Applying Sociotechnical Thinking in the Competitive, Agile, Lean, Data-Driven World of Routine Work, Knowledge Work, and Smart, Service-Oriented, Customer-Centric Value Creation Ecosystems

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Abstract. This paper responds to a need for a sociotechnical systems (STS) perspective that fits in a world that has changed greatly over the decades since the sociotechnical movement began. After a brief summary of the relevant background, this paper uses the various topics in its title to describe a view of sociotechnical thinking that might be more suitable for today's world.

Keywords: Sociotechnical system, Sociotechnical design, Sociotechnical thinking, Organizational ecosystem

1 What Would Reinvigorate Sociotechnical Thinking?

The home page of the website of the Fourth International Workshop on Sociotechnical Perspective in IS Development (STPIS'18) says that although "the sociotechnical perspective has been around for over half a century, it is often forgotten in the IS discourse today." Related views or concerns have been expressed by [10], [12], [15], [16], and others.

What about a new focus on collaborative ecosystems? This paper was inspired by a Jan. 31, 2018 webinar reviewing key learnings from the 31st annual Sociotechnical Systems Roundtable (2017), whose theme was "Designing Collaborative Ecosystems." The theme of ecosystems has seen increasing prominence in recent papers and discussions related to information systems. An award-winning paper [27] proposed moving beyond the organizational container in understanding sociotechnical work. Two articles [24, 25] based on research at MIT CISR (Center for Information System Research) spoke of thriving or surviving in digital ecosystems. [13] explored differences between biological and organizational ecosystems. A third version of service-dominant logic from marketing scholars [23] emphasized the increasing importance of understanding value co-creation in the context of business ecosystems.

Solution or niche? Despite covering many important insights, the webinar did not explain how focusing on collaborative ecosystems would be likely to reinvigorate the STS movement. Even with many potential benefits from more effective collaborative ecosystems in areas such as healthcare for local populations and open source

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development, the collaborative ecosystem route seems inherently limited and niche-oriented, i.e., interesting and valuable, but not a high probability path for reinvigorating the STS movement. This paper describes a different approach that is relevant across a much wider range of situations, including business ecosystems.

This paper tries to embrace and build upon central STS ideas and values in a business world in which ideas in this paper's overpacked title such as agile, lean, and data-driven are heard frequently, probably more frequently than *sociotechnical*. This paper presents an approach to sociotechnical thinking (STT). It uses the term STT to minimize entanglement in distinctions between different schools of STS thought (identified by [11] and others) related to "sociotechnical systems theory (STS-T), STS design (STS-D), and STS change (STS-C)" [5].

Goal. The challenge at hand is to articulate an approach to sociotechnical thinking that reflects the main STS values and is potentially useful for understanding, designing, and improving teams, organizations, and ecosystems in the current business world. The underlying assumption is that frequently repeated ideas such as the joint optimization of social and technical systems (e.g., [15, p. 321] are not suitable in many situations, such as where it is difficult to define the social system as a system or where a social system may be in flux. An additional assumption is that STT needs to move beyond being an activity that is inherently limited because it usually requires efforts by experienced consultants.

This paper builds on a short paper at STPIS'15 [3] by explaining a form of STT that addresses the challenges in this paper's purposefully overloaded title. First it identifies conditions and paradoxes that limit STS design in some ways and diffuse its message in other ways. It summarizes the work system method (WSM), a flexible systems analysis and design approach that came from the IS field and has been explained in detail elsewhere [1,2]. It explains how WSM supports STT and includes interests and needs of individuals and groups without forcing users to assume that a separate social system exists and without calling on sometimes artificial distinctions between routine work and knowledge work. A concluding section explains how WSM-based STT addresses challenges related to each term in the papers title.

2 Conditions and Paradoxes that Limit the STS Movement

Articles about the evolution of the STS movement and STS design reveal a variety of conditions and paradoxes that contribute to the STS movement's somewhat tenuous status today. Those issues are presented as a series of paradoxes.

Diffusion of ideas vs. diffuseness of message. Eason [10] says that the underlying ideas of STS have spread to so many different domains that it has become diluted to "a banner under which many different concepts and design principles can flourish that have little relation to one another." Part of that dilution is evident from divergent concerns of different STS communities discussed in [15,11, 7, 14]. For example, [11] speaks explicitly about four major variants on STS theory and practice: North American STS, Australian STS, Scandinavian STS, and Dutch STS. On the other hand, the diffusion to date of STS ideas could be viewed as a success. For example, [26] notes

that "the work design and processes of both STS and flexible manufacturing have been successfully integrated into most organizations today. It is difficult to find an organization that does not encourage team work, employee participation and decision making" (p. 2) even though "STS began to disappear both academically and in practice" in the late 80s early 90s." (p. 9),

Values vs. methods. [15] sees STS design as "more a philosophy than a methodology" (p. 317). "Throughout its history its practitioners have always tried to achieve its two most important values: the need to humanize work through the redesign of jobs and democracy at work." (p. 321). "The most important thing that socio-technical design can contribute is its value system. … although technology and organizational structures may change, the rights and needs of the employee must be given as high a priority as those of the non-human parts of the system." (p. 338)

While emphasizing values, Mumford spells out a complex method for STS design. "The objective of sociotechnical design has always been 'the joint optimization of the social and technical systems." …. "Relationships between the two systems, and between them and the outside environment, must also be carefully analysed. This approach led to the development of a complex method for analysing work systems, which went through a number of stages. Unit operations, or groups of tasks that fitted logically together into a discrete work activity, were first identified. Each of these unit operations was made the responsibility of a work group. Next, variances – problem areas where what did happen deviated from what should happen – were noted as areas for improved control by the work group." (pp. 321-322). Even though general awareness of STS values became more commonplace, the ascendancy of metaphors of agile and lean lead to questioning the suitability of such a complex STS approach.

Complexity vs. teachability and usability. This type of issue appears in many professional fields. Leading researchers in enterprise modeling (EM), an important subdiscipline of IS, co-authored a position paper called "Enterprise Modelling for the Masses– From Elitist Discipline to Common Practice" [18]. It proposed that "grassroots modelling could lead to groundbreaking innovations in EM." In the more mainstream realm of systems analysis and design, the title of [22] was "Systems analysis for everyone else: Empowering business professionals through a systems analysis method that fits their needs."

Similar issues apply to STS. It is difficult for a novice to obtain a full understanding of STS due to the simultaneous existence of different STS schools that are not reconciled conceptually. STS will continue to generate benefit if it remains as semi-visible background knowledge for running organizations and if it remains the bailiwick of sophisticated consultants. Its long-term impact might be much greater if it could help more in democratizing the analysis and enactment of humanistic ideals through methods that do not require efforts of expert consultants.

Human welfare vs. managerialist focus. Almost two decades ago, [12, pp. 115-116] described the status of the STS movement as follows. "Sociotechnical design is an enigma. It has offered so much and produced so little and we need to know why." ... "The sociotechnical philosophy rests on two perhaps contradictory premises. The first can be called the humanistic welfare paradigm. Sociotechnical methods focus on design of work systems to improve the welfare of employees." .... "The second can be called

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the managerial paradigm. All change (designed change) is instrumental and serves to improve the performance of the organization ... adding to shareholders values, making the business more competitive, improving the bottom line, making the organization more responsive to changing circumstances."

Traditional organizations vs. new organizational forms and practices. The STS movement's initial development occurred many decades ago, at a time when the use of computers and digital data did not come close to resembling the pervasive presence of ICT in today's business world. Most of today's businesses are much less hierarchical, much more controlled by process choices built into commercial software packages, and much more reliant on outsourced products and capabilities.

Table 1 uses key terms packed into this paper's purposefully overloaded title to highlight dissonances between today's business practices and traditional STS values and methods. Its second column summarizes areas where mainstream STS approaches may seem distant from ideas that many people in business take seriously today.

Table 1. Business topics and issues that STS should be able to address convincingly

Business topic	How traditional STS may overlook or underplay the topic
Competitive	Traditional STS focuses more on internal issues related to work practices and less on how well product/services meet or exceed customer needs.
Agile	With today's great push for speed, complex STS analysis seems inconsistent with strong trends toward agile approaches.
Lean	A focus on lean may conflict with or override STS-driven attempts at joint optimization of technical systems and social systems.
Data-driven	Data-driven organizations may place more attention on implications of data and less attention on social concerns.
Routine work	The original STS research and practice focused on routine work in organizational settings. Today, much routine work is structured through computerized systems that control major aspects of work practices.
Knowledge work	The trend toward computerization of work changed the nature of both routine work and knowledge work. Previously knowledge requirements were mostly about the content of work. With computerization, knowledge requirements expanded for many forms of both routine work and knowledge work because computerized tools required new types of knowledge across many work domains.
Smart	The term *smart* has been attached to a wide range of objects and arrangements including smart bombs, smart cards, smart houses, smart phones, and even smart cities. *Smart* in that sense generally refers to combinations of automated information processing, self-regulation, IT-enabled action, and knowledge acquisition, often focusing mostly on technical aspects that may direct attention away from social aspects.
Service-oriented	Service-orientation has many different meanings in today's business. If service is viewed as performing activities for the benefit of others, then service-orientation may override internal social concerns. Service in a more technical sense typically seems quite distant from STS values because it refers to operation or coordination through formal requests and responses.
Customer-centric	Customer-centricity may disrupt the traditional STS balance of the social and technical by focusing more on interests of customers who may be impersonal, distant, or known only as sources of demand rather than as people with human concerns.

Value creation	Economic activity always involves value creation. STS experts fully appreciate the importance of value creation, but the idea of value creation per se may not receive a great deal of attention in STS- oriented discussions that focus on joint optimization of social and technical systems.
Ecosystem	Traditional STS values and methods developed in organizational settings. Business ecosystems such as supply chains and value networks often operate more through transactions rather than through social relations.

3 Work System Theory

WST defines work system in a way that allows for both sociotechnical and totally automated work systems (thereby addressing many issues related to representing systems that could be of either type). A work system is a system in which human participants and/or machines perform processes and activities using information, technology, and other resources to produce product/ services for internal and/or external customers. A work system operates within an environment that matters (e.g., national and organizational culture, policies, history, competitive situation, demographics, technological change, other stakeholders, and so on). Work systems rely on human, informational, and technical infrastructure that is shared with other work systems. They may be governed to some extent by explicit strategies. (Note that this definition differs from definitions that treat a work system as the environment within which work is performed, e.g., descriptions of "high-performance work systems" that focus on organizational characteristics (e.g., high involvement, shared responsibility), but do not specify production processes, information, technologies or product/services).

According to the above definition, an information system is a work system all of whose activities are devoted to capturing, storing, retrieving, transmitting, manipulating and/or displaying information. In organizational settings many IS exist to support particular work systems. For example, a distribution IS exists to support the work system of distributing goods. In some cases, the work systems that are supported are also information systems. For example, accounting information system exists to support accounting work systems whose participants include accountants.

As shown in Figure 1, WST consists of three components, the definition of work system, the work system framework (WSF), and work system life cycle model (WSLC).

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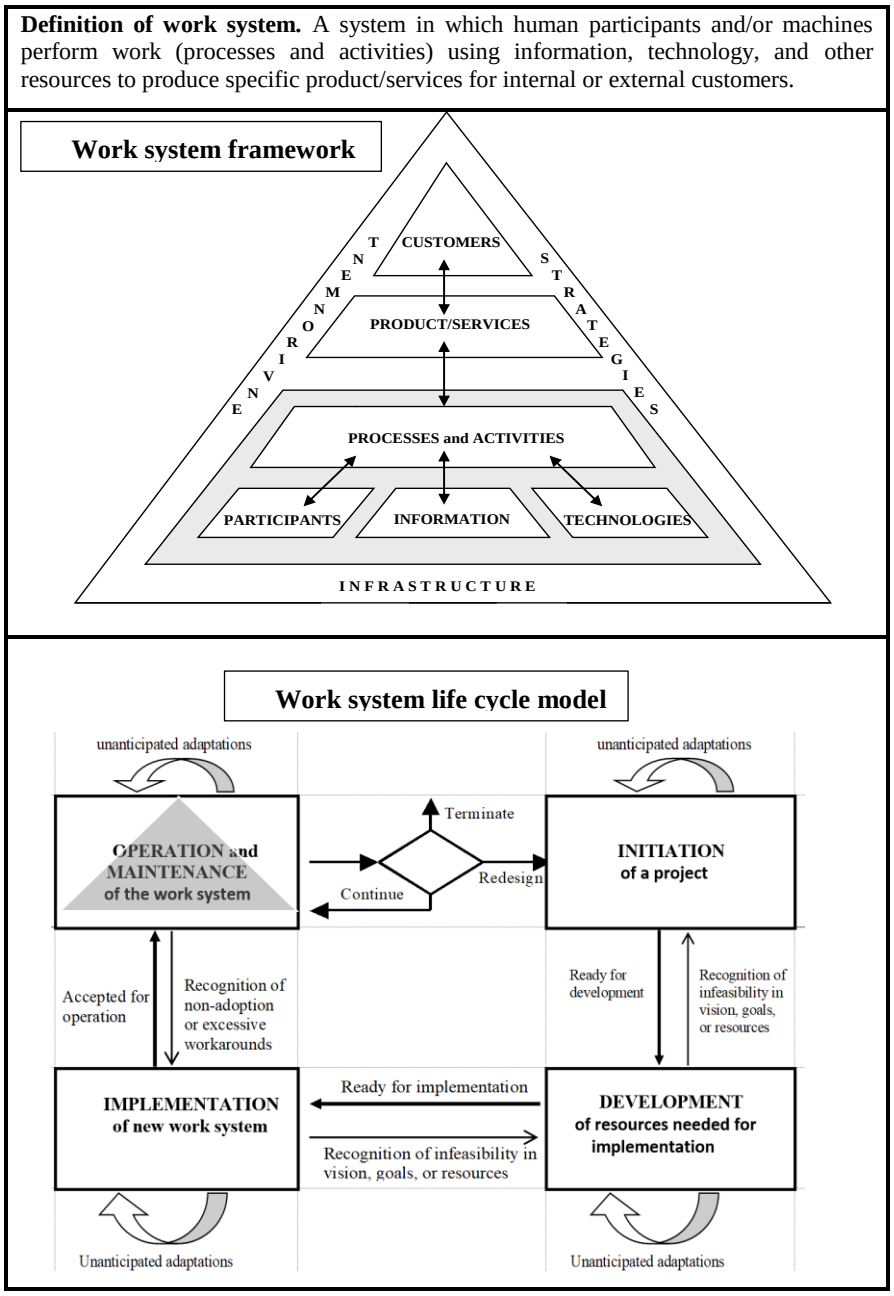

Figure 1. Three parts of work system theory: 1) the definition of work system, 2) the work system framework, 3) the work system life cycle model [2]

Work system framework. The WSF identifies and organizes nine elements of even a rudimentary understanding a work system's form, function, and environment during a period when it is relatively stable even though incremental changes such as minor personnel substitutions or technology upgrades may occur within what is still considered the same work system. Processes and activities, participants, information, and technologies are completely within the work system. Customers and product/services may be partially inside and partially outside because customers often participate in the processes and activities within work systems and because product/services take shape within work systems. Environment, infrastructure, and strategies are largely outside the work system even though they often have direct effects within work systems and therefore are part of a basic understanding of those systems. Figure 1 places the customer on top because work systems exist for the purpose of producing product/services for customers. For sociotechnical work systems this leads to trade-offs between internal management concerns about efficiency, morale, and vulnerability, versus customer concerns about the total cost to the customer, quality, and other characteristics of the product/services that they receive. Different internal vs. external trade-offs apply to totally automated systems.

Work system life cycle model. The WSLC represents the iterative process by which work systems evolve over time through a combination of planned change (formal projects) and unplanned (emergent) change via adaptations and workarounds. Those changes may include changes in any work system component. The WSLC represents planned change as projects that include initiation, development, and implementation phases. Initiation is the chartering of a work system creation or improvement project. Development involves creation or acquisition of resources required for implementation of desired changes in the organization. This may include software development or acquisition, software configuration, creation of new procedures, documentation, and training materials, and acquisition of other resources needed for implementation of the new work system. Implementation refers to implementation in the organization, not implementation of algorithms on computers. A full iteration from one operation and maintenance phase to the next might be viewed as a transition from a previous version of the work system to a subsequent version.

4 Sociotechnical Thinking Based on the Work System Method

The work system method (WSM – [1, 2]) is a flexible systems analysis and design method based on work system theory (WST - Alter, [2]), which treats the system of interest as a work system. It was created for use by business professionals and can be used jointly by business and IT professionals in designing system improvements that may or may not involve software changes. It can be used for high-level guidance in thinking about a work system or can organize a more detailed analysis by using systems analysis templates and extensions of WST. It starts from the work system problems, opportunities, or issues that launched the analysis. Many hundreds of MBA and Executive MBA students in the United States, China, India, Vietnam, and possibly

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elsewhere have produced preliminary management briefings suggesting improvements in work systems in their organizations by using WSM via work system analysis templates (e.g., [22]). A notable aspect of WSM is that the current and proposed systems are work systems rather than hardware/software configurations.

Areas of consistency between WSM and STS design approaches. The different versions of WSM have four main commonalities that do not conflict with most STS design approaches. First, the work system's scope is a choice rather a given, typically the smallest work system that exhibits problems or opportunities that motivated the analysis. Second, the current and proposed work systems are summarized using a formatted one-page summary of the work system's customers, product/services, processes and activities, participants, information, and technologies [2 p. 78]. Third, performance gaps are identified and alleviated in relation to both internal metrics such as productivity, speed, and error rate and external metrics such as quality, cost to the customer, responsiveness, and reliability. Fourth, the analysis leads to a justified recommendation for improving the work system. Overall, WSM focuses on the structure of the work system (including processes, participants, technologies, and information) and on addressing performance gaps, key incidents, customer needs, and so on. Six Sigma techniques such as Pareto charts, fishbone diagrams, and value stream mapping are just as relevant to the analysis as IT-oriented methods. The resulting project proposal outlines activities for moving from the "as is" work system to the proposed "to be" work system. Production, improvement, or installation of software may or may not be required in order to implement the new work system.

5 WSM Guidelines for Sociotechnical Thinking

This section presents WSM-based guidelines for STT that apply equally to work system participants, managers, business consultants, and IT professionals. Overall, WSM tries to retain STS values while providing a lens for visualizing, understanding, and analyzing systematic activity in teams, organizations, and even ecosystems at whatever level of detail is appropriate. Proper application of these ideas in practice brings the usual expectations about STS design and STS change, i.e., genuine involvement of everyone who should be involved in design deliberations, implementation that emphasizes quality of work life, and so on. The guidelines presented here focus on the work system as a system. Related ideas in a work system life cycle model [2] representing how work systems evolve over time through a combination of planned and unplanned change are not discussed here.

Treat "work system" as the unit of analysis. STS researchers and practitioners have recognized for decades that "work system" is a natural unit of analysis for thinking about systems in organizations (e.g., [16, 21]).

Define work system in a way that facilitates visualization and analysis. WSM and WST define work system is a system in which human participants and/or machines perform processes and activities using information, technology, and other resources to produce product/ services for internal and/or external customers. A work system operates within an environment that matters (e.g., national and organizational culture,

policies, history, competitive situation, demographics, technological change, other stakeholders, and so on). Work systems rely on human, informational, and technical infrastructure that is shared with other work systems. Work systems should support enterprise and departmental strategies. With this definition, an organization can be viewed as a series of interacting work systems, such as work systems for designing products, producing products, selling products, providing customer service, hiring employees, and generating accounting reports. The operation and interactions of those and other work systems define how the enterprise operates and serves its customers.

Using a clear definition of work system is important analytically. As noted earlier, this operational definition differs from definitions that treat work system as the environment within which work is performed, e.g., descriptions of "high-performance work systems" that focus on organizational characteristics but do not specify production processes, information, technologies, or product/services.

Attend to the various elements of a work system. This definition leads to the work system framework [1, 2] a triangular representation that identifies nine elements of even a rudimentary understanding of a work system: *customers, products/services, processes and activities, participants, information, technologies, environment, infrastructure,* and *strategies*. Arrows within the work system framework call for fit between the various elements. The framework emphasizes 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. Of its nine elements, *processes and activities, participants, information,* and *technologies* are viewed as completely within the work system. *Customers* and *product/services* may be partially inside and partially outside because *customers* often participate in the *processes and activities* within the work system and because *product/services* take shape within the work system. *Environment, infrastructure,* and *strategies* are viewed as largely outside the work system even though they have direct effects within the work system

Cover important special cases of work systems. Information systems are work systems whose activities focus on processing information, i.e., capturing, transmitting, storing, retrieving, manipulating, and displaying information. Supply chains are work systems or groups of interacting work systems that cross multiple organizations. Similarly, a business ecosystem can be viewed as a set of interacting work systems. A totally automated work system is a work system with no human participants. Those systems need to be recognized as work systems because realistic analysis of a nominally sociotechnical system may lead to its partial or complete automation in the future.

Maintain visibility of STS values and criteria. The spirit of the STS movement requires attention to STS values and criteria. Including participants and customers in the work system framework and in WSM (hence as part of the work system) leads to focusing on the human side more than typical systems analysis methods directed at producing software. Work system should include consideration of human dignity, the quality of work life, the concerns of work system participants, and the human impacts of product/services that are produced. Since work systems exist to produce product/ services for customers, design in the spirit of STS should consider trade-offs between internal concerns about efficiency and support of employees versus customer concerns about the total cost, quality, and other product/service characteristics.

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Recognize value creation. Operational work systems exist to create things of value and to facilitate value creation by internal and/or external customers (as in services).

Use descriptive dimensions to characterize possible directions for change. STS researchers such as [17] characterized differences between routine work, hybrid work such as projects, and nonroutine work. (e.g., see [5]). Figure 1 goes a step further by outlining a design space for positioning a current or proposed work system using two continuous dimensions. The nature of the payoff goes from social to economic; operational style goes from improvisational to rule-driven (with professional knowledge work typically in the middle). Those dimensions illustrate the range of possibilities that STT should cover while maintaining visibility of STS values and criteria. In other words, analysis of a work system should consider the possibility that the payoff anywhere from largely social or totally economic, especially if the work system is totally automated. Similarly, the work system may be largely improsational, as in some kinds of creative work, or may be highly rule-driven, as in some types of manufacturing and other work requiring high reliability. In addition, STT should recognize the effect of design incompletion [8, 9] adaptations, and workarounds, i.e., changes beyond whatever a design team designed.

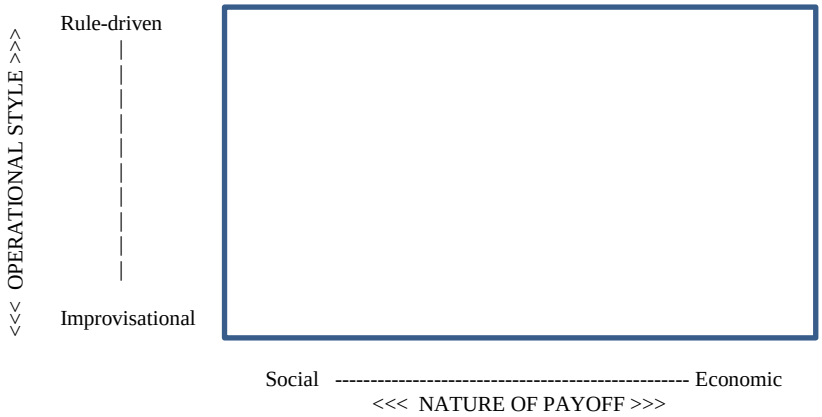

Fig. 1. Positioning a work system using nature of payoff and operational style

Give up on analytical distinctions between social system vs. technical system. Maintaining the visibility of STS values and criteria does not imply the necessity or desirability of analytic distinctions between social systems and technical systems. A social system does not exist at all in totally automated work systems, may not be amenable to "design" in the presence of rapid change, and may be difficult to define meaningfully in highly transactional work systems in supply chains or ecosystems. In addition, a social system and related technical system often overlap significantly [3] even when an STS expert might be able to describe a social system. *Processes and activities* that are not totally automated are both social and technical. Much important *information* is partially social and partially technical. Even *technology* is partially social in today's world, where people bring their own devices to work in what is often abbreviated BYOD – bring your own device. *Product/services* produced for *customers*

often are partly technical and partly social. With so many overlaps, distinctions between social system and technical system often seem more figurative than analytical. Expressing a stronger view, [20, p. 5) says, "The isolation of social and technical system elements into separate sub-systems blocks the view of the functional relations between the two, which are at the heart of a real production system. In consequence, the concepts [of social system and technical system] destroy the very object of analysis and impede rather than foster a comprehensive understanding of organizational dynamics."

Balance the needs and importance of different stakeholders. STT should aim at establishing and maintaining a mutually beneficial balance between interests and needs of internal stakeholders, of customers, and of other external stakeholders. In many cases, those needs include needs for cost control and internal efficiency that sometimes conflict with social interests and concerns.

Support agility. STT should not require excessive analysis time or documentation. It should help stakeholders pursue issues at whatever level of detail is needed.

Recognize the inevitability of adaptation. Sociotechnical principles [8. 9] include minimum critical specification and design incompletion. Minimum critical specification encourages work system participants to interpret their own situations and to decide how to do work consistent with the requirements of whatever systems are being served. Design incompletion says that design is never complete, and that the people doing the work continually adapt their practices to challenges they face.

Recognize technological change. Continued use of old technologies may not suffice in achieving business goals regardless of whether old or near obsolete technologies feel comfortable and are preferred by work system participants.

Produce artifacts that support IT work. Almost all significant work systems operate through computerized tools and systems. STT should fit into projects that need to provide information that IT professionals can use to acquire and/or implement whatever hardware/software configurations are needed by desired work practices.

Support change processes through easily used ideas. STT ideas for visualizing, understanding, and analyzing systems should support different kinds of change processes and interventions that are tailored to the specifics of the situation at hand.

6 Fit of WSM-Based Thinking with Today's Business World

This paper's title combined a selection of system-related terms that are used frequently in today's business world, including the term ecosystem, that was part of the theme of the 31st annual Sociotechnical Systems Roundtable in 2017. This section summarizes how WSM and elements of the work system framework (mentioned in parentheses for specific topics) deal with those terms.

Sociotechnical thinking. WSM was designed to support sociotechnical thinking, which occurs when understanding, describing, analyzing, designing, and implementing sociotechnical systems. *Work system* was defined to include both sociotechnical and totally automated work systems because many of the sociotechnical systems in today's world contain totally automated components that are work systems on their own right and that may be augmented at some point in the future. Many of WSM's ideas apply to entire organizations even though WSM operates at the work system level rather than

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organizational level. Its inclusion of the term *participant* instead of the term *user* avoids ignoring important participants who do not use computers. That minimizes confusion due to seeing stakeholders as users even if they do not participate at all in work system activities. Personal and political issues still pose a key challenge for sociotechnical thinking, i.e., how to have realistic discussions about whether work system participants have the skills, knowledge, and ambition that are required both by the characteristics and details of the work system being designed and by the surrounding environment.

Competitive. (*environment*) WSM is designed for use in situations where opportunities or problems call for describing, analyzing and improving work systems. It is not inherently about competition, although many of the system-related issues that it addresses are important due to competitive challenges from the environment.

Agile. (*processes and activities*) WSM can be viewed as an agile approach because it always keeps customers in mind (through locating the customer at the top of the work system framework) and because it can be used in varying degrees of depth and with varying amounts of documentation depending on user and stakeholder needs. Application of WSM may help in making a work system more agile if the problem is defined as a lack of flexibility, adaptability, or customer focus.

Lean. (*processes and activities*) The idea of lean can be used in WSM as part of its analysis of processes and activities. WSM itself is a lean approach because it can be used by individuals or teams at different levels of depth without requiring extensive resources. WSM can be used even when STS experts or consultants are not available, although the analysis results would likely be better if STS experts were available.

Data-driven. *(information)* All work systems use or create informational entities that are used, created, captured, transmitted, stored, retrieved, manipulated, updated, displayed, and/or deleted by processes and activities. While traditional STS analysis certainly used data to analyze "variances," being data-driven in an operational sense entails sustained focus on collecting information and using it for operational decisions and management control. WSM assumes that data is initially defined in a somewhat informal way, such as saying that the relevant data consists of orders, invoices, warranties, schedules, income statements, reservations, and so on. Detailed analysis of the data requires careful attention to data definitions and coding of data. That often goes beyond the typical notions of sociotechnical analysis, especially if the data needs to be consistent with data definitions and coding in related work systems elsewhere in the organization, regardless of what might be preferred within the local situation.

Routine work and knowledge work. (*processes and activities*) WSM does not attempt to categorize work as routine work versus knowledge work. The work within a work system is described using the term *processes and activities* because that work may or may not involve clearly specified steps whose beginning, sequential flow, and end are defined well enough to call it a business process. The principle of minimum critical specification [8, 9] presents a challenge in analyzing or designing a work system because of the temptation to build too much control into software. Different types of processes and activities involve different degrees of structure. The range of possibilities starts with *largely unstructured creative processes* (such as many design and management processes) and includes *semi-structured knowledge processes* (such as medical diagnosis or legal analysis), *workflow processes* (such as invoice verification or reimbursement), and *highly structured processes* (such as pharmaceutical and semiconductor manufacturing). Those types of processes differ in the extent to which

the sequence of activities, adherence to specified business rules, and reliance on knowledge and discretion are viewed as essential [4].

Smart. (*technologies*) The vastly overused term "smart" has been applied to different things in different ways. An object such as an electric toothbrush or a system such as a manufacturing system might be viewed as smart if it contains capabilities for some combination of information processing, self-regulation, action the world, and/or knowledge acquisition. In general, WSM treats technologies as tools that are used by work system participants or as automated services, i.e., totally automated work systems. A challenge when using WSM is to deal insightfully with technologies that play roles in the partial or total automation of work currently done by people, especially if they may not be able or willing to imagine automation of important aspects of their work.

Service-oriented. (*product/services, customers*) Work systems produce product/ services such as information, physical things, and/or actions for the benefit and use of their customers. Ignoring what a work system produces is tantamount to ignoring its effectiveness. The term "product/services" bypasses the controversial marketing and service science distinctions between products and services that are not important for understanding operational work systems. Note, however, that product-like vs. service-like is the basis of a series of valuable design dimensions for characterizing and designing whatever a work system produces. (e.g., tangible vs. intangible, transactional vs. relational, commodity-like vs. customized, produced vs. co-produced, and so on). Inclusion of *customers* and *product/services* in the work system framework encourages focus on how a work system's customers attain value from whatever is produced and discourages excessive inward focus on how work is done in local settings.

Customer-centric. (*customers*) Customers are recipients of a work system's product/services for purposes other than performing work activities within the work system. WSM needs to consider both internal and external customers, what they want, and how they use whatever the work system produces. A first challenge for WSM is to follow STS principles in a genuine sense and to try to assure that customers receive product/services that provide genuine benefit. Another challenge is that a work system's customers sometimes serve as work system participants. Participation by customers is especially common in service systems whose activities are coproduced (e.g., patients in a medical exam, students in an educational setting, and clients in a consulting engagement). In such instances, many customers, and possibly significant subgroups of customers with different concerns, may not be able to participate in design-related discussions.

Value creation. (*processes and activities, product/services, customers*) The term value has many different meanings ranging from value added (i.e. the value of resources consumed) through exchange value (such as price) and value-in-use (the fact that different people may value the same object quite differently based on their use of it, independent of price). WSM addresses value creation in all three areas. A WSM analysis often tries to reduce the resources used or increase the exchange value of whatever is produced. Understanding value-in-use is a more difficult problem because usage of product/services by customers may not be visible and may vary greatly between customers or groups of customers.

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Ecosystem. (*environment*) As noted earlier, business ecosystems can be viewed as a set of interacting work systems owned by different individuals or enterprises. Some ecosystems are largely transactional and operate with little or no social interaction or mutual attention to humanistic values. Collaborative ecosystems bring many interesting challenges for WSM because of questions about how to define the relevant work systems, how to obtain accurate information from independent actors with divergent incentives, and how to treat competition within the ecosystem.

7 Conclusion

This paper showed how sociotechnical thinking based on the single-system view in WSM addresses aspects of a fast-moving business world that traditional STS design rarely faced. This paper focused on a way to look at work systems themselves rather than on ideas about STS design or change processes, both of which are covered well by existing knowledge and practice. The work system framework and other ideas in WSM outline an approach to sociotechnical systems that may be useful to the STS community. That single-system approach (seeing an integrated work system, not separate social and technical systems) maintains awareness of interests of human participants, work system customers, and STS values even as digitization and automation expand to new applications that would have been difficult for most STS pioneers to imagine.

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