Communications of the Association for Information Systems

Volume 16 Article 50

December 2005

A Broad View of Systems Analysis and Design: Implications for Research

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

Glenn J. Browne
Texas Tech University, gbrowne@ba.ttu.edu

Recommended Citation
Alter, Steven and Browne, Glenn J. (2005) "A Broad View of Systems Analysis and Design: Implications for Research," *Communications of the Association for Information Systems*: Vol. 16 , Article 50.
DOI: 10.17705/1CAIS.01650
Available at: https://aisel.aisnet.org/cais/vol16/iss1/50

Communications of the Association for Information Systems

A BROAD VIEW OF SYSTEMS ANALYSIS AND DESIGN: IMPLICATIONS FOR RESEARCH

Steven Alter
University of San Francisco
alter@usfca.edu

Glenn J. Browne
Texas Tech University

ABSTRACT

This article presents a broad view of systems analysis and design (SA&D) research. Although SA&D is a critical area of research in the information systems field, relatively little such research has been published in leading IS journals. To point toward increased research opportunities for SA&D work, this article presents a framework that illustrates the broad range of activities within the SA&D area. This framework contrasts with narrower views that consider SA&D to be concerned primarily with software development. The framework positions SA&D activities in a two-dimensional space. We identify theoretical and practical research issues that apply across the full range of SA&D activities as well as issues that apply to specific situations. Research opportunities in SA&D are described and discussed.

Keywords: Systems analysis and design, IS research, Work systems, Organizational change

I. INTRODUCTION

Systems analysis and design (SA&D) is a significant area of research in the information systems field. Despite its central importance, however, "research in the IS field pays relatively little attention to IS analysis and design topics. Few of the articles published in leading IS research journals in the last decade deal with these topics." [Iivari et al. 2005, p. 810]. The same point has recently been made by Bajaj et al. [2005] and Glass and Vessey [2005].[1] The relative dearth of SA&D research is even more surprising given the widely accepted belief that errors, omissions, and other difficulties in determining IS requirements are a primary cause of IS project failure and disappointment (e.g., Ewusi-Mensah [1997], Lindquist [2005], Standish Group [2001], Vessey and Conger [1994], Wand and Weber [2002]).

[1] The current paper was originally conceived as a response to a recent article in *CAIS* by Bajaj et al. [2005], which discussed the importance of SA&D research, the comparatively small amount of such research that has been published, and the opportunities for applying design research approaches when studying conceptual modeling. The discussion of information systems SA&D appearing subsequently in Iivari et al. [2005] provides an additional impetus for presenting this article's broader view of SA&D and associated research issues and opportunities.

Given the importance of SA&D, identifying and describing research issues in the domain are crucial. Such descriptions may stimulate additional SA&D research and publication of results. We believe that definitions of SA&D are often unnecessarily restrictive and do not represent the complete range of SA&D activities. For example, Iivari et al. [2005] present a representative definition of SA&D, in which they state that

> *"Information systems analysis refers to a number of activities in the early stages of information systems development. The main purpose of systems analysis is to identify and document the requirements for an information system to support organizational activities. Information systems design refers to the process of defining the software architecture, components, modules, interfaces, and data for a software system to satisfy requirements specified during systems analysis" (p. 810).*

While we agree that this statement is one context for information systems SA&D, we suggest that information systems analysis also occurs when commercial software is acquired and configured, when existing software is modified, and when information system procedures are modified without changing the software. Further, SA&D can also be conceived as identifying and documenting requirements for the business systems being served [Checkland, 1997], regardless of whether they are called human activity systems [Checkland, 1999], work systems [Alter, 2003], or business processes.[2] Similarly, the information systems design process involves more than just technical aspects of developing software architecture and specifications. It also encompasses the human participants who perform information processing activities included in the information system as well as information and work practices that may not be computerized.

In our view, the full range of potential SA&D research issues has not been articulated in recent IS research. In this article, we present a framework that expresses our view of the broad scope of SA&D and identifies many of the research opportunities that emerge from this view.

The paper is organized as follows. We first present our framework for SA&D research and discuss its dimensions and contexts (Section II). Next, we discuss SA&D research issues that apply across all contexts (Section III) and then discuss issues that occur primarily in specific contexts (Section IV). We conclude with implications based on our framework and discussion (Section V).

II. THE BREADTH OF RESEARCH ON SYSTEMS ANALYSIS AND DESIGN

The field of SA&D encompasses diverse processes, techniques, tools, and concepts that can be applied when analyzing and designing systems. Figure 1 presents a framework that emphasizes the range of contexts in which SA&D applies. Six contexts for SA&D are represented as overlapping to some extent, but are often distinct enough that different SA&D methods can be used in different contexts. When there are overlaps, a combination of SA&D methods may be used.

The two dimensions provide a view of SA&D that is quite broad and that demonstrates the limits of viewing a system simply as software per se or software and its use. The figure also illustrates why better modeling of technical artifacts is only one of many directions for reducing the unacceptably high rate of project and system failure. Clearer, more precise technical specifications are, of course, desirable, but better understanding of the focus of the SA&D effort,

[2] With the advent of real time computing, human activity systems overlap increasingly with the information systems that support them [Alter, 2003]. That is, the analysis and design of many current information systems are inextricably intertwined with the analysis and design of the work systems that are being supported. One of the main problems in many failed systems development efforts is that the proposed work systems were never fully identified and documented (e.g., [Bass, 2003; Schrage 2005]).

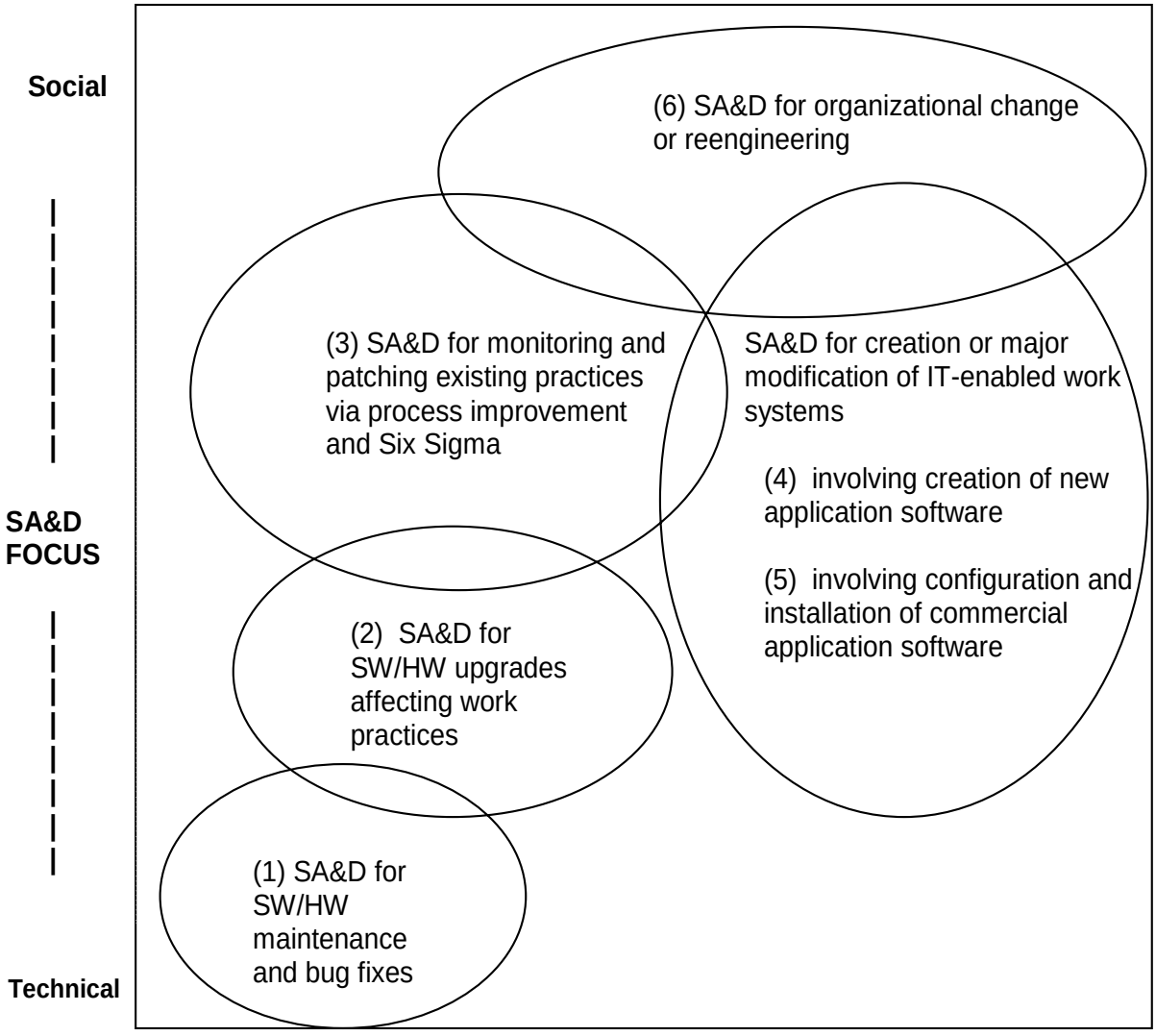

Figure 1. The Range and Scope of SA&D Contexts

the intended amount of change, and the organizational context are also essential parts of the puzzle.

The dimensions of the framework in Figure 1 are:

- the focus of SA&D efforts;
- the extent of change in work practices.

The vertical dimension, focus of SA&D efforts, refers to the relative amount of social versus technical emphasis in the SA&D project that is being performed. Information systems are sociotechnical systems, but that does not imply that all SA&D places equal emphasis on the social and on the technical. The primary focus of SA&D is technical when the analysts believe

that current work practices are adequate, but that bugs, technical obsolescence, or other shortcomings of the existing technology are obstacles to greater efficiency or effectiveness. In such cases, problems with the technology need to be fixed or mitigated. The primary focus of SA&D is social when the analysts believe that current work practices and the social/organizational environment are fundamentally inadequate and require improvements. Fixing or mitigating technology shortcomings may be part of the solution, but technology typically is not the starting point for the analysis. At intermediate points on this dimension, the analysts believe that a combination of social and technical analysis will be necessary to achieve better work system performance.

The horizontal dimension, extent of change in work practices, refers to the degree to which the project's goal is to change work practices in significant ways. At the low end of this dimension, the project's goal is to fix the technology but retain existing work practices; at intermediate points, the goal is to produce incremental changes; at the high end of the dimension, the goal is to produce significant changes in work practices.

These two dimensions are not totally independent, but in combination reveal a number of different potential focuses of SA&D research. The y-axis extends from a minimal emphasis on analyzing social issues to a primary emphasis on social issues and changes. The x-axis extends from minimal desired changes in work practices to significant desired changes. Although one might imagine that the relationship between these variables is highly linear, Figure 1 shows that the space generated by these two dimensions actually encompasses a series of distinct SA&D situations. Each of the six situations in Figure 1 is now discussed in turn.

1. SA&D for software or hardware maintenance or bug fixes is focused on technology and requires a low amount of change in work practices. In this type of situation, the work practices are considered satisfactory and the requirements are relatively unambiguous. The focus of such projects is on the architecture of the software, the clarity of documentation, identification of coding errors, updating based on unambiguous requirements, and other issues related to the technology that is used.
2. SA&D projects for software or hardware upgrades lie at an intermediate position between focusing on work practices and focusing on technology, although the primary focus is still on the technology. While upgrades may require some additional or different work practices within a firm, hardware or software upgrades tend not to require major changes in current work practices. A project intended to produce major changes in work practices would be viewed as a work system change, organizational change, or a reengineering project, not just as a hardware or software upgrade.
3. SA&D for monitoring and patching existing practices via process improvement and Six Sigma focuses more on work practices than on technology, although technology improvements may be part of the solution. Process improvement and Six Sigma efforts are driven by problems or unsatisfactory outcomes from existing work practices. Thus, the goals of these projects include business process improvement, greater control, better measurement, or other related concerns. At least incremental changes in work practices will be required in most of these projects. For example, more extensive documentation and reporting are often implemented. And, although not the primary focus, technology may be an important factor in attaining the project goals.
4. and 5. SA&D for the creation or major modification of IT-enabled work systems may involve the creation of new software and/or the configuration and installation of commercial application software. These types of projects are at an intermediate level of the SA&D focus dimension. New application software enables, enhances, and/or restricts previously-existing processes and procedures. Consequently, introducing new application software into the organization nearly always requires changes in work practices.
6. SA&D for organizational change or reengineering brings the most direct focus on work practices. Such projects are initiated to improve work practices that seem unsatisfactory. They often involve significant changes in computerized information systems, but there

may be cases in which the key issues concern, e.g., incentives or roles and responsibilities. In such cases, the SA&D effort is explicit about viewing the work system as a sociotechnical system (Cherns [1976], Mumford and Weir [1979]), human activity system (Checkland [1999]), IT-reliant work system (Alter [2003]), IT-enabled work system (Jasperson et al. [2005]), or other similar system. Because of the breadth of projects in this category, the extent of change in work practices is usually intermediate or high. For example, an analysis that discovers flaws in an organization's incentive system may change that system without significantly changing work practices. At the other extreme, work practices may be reengineered in such a way that entirely new procedures must be followed.

The six contexts in Figure 1 illustrate that a broad range of methods and research issues should be included within SA&D. By omission, Figure 1 also identifies issues that are not included in this article. We focus on a subset of what Andersen et al. [1990] and Iivari, Hirschheim, and Klein [2004] term "ISD performance processes." We do not focus on what they term "ISD management processes," which are primarily issues in project management. Among ISD performance processes, we are primarily concerned with organizational alignment and requirements construction. We are less concerned with such aspects as interface design, architectural design, database design, and software design.

Identification of the six contexts in Figure 1 implies that it is important to look at two groups of research issues and findings. The next section discusses a large number of SA&D research issues that apply across all six situations, i.e., the full SA&D space in Figure 1. Section IV looks at research opportunities that apply to individual situations in Figure 1.

III. RESEARCH ISSUES SPANNING MOST SA&D EFFORTS

In this section we identify issues that span the SA&D contexts shown in Figure 1. We do so by viewing SA&D as a type of work that is performed in organizations; thus, SA&D can be viewed as a work system[3]. The elements of the work system framework (Figure 2) provide a way to drill down into the different SA&D situations. This section will look at each element in turn to identify some of the topics and variables that SA&D research might study. The identification of these topics is based partly on the "slices" identified in Alter [2005], Table 2, pp. 14-16.[4]

WORK PRACTICES

Important slices for understanding SA&D work practices include business process, decision making, communication, coordination, sensemaking, and information processing. These slices overlap to some extent, but each provides a perspective for thinking about how SA&D work is performed and how it produces results. For example, the business process slice emphasizes workflow issues such as the identification of steps, conditions for starting and completing steps, and transitions between steps. In contrast, the decision making slice emphasizes decision-related concepts such as optimality, satisficing, utility, decision framing, and risk tolerance.

---

[3] 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. The work system framework identifies the basic elements for understanding and evaluating a current or proposed work system.

[4] The concept of slice is part of the architecture of Sysperanto, which is being developed as a model-based ontology of the IS field [Alter, 2005]. Within Sysperanto, a slice is a related set of properties that can be applied when trying to understand or analyze a particular work system. For example, when looking at the work practices within a work system, commonly used slices include business process, decision making, communication, coordination, sensemaking, and information processing. Each of those slices provides a related set of properties that can be used to analyze work practices.

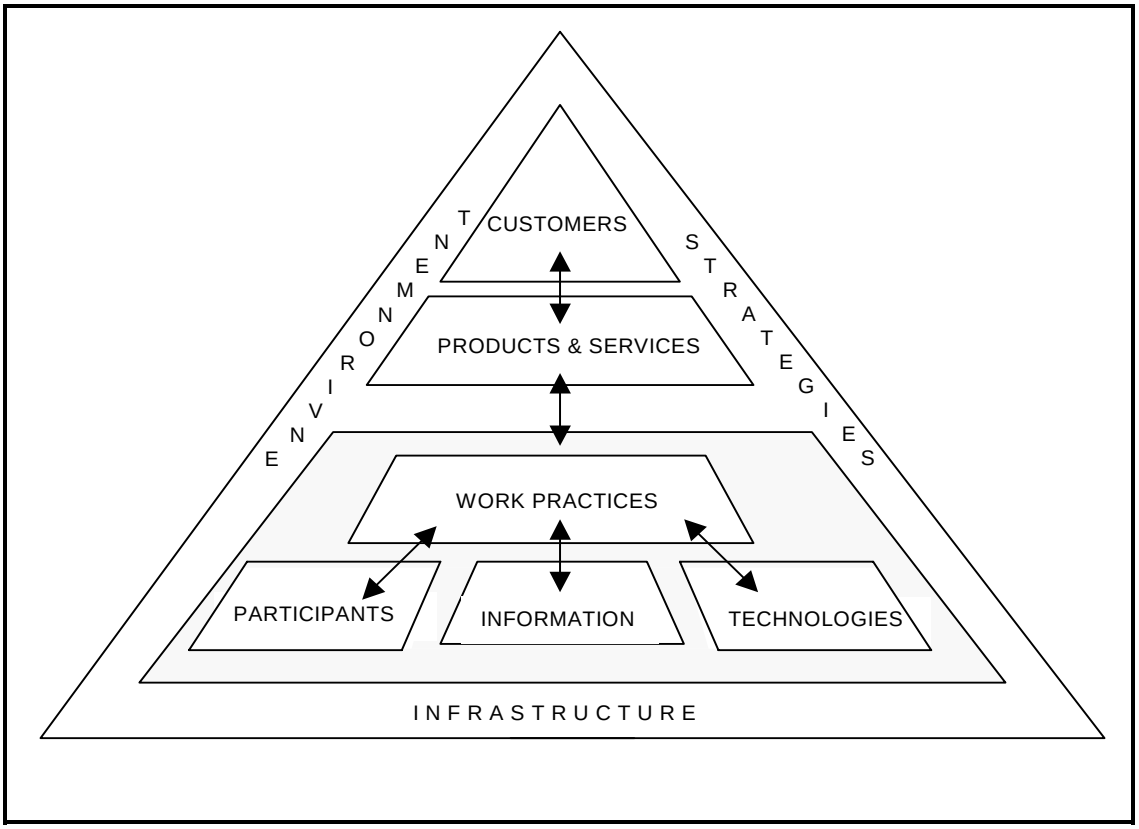

Figure 2. The Work System Framework [Alter, 2003]

Business Processes

Table 1 describes a generic business process for SA&D and identifies corresponding topics that might be studied in SA&D research.

Table 1. Generic Business Process for SA&D and Related Research Topics

Step in a Generic Business Process for SA&D	**Related Research Topics**
Identify the problem	• How can problems be identified? (e.g., Smith [1998]) • How can problems be described so as to clearly communicate the issues between interested parties?
Identify the system	• How directly is the system being analyzed related to the problem that launched the analysis? • What are the impacts of different analytical stances (vertical dimension in Figure 1)? - system as technical artifact - system as technical artifact used in the situation - system as sociotechnical system with human participants

Step in a Generic Business Process for SA&D	Related Research Topics
Gather information about the situation	• How is the information collected, organized, and stored? What requirements determination tools and techniques are relevant given the context? (e.g., Browne and Ramesh [2002]) • What are the sources of information? • How good is the information? (e.g., Fox, Levitin, and Redman [1993], Klein, Goodhue, and Davis [1997]) • How engaged are the people who provide the information? • What are the incentives of the people who provide information? How do those incentives affect the quality of the information used in SA&D? (e.g. Ba, Stallaert, and Whinston [2001], Raghu, Jayaraman, and Rao [2004])
Analyze information about the situation	• How is the analysis performed? • What factors are considered in the analysis and what factors are ignored, especially in relation to the analytical stance used for identifying the system?
Identify opportunities and alternatives	• How are opportunities and alternatives identified? • What types of opportunities are considered or ignored?
Develop an initial design recommendation	• What decision-making process is used to develop criteria and alternatives? (e.g., Jain, Tanniru, and Fazlollahi [1991]) • How many genuine alternatives are considered? • How are tradeoffs identified and resolved?
Obtain feedback	• How is feedback obtained? • What verification techniques are appropriate, and how effective are these techniques? [e.g., Browne et al. [2005]) • How well do the people providing the feedback understand the situation and the proposal?
Produce a final recommendation	• Which feedback is incorporated and which is ignored? • How are stakeholder interests identified and addressed? • How specific and detailed is the recommendation? • How good is the shared understanding of the recommendation? Which important issues and details are misunderstood? • What criteria are used to convert the initial design recommendation into the final recommendation? • What choice rules are used to make a final selection? • Is the final analysis and recommendation recorded in a form that allows a post-implementation audit?
Document the recommendation for programming	• How is the final recommendation converted into documentation for programming? • What requirements-related ambiguities do programmers have to resolve? Are programmers equipped to resolve such ambiguities? (e.g., Fichman and Moses [1999])

Many research issues are related to a business process view of SA&D work practices. Examples include:

- What are the advantages and disadvantages of particular business processes for SA&D?

- How does the choice of an SA&D business process affect metrics such as speed, quality, cost, and customer satisfaction?
- To what extent are SA&D business processes actually followed? (e.g., Gasson [1995]; Truex et al [2001]; Avison and Fitzgerald [2002])
- What are typical reasons for important types of workarounds or omissions?
- How do organizations decide which SA&D process they will use in specific projects?
- How adequate are SA&D processes involving acquisition and implementation of commercial software? (e.g., Anderson [1990], Buchowicz [1991])

Decision Making

The business process slice focuses primarily on the steps that are performed. The decision making slice focuses on the important decisions that are made. Important issues related to decision making include:

- What are the major decisions to be made in SA&D?
- Who has which decision rights [Weill and Ross, 2004] about the analysis of the existing system and the design of any improvements?
- Who influences which decisions? (Beath and Orlikowski [1994])
- Are decisions made heuristically or normatively? If decisions are made heuristically, whose heuristics are used? Are the heuristics understood by anyone other than the individual decision maker? (Simon [1996])
- How are priorities expressed, and how well are they represented in the recommendation?
- How are conflicts between stakeholder interests resolved?
- How do budgetary constraints affect choices in the analysis and design effort?
- What types of information are considered or ignored?
- What choice rules are used in decision making? (Svenson [1979])

Communication

Performing SA&D involves a great deal of communication between people in different work roles. Issues related to communication include:

- How well do IT professionals and business professionals communicate with one another? (e.g., Bostrom [1989], Valusek and Fryback [1987])
- What types of issues are discussed with mutual understanding, mentioned but not fully understood, or ignored?
- How does the quality of communication affect the quality of the requirements?
- How does geographic dispersion affect SA&D efforts? (e.g., Conkar, Noyes, and Kimble [1999])
- How effective are communication tools and techniques such as videoconferencing, electronic meetings, group support systems, document repositories, and CASE tools?

Coordination

Coordination is a central issue in large-scale SA&D projects, although it is a lesser concern in small-scale ones. Coordination is primarily a project management issue, and thus we do not address it extensively here. Research issues such as the following are important:

- What types of coordination issues arise in SA&D? (e.g., Crowston and Kammerer [1998]; Espinosa et al. [2002])
- How is SA&D participation coordinated with other responsibilities of business and IT participants?

Sensemaking

The challenge of making sense of both the organizational setting and the result of the analysis is central to SA&D activities but often overlooked in research and practice.

- How do stakeholders (particularly analysts and users) make sense of the SA&D process?
- How do sensemaking and sensegiving activities help analysts and users elicit and construct requirements for new systems? (e.g., Davidson [2002])
- How do business professionals make sense of technical documentation such as UML diagrams?
- How do IT professionals make sense of stories, culture, politics, and other non-technical indications in the workplace? (e.g., Walsham [1993])

Information Processing

SA&D collects and uses a substantial amount of information. An information processing slice for SA&D work practices emphasizes topics such as:

- How is information captured, organized, stored, and retrieved during analysis?
- How is this information archived for future use, such as post-implementation audits?
- How do participants in SA&D process and manage information? For example, does information overload negatively impact SA&D?

PARTICIPANTS

As in work systems of any type, the incentives, interests, morale, and knowledge of SA&D participants have an important impact on the success of the SA&D effort. In addition, communication and negotiation between business and IT professionals during SA&D is often problematic [Bostrom, 1989]. These problems are related to a variety of personal, interpersonal, and technical issues. Research questions related to participants include:

- What are the impacts of user participation on the SA&D process? (e.g., Barki and Hartwick [1994], Dean et al. [1997], Hunton and Beeler [1997])
- What are the required competencies of participants in the SA&D process?
- How are the job roles and characteristics of SA&D participants related to their ability to understand and use particular SA&D techniques?
- How do interactions between participants in different job roles affect the success of SA&D efforts?
- How are the beliefs and interests of SA&D participants related to the success of SA&D efforts? (e.g., Green [1989])
- How are conflicts between participants in the SA&D process resolved? (Barki and Hartwick [2001])

Figure 3 illustrates some of the issues related to job roles in relation to the project and the system being built. It shows that the roles of IT analyst and business analyst may overlap to some extent because effective analysts on both sides appreciate the other side. It also shows that the understandings and interests of work system participants (including IT users and IT-nonusers) may be different from those of other stakeholders who are not work system participants. Many personal, interpersonal, and organizational issues arise from inherent conflicts between these roles, understandings, and interests.

INFORMATION

Every step in SA&D involves information. SA&D creates a problem definition, collects information, analyzes information, and produces recommendations and specifications. Important questions related to information in SA&D include:

- Is it possible to identify and resolve omissions and inconsistencies in information gathered during analysis?
- Other than mechanical methods such as where-used lists, is there any way to verify that analysis or design information is internally consistent and complete? (e.g., Parsons [2002], Sakthivel and Tanniru [1989])

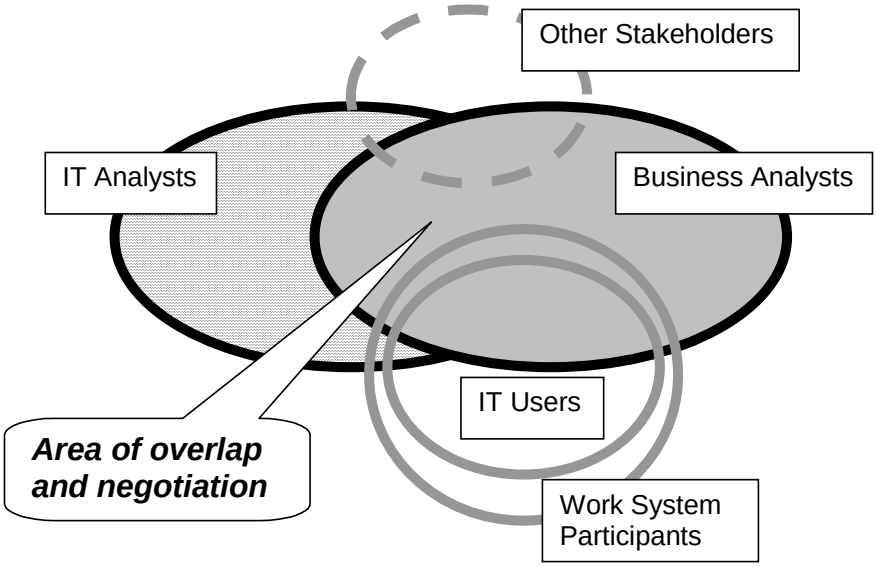

Figure 3. Roles in SA&D

- Is design information represented using formalisms that are effective for signoff by non-IT personnel? (e.g., Browne et al. [2005])
- Is design information represented using formalisms effective for programming? [Erickson and Siau, 2004]
- Is analysis and design information archived in a useful form?
- Is it possible to verify the source and realization of all requirements? (e.g., [Balasubramaniam, 1998])

TECHNOLOGIES

As with other technologies, technologies used in SA&D can be described as techniques inscribed on artifacts (tools). For example, a program for drawing ERDs is a technique (the ERD) inscribed on a tool, a computer program that runs on a computer. Research questions about SA&D technologies include:

- What are the advantages and disadvantages of specific techniques (such as ERDs or UML)?
- How well are techniques used in particular types of situations?
- Why do techniques matter?
- How do the affordances of specific tools (e.g., Smartdraw, Visio) affect the success of SA&D?

PRODUCTS AND SERVICES

\Work systems exist to produce products and services for their internal or external customers. The visible products produced by SA&D are documents such as functional specifications, UML diagrams, and project repositories. SA&D efforts also produce important intangibles, such as stakeholders' feelings and beliefs. Research questions include:

- How do shared (or unshared) understandings of the situation, the recommendation, and its justification affect SA&D outputs? [Senge, 1990; Ackoff, 1999]

- How do feelings and beliefs about whether stakeholders' voices and interests were taken seriously affect SA&D products and services?
- How do stakeholders' impressions affect SA&D outputs? (e.g., impressions about whether business and IT professionals are able to work together comfortably)

CUSTOMERS

The customers for SA&D work are:

1. Business professionals directly affected by the system that is being analyzed,
2. IT professionals who build and maintain the software, and
3. Managers and other stakeholders with indirect interests.

Related research topics include:

- What tactics do business professionals use to influence the ultimate design recommendation, and how effective are those tactics? (Robey, Farrow, and Franz [1989])
- How well do IT professionals assert their interest in high quality software versus quick and dirty software that will be difficult to maintain?
- What tactics do managers and other stakeholders use to influence design recommendations and allocations of resources for projects?
- What tactics are sometimes used to sabotage or delay SA&D efforts (e.g., Keen's [1981] discussion of counter-implementation)

ENVIRONMENT

Aspects of the internal and external environment surrounding an SA&D effort include organizational culture, the organization's policies and procedures, the organization's history, the resource environment, the competitive environment, the political environment, and industry and governmental regulations and standards. Each of these aspects can impact SA&D practices and outcomes.

- How does an organization's culture and balance of power affect the analysis process and design decisions?
- How are organizational policies and procedures made visible in SA&D efforts?
- What are the implications for SA&D of attempts to attain higher levels in the capability maturity model (Adler et al. [2005])
- How do the availability of vendors and other resources (e.g., component vendors) affect the SA&D effort?
- Does the nature and intensity of competition in the environment affect the quality, speed, or content of SA&D?
- Do industry and governmental regulations affect SA&D practices?

INFRASTRUCTURE

An organization's infrastructure includes human, informational, and technical capabilities that are shared across multiple work systems. Infrastructure seems less important for SA&D work systems than for other types of work systems, but some research questions need to be examined:

- Does technical infrastructure impact SA&D work, especially when geographically distributed systems are involved? (e.g., Lyytinen and Yoo [2002])
- What are effective ways to share centralized SA&D competence across an organization?
- To what extent do firms or departments have standard or semi-standard methods for SA&D related to building software or related to work systems in general? If such methods exist, what are they and how effective are they? [Avison and Fitzgerald, 2003]

- To what extent do firms attempt to reuse software components, either formally (as in a reuse library) or informally? What infrastructure and support are there for such efforts? (e.g., Kim and Stohr [1998])

STRATEGIES

Ideally an organization's systems should be aligned with its strategy [Luftman, Papp, and Brier, 1999; Reich and Benbasat, 2000]. Related research questions include:

- What are the mechanisms through which a strategy used in a target work system is made visible during SA&D (as opposed to focusing mainly on process and information details)?
- What are the mechanisms through which a firm's strategy is made visible during SA&D?
- To what extent do choices during analysis and design efforts genuinely reflect a firm's strategy?

IV. RESEARCH RELATED TO SPECIFIC SA&D CONTEXTS

This section discusses issues related to the six SA&D contexts identified in Figure 1. Many of the topics in this section can be addressed using a variety of research approaches, including experimental, qualitative, and theoretical research as well as design research. This section identifies some of the past research in each area and suggests additional research directions.

SOFTWARE MAINTENANCE AND BUG FIXES

Except in the simplest examples, maintenance and bug fixes require analysis and design work. Although software maintenance and bug fixes absorb a large percentage of the resources in most IT groups (e.g., Kaplan [2002]), relatively little research looks at SA&D for software and bug fixes, and at the relationship between earlier SA&D activities and the success of software maintenance. Key relationships involve the quality and completeness of the original requirements, the formalisms used, and the efficiency and reliability of software maintenance and bug fixes. In what ways do the quality and completeness of the original requirements affect maintenance and bug fixes, especially in legacy systems that change many times? How do SA&D formalisms affect maintenance and bug fixes in practice (e.g., Dekleva [1992])? How are the documents produced by SA&D related to software maintenance and bug fixes retained for future use in software maintenance and upgrades?

SOFTWARE UPGRADES

Relatively little SA&D research focuses on software upgrades. Yet various forms of upgrades generate a large percentage of IT costs. With software upgrades, the purchasing organization must compare its needs against the features and potential process improvements enabled by the upgrade. How is this form of SA&D accomplished by the organization? What informal methods are typically used? How often are formal methods used, and what additional insight do they provide in practice? How are economic considerations, usability, and other criteria combined in deciding what to do?

PROCESS IMPROVEMENT AND SIX SIGMA

The basic idea underlying process improvement methods and Six Sigma [Pande et al., 2000] is to document processes, track process results, identify problems, make corrections, and determine whether the corrections were successful. Except when the discussion is about the promise of business process reengineering [Hammer and Champy, 1993], the primary focus is on incremental changes in which measurement and tracking of performance indicators are key. Process improvement and Six Sigma efforts sometimes require software changes, but are often discussed without reference to SA&D techniques for software. Thus, integration of SA&D techniques with process improvement techniques from operations management should be a valuable research area. At a minimum, SA&D analysts should be aware of process and data

analysis methods used to track and improve operational business processes. One area for research is whether and how SA&D analysts use control charts, fishbone diagrams, and other analysis techniques (e.g., George et al. [2005]; Smith [1998]) that are typically associated with process improvement and Six Sigma.

Current research and tool development under headings such as workflow management, process automation and management, and business process management could also provide a focus for SA&D research. The basic goal of process automation and management tools is to create and enforce workflow and process definitions and to modify those definitions when necessary (zur Muehlen [2004], Smith and Fingar [2003]). These developments raise several questions for SA&D. First, how can SA&D concepts be used effectively in conjunction with these tools? Second, in what ways are SA&D concepts incorporated into these tools, and with what effectiveness?

FUNDAMENTAL CHANGES IN IT-RELIANT WORK SYSTEMS: DEVELOPING NEW SOFTWARE

Developing new software is the starting point for most SA&D textbooks and research in conceptual modeling. The research in this area has been extraordinarily valuable in software development and information systems development more generally. Because of the extensive coverage of these topics in IS textbooks and research, our only comment is that many people believe that these topics are the core of SA&D, and that other aspects of SA&D are of much less significance. As our conceptualization and model suggest, we believe that legitimate areas for research in SA&D encompass many situations other than developing new software.

FUNDAMENTAL CHANGES IN IT-RELIANT WORK SYSTEMS: CONFIGURATION AND IMPLEMENTATION OF COMMERCIAL SOFTWARE

Development of new software is less prevalent today than in past decades. Many companies view such development as reinventing the wheel, and choose instead to acquire commercially available application software when the application is not of competitive significance or when the acquisition of commercial software is the only practical way to attain an acceptable level of informational and transactional integration across the organization. Critical questions that arise include how such acquisition decisions should be made and how the commercial applications should be tailored to the purchasing organization. Purchase decisions are often based on economic feasibility rather than operational or technical feasibility. The tailoring of the software to the organization's requirements is often left to designers. However, designers charged with configuring software and implementing upgraded work systems in the organization may be ill-equipped to gather requirements in such a post hoc fashion. As noted by Fichman and Moses [1999, p. 41],

> *"The software configuration challenge consists of a process in which implementers develop an understanding of the software itself and the organizational design options enabled by it, after which they strive to actually configure, deliver, and continuously evolve the software and corresponding organizational changes. . . . Ironically, as software packages have become more sophisticated and flexible, the act of configuring and implementing the software has begun to assume some of the complexity formerly associated with developing a customized system. "*

SA&D related to selection and configuration of software packages raises a series of research issues. How can requirements be gathered in such a situation? Which SA&D methodologies should be used? Who should perform such analyses? How can SA&D identify and resolve issues related to task-technology fit [Goodhue and Thompson, 1995] in such situations?

ORGANIZATIONAL ANALYSIS, SOCIOTECHNICAL ANALYSIS, AND CHANGE MANAGEMENT

Traditional SA&D in the IS field emphasizes the structured and computerized aspects of IT-reliant work systems. A largely separate stream of SA&D practice focuses on organizational analysis, sociotechnical analysis, and change management. For example, Mumford's ETHICS (Effective Technical and Human Implementation of Computer Systems) method is a sociotechnical method that includes separate analyses of the technical system and social system (Mumford and Weir [1979], Hirschheim and Klein [1994]). Checkland's soft systems methodology originally used a seven step process, but was more recently described as four steps directed at finding out about a problem, formulating relevant activity models, debating the situation and conflicting interests, and taking action [Checkland, 1999]. Multiview, which has been in a "continual state of development since 1985," combines organizational analysis, information modeling, sociotechnical analysis and design, and technical design and construction. [Avison, Vigden, and Wood-Harper, 2004, p. 34] The work system method uses the work system framework to provide depth and focus for a problem solving process that applies regardless of whether IT plays a major role in a work system [Alter, 2003]. All of these approaches emphasize understanding systems in organizations and deemphasize or ignore production of precise, verifiable documentation that can be used directly by programmers. In each case, better links between the sociotechnical or organizational analysis and programming requirements could increase effectiveness of the entire effort.

V. CONCLUSION

This article sets a broad agenda for research in SA&D. The view of SA&D expressed in Figure 1 encompasses a number of topics that are downplayed or assumed as givens in narrower views of SA&D. The broad view draws attention to the following major issues:

- **Focus of SA&D efforts**. Depending on one's analytical stance, the system being studied may be a technical artifact operating on a computer, a tool whose use is included in the analysis, or a sociotechnical system that includes work practices, human participants, information, and technology. Each stance is valid, each has motivated research, and each offers potential for future research.
- **Causes of system failure.** Some failures may result from inadequate technical requirements, but many other failures result from issues related to behavioral requirements and the interplay of work practices, participants, information, and technology. In other words, a broad view of SA&D includes important causes of system failure that a narrower view tends to ignore or downplay.
- **Ambiguity of requirements**. SA&D research may assume the potential existence of verifiably correct, unambiguous requirements. However, such a view is almost always unrealistic. A better perspective is for SA&D research to assume that requirements are the product of data gathering and negotiations undertaken in a climate of time pressure, inadequate knowledge, and conflicting interests. This view encompasses many theoretical and practical issues that are ignored if SA&D research assumes that the task is to capture unambiguous requirements.
- **Precision of formalisms and documentation**. Closer links between SA&D and programming call for documentation using precise formalisms. On the other hand, SA&D is also directed at a more general understanding of big picture issues emphasizing clarity, communication, and insight rather than precise documentation of details. The broader view of SA&D recognizes both types of issues.
- **Importance of information for decision making**. Many information systems are developed to support decision making (Davis and Olson [1985], Wetherbe [1991]). Effective decision making requires relevant information. Thus, in understanding and representing IT-reliant work systems, SA&D efforts should be directed toward capturing the ambiguities, uncertainties, incomplete knowledge, conflicts, heuristics, biases, evaluations, and choices associated with those processes. Gathering only those requirements that are convenient, easy for the analyst to understand, or easy to represent using available

diagramming techniques is not enough (e.g., Ramesh and Browne [1999]). A broad view of SA&D includes gathering many types of relevant information to build an understanding of business processes and the organizational decisions they support.

- **Attention to personalities, organizational politics, and culture**. If SA&D is mostly a technical activity related to technical topics, then personalities, organizational politics, and culture are unimportant. If SA&D relies heavily on negotiations involving diverse and often conflicting interests, then human and organizational issues must be recognized fully.

Our broad view of SA&D generates significant challenges. Emphasis on any particular aspect of SA&D almost guarantees that other important aspects will be ignored or considered unproblematic. Research emphasizing organizational analysis and change management usually ignores or downplays SA&D issues related to programming and software technology. Conversely, research on conceptual modeling and links between design and programming typically assumes the existence of stable, unambiguous requirements that only need to be captured faithfully and represented clearly. Combined approaches are likely to be more successful and should depend on a project's position in the two-dimensional space shown in Figure 1.

We agree with several recent papers (e.g., Iivari et al. [2005] and Bajaj et al. [2005]) noting that SA&D is a central topic in the IS field and that surprisingly little SA&D research has been published in leading IS journals. The broad view of SA&D presented in this article suggests the variety of topics that are important to both researchers and practitioners. We believe that this view can lead to increased publishing of SA&D research in top IS journals, due to both a broader definition of topics for SA&D (e.g., analysis for purchase and configuration of software) and a broader conceptualization of context (e.g., including explicit analysis of the business systems that are served by information systems). We hope that this view will encourage research in a wide range of areas that are important to the IS field both theoretically and practically.

Editor's Note: This article was received on July 20, 2005 and was published on December 30, 2005. It was with the authors for two revisions.

REFERENCES

EDITOR'S NOTE: The following reference list contains the address of World Wide Web pages. Readers who have the ability to access the Web directly from their computer or are reading the paper on the Web, can gain direct access to these references. Readers are warned, however, that

> 1. these links existed as of the date of publication but are not guaranteed to be working thereafter.
>
> 2. the contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
>
> 3. the authors of the Web pages, not CAIS, are responsible for the accuracy of their content.
>
> 4. the authors of this article, not CAIS, are responsible for the accuracy of the URL and version information.

Ackoff, R.L. (1999) "Alternative Types of Planning," in *Ackoff's Best*. New York: John Wiley & Sons, pp. 104-114.

Adler, P.S., F.E. McGarry, W.B. Irion-Talbot, D.J. Binney (2005), "Enabling Process Discipline: Lessons from the Journey to CMM Level 5," *MIS Quarterly Executive*, 4(1), March, pp. 215-227.

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 AIS,* 12(23), October, pp. 365-394.

Alter, S. (2005) "Architecture of Sysperanto - A Model-Based Ontology of the IS Field," *Communications of the AIS*, 15(1), January, pp. 1-40.

Andersen, N., F. Kensing, J. London, L. Mathiassen, A. Munk-Madsen, M. Rasbech, and P. Sorgaard. (1990) *Professional Systems Development: Experience, Ideas, and Action*. Hemel Hempstead, U.K.: Prentice-Hall.

Anderson, E. E. (1990) "Choice Models for the Evaluation and Selection of Software Packages." *Journal of Management Information Systems*, 6(4), pp. 123-137.

Avison, D. and G. Fitzgerald (2003) "Where now for development methodologies?" *Communications of the ACM*, 46(1), January, pp. 78-82.

Avison, D, R. Vigden, and T. Wood-Harper (2004) "Forming a contingent, multi-disciplinary and ethical approach to IS development," In K.V. Andersen and M. T. Vendelø, *The Past and Future of Information Systems*, Butterworth-Heinemann (2004) pp 29-42.

Ba, S., J. Stallaert, and A.B. Whinston. (2001) "Research Commentary: Introducing a Third Dimension in Information Systems Design—The Case for Incentive Alignment." *Information Systems Research*, 12(3), pp. 225-239.

Bajaj, A., D. Batra, A. Hevner, J. Parsons, and K. Siau (2005) "Systems Analysis and Design: Should We Be Researching What We Teach?" *Communications of the AIS*, 15, pp. 478-493.

Balasubramaniam, R. (1998) "Factors Influencing Requirements Traceability," *Communications of the ACM*, 41(12), December, pp 37-44.

Barki, H. and J. Hartwick (1994) "Measuring User Participation, User Involvement, and User Attitude." *MIS Quarterly*, 18(1), pp. 59-82.

Barki, H. and J. Hartwick (2001) "Interpersonal Conflict and its Management in Information System Development." *MIS Quarterly*, 25(2). pp. 195-228.

Bass, Alison, "Cigna's Self-Inflicted Wounds," *CIO Magazine*, Mar. 15, 2003. http://www.cio.com/archive/031503/cigna.html

Beath, Cynthia M. and Wanda J. Orlikowski (1994) "The Contradictory Structure of Systems Development Methodologies: Deconstructing the IS-User Relationship in Information Engineering," *Information Systems Research,* December, pp. 350-377.

Bostrom, R.P. (1989) "Successful Application of Communication Techniques to Improve the Systems Development Process." *Information & Management*, 16, pp. 279-295.

Browne, G. J. and V. Ramesh. (2002) "Improving Information Requirements Determination: A Cognitive Perspective." *Information & Management*, 39, pp. 625-645.

Browne, G.J., V. Ramesh, S. Balaji, and V. Khatri. (2005) "User Requirements Verification: Evaluating the Effect of Formality in Presentation Modeling Representations." In *Proceedings of the Fourth Annual Symposium on Systems Analysis and Design*, Cincinnati, OH, pp. 50-56.

Buchowicz, B. S. (1991) "A Process Model of Make-vs.-Buy Decision-Making: The Case of Manufacturing Software." *IEEE Transactions on Engineering Management*, 38(1), pp. 24-32.Checkland, P. (1999) *Systems Thinking, Systems Practice*, Chichester, UK: John Wiley.

Cherns, A. (1976) "Principles of Socio-technical Design." *Human Relations*, 2(9) pp. 783-792.

Checkland, P. (1997) *Information, Systems, and Information Systems,* Chichester, UK: John Wiley, cited in Rose and Meldrum (1999)

Checkland, P. (1999) *Systems Thinking, Systems Practice*, Chichester, UK: John Wiley.

Conkar, T., J.M. Noyes, and C. Kimble. (1999) "CLIMATE: A Framework for Developing Holistic Requirements Analysis in Virtual Environments." *Interacting with Computers*, 11(4), pp. 387-402.

Crowston, K. and E.E. Kammerer (1998) "Coordination and Collective Mind in Software Requirements Development," *IBM Systems Journal*, 37(2), pp. 227-245.

Davidson, E.J. (2002) "Technology Frames and Framing: A Socio-Cognitive Investigation of Requirements Determination." *MIS Quarterly*, 26(4), pp. 329-358.

Davis, G.B. and M.H. Olson. (1985) *Management Information Systems: Conceptual Foundations, Structure, and Development*. New York: McGraw-Hill.

Dean, D.L., J.D. Lee, M.O. Pendergast, A.M. Hickey, and J.F. Nunamaker, Jr. (1997) "Enabling the Effective Involvement of Multiple Users: Methods and Tools for Collaborative Software Engineering." *Journal of Management Information Systems*, 14(3), pp. 179-222.

Dekleva, S.M. (1992) "The Influence of the Information Systems Development Approach on Maintenance." *MIS Quarterly*, 16(3), pp. 355-372.

Erickson, J and K. Siau (2004) "Theoretical and Practical Complexity of Unified Modeling Language: Delphi Study and Metrics Analyses," *Proceedings of the International Conference on Information Systems*, ICIS –2004, pp. 183-194.

Espinosa, J.A., R. Kraut, S. A. Slaughter, J.F. Lerch, J. D. Hersleb, A. Mockus. (2002) "Shared Mental Models, Familiarity, and Coordination: A Multi-Method Study of Distributed Software Teams." *Proceedings of the Twenty-Third International Conference on Information Systems*, Barcelona, Spain.

Ewusi-Mensah, K. (1997) "Critical Issues in Abandoned Information Systems Projects." *Communications of the ACM*, 40, pp. 74-80.

Fichman, R.G. and S.A. Moses. (1999) "An Incremental Approach for Software Implementation." *Sloan Management Review*, 40 (2), pp. 39-52.

Fox, C., A. Levitin and T. Redman. (1993) "The Notion of Data and Its Quality Dimensions." *Information Processing & Management*, 30(1), pp. 9-19.

Gasson, S. (1995) "The Role Of Methodologies In IT-Related Organisational Change," in *Proceedings of the Conference of the BCS IS Methods Specialist Group*, Heriot-Watt University, Edinburgh.

Glass, R. and I. Vessey (2005) "Predicting the Future of the IS Discipline: An Analysis Based on Current IS Research," *The Gordon B. Davis Symposium*, Minneapolis, MN, May 13-14, 2005.

George, M.L., D. Rowlands, M. Price, and J. Maxey (2005) *The Lean Six Sigma Pocket Toolbook*, New York, NY: McGraw Hill.

Goodhue, D. L. and R. L. Thompson (1995) "Task Technology Fit and Individual Performance," *MIS Quarterly*, 19(2), June, pp. 213-236.

Green, G.I. (1989) "Perceived Importance of Systems Analysts' Job Skills, Roles, and Non-Salary Incentives." *MIS Quarterly*, 13(2), pp. 114-133.

Hammer, M. and Champy, J. (2003) *Reengineering the Corporation: A Manifesto for a Business Revolution*, New York, NY: HarperBusiness.

Hevner, A., S. March, S. Ram, and J. Park (2004) "Design Science Research in Information Systems." *MIS Quarterly* 28(1), pp. 75-105.

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

Hunton, J.E. and J.O. Beeler. (1997) "Effects of User Participation in Systems Development: A Longitudinal Field Experiment." *MIS Quarterly*, 21(4), pp. 359-388.

Iivari, J., R. Hirschheim, and H. Klein. (2004) "Towards a Distinctive Body of Knowledge for Information Systems Experts: Coding ISD Process Knowledge in Two IS Journals." *Information Systems Journal*, 14, pp. 313-342.

Iivari, J., J. Parsons, and A. R. Hevner (2005) "Research in Information Systems Analysis and Design: Introduction to the Special Theme Papers," *Communcations of the AIS*, 16, pp. 810-813.

Jain, H.K., M.R. Tanniru, and B. Fazlollahi. (1991) "MCDM Approach for Generating and Evaluating Alternatives in Requirement Analysis." *Information Systems Research*, 2(3), pp. 223-239.

Jasperson, J., P.E. Carter, and R.W. Zmud (2005) "A Comprehensive Conceptualization of Post-Adoptive Behaviors Associated with Information Technology Enabled Work Systems," *MIS Quarterly*, 29(3), September, pp. 525-557.

Kaplan, S. (2002) "Now is the Time to Pull the Plug on Your Legacy Apps." *CIO Magazine*. Viewed on June 30, 2005 at http://www.cio.com/archive/031502/infrastructure.html .

Keen, P.G.W. (1981) "Information Systems and Organizational Change," *Communications of the ACM*, 24(1), January, pp. 24-33.

Kim, Y. and E. A. Stohr. (1998) "Software Reuse: Survey and Research Directions." *Journal of Management Information Systems*, 14 (4), pp. 113-147.

Klein, B.D., D.L. Goodhue, and G.B. Davis. (1997) "Can Humans Detect Errors in Data? Impact of Base Rates, Incentives, and Goals." *MIS Quarterly*, 21(2), pp. 169-194.

Lindquist, C. (2005) "Fixing the Requirements Mess." *CIO Magazine*, November 15, 2005. Viewed on November 27, 2005 at http://www.cio.com/archive/111505/require.html.

Luftman, J.N., R. Papp, and T. Brier. (1999) "Enablers and Inhibitors of Business-IT Alignment." *Communications of the AIS*, 1(11), pp. 1-33.

Lyytinen, K. and Y. Yoo. (2002) "Research Commentary: The Next Wave of Nomadic Computing." *Information Systems Research*, 13(4), pp. 377-388.

Malone, T.W., K. Crowston, J. Lee, B. Pentland, C. Dellarocas, G. Wyner, J. Quimby, C. S. Osborn, A. Bernstein, G. Herman, M. Klein, and E. O'Donnell. (1999) "Tools for Inventing Organizations: Toward a Handbook of Organizational Processes," *Management Science*, 45(3), pp. 425-443.

Mumford, E. and M. Weir. (1979) *Computer Systems in Work Design – The ETHICS Method*, New York: John Wiley & Sons.

Pande, P.S., R.P. Neuman, R.R. Cavanaugh (2000) *The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing Their Performance*, New York: McGraw-Hill.

Parsons, J. (2002) "Effects of Local Versus Global Schema Diagrams on Verification and Communication in Conceptual Data Modeling." *Journal of Management Information Systems*, 19(3), pp. 155-183.

Raghu, T.S., B. Jayaraman, and H.R. Rao. (2004) "Toward an Integration of Agent-and Activity-Centric Approaches in Organizational Process Modeling: Incorporating Incentive Mechanisms." *Information Systems Research*, 15(4), pp. 316-335.

Ramesh, V. and G.J. Browne. (1999) "Expressing Causal Relationships in Conceptual Database Schemas." *Journal of Systems and Software*, 45, pp. 225-232.

Reich, B.H. and I. Benbasat. (2000) "Factors That Influence the Social Dimension of Alignment Between Business and Information Technology Objectives." *MIS Quarterly*, 24(1), pp. 81-113.

Robey, D., D.L. Farrow, and C.R. Franz. (1989) "Group Process and Conflict in System Development." *Management Science* 35(10), pp. 1172-1191.

Rose, J and M. Meldrum (1999) "Requirements generation for web site developments using SSM and the ICDT model," *Proceedings of the 9th Business Information Technology Conference*, R. Hackney and D. Dunn, (eds), Manchester Metropolitan University

Sakthivel, S., and M.R. Tanniru. (1989) Information System Verification and Validation During Requirement Analysis Using Petri Nets." *Journal of Management Information Systems*, 5(3) pp. 33-52.Schrage, M., "IT's Hardest Puzzle," *CIO Magazine*, July 15, 2005. http://www.cio.com/archive/071505/leadership.html

Senge, P. (1990) *The Fifth Discipline: The Art and Practice of the Learning Organization*, New York: Doubleday/ Currency.

Silver, M., M.L Markus, and C.M. Beath, (1995) "The Information Technology Interaction Model: A Foundation for the MBA Core Course," *MIS Quarterly* (19)3, September, pp. 361-390

Simon, H.A. (1996) *The Sciences of the Artificial*. Cambridge, MA: MIT Press.

Smith, G.F. (1998) *Quality Problem Solving*. Milwaukee: ASQ Quality Press.

Smith, H. and P. Fingar (2003) *Business Process Management: The Third Wave*, Tampa, FL: Meghan-Kieffer Press.

Standish Group (2001) "Extreme Chaos." Viewed on Feb. 2, 2005 at http://www.standishgroup.com/sample_research/PDFpages/extreme_chaos.pdf.

Svenson, O. (1979) "Process Descriptions of Decision Making. *Organizational Behavior and Human Performance*, 23, pp. 86-112.

Truex, D.P., R. Baskerville, and J. Travis (2001) "Amethodological Systems Development: The Deferred Meaning of Systems Development Methods," *Accounting, Management and Information Technology*, vol. 10, pp. 53-79.

Valusek, J.R. and D.G. Fryback. (1987) "Information Requirements Determination: Obstacles Within, Among, and Between Participants." In R. Galliers (ed.), *Information Analysis: Selected Readings*. Reading, MA: Addison-Wesley.

Vessey, I. and S. Conger. (1994) "Requirements Specification: Learning Object, Process, and Data Methodologies." *Communications of the ACM*, 37, pp. 102-113.

Walsham, G. (1993) *Interpreting Information Systems in Organizations*. Chichester, UK: Wiley & Sons.

Wand, Y. and R. Weber (2002) "Research Commentary: Information Systems and Conceptual Modeling – A Research Agenda." *Information Systems Research*, 13(4), December, pp. 363-376.

Weill, P. and J. W. Ross (2004) *IT Governance: How Top Performers Manage IT Decision Rights for Superior Results*, Boston, MA: Harvard Business School Press.

Wetherbe, J.C. (1991) "Executive Information Requirements: Getting It Right." *MIS Quarterly*, 15(1), pp. 51-65.

zur Muehlen, M. (2004) *Workflow Based Process Controlling: Foundation, Design, and Application of Workflow-Driven Process Information Systems*. Berlin: Logos Verlag.

ABOUT THE AUTHORS

Steven Alter is Professor of Information Systems at the University of San Francisco. He holds a B.S. and Ph.D. from MIT. He extended his 1975 Ph.D. thesis into one of the first books on decision support systems. After teaching at the University of Southern California he served for eight years as co-founder and Vice President of Consilium, a manufacturing software firm that was acquired by Applied Materials in 1998. His research concerns developing systems analysis concepts and methods that can be used by typical business professionals and can support communication with IT professionals. His new book is called *The Work System Method: Connecting People, Processes, and IT for Business Results*. His articles appear in *Harvard Business Review, Sloan Management Review, MIS Quarterly, European Journal of Information Systems, Decision Support Systems, Interfaces, Communications of the ACM, Communications of the AIS, CIO Insight, Futures, The Futurist,* and many conference transactions.

Glenn J. Browne is associate professor and the James C. Wetherbe Professor of Information Technology at Texas Tech University. He received his Ph.D. from the Carlson School of Management at the University of Minnesota. His research interests include cognitive and behavioral issues in information requirements determination, systems development, e-business, and managerial decision making. His articles appear in *Management Science, Organizational Behavior and Human Decision Processes,* the *Journal of Management Information Systems*, *MIS Quarterly*, *IEEE Software*, and other journals.

Communications of the Association for Information Systems

ISSN: 1529-3181