2010

Design Spaces for Sociotechnical Systems

Steven Alter
University of San Francisco, alter@usfca.edu

DESIGN SPACES FOR SOCIOTECHNICAL SYSTEMS

Journal:	*18th European Conference on Information Systems*
Manuscript ID:	ECIS2010-0030.R1
Submission Type:	Research Paper
Keyword:	Socio-technical approach, Work redesign, Systems analysis and design/development, Design/design science

DESIGN SPACES FOR SOCIOTECHNICAL SYSTEMS

Alter, Steven, University of San Francisco, School of Business and Professional Studies, 2130 Fulton Street, San Francisco, California, 94117, USA. alter@usfca.edu

Abstract

This conceptual paper is a step toward bridging the gap between thinking of systems as tools that are used and thinking of systems as sociotechnical systems with human participants. Its description of design spaces for sociotechnical systems applies a work system perspective. Its theory of sociotechnical design encompasses planned and unplanned change in those work systems. Its overall approach supports analysis and design at various levels of depth without implicitly biasing the result toward non-technical or technical aspects of the situation.

The work system approach to sociotechnical design provides a path for going far beyond simple relationships between function and form. This paper summarizes aspects of that path, including:

- *Framework for summarizing work systems within organizations;*
- *A theory of sociotechnical design;*
- *Decomposition of work systems into subsystems and their interactions;*
- *Parallel application of multiple design spaces organized around work system elements.*

The paper concludes by listing advantages of its approach to sociotechnical design.

Keywords: sociotechnical systems, sociotechnical design, systems analysis and design, work systems

1 DESIGNING TOOLS OR DESIGNING SOCIOTECHNICAL SYSTEMS WITH HUMAN PARTICIPANTS?

The IS field is ambivalent about whether information systems are sociotechnical systems. On the one hand, sociotechnical concerns appear prominently in IS literature from authors strongly associated with sociotechnical issues (e.g, Cherns, Mumford, Trist, Pasmore, Avison, Fitzgerald, Bostrom, Majchrzak), system thinking (e.g., Ackoff, Ashby, Checkland, Churchman), social informatics (e.g., Kling) and implementation in organizations (e.g., Markus, Robey, Zmud). On the other hand, typical systems analysis and design textbooks basically treat "the system" as a technical object that is "used" by users. For example, in a summary of the design phase of the SDLC, Hoffer et al (2008, p. 13) say "analysts must design all aspects of the system, from input and output screens to reports, databases, and computer processes." Similar statements appear in Kendall and Kendall (2008, p. 13), Dennis et al. (2002, p. 7), and Mathiassen et al. (2000, p. 7). The Aims and Objectives page of the web site for IFIP Technical Committee 13 on Human Computer Interaction adopts a similar view by referring to system usability, human-oriented computer systems, and "modeling the user as an aid to better system design." (IFIP TC.13, 2009) The widely cited IS Success Model proposed by DeLone and McLean (1992) also views "the system" as a technical artifact that is used by users when it says that "system quality and information quality singularly and jointly affect use and user satisfaction."

This conceptual paper is a step toward bridging the gap between thinking of systems as tools that are used and thinking of systems as sociotechnical systems with human participants. It proposes a new way to address challenges articulated in the first paragraph of the call for papers for a sociotechnical insights workshop at INTERACT 2009, the annual IFIP conference on human-computer interaction:

> The translation of social knowledge into design decisions is not a simple problem, but one that requires a redefinition of disciplinary boundaries and the subject and object of interaction design. Addressing this socio-technical gap requires a fresh look at how diverse areas of the social sciences explore and conceptualise the relation between people, society and technology under the rubric of 'sociotechnical'. (Sociotech-ID 2009)

This paper's new approach is to identify a series of design spaces for sociotechnical systems based on a work system perspective rather than a tool perspective. Those design spaces include both human and technical considerations. Given its 12-page length limit, this paper cannot provide pages of references to a broad and diverse swath of relevant literature while also explaining a number of new ideas. Therefore its main goal is to present a work system perspective on sociotechnical design rather than to justify that approach in relation to multiple disciplines. It is organized as follows:

- It summarizes basic work system concepts that are related to sociotechnical design.
- It proposes a general theory of sociotechnical design.
- It summarizes a work system approach to sociotechnical design.
- It summarizes three design spaces that are organized using work system concepts.
- It summarizes the advantages of a work system approach to sociotechnical design.

Integrating non-technical and technical. This paper assumes that sociotechnical systems should be viewed as integrated systems that can be understood and designed using concepts and methods from social and technical disciplines. The latter assumption diverges from some sociotechnical literature. For example, Hirschheim and Klein's (1994) summary of Mumford's ETHICS (Effective Technical and Human Implementation of Computer Systems) method (Mumford and Weir, 1979) describes social and technical analysis as separate efforts that converge where design decisions are made.

In general, sociotechnical design should apply any relevant knowledge, including formal knowledge from social science and computer science and informal knowledge from the practical experience of business and IT professionals. That knowledge combines divergent approaches to design. Non-technical approaches tend to focus on intentions, guidelines, and directions, broadly stated as descriptions of desired form, function, and level of performance. Technical approaches emphasize completeness and precision in identifying components and their interactions, analyzing actual or potential behavior of systems, and identifying system modifications that might generate better performance.

Sociotechnical design should take advantage of both approaches while recognizing their inherent limitations in a sociotechnical realm. Non-technical design without details is meaningful in its own terms, but requires technical engineering efforts if software and other technical artifacts are to play important, predictable roles. Conversely, viewing sociotechnical systems solely from a technical perspective is highly error-prone due to the inconsistency and human foibles of participants in sociotechnical systems. Design of these systems also needs to reflect the dynamic nature of organizations, and how they change over time through a combination of planned and unplanned change. The evaluation of sociotechnical designs should include evaluation of how those designs will tolerate, support, or promote future combinations of unplanned or planned change.

2 WORK SYSTEMS AS THE UNIT OF ANALYSIS AND DESIGN

The basic ideas of the work system approach have been presented in a number of times (Alter (2003, 2006a, 2008a, 2008b)). Figure 1 shows the work system framework, which identifies nine elements that should be considered in even a rudimentary understanding of a work system. Past and current research (Alter (2006b), Petkov and Petkova (2006), and Truex and Alter (2010) discusses use of the work system framework and related ideas by hundreds of undergraduate, MBA, and Executive MBA students in different universities. The second central framework of the work system approach is the work system life cycle model (Figure 2), which summarizes how work systems change over time.

Definition of work system. A work system is a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal or external customers. Typical business organizations contain work systems that procure materials from suppliers, produce products, deliver products to customers, find customers, create financial reports, hire employees, coordinate work across departments, and perform many other functions. Almost all significant work systems in business and governmental organizations rely on IT in order to operate efficiently and effectively.

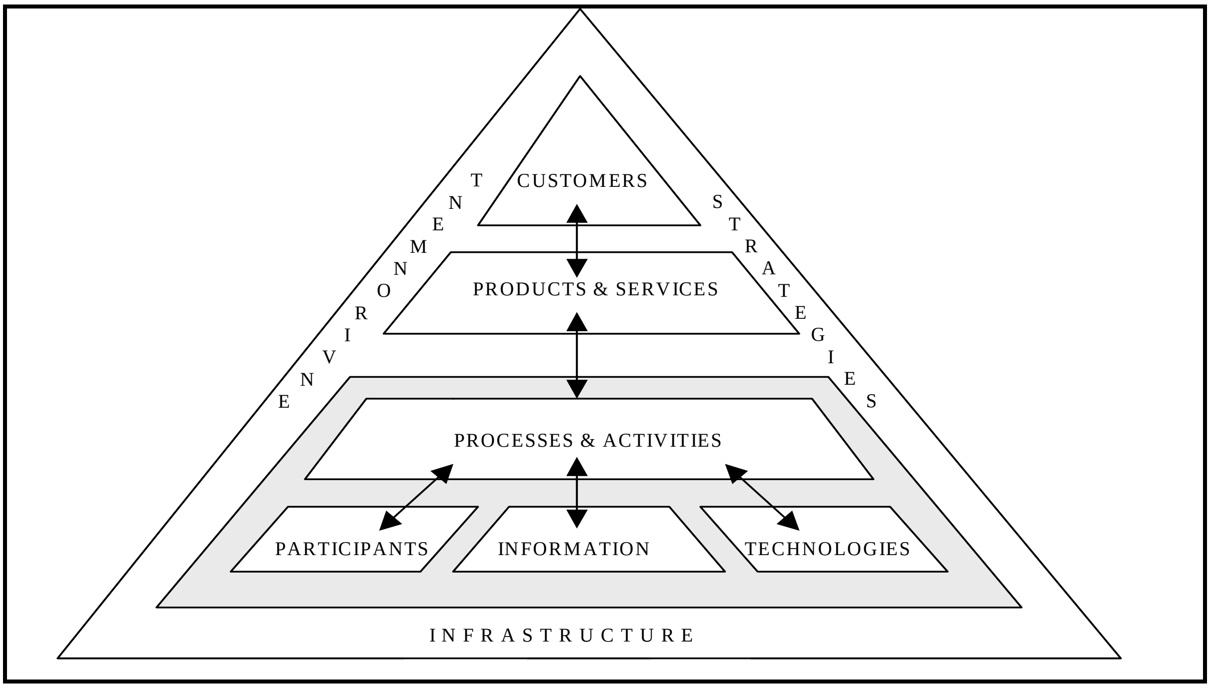

Figure 1. The Work System Framework. Alter (2008a, 2008b)

Work system is a general case for thinking about systems within or across organizations. Many special cases inherit the related concepts and body of knowledge. For example, information systems are work systems whose processes and activities are totally devoted to processing information. Supply chains are inter-organizational work systems whose goal is to provide supplies required for the operation of organizations that use whatever the supply chain produces. Rather than just being aligned with the work system, technologies are part it and are designed or configured as part of its design.

An entire enterprise or organization can be viewed as a work system. However, the analysis of a large organization (e.g., Toyota) as a single work system is impractical because too many different groups of people are doing too many different things. For meaningful analysis using a work system approach, most organizations should be decomposed into a set of work systems (rather than departments, economic input/output mechanisms, or accounting entities).

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 is designed to emphasize business rather than IT concerns. It covers situations that might or might not have a tightly defined business process and might or might not be IT-intensive. Careful definitions of each term (beyond the scope of this paper) would provide clarifications such as the possibility that customers can also be participants (e.g., in ecommerce work systems) and the fact that processes and activities include both highly structured workflows and semi-structured routines.

Work system life cycle model. In contrast with the static view in Figure 1, the work system life cycle model (WSLC) in Figure 2 outlines a work system's evolution over time through iterations of planned and unplanned change. Sociotechnical design occurs in each stage of the WSLC. Planned change in the WSLC is represented by projects that include initiation, development, and implementation phases. Consistent with Markus and Mao (2004), development involves creation or acquisition of resources required for implementation of desired changes in the organization.

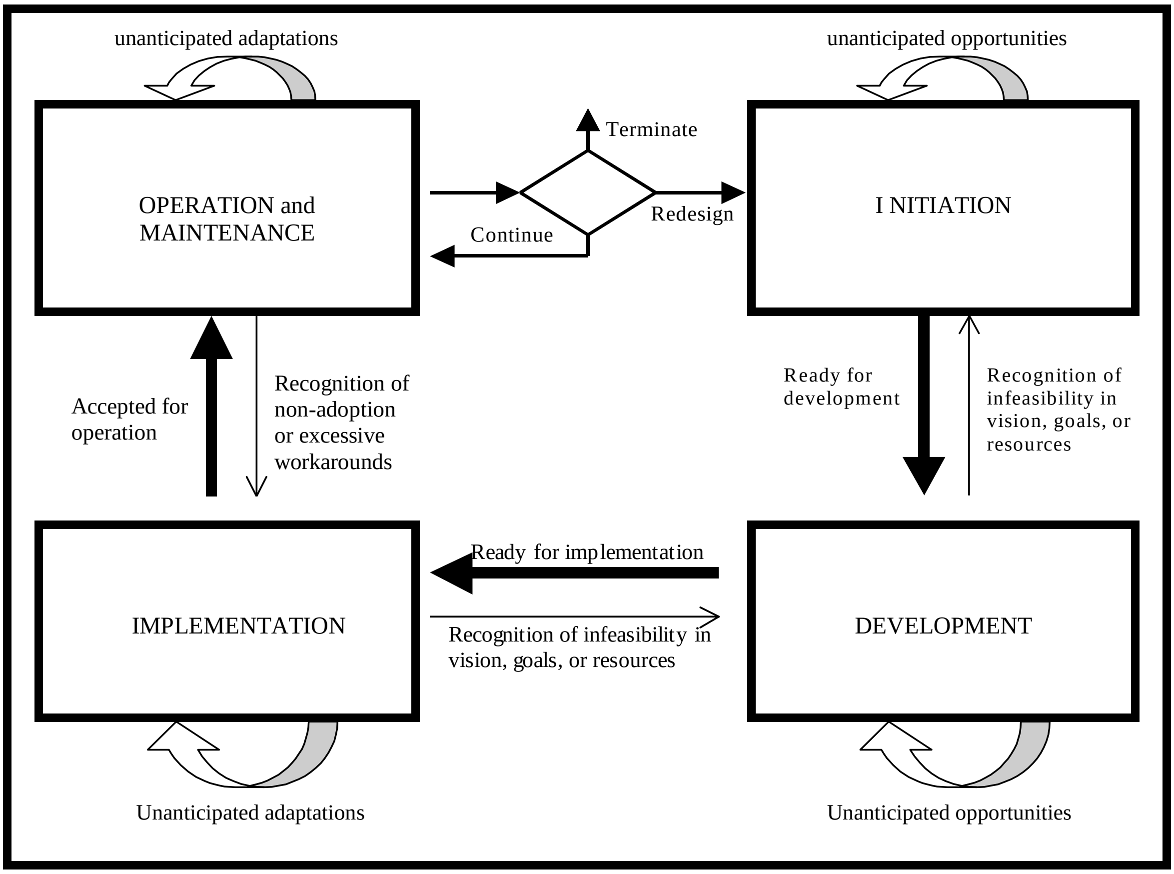

Figure 2. The Work System Life Cycle Model (Alter 2003, 2006, 2008a, 2008b)

Unplanned changes, represented by inward-facing arrows, are ongoing adaptations and experimentation that change aspects of the current work system or of ongoing work system projects without separate allocation of significant project resources. For example, the inward facing arrow attached to the operation and maintenance phase is about small work system changes that did not require formal projects or allocation of significant resources. The inward-facing arrows for development and implementation phases of formal projects represent emergent changes in intentions, designs, and plans based on insights and knowledge that were not considered in the initiation phase.

The WSLC differs fundamentally from the "system development life cycle" (SDLC), which is basically a project model rather than a system life cycle. (Even current versions of the SDLC that contain iterations are basically iterations within a project.) The system in the SDLC is a basically a technical artifact that is being programmed. In contrast, the system in the WSLC is a work system that evolves over time through multiple iterations. This evolution occurs through a combination of defined projects and incremental changes resulting from small adaptations and experimentation. Unlike control-oriented versions of the SDLC, the WSLC treats unplanned changes as part of a work system's natural evolution. A more detailed discussion of the WSLC appears in Alter (2006a).

3 A THEORY OF SOCIOTECHNICAL DESIGN

Figure 3 summarizes a theory of sociotechnical design that is consistent with the work system life cycle in Figure 2. The first two parts of Figure 3 highlight specific parts of the theory that are incorporated into the complete diagram in the third part. In terms of the five types of IS theory described in *MIS Quarterly* by Gregor (2006), this would be classified as a "theory for understanding."

Definition. Sociotechnical design is a set of activities that determine an organization or work system's requirements, which in turn determine its form and function, which in turn include what will be produced for customers and how the related work will be done within the social and technical context.

- Sociotechnical design starts from whatever is the current state of the relevant situation or system and its surrounding environment.
- Sociotechnical design occurs across all four phases of the WSLC (Figure 2). It occurs within the planning of major projects (planned change) and within emergent, incremental changes that occur without significant projects.
- Sociotechnical design includes both characteristic-oriented and goal-oriented analysis and design, and rigorous specifications needed to perform work accurately and consistently.

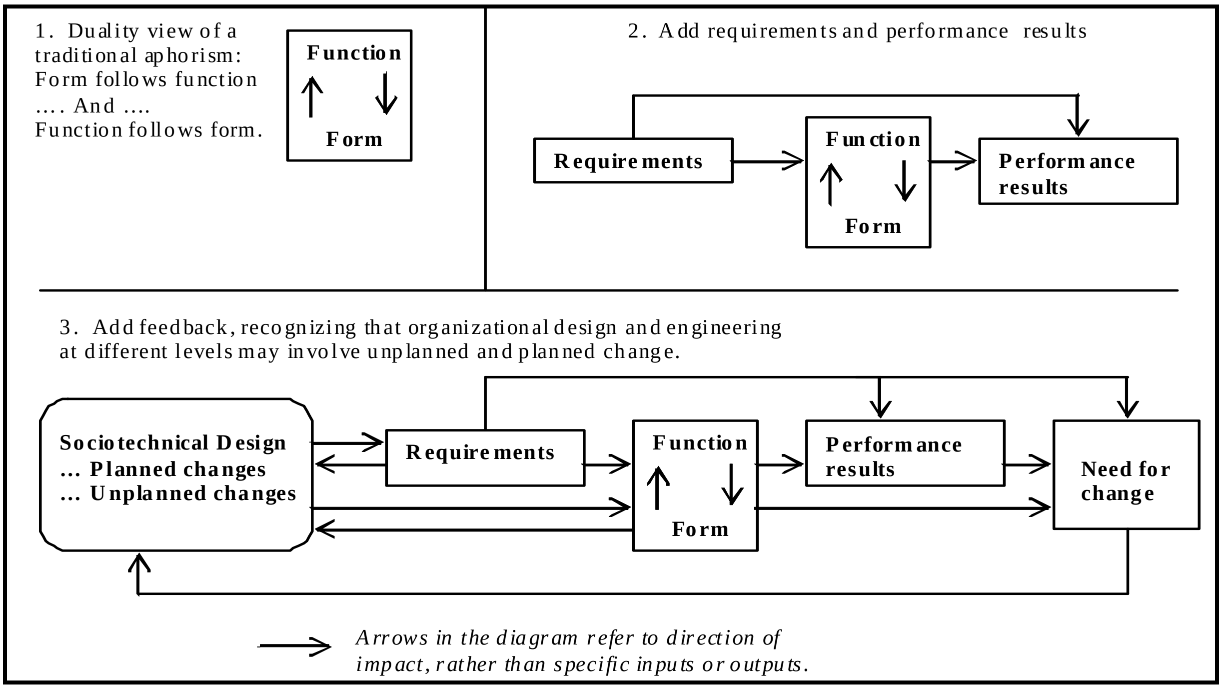

Figure 3: A Theory of Sociotechnical Design

Duality of form and function. (Part 1 of Figure 3) The architectural aphorism that "form follows function" (attributed to Sullivan (1896) by Wikipedia (2009)) also appears in organizational studies as a rationale for an organization's current form. The duality of function and form is more useful for sociotechnical design because it provides richer insights about change processes. Form follows function because an organization's form should be related to what it produces for its customers. Conversely, function follows form because form tends to constrain the effective design space as the organization changes over time. (e.g., Tyre and Orlikowski, 1994) Emergent and unplanned changes tend to be incremental; planned changes tend to be anchored in the current organizational form and have a high risk of relapsing into previous patterns. (Weick, 2000)

Requirements and performance results. The second part of Figure 3 introduces requirements and performance results. The current requirements for an organization or work system include what it is supposed to produce (function), how it is supposed to operate (form) and the level of performance it is supposed to attain. Function, form, and requirements strongly affect actual performance. In other words, two organizations with essentially similar function and form may generate different performance results due to differences in explicit or implicit requirements that combine aspects of performance goals, shared ambitions, organizational culture, and incentive systems.

Feedback. The third part of Figure 3 adds the observation that inadequate fit between function and form, requirements, and performance results creates a need for change, which provides the impetus for additional analysis and design activities that may modify requirements, form, and function. As represented by the inward-facing arrows in Figure 2, unplanned changes are often incremental and emergent, and may not require formal projects or approvals. Planned changes, and especially those that rely heavily on IT, usually occur through formal projects with discernible initiation, development, and implementation phases. In sociotechnical design, both planned and unplanned change may affect not only function and form, but also requirements concerning performance results and other issues. In addition, recent requirements and form and function affect current sociotechnical design efforts by influencing mental models of designers and expectations about what is reasonable and possible.

Need to look more deeply. The theory of sociotechnical design summarized in Figure 3 applies to any organization or work system and can be used in conjunction with many theories related to organizations and work. For example, Galbraith's (1973) theory about the relationship between information processing and uncertainty is consistent with Figure 3. A sociotechnical design process would consider environmental uncertainty and would use that evaluation to determine requirements related to function, form, and performance results. Form, function, and requirements would have an impact on performance results. Gaps between performance results and requirements would be the impetus for planned and/or unplanned change, some of which would address beliefs about the desired amount of information processing given the level of uncertainty.

While easy interpretability of theories of organization and work such as Galbraith's supports the potential validity of the theory of sociotechnical design in Figure 3, relationships between several variables are not sufficient as a basis for sociotechnical design. Effective sociotechnical design requires consideration and integration of a large number of topics and concerns without losing track of the big picture. A work system approach starting with the work system framework (Figure 1) provides a way to drill down while also maintaining a coherent view of the system as a whole. The next section shows how a work system approach to sociotechnical design leads in fruitful directions.

4 WORK SYSTEM APPROACH TO SOCIOTECHNICAL DESIGN

The theory of sociotechnical design in Figure 3 applies to organizations and to individual work systems that they contain. The remainder of this paper explains how a work system approach to sociotechnical design encourages a balanced path that keeps the business situation in focus while delving into technical details as needed. This form of sociotechnical design can be used with various purposes and at various levels of detail. It can be used by business professionals, executives, workers, and IT professionals whose goals and ideological viewpoints may be based on the entire gamut of interests ranging from competitive and managerialist concerns through workplace democracy and human relations. It can be summarized as follows:

- Sociotechnical design applies to organizations as a whole and to the work systems into which the organization can be decomposed.
- The analysis of most organizations and of large work systems within organizations usually requires decomposition into smaller subsystems that are also work systems.
- The work system framework (Figure 1) identifies nine elements required in even a rudimentary understanding of a work system. Sociotechnical design should attend to all of those elements.
- Planned and unplanned change at the work system level can be described using the work system life cycle model in its summary form (Figure 2) and more detailed forms.
- In essence, sociotechnical design encompasses the design of work systems and their interactions, from broad conceptual descriptions all the way to specifics of roles and responsibilities, division of labor between people and machines, specification of process flows and business rules, design of databases, and many technical details that IT specialists need in order to produce reliable software.

- Effective implementation of sociotechnical designs calls for effective integration between non-technical and technical descriptions.
- Sociotechnical design should reflect the inevitability of organizational change even though the existence of an organization implies at least some degree of enduring structure.

Certain points require additional explanation:

Decomposition of work systems into subsystems. The decomposition of an organization into work systems and of those work systems into subsystems should reflect the aspects of form and function that matter in the sociotechnical design effort. For example, if the goal is to improve the creation of value for customers, the decomposition should focus on illuminating the organization's value chain. If the goal is to make information processing, organizational communication, or high-level decision making more effective, the decomposition should emphasize work systems that focus on those topics. For example, consider a project related to an HR information system that plays a role in the following work systems: new employee in-take, employee performance reviews, resource access, employment termination, payroll, and employee benefits. The affected work systems all include information processing to some extent. The decomposition of the HR work system into smaller work systems should support the goals of the sociotechnical design effort. If the effort mostly concerns the HR value chain or the cycle from hiring to termination, the decomposition should focus on those topics. If the goal is to make information processing more effective, the decomposition should emphasize information processing steps even if some of those steps occur within other work systems.

Limits of decomposition. Individual work systems should be decomposed into subsystems if doing so will make it easier to understand and manage important issues and specifics of the situation. There is a point of diminishing returns, however. That point occurs where the action or activity within the work system is so simple as to be unworthy of further decomposition. Thus, the decomposition of work systems into smaller work systems might be viewed as semi-fractal because the same general structure of nine elements appears and reappears until the point where further decomposition is meaningless.

Artifacts generated by sociotechnical design. The theory of sociotechnical design summarized in Figure 3 makes no distinction between non-technical and technical aspects. Non-technical aspects are associated with intentions and directions, broadly stated as descriptions of desired form, function, and level of performance. Technical aspects are associated with completeness and precision in identifying components and their interactions, analyzing actual or potential behavior of systems, and identifying system modifications that might generate better performance. Table 1 uses six central elements of the work system framework to organize typical understandings and artifacts produced by non-technical and technical aspects of sociotechnical design.

Table 1. Understandings and artifacts generated by sociotechnical design

Work system element	**Non-technical design (guidelines, preferences, directions)**	**Technical design (detailed specifications of components and interactions)**
Work system as a whole	• mission and vision	• explicit work system boundaries
Participants	• incentives, interaction style	• organization chart • employee manual • location of offices to maximize interaction
Information	• characteristics of informational entities (e.g., invoices, orders)	• class diagrams • entity relationship diagrams • database schema
Technology	• affordances of specific technologies • characteristics and external appearance of technology • basic features of user interfaces	• network configuration • software documentation • hardware and software training manuals
Processes and activities	• characteristics and performance expectations for processes and activities	• workflows • business rules • policies and procedures
Products and services	• value that the customer receives	• exactly what the customer receives
Customer	• customer activities and responsibilities	• exactly what the customer must do to receive and use products and services

5 MULTIPLE DESIGN SPACES

Delving deeper into a work system approach to sociotechnical design reveals the existence of a number of separate design spaces that should be considered in a sociotechnical design effort. A sociotechnical design space can be defined as an organized, interrelated set of factors or topics that are amenable to design, that frequently affect system performance, and that therefore should be considered during the process of sociotechnical design.

This section presents three tables in the format of the work system snapshot to show some of the basic ideas in three of those design spaces. (A work system snapshot (Alter, 2008a, 2008b) is a basic tool in the work system method that helps business and IT professionals summarize the work system that they are discussing). Beyond this paper's scope are other design spaces that can be summarized in a similar fashion, including design spaces related to consistency with work system principles (Alter, 2004, 2006), performance expectations (metrics), avoidance of typical pitfalls and obstacles, responses to likely exceptions and workarounds, and anticipation of implementation risks.

Design space #1 – Possible changes in components, subsystems, and interactions. Typical systems analysis and design focuses on identifying and improving specific components, subsystems, or interactions, both at aggregated and detailed levels. Table 2 lists many types of changes that a sociotechnical design effort might consider. Some are in the spirit of engineering, such as adding, combining, or eliminating steps in a business process, or upgrading hardware and software. Others are more in the spirit of management, such as changing the nature of customer relationships or the customer experience. This table or another way of expressing information about possible changes could support sociotechnical design efforts through general knowledge, checklists, or design tools.

Table 2. Design space #1: Possibilities for changing components, subsystems, and interactions.

<table>
<tr><td colspan="6"></td></tr>
<tr><th colspan="3">Customers</th><th colspan="3">Products & Services</th></tr>
<tr><td colspan="3">• Add or eliminate customer groups.
• Change customer expectations, customer relationships or the customer experience.</td><td colspan="3">• Change the informational, physical, or service content of products and services.
• Change the amount of customization and the degree of controllability or adaptability by the customer.</td></tr>
<tr><th colspan="6">Activities or Processes</th></tr>
<tr><td colspan="3">• Improve processes and activities by adding, combining, or eliminating steps, changing sequences, or changing methods used within steps.
• Add new functions not currently performed.</td><td colspan="3">• Change roles and division of labor.
• Improve coordination, decision making, information processing, physical activities, or communication practices.</td></tr>
<tr><th colspan="2">Participants</th><th colspan="2">Information</th><th colspan="2">Technologies</th></tr>
<tr><td colspan="2">• Change the participants.
• Assure understanding of details and significance of the work.
• Provide resources for doing work.
• Change incentives, organizational structures, and social relations within the work system.</td><td colspan="2">• Provide different information or codified knowledge.
• Organize information more effectively.
• Improve information organization, quality, or usability
• Improve protection of information.</td><td colspan="2">• Upgrade technology.
• Reconfigure existing technology
• Improve technology usability.
• Reduce the cost of ownership of technology.</td></tr>
<tr><th>Infrastructure</th><td colspan="5">• Make better use of human, informational, and technical infrastructure.</td></tr>
<tr><th>Environment</th><td colspan="5">• Improve fit with organizational policies and procedures, organizational politics, and organizational culture.
• Respond to competitive pressures, regulatory requirements, and industry standards.</td></tr>
<tr><th>Strategies</th><td colspan="5">• Change the work system's overall strategy to improve alignment with the organization's strategy.</td></tr>
<tr><th>Work System as a Whole</th><td colspan="5">• Reduce imbalances between elements.
• Improve problematic relationships with other work systems.</td></tr>
</table>

Design space #2 – Calibration of design characteristics. The concluding section of Magalhães and Silva's (2009, p. 28) proposal for the development of "organizational design and engineering," which is somewhat akin to sociotechnical design, says, "Organizational design dimensions or qualities offer a very promising avenue for research and development in ODE [organizational design and engineering], given that they can be investigated from both points of view: the social architecture and the technological architecture." Table 3 provides an organized way to follow their suggestion by using work system elements (plus "work system as a whole") to organize design characteristics that are relevant to many work systems. The characteristics in Table 3 imply design variables that can be assessed on a numerical scale (e.g., 1 to 5). These characteristics represent big picture choices that should be considered before determining a work system's details. Typical systems analysis and design texts for IS students say relatively little about these design characteristics, and move quickly to technical documentation methods.

Table 3: Design Space #2: Calibration of design characteristics

<table>
<tr><td colspan="6"></td></tr>
<tr><th colspan="3">Customers</th><th colspan="3">Products & Services</th></tr>
<tr><td colspan="3">• Customer segmentation
• Style of interaction with the customer
• Nature of the customer experience</td><td colspan="3">• Relative preponderance of product, service, and informational characteristics
• Mix of commodity and customisation
• Controllability and adaptability by customer</td></tr>
<tr><th colspan="6">Activities or Processes</th></tr>
<tr><td colspan="3">• Degree of structure
• Range of involvement
• Level of integration
• Complexity
• Variety of work
• Amount of automation</td><td colspan="3">• Rhythm
• Time pressure
• Amount of interruption
• Form of feedback and control
• Error-proneness
• Formality of exception handling</td></tr>
<tr><th colspan="2">Participants</th><th colspan="2">Information</th><th colspan="2">Technologies</th></tr>
<tr><td colspan="2">• Reliance on knowledge and skills
• Personal autonomy
• Personal challenge
• Personal growth</td><td colspan="2">• Quality assurance
• Quality awareness
• Ease of use
• Security</td><td colspan="2">• Range of functionality
• Ease of use
• Ease of technical support
• Ease of maintenance</td></tr>
<tr><th>Infrastructure</th><td colspan="5">• Reliance on human, informational, and technical infrastructure</td></tr>
<tr><th>Environment</th><td colspan="5">• Alignment with organizational culture, policies, and procedures</td></tr>
<tr><th>Strategies</th><td colspan="5">• Fit with the organization's strategy</td></tr>
<tr><th>Work System as a Whole</th><td colspan="3">• Centralization/ decentralization
• Capacity
• Leanness
• Scalability</td><td colspan="2">• Resilience
• Agility
• Transparency</td></tr>
</table>

These design characteristics can be applied as follows: For each of the design characteristics that seem to be of greatest interest for a particular work system:

- Think of the design characteristic as a continuous variable or dimension, and identify a low point and a high point for that dimension.
- Describe the position of the current work system along that dimension.
- Describe the ideal position along that dimension for a future, improved version of the work system.
- Identify specific changes (e.g., from design space #1) that would result in improvements in the desired direction.

As an example, consider how to use the dimension "degree of structure" when thinking about processes and activities for admitting students to college. In general, too little structure implies that work system participants have insufficient guidelines and methods for doing their work, as a result of which work may be performed inconsistently; too much structure implies that guidelines and methods for doing work are so restrictive that work system participants cannot use appropriate judgment. In this case, a very structured approach would be combine test scores and other scores into a single numerical score that would be the sole basis of the admission decision. With an unstructured approach, work system participants would evaluate an application based mostly on subjective impressions. Between the two extremes, intermediate approaches would combine objective scores and subjective ratings.

The characteristics in Table 3 are far from exhaustive. For example, trying to apply a conscious service perspective to the design might lead one to use many other design dimensions such as the relative importance of customer interactions, the relative prominence of front stage and back stage when providing service, and the extent to which value from products and services is viewed as being produced by a service provider or co-produced by providers and customers. (Alter, 2008b)

Design space #3 – treatment of information and knowledge. Magalhães and Silva (2009) pay a lot of attention to the role of information and knowledge in organizations. Table 4 uses the format of a work system snapshot to show that relevant information and knowledge can reside within any of the work system elements, thereby illustrating the broad range of possible design choices for handling information and knowledge. For example, knowledge about aspects of a particular process might be tacit knowledge in the heads of work system participants; might be built into business rules of the activities within the process; might be codified in expert systems; or might be built into hardware or software technologies designed to support and/or de-skill workers.

Table 4. Design space #3: Alternative locations of information and knowledge

<table>
<tr><td colspan="6"></td></tr>
<tr><td colspan="3">Customers</td><td colspan="3">Products & Services</td></tr>
<tr><td colspan="3">• The customer’s information and knowledge are essential for attaining value from products &services.</td><td colspan="3">• Information and knowledge are both implicit and explicit in the work system’s products and services.</td></tr>
<tr><td colspan="6">Activities or Processes</td></tr>
<tr><td colspan="3">• Information and knowledge guide processes and activities within a work system. Knowledge is the basis of business process design.</td><td colspan="3">• Knowledge may be encoded within business processes in forms such as process flows, business rules, and routines for handling exceptions.</td></tr>
<tr><td colspan="2">Participants</td><td colspan="2">Information</td><td colspan="2">Technologies</td></tr>
<tr><td colspan="2">• Participants can recall facts, observations, and opinions. They have both explicit and tacit knowledge about how to perform particular tasks, how to interpret communications and actions of their colleagues, and how to exist within organizational cultures.</td><td colspan="2">• Information that is significant for the system’s operation or is produced for the system’s customers may be codified information, such as data in databases, or maybe non-codified information such as tacit knowledge.</td><td colspan="2">• Information and knowledge are stored explicitly and implicitly in technology. Implicit forms of knowledge involve the way people interact with technology and the way the technology stores and retrieves information. Explicit forms of knowledge are specific information encoded in the technology.</td></tr>
<tr><td colspan="2">Infrastructure</td><td colspan="4">• Information and knowledge exist in the infrastructure.</td></tr>
<tr><td colspan="2">Environment</td><td colspan="4">• Information and knowledge exist in the environment.</td></tr>
<tr><td colspan="2">Strategies</td><td colspan="4">• Strategies are information; they are developed, interpreted, and used based on information and knowledge at various organizational levels.</td></tr>
<tr><td colspan="2">Work System as a Whole</td><td colspan="4">• In a work system as a whole, information and knowledge include information and knowledge in its various components, plus any additional information and knowledge about how the work system operates as a whole.</td></tr>
</table>

6 CONCLUSION – BENEFITS OF A WORK SYSTEM APPROACH TO SOCIOTECHNICAL DESIGN

This paper presented a theory of sociotechnical design and showed how sociotechnical design can proceed by viewing an organization as a set of work systems. Those work systems can be analyzed and designed individually or in combination, depending on the problems or opportunities that are being addressed. Furthermore, this paper showed how the work system framework leads to a series of design spaces that can help analysts and designers explore non-technical and technical aspects of work systems. This approach has a number of beneficial characteristics:

Inclusiveness and scope. A work system approach covers the realm of sociotechnical design. It provides a way to express and combine managerialist and economic interests, on the one hand, and interests rated to workplace democracy and human relations, on the other. It can be used by individuals or groups at different levels of detail depending on the goal of specific users.

Statics and dynamics. A work system approach provides straightforward frameworks that can be presented and used at different levels of depth to describe how work systems operate and how they change over time through planned and unplanned change processes.

Understandability. A work system approach is understandable to business and IT professionals. Understanding and using this approach does not require a technical degree or years of training. For example, Truex and Alter (2010) report positive results in the use of a work system analysis template by 75 MBA students who analyzed IT-reliant work systems in their own organizations. These individuals were employed business professionals averaging six years of business experience when they began their MBA programs.

Neither socially nor technically biased. A work system approach encompasses both sides of sociotechnical design and is not biased toward either side. The social side appears in the work system framework as work system participants, customers, informal information, semi-structured or unstructured activities, and the environment. The technical side appears as technologies, and as formal specifications for information, processes, and products and services. Whether a specific step should be performed by a human participant or a technology is treated as a design decision that should be determined by the appropriate balance between social issues, technical capabilities, and organizational goals.

Not biased toward particular software development approaches. Design spaces organized around the work system framework can be used in early stages of any software development or acquisition approach, including waterfall, agile, and configuration of commercial software. The work system life cycle model summarizes the iterative process of work system evolution, regardless of which software development or acquisition approach is used during any particular iteration. In fact, it is likely that different approaches might be used in different iterations of a work system's form and function.

Application to empirical research. Sociotechnical design spaces can be used in research in a number of ways. For example, design spaces such as Tables 2, 3, and 4 could be used to characterize and classify accounts from case study, interpretive, and survey research. Insights about settings, research, and even researchers might be gleaned from choices about which design components and characteristics appear prominently, which are mentioned, and which are not be mentioned at all.

Systems analysis and design. In both research and practice, sociotechnical design spaces provide a challenge for past and current research and methods in systems analysis and design. The basic question involves whether and how research and methods in this area actually engage the types of topics that appear in the design spaces. Based on the subject matter of textbooks mentioned earlier, it seems likely that sociotechnical design spaces could increase the power and scope of what is now called systems analysis and design in the information system field.

Real world practicality and empowerment. The theme of ECIS 2010 is "IT to empower." As noted by Beath and Orlikowski (1994) and many others, non-technical participants in IS projects are often disadvantaged by their lack of technical knowledge. Use of this paper's sociotechnical design spaces could empower business professionals by helping them communicate their knowledge and insights in IS/IT projects that affect them, their work, their colleagues, and their organizations. From the other side, the sociotechnical viewpoint built into the design spaces could help in addressing longstanding difficulties related to user participation and business/IT alignment (Markus and Mao, 2004; Alter, 2009). That viewpoint could help by empowering IT professionals to focus more directly on the work systems that produce business results and therefore to communicate more effectively with business professionals.

References

Alter, S. (2003). 18 Reasons why IT-Reliant Work Systems Should Replace the IT Artifact as the Core Subject Matter of the IS Field. Communications of the Association for Information Systems, 12(23), 365-394.

Alter, S. (2004). Making Work System Principles Visible in Systems Analysis. Proceedings of AMCIS 2004, New York City, NY.

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

Alter, S. (2006b). Pitfalls in Analyzing Systems in Organizations. Journal of Information System Education, 17(3), 295-302.

Alter, S. (2008a). Defining Information Systems as Work Systems: Implications for the IS Field. European Journal of Information Systems, 17(5), 448-469.

Alter, S. (2008b). Service system fundamentals: work system, value chain, and life cycle. IBM Systems Journal, 47(1) 71-85.

Alter, S. (2009). Project Collaboration, not just User Participation. AMCIS 2009 - Americas Conference on Information Systems, San Francisco, CA.

Beath, C. and W. Orlikowski (1994). The contradictory structure of systems development methodologies: deconstructing the IS-user relationship in information engineering, Information Systems Research, 5(4), 350-377

Delone, W.H. and E.R. McLean (1992). Information systems success: the quest for the dependent variable. Information Systems Research. 3(1), 60-95.

Dennis, A., B.H. Wixom, and D. Tegarden. (2002). Systems Analysis & Design: An Object-Oriented Approach with UML. John Wiley & Sons, Inc., New York, NY.

Galbraith, J. (1973). Designing Complex Organizations. Addison-Wesley, Reading, MA.

Gregor, S. (2006). The Nature of Theory in Information Systems. MIS Quarterly, 30(3), 611-642.

Hirschheim, R. and H.K. Klein (1994). Realizing Emancipatory Principles for Information Systems Development: The Case for ETHICS. MIS Quarterly. 18(1), 83-109.

Hoffer, J.A., J.F George, and J.S. Valacich (2008). Modern Systems Analysis and Design, 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.

IFIP TC.13 (2009). Aims and Objectives. http://csmobile.upe.ac.za/ifip/about-ifip-tc.13/the-current-position-and-scope-of-hci-in-ifip-tc.13

Kendall, K.E. and J.E. Kendall. (2008). Systems Analysis and Design. 7th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.

Magalhães, R. and Silva, A. R. (2009) "Organizational Design and Engineering (ODE)," Working Paper No. 1, Version #4, Centre for Organization Design and Engineering, Lisboa, Portugal.

Malone, T.W., et al. (1999) Tools for inventing organizations: Toward a handbook of organizational processes. Management Science 45(3), 425-443.

Markus, M.L. and J-Y Mao (2004). Participation in Development and Implementation – Updating An Old, tired Concept for Today's IS Contexts, Journal of the Association for Information Systems, 5(11), 514-544.

Mathiassen, L., A. Munk-Madsen, P.A. Neilsen, and J. Stage (2000). Object Oriented Analysis & Design. Marko Publishing ApS, Aalborg, Denmark.

Mumford, E. and M. Weir (1979). Computer Systems in Work Design – the ETHICS method. John Wiley & Sons, New York.

Petkov, D and O. Petkova (2006). The Work System Model as a Tool for Understanding the Problem in an Introductory IS Project. Proceedings of the 23rd Information Systems Education Conference (ISECON 2006), Dallas, TX.

Sociotech-ID 2009 Workshop (2009) Call for papers, http://itcentre.tvu.ac.uk/~jabdelno/sociotechid09

Sullivan, L. (1896). The tall office building artistically considered, Lippincott's Magazine, http://academics.triton.edu/faculty/fheitzman/tallofficebuilding.html

Thompson, J.D. (1967). Organization in Action. Mc Graw- Hill, Chicago, IL.

Truex, D. P. and Alter, S. (2010). Systems Analysis for Everyone Else: Empowering Business Professionals through a Systems Analysis Method that Meets their Needs, ECIS 2010, European Conference on Information Systems, Pretoria, South Africa.

Tyre, M. and W. Orlikowski (1994). Windows of Opportunity: Temporal Patterns of Technological Adaptation in Organizations. Organization Science, 5(1), 98-118.

Weick, K.L. (2000). "Emergent Change as a Universal in Organizations," pp. 223- 241 in M. Beer and N. Nohria (2000). Breaking the Code of Change, Boston, MA: Harvard Business Press.

Wikipedia (2009). "Form follows function," http://en.wikipedia.org/wiki/Form_follows_function