to be done, not what is in the formal documentation of the baseline which represents a snapshot at a point in time.

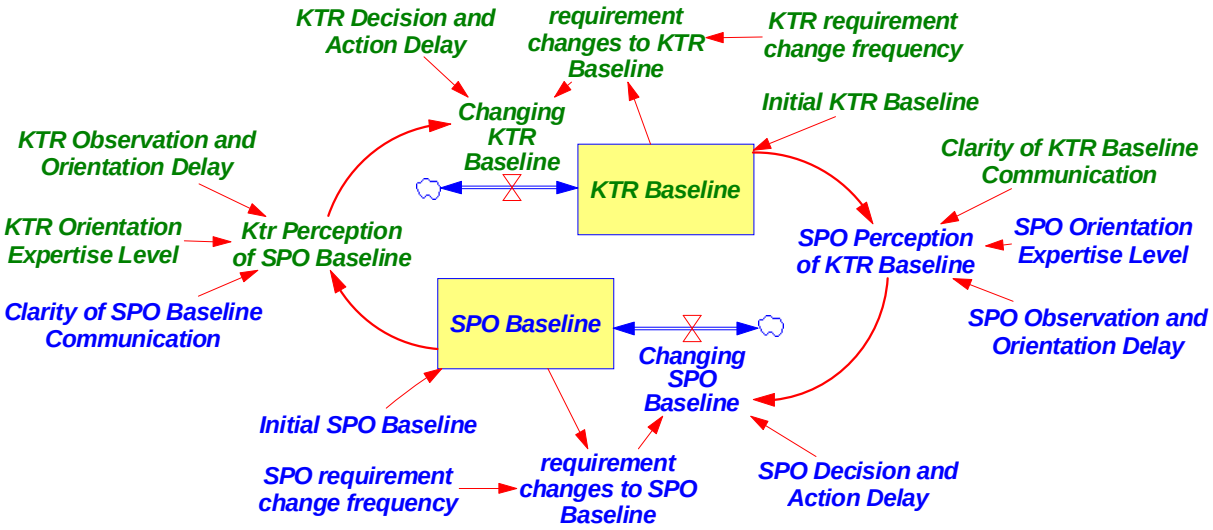

Figure 4

The team also recognized that one is not able to directly observe another's understanding of the baseline. Given the confusion and complaints documented in interviews concerning the need for writing clear requirements and specifications, the team sought to represent the subjective reality of perceiving a baseline not objectively knowing it—that no matter how good the representation, an interpretive process is needed to perceive what is meant. Model variables KTR Perception of SPO Baseline and SPO Perception of KTR Baseline were used to represent this concept.

During the interview process we became increasingly aware that the documents used to represent the baseline, or a change to the baseline, were usually Microsoft Office documents. Interviewees reported that some change documents were 800 page text documents with few tables or graphics. The team also learned that the contractor "dumbed down" the deliverables to the SPO because the SPO decided not to invest in training its staff to use more sophisticated communication forms because of *planned* high turnover rates mandated by the military services. Issues like this are represented in the model as: Clarity of SPO Baseline Communication and Clarity of KTR Baseline Communication and are modeled as affecting the perceptive abilities of the organizations to understand the other's baseline.

Staff turnover rates, both within the SPO and the contractor and among management and technical workers were cited in interviews as critical elements of the disconnect problem. The work to be done requires significant expertise development while on the project "just to be somewhat competent." One of the affinity cards that caused the team to represent expertise as relevant to baseline perception was the comment: "Poor Lt. S....., couldn't tell that what the contractor gave him was crap." From this comment the team connected expertise to the ability to accurately perceive something and modeled expertise as a key element of perceiving.

System dynamics modeling was not generally understood among members of the SPO, though many members had a robust understanding of control theory and a few had extensive backgrounds in cybernetics. Even with the staff that had this knowledge background, it was novel to all interviewees that system dynamics simulation could be applied to social problems. The project team recognized that the way system dynamics models were introduced to the organization was critical to long-term acceptance of the capability. The team decided, therefore, that the model must be as simple as possible—even to the point of not exceeding one page and should be presented in a context that was rapidly understood by a very busy person. The decision to use Boyd's OODA loop framework as a way to tell the project story was selected for this reason. The structure was one they were familiar with and represented a closed-loop management cycle. It was also useful because it was relatively easy to map the project issues to stages in the OODA loop.

A last element of the two-player model (SPO and contractor) was the recognition that noise was an inherent part of the communication processes within the SPO. Given the breath of the 103 issues identified during the interviews, it seemed to the modeling team that the SPO members were working in a type of fog trying to sift the information they received for relevance to the work they were assigned and held accountable. From the interview notes, it appeared that all information in the SPO was noise unless one had the experience and knowledge to discern the relevant signal(s) from all the noise. The two-player model was constructed, therefore, with

noise as an unavoidable element of communication between the two players. (See Greer Black Adams 2006 for details on the formulation of this noise function.)

Upon completion of the two-player model a series of scenarios were run and the findings presented to the project sponsor (see Greer Black Adams 2006 for a summary of key simulated scenarios and findings). The sponsor asked if it were possible to expand the model to four players because the contractor actually works with a subcontractor and the subcontractor interacts with a vendor for parts.

Simulation model—four players

The project team then set out to model four organizations in a chain interacting with each other. To accomplish this, the simulation model was arrayed as represented in Figure 5.

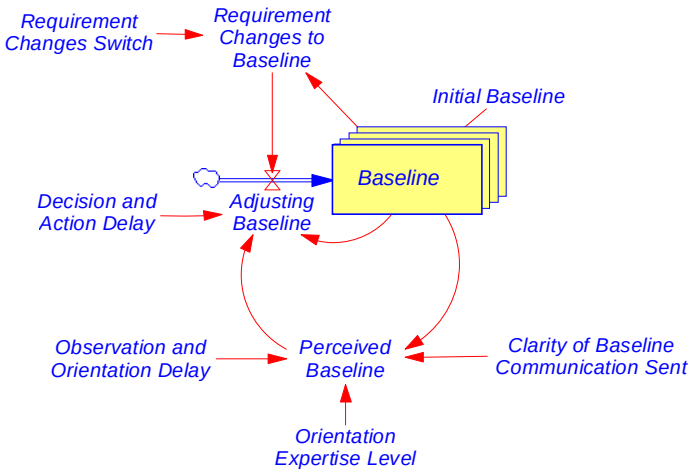

Figure 5

The model was arrayed to allow an expected request for any number of interacting players but was held to four interacting organizations in the second iteration.

One new variable was needed, however, when the model was expanded to four players. With four players, the contractor was no longer only listening to the SPO for changes in its baseline but also to the subcontractor. The subcontractor, likewise, had to listen to the contractor and the vendor. Given this problem, the modeling team added new variables called Listening Priority (not shown here) to allocate the weight of influence on baseline adjustments by the contractor and subcontractor. In other words, the contractor was not only adjusting to perceived changes in the SPO's baseline but also chances in the subcontractors baseline and had to decide which one had more priority. The subcontractor also had to make a similar listening priority decision.

What we learned from model versions and scenarios

The process of building the model and testing various scenarios began to bring our attention to issues of learning and knowledge creation. This triggered a literature search by the team which

led to the work of Stacey (2001) in which he offered a diagram very similar to the structure of the teams simulation model—a structure based upon Mead's theory of symbolic interaction. That reference lead to additional literature searches which yielded the recognition of the strong connection between the model and Mead's theories.

Additionally, as noted earlier, the need to create a variable called listening priority also caused the team to begin literature searches on this topic as a way to confirm/disconfirm the model and our findings. The literature search on "listening priority" became a search on theories of attention that led to the work of Ocasio (1997). Ocasio discusses the social construction of attention and the nature of attention within organizations. Noting the connection between Mead and Ocasio the team began to see a rich body of social science research building on Mead and symbolic interaction. This body of knowledge became known as interactionism and has developed into a sub-field of social science.

The team did not build the model based on a social theory. Rather, the team built the model on empirical data and ended with a structure in substantial alignment with a large body of social theory relating to learning, knowledge, social construction, and meaning—all identified as key issues in the disconnect problem within the SPO. The results of the modeling process drew us into the relevant theory by driving us to ask the right questions and help shape our understanding of what ideas were most important. The resulting model has also helped us think more precisely about the social theories and the logical implications of the causal relations asserted by the theories. Below we summarize insights from looking at the model through the theoretical lens of interactionism.

Differences between accumulated experiences and situated meaning. We concluded that accumulating knowledge is a less useful construct than accumulating internalized social experiences, and that meaning is better considered as an in-the-moment situated occurrence. Interestingly, "experiences" avoids the common assumption that all knowledge is good. While people frequently have trouble admitting they need to unlearn previous "knowledge" in order to learn more, few dispute that experiences can be reinterpreted, revisited, reprioritized as we experience new sensations and interactions that help us consider different and new aspects of previous experiences.

Figures 4 and 5 shows stocks (Baselines), which represent the accumulation of the organization's social experiences as it interacted with another—in this case, the SPO interacting with the contractor about the work to be done. This model structure maps directly to Mead's theory of interaction described earlier. Moreover, Mead asserted that meaning is not an abstract concept but is the action by one to adjust to a gesture or symbol presented by the other party. Therefore the flows in figures 4 and 5 represent the situated meaning (actions) by the SPO and contractor to adjust their baselines based upon their perception of the other's baseline. An interesting point here is, even if both organizations adjust with a quantitatively equal amount in a given time period, that does not mean that each organization is seeing an equal meaning in the representations, since the adjustment is relative to each one's previously accumulated social experiences, which in most cases is not equivalent (just as two people can undertake the same action for very different motivations). This difference between equal rates (temporarily) and equivalent meanings (revealed by the precise grammar of "flow" that system dynamics affords),

gives us insight into deeper implications of the word "situated," and how challenging it is for parties to perceive the same situation.

Implications of situated meaning on knowledge networks. The recognition that experience accumulates (a stock) but knowledge is always situated (a flow) led us to appreciate that we were underestimating the impact of turnover on the SPO's performance—even when we already believed it had a significant impact. If knowledge is situated and always between interacting people, then turnover has a network effect because people who leave remove their social relations and the socially constructed knowledge between the people with whom they interacted. Additionally, it is never possible for any artifact to objectively deliver its information without interaction between people. The artifact may provide a starting point for the conversation but without interaction with another to reconstruct meaning in the new context the substantial meaning of the artifact is at risk. This finding reveals theoretical basis for the fundamental weakness of "throwing deliverables over the transom."

Importance of pacing iterations on "ugly drafts." The modeling team ran optimization runs on the model and found that higher iteration rates (OODA loop speeds) on noisy data yields better outcomes than lower rates with perfect data. Simulations indicated that orienting 4 to 5 times per action improved convergence among the players significantly. The connection between OODA loop speed and "noisy" deliverables was not understood prior to this analysis. Essentially, by iterating more times with less drastic action, we are giving players the chance to re-observe and re-orient (re-presenting the information to their senses) multiple times for every large action. Since analyzing the simulation scenarios, the authors have tested this finding by sharing ugly drafts sooner, rather than better drafts later, in the production of deliverables. Our experiences affirm the finding from the simulated explorations. Corroborating evidence for this is found in Argyres (1999), whose empirical study of the development of the B-2 bomber noted that integration testing of wing components manufactured by multiple organizations required seven iterations to reach a solid integration of the components. Implications for practice are that deliverable production must include a plan for iteration and that iteration should be on "ugly" drafts until the last iteration. Premature closure by iterating too few times can generate disconnects later. This is often challenging advice to implement across functions, with people among whom there is low trust, or when people have high competence expectations (because they want their work to be perceived as excellent by others, so they want to perfect it before sharing it).

Attention and persistence.
As noted above, attention is a process of social construction within an organization. It is the process by which the organization determines what is important to attend to in the environment within which it finds itself (in Boyd's terms, the data to Observe and from which to Orient). One of the team's simulated explorations was to test how long it took a change to propagate through the network of interacting organizations. We found that, due to differing attentions, a change (signal) must be persistent to propagate throughout the network. Without persistence, the proposed change would be lost in the noise of other issues. In practice what is typically attributed as "resistance" to an idea or a change proposition may actually be the time needed to get the message through the socially constructed maze of differing organizational attentions.

The idea that we attend to and make "objects" of some experiences, sensations, and thoughts but not others suggests that attention is a noisy process. If interaction is noisy, then how do we damp noise to converge on a shared meaning in a given context? Through simulations we find that (as in many engineering applications) noise is damped primarily through iteration, or repetition of the signal. The signal that perseveres longest is perceived as the "true" signal, and ephemeral signals are considered "noise." In view of the attention-based view of the firm, this has grave implications for innovative ideas that may not receive multiple hearings until they are fully comprehended, over more persistent signals of previously socially constructed "conventional" wisdom.

Concluding remarks

There are precedents of using system dynamics modeling for both refining and building rich social and organizational theories (Davis, Eisenhardt and Bingham, 2007, summarizes some of these). System dynamic models have been used to refine existing social theories by providing checks for completeness and internal consistency (e.g., Sastry 1997 on punctuated equilibria in organizational change; Rudolph and Repenning 2002 on disastrous consequences of accumulating interruptions). System dynamics models have also been used to complement and extend rich qualitative data to more formal theorizing (e.g., Black, Carlile, and Repenning 2004 on structuration influenced by new technologies). Even so, some argue that system dynamics is isolated from social science, theoretically conflicted, or perhaps missing opportunities to contribute to prominent social science conversations (Repenning 2003, Lane 2001). We believe that another look at Mead's interactionism is valuable because it underlies so many well-respected social theories. Furthermore, with the representations of system dynamics, we have an explicit mechanism to play out through simulation the dynamics of interactions, and so recognize, underscore, and value certain points that Mead made and then build on those insights.

More generally, modeling provides complementary insights to social theories in at least two ways. First, the process of building a model demands rigorous questioning of constructs and their interrelationships, construct-to-construct and construct-to-empirical phenomenon because a computer cannot simulate a vague concept, but only precise specifications. The model-building process also reveals more specificity about what we do and do not know, often sending us back for more careful review of the literature and/or the data. Each cause-and-effect relationship represented in a model can be based specifically on field informants' assertions of cause and effect, on laws of physics, on theoretical and empirically validated assertions in the literature, and/or on inferences of cause-effect connections among the constructs not identified by these other means. Second, the outcomes of simulating a model provide a tractable check on the internal consistency of theorizing about constructs and their interrelationships. Simulations methodically take into account the multiple interrelationships and cumulative impacts of many single cause-effect relationships and allow visible, tractable examination of the consequences in multiple variables, over time. For those theories positing notions of path-dependence, feedback, and iteration, simulation provides valuable graphical representations of the structures and outcomes of these concepts which often become convoluted in text. These simulations also sometimes produce unexpected dynamic behaviors which then stimulate deeper investigations to

explain them. Investigations of "problem behaviors" often lead to new insights by discovering omissions or errors either in the model or in the theory or in both.

Just as there is no "one right experiment" that embodies the scientific method's approach to a given situation, there is also no "one right model" that represents a theory; many models, like many experiments, may generate insight into a given situation. According to Kuhn (1962), our recognition of "problems" is constrained and enabled by our methods at hand for measuring, analyzing, and intervening in a given empirical context. If we take seriously this notion, then expanding the tools we use can advance our analyses and insights into complex empirical problems—and complex social theories—since changing the tools changes what we can perceive and address.

According to Thomas Kuhn, a theory is "good" to the extent that it helps people make sense of phenomena they experience. In this spirit, we believe the theory of socially constructed knowledge is good, particularly as we pause to examine the processes by which shared meaning can be actually constructed. Simulating the causal relations in Mead's assertions helps us recognize what aspects of interaction influence how quickly and effectively we move to shared meaning, and therefore suggests, beyond a single situated context, how to design interactions to benefit the individuals and organizations to whom knowledge-work is critical.

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