2012

Exploring the Temporal Nature of Sociomateriality from a Work System Perspective

Steven Alter, *University of San Francisco*

Exploring the Temporal Nature of Sociomateriality from a Work System Perspective

Journal:	*18th Americas Conference on Information Systems*
Manuscript ID:	AMCIS-1303-2012.R1
Submission Type:	Paper
Track:	Socio-Technical Aspects of Information Systems < Philosophical Perspectives in IS (SIGPhilosophy)

Exploring the Temporal Nature of Sociomateriality from a Work System Perspective

Steven Alter
University of San Francisco
alter@usfca.edu

ABSTRACT

This paper uses work system theory (WST) to explore the temporal nature of sociomateriality. It summarizes concepts related to WST and sociomateriality, and notes sociomaterial aspects of WST. It uses static and dynamic views of a work system to examine six examples that can be classified in one of three time frames, minutes-to-hours, days-to-weeks, and months-to-years. The result is a straightforward interpretation of systems and related events across all of the time frames, which exhibit different types of phenomena related to adaptations, workarounds, emergence of informal work patterns, and sequences of formal projects. After approaching sociomateriality from a perspective not usually associated with that genre, this paper concludes that ambiguity about the intended time span of assertions related to entanglement and inseparability should be remedied. At minimum, it should be clear whether these phenomena occur instantaneously or in time spans of minutes-to-hours, days-to- weeks, or months-to-years.

Keywords

Sociomateriality, sociomaterial phenomena, work system theory, temporality, work system life cycle

INTRODUCTION

The discourse on sociomateriality contains many statements that are meaningful to experts in the sociology of technology, but that elsewhere probably sound exaggerated, if not strange. Orlikowski and Scott (2008) refers to "the inherent inseparability of the social and the technical" (p. 456) and says that within the lens of sociomateriality, "humans/organizations and technology are assumed to exist only through their temporally emergent constitutive entanglement." (p. 457). The Call for Papers for *MIS Quarterly's* Special Issue on Sociomateriality (Cecez-Kecmanovic et al. 2011) says, "the notion of sociomateriality ... implies that things, technologies, people, and organizations do not have inherently determinate meanings, boundaries, or properties." It also says, "Most IS research assumes a conventional duality between the technological (material) and the social/human. ... As we understand the intimate tangle of IS and organizations, their co-emergence, co-production, and mediation, it becomes more urgent for the 'conceptual bubble' of the social/material duality to be burst (Woolgar 2002)." Feldman and Orlikowski (2011, pp. 17-18) recognizes difficulties in pursuing this type of approach, saying that "it is unsettling to take on the notion that a resource is defined not by what it *is* but by the practices through which it is enacted as a resource, and that such enactment as a resource is an ongoing and thus necessarily temporary accomplishment. ... The premise that characteristics and capabilities of technologies are relational and enacted in practice is a challenging one to absorb when confronted with the manifest physicality of assembly lines, CT scanners, and computers." Such difficulties lead theorists to create new words such as habitus and structuration, and sometimes "to write sentences that seem to go in circles: 'structured structures predisposed to function as structuring structures' (Bourdieu 1990, p. 53) or 'structure as the medium and outcome of the conduct it recursively organizes' (Giddens 1984, p. 374)."

The complexity and abstract nature of the sociomateriality discourse are appropriate for the subtlety of the subject matter and sophistication of participants in the discourse. Unfortunately, those characteristics constitute a substantial obstacle to real world application of the results. In a purportedly applied field such as IS, it is unfortunate that typical IS/IT professionals and many IS researchers would be mystified by statements from an emerging genre of research that has produced valuable insights concerning people, technologies, and systems in organizations.

Goals and organization. This paper uses work system theory (WST) to explore the temporal nature of sociomateriality, a topic that receives little attention in that discourse. This paper's coverage of that topic is part of a larger attempt to combine aspects of work system and sociomateriality lenses for analysis, evaluation, and design efforts, rather than mostly for theorizing. That larger effort covers issues related to temporality, agency, workarounds, emergence, and technological affordances that cannot be covered within this paper's length limits.

The next section summarizes previously published ideas about WST and links those ideas to aspects of sociomateriality. Two examples from Orlikowski (2006) illustrate the range of time spans in which sociomateriality applies. Next is a discussion of sociomaterial aspects of four published studies that occurred in different time frames including minutes-to-hours (workarounds in a nursing ward), days-to-weeks (emergence of informal work patterns in a sales process supported by ERP) and months-to-years (emergent change in testing automotive designs and disruptive change in switching from analog to digital infotainment systems for automobiles). The concluding section suggests that the temporal nature of sociomateriality is often underplayed and might be understood better by using the relatively simple language of WST.

WORK SYSTEM THEORY

WST is a theory for analysis (Gregor 2006) that provides a way to view a situation as a work system, just as actor-network theory, activity theory, coordination theory, and structuration theory provide ways to analyze or explain situations using other concepts. Since many of the ideas in WST have been published previously, we review basic premises and two central frameworks before using WST in relation to sociomateriality.

Domain of relevance. WST is relevant for describing, analyzing, designing, or evaluating systems within organizations, whether or not IT is involved. It also covers systems that cross organizations.

Unit of analysis. The unit of analysis is a work system, a system in which people and/or machines perform processes and activities using information, technology, and other resources in order to produce products and/or services for internal or external customers. Enterprises that grow beyond a largely improvised start-up phase can be viewed as consisting of multiple work systems. Almost all significant work systems in business and governmental organizations rely on IT in order to operate efficiently and effectively.

Information systems. WST applies to work systems in general and, by inheritance, to special cases of work systems such as information systems, where all processes and activities involve processing information. (Alter, 2008). Sociotechnical IS include accounting systems in which accountants produce financial statements and planning systems in which managers produce plans. Automated IS include search engines that produce search results and automated stock trading systems that produce and/or execute buy orders or sell orders.

Static View of a Work System

Work System Framework. The nine elements of the work system framework (Figure 1) are the basis for describing and analyzing an IT-reliant work system in an organization. The framework outlines a static view of a work system's form and function at a point in time and emphasizes business rather than IT concerns. Figure 1 identifies four internal elements of a work system (process and activities, participants, information, and technologies) plus five other elements (customers, products/ services produced, environment, infrastructure, and strategies) that are part of even a rudimentary understanding of a work system. Customers of a work system often are participants, as when doctors examine patients. The elements of the work system framework are explained in Alter (2006; 2008). The framework covers situations that might or might not have a tightly defined business process and might or might not be IT-intensive. Figure 1 says that work systems exist to produce products/ services for customers. The arrows say that the elements of a work system should be in alignment.

System identity and integrity in the presence of change. A work system maintains enough integrity to be described, measured, and managed as a system even though specific features or components may change incrementally or may not operate in accordance with designer intentions. Recognition of incremental change mirrors Feldman and Pentland's (2003) distinction between espoused structure and the actual activities that occur (ostensive vs. performative aspects of routines), which "creates an on-going opportunity for variation, selection, and retention of new practices and patterns of action within routines."

Technology and Process in the Work System Framework. Various researchers have viewed technology either as devices or as processes and techniques that typically use devices. WST uses the first option, distinguishing between processes and technologies because essentially the same process can be performed with different technologies, such as different brands of computers or different versions of software. In relation to sociomateriality, the efficiency and/or effectiveness of a process may or may not depend on which brand or version is used. Switching from one word processor to another version may not affect the process of writing a book, whereas upgrading from an old PC may allow use of software that enables new process capabilities, greater efficiency and effectiveness, and new understandings of the technology-in-practice.

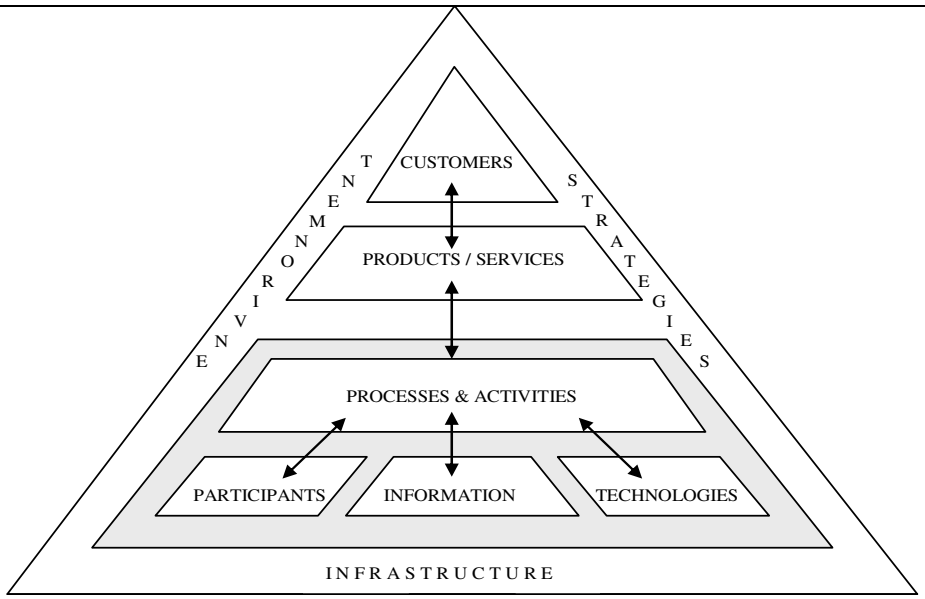

Figure 1. Work System Framework (Alter, 2006, p. 13; 2008, p. 461)

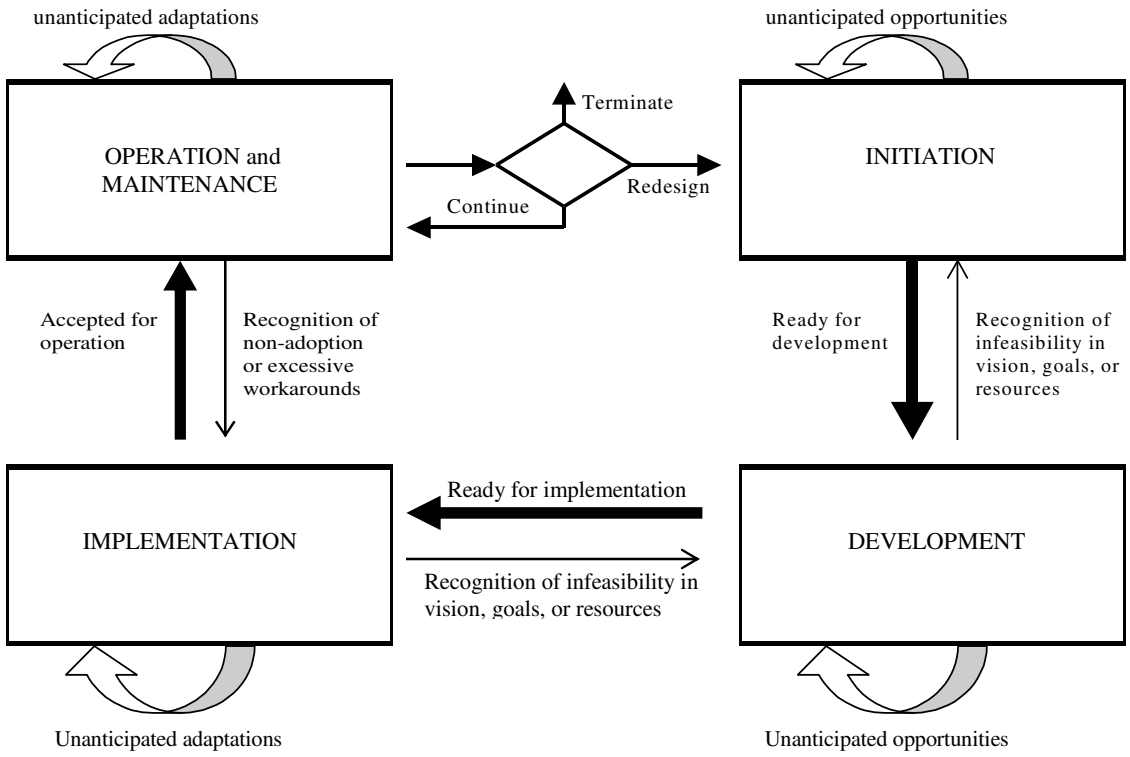

Figure 2. The Work System Life Cycle Model (Alter, 2006, p. 91; 2008, p. 467)

Dynamic View of a Work System

Work System Life Cycle Model (WSLC). Figure 2 says that work systems change over time through iterations involving planned and emergent change. (Alter, 2006; 2008). Planned change occurs through defined projects in which resources are allocated to create a work system or change aspects of an existing work system. Emergent or unplanned change occurs through incremental adaptations and workarounds as work system participants try to minimize or bypass obstacles that interfere with expeditious achievement of work goals.

The WSLC represents planned change as projects that include initiation, development, and implementation phases. Development involves creation or acquisition of resources, e.g., software development, acquisition, or configuration and creation of procedures, documentation and training materials needed for implementation of the new version of the work system. Implementation means implementation in the organization, not implementation of algorithms on computers.

Figure 2 uses inward-facing arrows to represent emergent change such as ongoing adaptations, workarounds, and experimentation, all of which do not involve separate allocation of significant project resources. The inward-facing arrow for the operation and maintenance phase also represents emergent changes in practices or goals that occur over longer periods without explicit planning. The inward-facing arrows for development and implementation phases of formal projects represent emergent changes in intentions, designs, and plans based on insights after the initiation phase.

DIVERGENCE BETWEEN SOCIOMATERIALITY AND WORK SYSTEM THEORY

The ephemeral character of sociomateriality is a challenge for any attempt to unravel it or its temporal nature. Orlikowski and Scott (2008) does not define sociomateriality specifically, but instead treats it as an "umbrella term" for a genre of research that challenges "the deeply taken-for-granted assumption that technology, work, and organizations should be conceptualized separately." That genre of research "advances the view that there is an inherent inseparability between the technical and the social." (p. 434). It associates this stream with "sociomaterial assemblages" because the "analytical gaze moves away from discrete entities of people and technology, or ensembles "of equipment, techniques, applications, and people" (Orlikowski and Iacono 2001) to composite and shifting assemblages." (p. 455). "From this perspective, people and things only exist in relation to each other .... In other words, entities (whether humans or technologies) have no inherent properties, but acquire form, attributes, and capabilities through their interpenetration." (pp. 455-456).

Sociomaterial vs. sociomateriality. Except in several direct quotations, the remainder of this paper will use the term *sociomateriality* to refer to concerns and assumptions of a genre of research whose view of social and technical worlds is summarized as "humans/organizations and technology are assumed to exist only through their temporally emergent constitutive entanglement." (p. 457) In contrast, the term *sociomaterial* will refer to topics and issues related to the everyday materiality that everyone encounters and recognizes when performing work or other activities.

WST recognizes sociomaterial topics and issues without assuming that humans and technologies have no inherent properties. WST assumes that a work system's identity, integrity, and capabilities are determined by its components, their characteristics, and their interactions, including possibly divergent perceptions of technologies-in-practice by different work system participants, designers, and managers. In effect, the work system is enacted based on interactions between human capabilities, knowledge, perceptions, motives, and intentions, on the one hand, and affordances and constraints of processes, information, and technology, on the other. WST recognizes the importance of perceptions and beliefs about technology in general and technology-in-use, but does not go so far as to adopt the metaphor of constitutive entanglement or the image of Escher's lithograph *Drawing Hands*, "where the right hand draws the left hand even as the left hand draws the right hand" (Orlikowski 2002, p. 251). WST avoids verbal and pictorial images of entanglement because it evolved to help business and IT professionals recognize the broad range of substitutions and variations that are possible, both in emergent change in which workarounds and adaptations attempt to overcome short term obstacles and in planned change in which projects attempt to modify a work system's form and function. The metaphor of recursive entanglement spirals inward, with actions enacting structures and structures guiding actions. In contrast, the goal of systems analysis and design is to spiral outward toward better systems.

TIME SPAN OF SOCIOMATERIALITY

The time span implied in sociomateriality generalizations is often unclear. For example, no clear time span is implied by constitutive entanglement in general and by phenomena such as structural contours of social life (Feldman and Orlikowski 2011, p. 4), the inherent inseparability of the social and the technical (Orlikowski and Scott 2008, p. 456), and ways in which "things, technologies, people, and organizations do not have inherently determinate meanings, boundaries, or properties" (Cecez-Kecmanovic et al. 2011). Do these phenomena vanish an instant after they occur, or do they persist over years?

Consider field notes cited by Orlikowski (2006) in an article on "material knowing":

> "Dick and Jane come into the conference room in Facilities North East Building, and sit down at the table. Dick plugs in his laptop computer and tries to get onto the company Intranet .... Dick then turns on the Polycom phone on the table and dials into the conference call. ... The meeting lasts 45 minutes. ... At the end of the meeting, there are lot of beeps as people shut off their Polycoms and get off the conference call. There are no goodbyes. Dick unplugs his laptop and his connection to the network, and he and Jane leave the conference room."

Participants in this meeting depended on affordances of technologies including laptops, the Intranet, Polycom phones, and so on. When the meeting ended, they left and moved to other concerns. It seems exaggerated to say that they and the technologies were constitutively entangled or that technologies in the meeting coproduced the structural contours of social life. The virtual meeting depended on affordances of technologies and was constrained by their limitations during its 45 minutes of existence. However, it is certainly possible that other technologies might have been used to accomplish similar objectives. Substitutability of that type does not support general statements that the social and the technical are inseparable.

The example of Google search adds another wrinkle related to much longer time spans. According to Orlikowski and Scott (2008, p. 465), "a web search conducted with the Google search engine is sociomaterial 'all the way down,' entailing computer code written and updated by software engineers, executing on computers (configured with particular hardware and software elements which were designed and built by computer engineers and production workers), and whose operation depends on the millions of people who use computers to create and update Web pages every day, and millions of people around the world ..." who use their computers to obtain search results. For Dick and Jane, the constitutive entanglement occurred during a 45 minute virtual meeting. For Google search, millions of people are involved directly or indirectly, often through artifacts such as computer programs, web pages, or posted documents that they haven't seen or considered in months or years. In both cases, one might wonder about the meaning of the "view of social and technical worlds" in sociomateriality, as summarized in Orlikowski and Scott (2008, Table 10.5, p. 457): "humans/ organizations and technology are assumed to exist only through their temporally emergent constitutive entanglement."

SOCIOMATERIAL ISSUES IN FOUR EXAMPLES WITH DIFFERENT TIME FRAMES

This section summarizes situations from four recent papers that cover different time frames (minutes–to–hours, days–to-weeks, months-to-years) and whose case-related empirical findings are strongly tied to sociomaterial issues. A combination of human and nonhuman agency is important in all four situations. Taken together, the examples show that sociomaterial phenomena occur across different time frames. Ideally, a theory of sociomateriality should take into account different effects and time frames. The minutes-to-hours time frame involves improvisations responding to immediate, and often transient obstacles. The days-to-weeks time frame benefits from the results of previous improvisations and affords more deliberation about how to eliminate persistent obstacles. The months-to-years time frame allows for formal projects that may or may not consider causes and results of improvisations within shorter time frames. It is not clear whether generalizations about the inseparability of the social and technical are valid or relevant in the same way across these time spans.

Minutes and Hours: Workarounds in a Nursing Ward

Koppel et al. (2008) describes an extensive multi-hospital study of workarounds by nurses using state-of-the-art barcode medication administration (BCMA) technology designed to assure administering the right medication and dose to the right patient at the right time by matching patient bar codes and medication bar codes to medical orders. This study viewed deviations from BCMA-use protocols as deviations or violations in which staff actions "do not follow explicit or implicit rules, assumptions, workflow regulations, or intentions of system designers." The authors collected data through direct observations and interviews. Reflecting sociomaterial issues in action, they identified 15 types of workarounds, such as affixing patient identification barcodes to computer carts, scanners, doorjambs, or nurses' belt rings; carrying several patients' pre-scanned medications on carts; giving a partial dose that is recorded as a full dose; disabling audio alarms on the bar code device. They identified 31 types of causes of workarounds, such as "unreadable medication barcodes (crinkled, smudged, torn, missing, covered by another label); malfunctioning scanners; unreadable or missing patient identification wristbands (chewed, soaked, missing); ..." Nurses overrode BCMA alerts for 4.2% of patients charted and for 10.3% of medications charted. Possible consequences include wrong administration of medications, wrong doses, wrong times, and wrong formulations.

The workarounds within this study fall primarily in the minute-to-hour time frame. Most involve issues that became evident at the time when the BCMA system was used and often were due to "deficiencies in system or workflow design." Most were

not longer-term adaptations that became part of organizational routines. The authors conclude that integrating BCMAs within real-world clinical workflows requires ensuring that safety features are used as intended and that systems are designed to support this use. Furthermore, "compliance with patient safety protocols is best achieved by configuring BCMAs for efficient as well as safe patient care."

Sociomaterial issues in causes of workarounds. Koppel et al. (2008) divided causes of workarounds into five categories that were described as technology related, task-related, organizational, patient-related, and environmental. Not shown here is re-classification of the causes using elements of the work system framework. In addition to providing a clearer set of categories, the re-classification provides a substantially finer-grained view of causes than would be generated by traditional distinctions between human vs. machine agency. System designers probably did not assume that the materiality of sizes of patients' room would affect the ability to use BCMA technology correctly or that willful interference by patients might occur.

Days and Weeks: Workarounds of Espoused ERP Requirements by Process Gatekeepers

In Berente et al. (2010), an order attainment and fulfillment process was implemented in a large multinational manufacturing firm that produces specialized products involving customer-specific configurations and custom installations. That process was designed to improve customer service, which had suffered due to incomplete information early in the ordering process. Many salespeople were not complying with expectations that they would generate quotations using an ERP system, would enter sales orders into ERP, would verify product configurations, implementation costs and pricing, and would make sure that necessary agreement details and associated paperwork were collected completely. The initial planning for this process assumed hiring of administrative personnel to help with the data entry. Because that never happened, data entry tasks fell to the salespeople, who were more interested in performing sales work than entering complex orders into computerized forms.

The analysis in Berente et al. (2010) focuses on cooperation between sales people and support staff who were supposed to serve as process gatekeepers. "Once an order has been placed by a salesperson, an administrative person, known as the 'Product Support Specialist' or 'PSS' verifies that the orders are properly configured and that all procedural steps have been met before approving the order and transferring it to the manufacturing group. Although the name of the position implies product support, the actual role of the PSS might be better described as an order checker. A single PSS typically works with dozens of sales people in hundreds of accounts across multiple states."

Many salespeople did not comply with the prescribed process and used ERP software in ways that violated its internal logic. Some salespeople tried a cloning process to enter multiple orders that would go to different locations within the same customer firm. That error-prone workaround disrupted downstream activities and caused extra paperwork for manufacturing and accounts receivable functions. Salespeople also bypassed order expediting capabilities in ERP because processes related to those capabilities cause delays of a day or more that made those capabilities inadequate for rush orders. Bypassing those expediting capabilities involved using personal networks of contacts in manufacturing and elsewhere in the organizational hierarchy.

Berente et al. (2010) observed how different relationships between salespeople and product support specialists led to different outcomes in a process that might have been seen essentially as a routine use of technology. Salespeople often asked their PSS to help in entering orders, a direct violation of the prescribed process, especially since there might be no one to cross check the orders if the PSS made a mistake. Some PSSs helped salespeople and earned trust from them. Many salespeople indicated that the flexibility of their PSS help them comply with the order attainment and fulfillment process. Other PSSs viewed data entry as a salesperson's responsibility, and sometimes were viewed as "difficult" by their salespeople. In other words, different specialists performed the same PSS role differently.

Sociomaterial issues in using ERP for order processing. The materiality of the technology caused problems for salespeople because ERP capabilities often fit poorly for complex orders that salespeople wanted to enter efficiently. The prescribed process for expediting orders caused a delay. Practices that emerged from social aspects of the situation included varying degrees of support from PSSs. The support was inconsistent with prescribed processes, but nonetheless helped salespeople accomplish goals. Aspects of this situation could be viewed as an interplay of inconsistent human agency and material agency of technologies, information, and processes. Days-to-weeks seemed to be the time frame for understanding recurrent adaptations, negotiations, and workarounds that led to inconsistent enactment of processes for entering, checking, and expediting orders using software that had been in place for five years.

Months and Years: Emergent Change in Design Testing in an Automotive Engineering Group

The first two examples involved the minute-to-hour and day-to-week time frames. Sociomaterial effects in the next two examples occurred in the months-to-years time frame.

Leonardi (2011) reports on a lengthy process during which an automobile company's design engineers progressed through five iterations of work systems for analyzing crashworthiness. Leonardi's extensive discussion of the imbrication of human and material agencies emphasizes the interplay over time between affordances and constraints of technology. While he describes this as a sequence of five "imbrications" of human and material agency, in work system terms these are five successive versions of a work system for evaluating crashworthiness of an automobile that is being designed. These versions operated between 1995 and 2006. In version #1, engineers used finite element modeling tools whose results were not presented or analyzed systematically. Engineers launched a three-year project to develop better tools that could be used more systematically. Those tools plus efforts to standardize engineering work led to version #2, which included documentation of how engineers should set up and analyze crashworthiness models. Version #3 automated the flow of steps in building models, thereby reducing delays before producing results. Version #4 used automated tools to help engineers compare and coordinate their analyses, leading to higher levels of communication between engineers about results generated using their models. Version #5 helped engineers plot results from multiple iterations of models on a single chart. It became increasingly possible to code, analyze, and compare data that different engineers generated.

Sociomaterial issues in the evolution of work systems for crashworthiness analysis. As Leonardi (2011) explains, human and material agency played key roles in a path that included five separate imbrications of human and material agencies. This evolution unfolded over 11 years and involved significant software development projects. New technical capabilities led to new affordances that made the work system for crashworthiness analysis more effective. Each improvement led engineers to recognize new constraints that never mattered in the past and that could be overcome by new technical improvements. Shortcomings in the initial work system led to initiation of a project (see Figure 2) that eventually led to the next version, whose shortcomings eventually led to the subsequent version. While it is possible to describe this as a process of emergent change, clearly the emergent changes involved a great deal more than incremental adaptations, workarounds, and improvisation. This long term evolution involved a series of formal projects whose deliverables were incorporated in the next version of the work system.

Looking at Leonardi's (2011) imbrication sequence in substantially more detail might lead to a finer-grained view of human and material agency across the 11 years. Specifically, careful use of the elements of the work system framework might identify aspects of many different types of agency (not just human and material agency), thereby potentially unraveling sociomaterial issues to a greater extent than the imbrication perspective. The different types of agency related to elements of the work system framework include:

- agency of customers (who demand particular levels of cost and quality)
- agency of products/services (which, in effect, demand specific forms and levels of production capabilities)
- agency of processes (whose sequence and business rules force or guide participants to act in certain ways)
- agency of participants (who perform work based on their personal capabilities, needs, emotions, and intentions)
- agency of information (which may impel or constrain action based on its content and expression in the world)
- agency of technology (in the guise of tools that add to users' capabilities or as automated agents that perform work autonomously)
- agency of various aspects of the environment (which affect whether the work system can operate efficiently and effectively).

Months and Years: Disruptive Change by Moving from Analog to Digital Infotainment Products in Automobiles

Svahn et al. (2009) reports on cases of disruptive change in the automobile industry in which two automobile companies switched from analog infotainment systems to digital infotainment systems for their new models. These changes involved much more than a change in technology because processes and social relations that automobile companies used for specifying and sourcing analog infotainment systems differ substantially from processes and social relations that fit with more flexible digital systems. For analog infotainment systems, these processes were designed around a component-based modularity, which required hierarchical control over suppliers of amplifiers, radios, and CD players, each of which remained separate physical entities that were connected through proprietary networks, protocols, and harnesses. Tight physical integration between the components made it difficult to upgrade analog infotainment systems after cars were sold. In

contrast, digital infotainment systems brought the possibility of greater flexibility in the initial customer offering and in subsequent upgrades.

The switch from analog to digital required a different approach to product specification. As the companies launched their digital infotainment initiatives, "a potentially service-oriented approach - characterized by a combination of extensive, generic communication capacity and object-oriented, event-driven computing - was about to be applied in a domain based on component-based modularity." In both cases, the auto manufacturers recognized that the old ways of specifying and sourcing infotainment systems did not fit the realities of creating digital systems. With the digital systems, less of the functionality existed at the component level, and more existed at the system level. Since many detailed design choices could be deferred to a time closer to the point of auto assembly, the upfront specification of component details was replaced by many iterations of communication between designers who controlled the overall digital architecture and suppliers who had to fit into that architecture. Svahn et al. (2009) reports that many potential benefits were not accomplished, partly because of unanticipated difficulties in moving to the new digital logic.

Sociomaterial issues in the design and production of digital entertainment systems. Svahn et al. (2009) examined "how the existing sociomateriality established with the materiality of hardware-centric component-based modularity responded to the designers attempts to introduce a new form of materiality, based on software centric service-based modularity." ... "Social structures of the organizations were deeply entangled with the materiality of component-based modularity. The established sociomateriality resisted engineers efforts to introduce service-oriented modularity. Consequently engineers had to accommodate the principles [of the new digital system] through a continuous compromise in adaptations of materiality, creation of new design practices, and establishment of new social structures."

The work system framework and WSLC provide a way to report the same situation as a story about disruptive change in going from a previous version of a work system to a new version. The narrative in Svahn et al. (2009) explains some of the ways in which aspects of the required changes were recognized at the outset even though the magnitude of the changes, including its impact on social structures, was not appreciated until later.

A work system approach would use aspects of WST to summarize and evaluate the current work system, including whether current processes, participants, information, and technology were appropriate for producing a different type of product in the form of a negotiated specification of a digital infotainment system. That approach would surely address many sociomaterial issues because the internal links within the work system framework say that process, participants, information, and technology should be aligned and that mutual adjustment may be required. As applied to the infotainment example, that approach would quickly highlight the fact that the new product would be different from the old product and therefore that the process, technologies, and information for producing the new product would also be different. In turn, that would raise questions about whether and how the work system for producing analog infotainment systems should have been modified to create a more appropriate work system for digital infotainment systems.

WHAT DO THE EXAMPLES SAY ABOUT THE "TEMPORALLY EMERGENT CONSTITUTIVE ENTANGLEMENT" OF HUMANS, ORGANIZATIONS, AND TECHNOLOGIES?

This paper approached sociomateriality from a perspective not usually associated with that genre of research. It applied a work system perspective for describing sociomaterial issues from the viewpoint of fit and interaction rather than entanglement and inseparability. Its exploration of the temporal nature of sociomateriality was based on two examples from Orlikowski (2006) and four other examples from the recent literature. The distinction between static and dynamic views of a work system (Figures 1 and 2) supported a way to look at temporal issues, an area in which the sociomateriality discourse tends to be vague. The approach to temporal issues used the static view to identify a work system at a point in time and the dynamic view to describe how it changed over time. In each example, a lengthier discussion could have filled in many more details based on WST and its extensions.

This paper's coverage of the six situations leads to a number of conclusions and implications about sociomateriality and its temporal nature.

Sociomaterial or sociomateriality? It is obvious that sociomaterial issues are relevant in all of the cases. In every situation, the courses of action and the outcomes depend on the ways in which work system participants perceive and respond to the materiality of the shared fields of work that confront them. In all cases, important aspects of their perceptions and responses are related to their understandings of technology-in-practice. In cases such as the nurses using the BCMA technology, the materiality is largely physical; in the infotainment systems it is partially physical and partially digital; in the crashworthiness example it can be described as "digital materiality" (Leonardi, 2010).

While sociomaterial issues are relevant, the assumptions of sociomateriality that this paper has mentioned several times are not supported strongly. Courses of action in each situation depended on a combination of factors including the capabilities and features of technologies; the participants' knowledge, incentives, and goals; their personal and shared understandings of the available methods and technologies; practices and resources for doing the work; and the situational factors that were seen as obstacles to be overcome. Describing that combination of factors as "constitutive entanglement" seems overstated. Similarly for assumptions about the "inherent inseparability of the social and the technical." It seems simpler and more direct to appy a WST perspective, whereby inherent properties associated with people, processes, and technologies can be described (with varying degrees of agreement) and are relevant, but certainly are not sole determinants of human decisions about what to do under particular circumstances. Other key determinants are found in the web of understandings and practices within which people use technologies to accomplish their personal goals and those of their organizations. The high level of effort needed to understand and describe shifting perspectives and emergent responses and arrangements within that web of understandings and practices does not imply that the social and technical are inseparable.

Temporal nature of sociomaterial phenomena. In combination the six cases reveal differences between sociomaterial phenomena in different time spans:

- In the minutes-to-hours time span (the virtual meeting and nursing examples) sociomaterial concerns were addressed through adaptations, bricolage, improvisation, and workarounds in an attempt to meet immediate goals.
- In the days-to-weeks time span (sales order example), sociomaterial concerns led to the emergence of new, informal work patterns that conflicted with prescribed roles and responsibilities but generally seemed to have beneficial results.
- In the months-to-years time span (Google, crashworthiness, and infotainment examples), sociomaterial concerns led to identification of changes in IT requirements that became the basis of new capabilities implemented through formal projects.

The many sociomaterial issues in the short, medium, and long-duration examples can all be described and explained using the relatively simple language of the work system life cycle model, which was developed to encompass the entire gamut from short-term adaptations and workarounds through emergent and planned change. Elaborating the work system life cycle in a way that incorporates improvisation, adaptations, and workarounds more clearly may provide a basis for describing and explaining those topics in greater depth. Ongoing research in that area uses WST as a basis for understanding a broader version of the types of phenomena that are discussed in relation to organizational routines.

Temporal nature of sociomateriality. The step from sociomaterial factors to sociomateriality is unclear in relation to temporality. Most of the frequently repeated assumptions of sociomateriality (constitutive entanglement, inseparability, etc.) come without a time span, leaving it unclear whether those assumptions are related to a point in time or an extended period. An interesting qualification appears in the way Orlikowski and Scott (2008) include time in their phrase, "temporally emergent constitutive entanglement." Attention to the temporal leads to questions such as how to determine whether constitutive entanglement at a particular instant is different from constitutive entanglement at another instant. Another question is whether constitutive entanglement is perpetual, i.e., that the settings may change through a day or other time span, but that people are always constitutively entangled in the situations in which they work and live. At minimum, the ambiguity about the intended time span of sociomateriality assertions related to constitutive entanglement, inseparability, and indissolubility should be clarified. It should be clear whether these statements are about phenomena that occur instantaneously or in time spans of minutes-to- hours, days-to-weeks, or months-to-years.

This paper covers part of a larger attempt to combine aspects of a work system lens and a sociomateriality lens in order to understand and integrate temporality, agency, workarounds, emergence, and technological affordances in the context of systems in organizations. If successful, that attempt could contribute to the further development of both WST and sociomateriality. The discourse on sociomateriality is fascinating, but highly abstract and difficult to apply to everyday practice. This paper's links between work system perspectives and sociomaterial factors and its identification of different times spans for sociomaterial phenomena could be a step toward methods for applying those ideas in practice.

REFERENCES

1. Alter, S. (2006) *The Work System Method: Connecting People, Processes, and IT for Business Results*, Larkspur, CA: Work System Press.

2. Alter, S. (2008) "Defining Information Systems as Work Systems: Implications for the IS Field." *European Journal of Information Systems*, 17, 5 448-469.
3. Alter, S. (2010) "Bridging the Chasm between Sociotechnical and Technical Views of Systems in Organizations," Proceedings of ICIS 2010, the 31st International Conference on Information Systems.
4. Berente, N., Ivanov, D, and Vandenbosch, B. (2010) "Process Gatekeepers and compliance with enterprise processes," *Business Process Management Journal*, 16, 3, 394-419.
5. Bourdieu, P. (1990) *The Logic of Practice*, Stanford University Press, Stanford, CA.
6. Cecez-Kecmanovic, D. Galliers, B., Henfridsson, O., Newell, S., and Vidgen, R. (2011) "Call for Papers, MISQ Special Issue On Sociomateriality of Information Systems and Organizing," Call for Papers," *MIS Quarterly*, http://www.misq.org/skin/frontend/default/misq/pdf/CurrentCalls/SI_Sociomateriality.pdf
7. Feldman, M. and Pentland, B.T. 2003. "Reconceptualizing Organizational Routines as a Source of Flexibility and Change," *Administrative Science Quarterly*, 48,1, 94-118.
8. Feldman, M. and Orlikowski, W. (2011) "Theorizing Practice and Practicing Theory," *Organization Science,* 22,5, 1240-1253. Draft manuscript, viewed Feb.10, 2012 at http://hdl.handle.net/1721.1/66516. Note: In text references are to manuscript, not final pagination.
9. Giddens, A. (1984) *The Constitution of Society*. Cambridge, UK: Polity Press.
10. Gregor, S. (2006) "The Nature of Theory in Information Systems," *MIS Quarterly*, 30, 3, 611-642.
11. Koppel, R., Wetterneck, T., Telles, J. L., and Karsh, B-T. (2008) "Workarounds to barcode medication administration systems: their occurrences, causes, and threats to patient safety," *Journal of the American Medical Informatics Association*, 15,4, 408-423.
12. Leonardi, P.M. (2010) "Digital materiality? How artifacts without matter, matter," *First Monday*, 15, 6, viewed on Apr. 10, 2012 at http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/3036/2567
13. Leonardi, P. M. (2011) "When Flexible Routines Meet Flexible Technologies: Affordance, Constraint, and the Imbrication of Human and Material Agencies," *MIS Quarterly*, 35,1, 147-167.
14. Orlikowski, W.J. and Iacono, C. S. (2001) "Research Commentary: Desperately Seeking the "IT" in IT Research - A Call to Theorizing the IT Artifact," *Information Systems Research*, 12,2, pp. 121-134.
15. Orlikowski, W. J. (2002) "Knowing in practice: enacting a collective capability in distributed organizing. *Organization Science*, 13, 3, 249–273.
16. Orlikowski, W. J. (2006) "Material Knowing: the scaffolding of human knowledgeability," *European Journal of Information Systems*," 15, 460-466.
17. Orlikowski, W. J., and Scott, S. V. (2008) "Sociomateriality: Challenging the Separation of Technology, Work and Organization," *Academy of Management Annals*, 2, 1, 433-474.
18. Svahn, F., Henfridsson, O., and Yoo, Y. (2009) "The Threesome Dance of Agency: Mangling the Sociomateriality of Technological Regimes in Digital Innovation," *ICIS 2009 Proceedings*, Paper 5.
19. Woolgar, S. (2002) "After Word: On Some Dynamics of Duality Interrogation," *Theory, Culture and Society*, 19,5/6, 261-270.