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Richard Orwig

Susquehanna University, orwig@susqu.edu

Douglas L. Dean

Brigham Young University, doug_dean@byu.edu

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Communications of the **A**ssociation for **I**nformation **S**ystems

A METHOD FOR BUILDING A REFERENT BUSINESS ACTIVITY MODEL FOR EVALUATING INFORMATION SYSTEMS: RESULTS FROM A CASE STUDY

Richard Orwig, Ph.D.
Susquehanna University
orwig@susqu.edu

Douglas Dean, Ph.D.
Brigham Young University

ABSTRACT

In this dynamic age of corporate acquisitions, mergers, and enterprise integration, decisions concerning the evaluation and selection of information systems require comparing the functionality of each candidate system to the intended business activities that it will support. However, consensus on the definition of business activities used to support this evaluation is rare. What is needed is a referent business activity model that defines the business in a manner to serve as the basis for determining how well each candidate system supports the business. This paper 1) defines the referent business activity model concept; 2) provides an example from a case study of business activity modeling; and 3) demonstrates the utility of this model in defining functional requirements for selecting the optimal system from a set of 30 legacy systems to be used throughout the United States Department of Defense (DoD). Twenty-nine DoD business experts were able to construct a referent business activity model consisting of 65 business activities organized in a hierarchical manner. These activities served as the foundation for a questionnaire of 165 questions used to select three information systems out of the over 300 known systems that supported one or more of the 65 business activities. This experience demonstrated the feasibility of achieving consensus among business experts on one referent business model. It also demonstrated the utility of that model in evaluating legacy systems. This case provides a detailed example that business experts can bridge the gulf of ambiguous systems requirements that exists between real-world business activities and the information systems that support them.

Keywords: business referent model, process model, workflow, business-system alignment, system evaluation

I. INTRODUCTION

In this dynamic age of corporate acquisitions, mergers, and enterprise integration, decisions concerning the evaluation and selection of candidate information systems require comparing the functionality of each candidate system to the intended set of business activity that it will support. To determine how well any information system supports an organization's business activities, a method of evaluating existing information systems against a business activity model may be needed to select optimal systems or modules to support those activities.

This paper describes action research associated with the modeling of business activities and the development of an instrument that was used to evaluate an estimated three hundred information systems. Analysis of this case study contributes several interesting points. Application domain experts were able to reach consensus upon a referent business activity model prior to consideration of functional requirements. The referent model created by the domain experts in this case enabled them to specify requirements objectively for an information system that would best support business activities in that domain. The contribution of this research is that it demonstrates the feasibility of achieving consensus among business domain experts on definition of the business activities before actually specifying the functionality of an information system that should optimally support those activities. Second, it demonstrates the utility of the resulting model in objectively evaluating legacy systems. Finally, it endeavors to demonstrate the need for consensus upon a clear task definition in order to do further research in task-technology-fit research.

We began the effort to merge the hazardous substance management processes of the United State Air Force, Army, Marine Corps, Navy, and Defense Logistics Agency in October of 1992. As many as 35 representatives of the services met three times over a period of six months to develop an activity model and data model of the business of managing hazardous substances at a typical United States military installation. A 12-member subgroup was elected to evaluate and select three out of over three hundred information systems that supported those activities. These three systems were then evaluated from a technical perspective with recommendation for their use throughout the United States Department of Defense (DoD). This paper describes the method used to create consensus upon one "should-be" model of managing hazardous substances at United States military installations throughout the world. It also describes development of a questionnaire that was used to evaluate the existing information systems that supported the model. While this project was accomplished some years ago, the lessons learned are applicable to many information systems selection efforts today.

The form of the hazardous substance activity model captures domain knowledge that is different from conceptual models typically discussed in information systems research literature [Khatri et al., 2006]. A referent business model such as one captured in this research can provide welcome support to business analysts needing to span the gulf of ambiguity between real world domains and information systems conceptual models.

In the following section, we describe the motivation and literature foundation for support of business referent modeling. We then discuss the background of our case study followed by a description of the business of hazardous substance management within the United States Department of Defense. In Section IV we describe the process used in modeling the business activities. Section V describes the method of developing the questionnaire and process used in evaluating existing information systems that supported various hazardous substance management activities. The final section describes some of the lessons learned and conclusions of the case study.

II. BUSINESS REFERENT MODELS—MOTIVATION AND LITERATURE FOUNDATION

This study is based on the question posed by Wand and Weber [2002]: How can we model the world to facilitate the development, implementation, use, and maintenance of more valuable information systems? In particular, we want a model that business managers can embrace but that can also be used to specify the functional requirements of an information system.

We wish to establish our concept of a referent business model as a business tool for describing business activities. The referent business model is a hierarchical breakdown of business activities that support organizational goals, which are derived by consensus among business managers. This referent business model is a baseline model for business managers to use in communicating and coordinating work activities as well as setting the context for specifying requirements for information systems that support those activities. Thus, we wish to focus on an organizational unit

of analysis such that a business referent model would define the business activities within one organization in its effort to support its vision, mission, and strategic goals.

Terms such as “business model,” “reference model,” “domain model,” and “activity model” have many meanings in information systems research literature. In general, we wish to distinguish our referent business model from these in four ways. First, our model is created by business experts themselves. Second, our model is at a higher level of abstraction than that found in requirements engineering, business process modeling, or workflow modeling. Third, a referent business model serves as a problem-space definition instead of a solution-space definition. The problem-space focus means that the referent model defines portions of a business that may need information systems support without a detailed information systems analysis. Finally, our model captures the complexity of business activities at multiple levels of abstraction in a predominantly hierarchical manner instead of a detailed-level linear representation that facilitates information systems analysis.

BUSINESS MODELS

Much of the literature on business models resulted from an immense increase in e-commerce and e-business systems development. Alt and Zimmermann [2001] found too many different dimensions in their search for a business model definition to develop categories. They determined that six generic elements make up business models, which they organized into two dimensions to form the matrix shown in Table 1.

Table 1. Six Generic Business Model Elements

| | Legal issues | Technology |
|-----------|--------------|------------|
| Mission | | |
| Structure | | |
| Processes | | |
| Revenues | | |

While these six elements reflect important dimensions that could be addressed in business models, a more detailed view is required to help managers represent specific aspects of their responsibilities and to suggest requirements for technological support.

Magretta [2002] describes business models as stories that explain how enterprises work. These stories answer certain questions such as: Who is the customer? How do we make money? What underlying economic logic explains how to deliver value to customers at an appropriate cost? The business referent model concept that we envision is the result of obtaining consensus among managers upon the answers to these questions and developing a hierarchical arrangement of specific business activities that support one organization’s story.

Similarly, much of the e-commerce trade and research literature speak of a business model in a variety of high-level connotations: the auction model, the catalog model, or, more generally, the on-line B2B model. For examples see [Ding et al. 2005, Ordanini 2006, Recker and Mendling 2006]. Models such as these suggest a business approach. They suggest but do not offer an organized set of specific business activities. For example, an auction model suggests inventory management with bidding activities to support transactions. A catalog model suggests inventory management and product selection by customers through pictures. B2B suggests ordering and fulfillment of inter-organizational transactions. While useful in describing approaches, they are too high in abstraction to depict a problem-space model that would support information systems requirements specification.

Pateli and Giaglis [2004] reviewed 29 articles on business models in subject-area domains related to e-business (14), strategy (8), information systems (5), management (1), and economics (1). Patterns in these articles included eight research subdomains: definitions, components, taxonomies, conceptual models, design methods and tools, adoption factors, evaluation models, and change methodologies. The authors do not claim that this list is exhaustive but review characteristics of research in each of these subdomains.

Osterwalder et al. [2005] differentiate between a firm's "business model" and a firm's "business process model" in this way: "A business model is a view of a firm's logic for creating and commercializing value, while the business process model is more about how a business case is implemented in processes". In this paper, we take the business model as defined by Osterwalder et al. [2005] as given and concentrate on the organizational business activities that represent what the organization does to transform inputs into outputs as it conducts business. For the remainder of this paper, when we refer to "business model," we are referring to a model of business activities, which is similar to a model of business processes.

CONCEPTUAL/DOMAIN/UML ACTIVITY MODELS

Business process models in the information research literature tend to be conceptual or domain models, where the model is a representation of the user's perception of the real world [Davis 1992] (Figure 1).

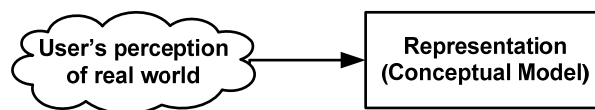


Figure 1. Conceptual Models as Representations

As shown in Figure 2, Burton-Jones and Meso [2006] noted that during conceptual model creation, an analyst identifies phenomena to model and then maps these phenomena into the grammatical constructs of the modeling language.

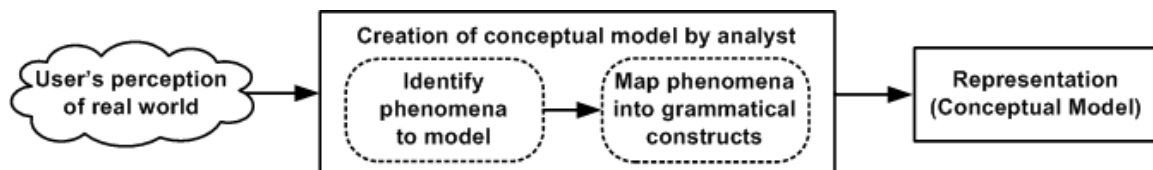


Figure 2. Identification and Mapping During Modeling

The traditional view in the literature that analyst construct conceptual models through interactions with subject matter experts (SMEs) results in three fundamental problems. First, when an analyst creates conceptual models based on interviews with SMEs, the representation is four-steps-removed from the reality: 1) users' perceptions; 2) analysts' perceptions of users' perceptions; 3) mapping to modeling constructs; and 4) the actual conceptual model. Distortions in the model can occur since the model has passed through at least three filters on the way to the conceptual model. Second, because the model is developed by the analyst it does not necessarily mean that SMEs have a comprehensive view of the overall model. Thus benefits to SMEs of being able to comprehend a broader, scope of related business activities can be lost. Third, and perhaps most importantly, the traditional approach means that an analyst talks to SMEs instead of SMEs talking to each other. Thus opportunities for SMEs to confer with other SMEs and to identify existing problems and opportunities for improvement are postponed to the end of the modeling process, which reduces opportunities for problem solving and incubation during the process. To avoid these problems, our work proceeded from the assumption that we can help business experts model business activities and achieve consensus on one shared view of the real world problem

space [Dean, et al, 2000]. In essence, we used facilitation, modeling methods, and tools to help business managers define their own activity models.

The purposes for creating high-level business activity models and low-level information-systems-centric conceptual models are quite different. These models also differ from each in terms of form. Activity models define activity performed by the organization without the details of how a system should could or should help accomplish each activity. For example, it can be useful to model the steps an organization takes to recruit new employees without getting into the details of how information systems support these steps. It is useful to know that to recruit new employees an organization identifies potential candidates, screens candidates, and makes offers to candidates because a model of these activities can help support process improvements, cost/benefit evaluations, and a variety of other purposes without the huge investment required to model all of the system's related activity. In the case described in this paper, we helped SMEs define an activity model that was used to identify best business practices. This same activity model later served to develop a rigorous way to evaluate the desirability of available information systems features.

In contrast, systems analysts often develop information-centric conceptual models to support information systems design and development efforts. UML Activity models and Use Cases [Dennis et al. 2005, George et al. 2007, Schach 2004] are typical methods for conceptual modeling that have information systems solution-space viewpoints. Such models can be found in requirements engineering, workflow, and business process modeling literature. Indeed, there is a large body of literature that discusses modeling techniques at a very detailed level [Dalal et al. 2004, Gerard 2005, Green and Rosemann 2000, Leymann and Roller 2006, van der Aalst et al. 2003, Xinming and Haikun 2006]. Recognition of the distinction between business-centric and information-systems-centric conceptual models is increasing in the literature as is the awareness that knowledge of the application domain and knowledge and IS domain are not the same thing [Khatri et al.,2006].

REFERENCE MODELS

The term "reference (or referent) model" refers to a model of the baseline business problem-space. Fettke and Loos [2003a] and Thomas et al. [2006] present arguments for the need for business referent models. For a good discussion of the difference between a reference model and an information-systems-centric model see [Thomas 2005]. Eriksson and Penker [2000] separate the concept of a business reference model from lower-level business process models. Fettke and Loos [2007] provided an edited book that focuses on reference modeling. However, the reference model concept focuses on very specific business process details that are difficult for end users to appreciate as well as tend to represent the business processes linearly instead of hierarchically as activities and sub-activities.

In summary, we find some business model concepts as described in the literature either too abstract or too specific for use by business managers who wish to conceptualize how an information system will change their business activities. To overcome the problem of abstractness, high-level views of the business activities need to be decomposed into sub-activities and each of those sub-activities need to be decomposed to a level that will support analytic rigor.

The ability to view activities and sub-activities in a hierarchy of abstractions is a powerful way of reducing complexity while at the same time supporting analytical rigor [Ross, 1977]. For our purpose, "process" and "activity" are synonyms. This study provides empirical evidence that business domain experts can come to consensus in building a hierarchical business reference model acceptable to participants as well as providing sufficient rigor for information systems evaluation.

III. MANAGING HAZARDOUS SUBSTANCES—BACKGROUND

The management of hazardous substances was one of twenty functional areas within the Defense Environmental Security Corporate Information Management (DESCIM) program. Under the direction of the Deputy Under-Secretary of Defense for Environmental Security, DESCIM was chartered to provide process improvement for functions under its authority. The functional areas identified are listed in Table 2 and include areas such as environmental restoration of military bases as part of base realignment and closure, conservation of natural resources at military installations, hazardous materials and hazardous waste management, and seventeen other environmental functional areas within the DoD.

The initial guidance for performing functional process improvement was specified in [DoD_8020.1-M 1992]. DESCIM was approximately \$150M of a \$5 billion initiative that began in 1991 entitled Corporate Information Management (CIM). CIM specified that the DoD should understand its business processes through modeling and then improve them through process analysis and/or information systems development. There is research that provides guidance for business activity modeling and business process improvement, e.g., [Bitzer and Kamel 1997] and [Georgakopoulos et al. 1995]. The DoD guidance document was based upon structured analysis and design techniques developed by Douglas Ross [Ross 1977] and Marca and McGowan [1988].

While the CIM initiative came from the top levels of the DoD, the focus of the effort was the military installation-level and there was a great deal of bottom-level interest in the initiative. In the case of hazardous substance management, every military installation has an environmental coordinator who is responsible for making certain that proper hazardous materials are acquired for use in operations of the military base. Additionally, the environmental coordinator is responsible for making sure that the hazardous wastes from those operations are properly captured and disposed of. The environmental coordinator typically answers directly to the military installation's commander. Environmental coordinators were anxious to work together to identify their business activities and identify optimal information systems support for those activities.

Table 2. DESCIM Functional Areas

| | |
|---|--|
| Cleanup Management & Reporting | Noise Monitoring and Reduction |
| Compliance Deficiency Management | Solid Waste Management |
| Cleanup Technology | Environmental Information Exchange |
| Spill Prevention and Tracking | Military Installation Audit/Assessment |
| NEPA Planning | Environmental Documentation Templates |
| Hazardous Substance Management | Air Emissions |
| Toxic Substances | Storage Tank Management |
| Pest Management | Wastewater, Storm water, Potable water |
| Explosives Safety | Occupational Safety and Health |
| Environmental Program Requirements Tracking | Conservation of Natural and Cultural Resources |

IV. THE HAZARDOUS SUBSTANCES PROJECT

We could not assume environmental coordinators from the Air Force, Army, Marine Corps, Navy, and Defense Logistics Agency (DLA) would agree on anything. As one of the SMEs told us, "We have had a 200-year history of non-cooperation among the services. We would almost hate to spoil it." We needed to prove the assumption that there was sufficient commonality across the services in their business of managing hazardous material and hazardous waste. Department of Defense officials knowledgeable about environmental coordinator responsibilities across the services felt that this was possible and a meeting was scheduled in October to validate the commonality and achieve buy-in from the environmental SMEs.

PROJECT INITIATION

Five members from each service and agency attended a three-day meeting in October of 1992 to determine if there was sufficient commonality in business activities across the services to warrant modeling the business and, if so, to develop a plan to do so. We used an electronic meeting system to support the brainstorming of activities and voting of common versus unique activities. Participants felt that there were very few activities that were unique to a particular service and that only some naming differences existed among the services for many of the common activities. A modeling session was then scheduled for a five-day meeting in December. The outcome of this meeting was a high-level business activity chart shown in Figure 3.

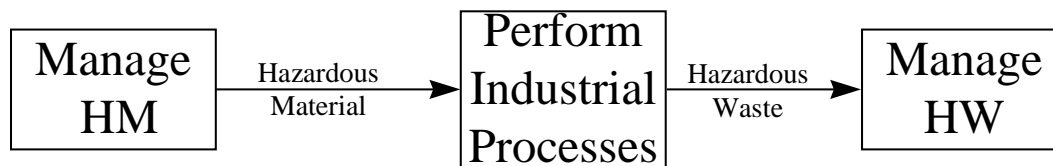


Figure 3. High-Level Business activity

Environmental coordinators are primarily responsible for the receipt and control of hazardous materials in a military installation and the collection and removal of hazardous wastes generated by the industrial processes that take place. This involves anything from the oil purchased, installed, and collected at the base motor pool to the paints, solvents, glues, and other materials used to clean and repair military equipment such as ships, planes, and tanks. Environmental coordinators differed in the amount of influence that they had in changing the industrial processes themselves to minimize the amount of hazardous wastes that they generate.

MODELING BUSINESS ACTIVITIES

Twenty-four representatives (SMEs) of the services and DLA met in two electronic-meeting-system-supported meetings in Tucson to model the business of hazardous material and hazardous waste management. A five-day meeting was held in December of 1992 and a nine-day meeting was held in April of 1993 specifically to model the "As Is" business and "To Be" business of the SMEs [DoD_8020.1-M 1992] specified that a model of the business as currently performed be created followed by an "improved" business model to be created by SMEs. It also specified that IDEF0 be used as a modeling technique. A group-modeling tool was developed by the University of Arizona to support the IDEF0 activity modeling method that was prescribed by DoD 8020.1-M. This tool supported the simultaneous construction of activity decomposition by multiple people working on the same model. A complete description of this tool and the process of collaborative modeling is beyond the scope of this article but can be found in [Dean et al. 1994] and [Dean et al. 2000].

The modeling process involves a top-down specification of the activities of the modeled business. In this case, we had the SMEs identify and define the business. Their definition was "hazardous

substance management: The cradle to grave management of hazardous substances.” “Hazardous substances” was a generalization of the two relevant topics of hazardous material and hazardous waste. A viewpoint of the model was also established — that of the installation-level environmental coordinator. The quick-response definition of the duties of the environmental coordinator was “to keep the base commander out of pollution jail.” Defining the business and viewpoint sets the scope for further definition of the business.

An activity in IDEF0 consists of an identifier (a verb/noun pair), a textual definition, and four attribute types consisting of outputs of the activity, inputs to the activity, controls, and mechanisms. These attribute types are called ICOMs, collectively, based upon the first character in each attribute type. Figure 4 shows the topmost definition of the business of managing hazardous substances as defined by the 24 SMEs.

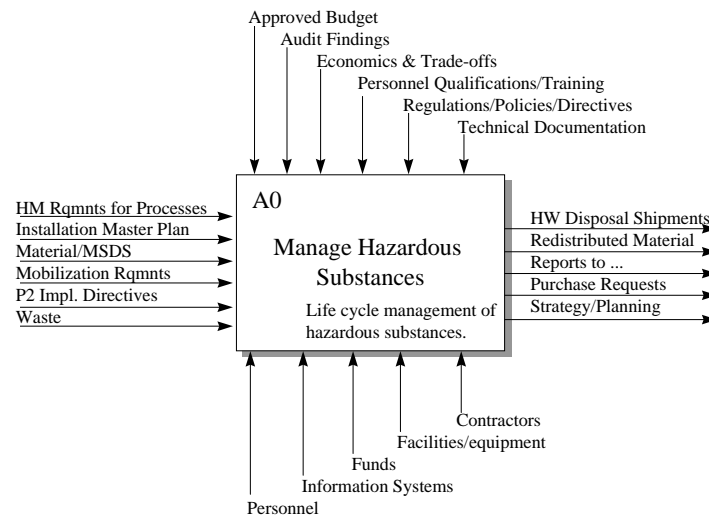


Figure 4. Topmost Activity Definition

The “A0” (A zero) indicates that this is the root node of a top-down decomposition of an IDEF0 diagram. Outputs of the activity are listed on the right side of the box and are represented by the outward arrows. Inputs enter the activity from the left and are considered to be transformed by the activity. Controls are those constraints on the activity, which govern how it is performed and are shown by the arrows entering the top of the activity box in Figure 4. Mechanisms are those assets or tools which contribute to the performance of the activity but which do not materially appear in the outputs. ICOMs also have textual descriptions entered by the SMEs. Further understanding of the IDEF0 modeling method can be found in [Paragon Systems, 1992].

The combination of the activity description and ICOMs define the activity. Having defined the business activity at the top-most level, SMEs brainstormed on the breakdown of sub-activities, which comprise this high level activity (shown in Figure 5).

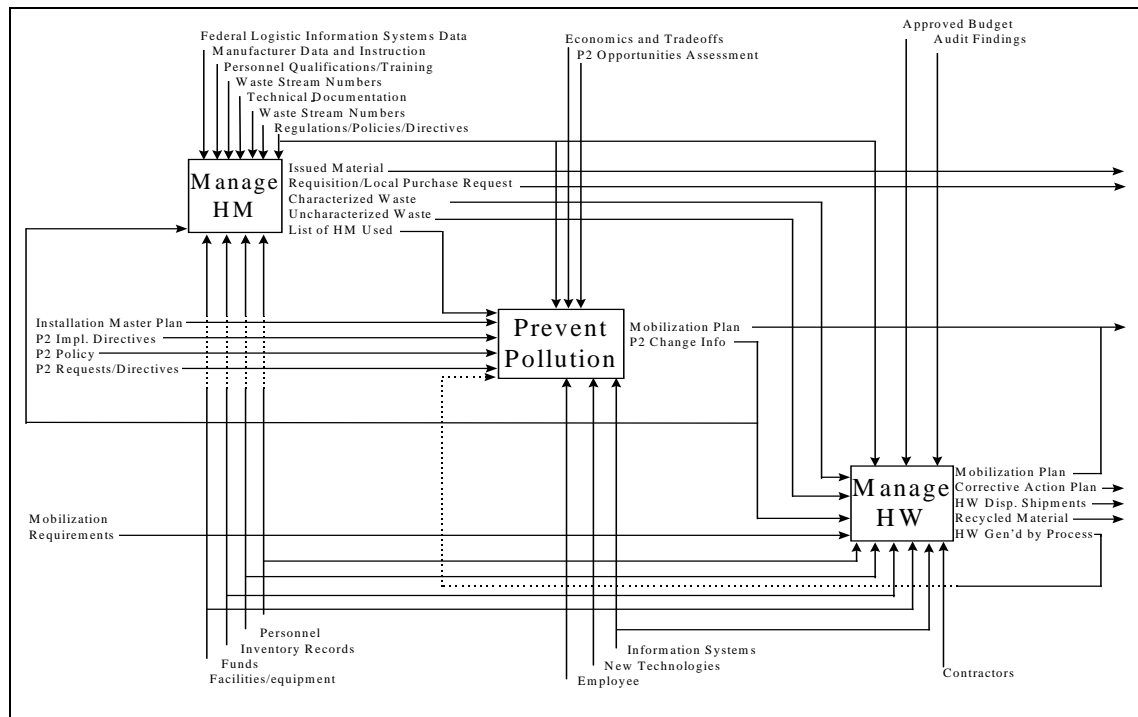


Figure 5. IDEF0 Sibling Set Diagram

The SMEs achieved consensus that from an environmental coordinator's viewpoint three major activities comprise the business of managing hazardous substances: manage hazardous material, prevent pollution, and manage hazardous waste. This confirmed the high-level business activities represented in Figure 3, where the environmental coordinator is responsible for tracking hazardous materials that are received, stored, and delivered for use as well as the collection and removal of hazardous wastes. Environmental coordinators are not responsible for the operational processes on the installation and can only attempt to influence how those processes are performed to prevent pollution.

Each of these three activities was further defined by adding ICOMs to each. Common ICOMs were then connected among the three activities to form what is called a "sibling-set diagram" represented in Figure 5. Theoretically, IDEF0 diagrams are not flow diagrams. IDEF0 purists do not even allow the mention of flows between activities — ICOMs are supposed to represent relationships among activities. However, SMEs consistently thought about "sequences of activities" — even at a high-level of abstraction of their business.

The sibling set diagram shown in Figure 5 shows how each sub-activity of the parent activity is related. One can think of this sibling set diagram also as a collective definition of the parent activity (Figure 4). Thus, SMEs agreed on definitions of activities individually as well as the decomposition of each activity into sub-activities and ICOMs relating those sub-activities.

SMEs then iteratively performed the same tasks that they did to define "manage hazardous material (hm)," "prevent pollution (p2)," and "manage hazardous waste (hw)" from "manage hazardous substances." In this case, they started brainstorming activities which comprise "manage HM," "p2," and "manage HW;" defined these sub-activities; and identified, defined, and linked their ICOMs. Thus any given activity node was defined from two perspectives: itself and its set of sub-activities (sibling set). The single activity defined "what" needed to be done. The sibling set defined "how" that activity was performed.

After 12 days' work spread out over the December five-day and April nine-day meetings, the SMEs completed an IDEF0 "As Is" model. The model was a hierarchical structure (node-tree)

with no more than six activities defined at any level. The hierarchy was five levels deep with a total number of 65 activities. Thirty-six of those activities were leaf-node activities (bottom-level, most detailed).

This resulting model was a “should be” model from the standpoint of the SMEs. Because the SMEs came from the Air Force, Army, Navy, Marines, and Defense Logistics Agency, the resulting model was a “best practices” model of the existing activities as agreed upon by experts from all of those agencies. This was a DoD model of the way hazardous substances should be handled at any military installation.

IDEF0 specifications include a Node Tree view which presents the hierarchical organization of the model. Figure 6 contains the node-tree view of the activities that was created by the SMEs. For example, the “manage hazardous materials” activity on the left of diagram decomposed into four activities 1) Review/Approve HM Authorization Request; 2) Requisition/Procure HM; 3) Receive, Store, Distribute and Control HM; and 4) Monitor HM Use. The activity “Receive, Store, Distribute and Control HM” required the most definition, as reflected by the “(17)”, which indicates that there are 17 sub-activities in the decomposition of the receipt, storage, distribution, and control of HM activity.

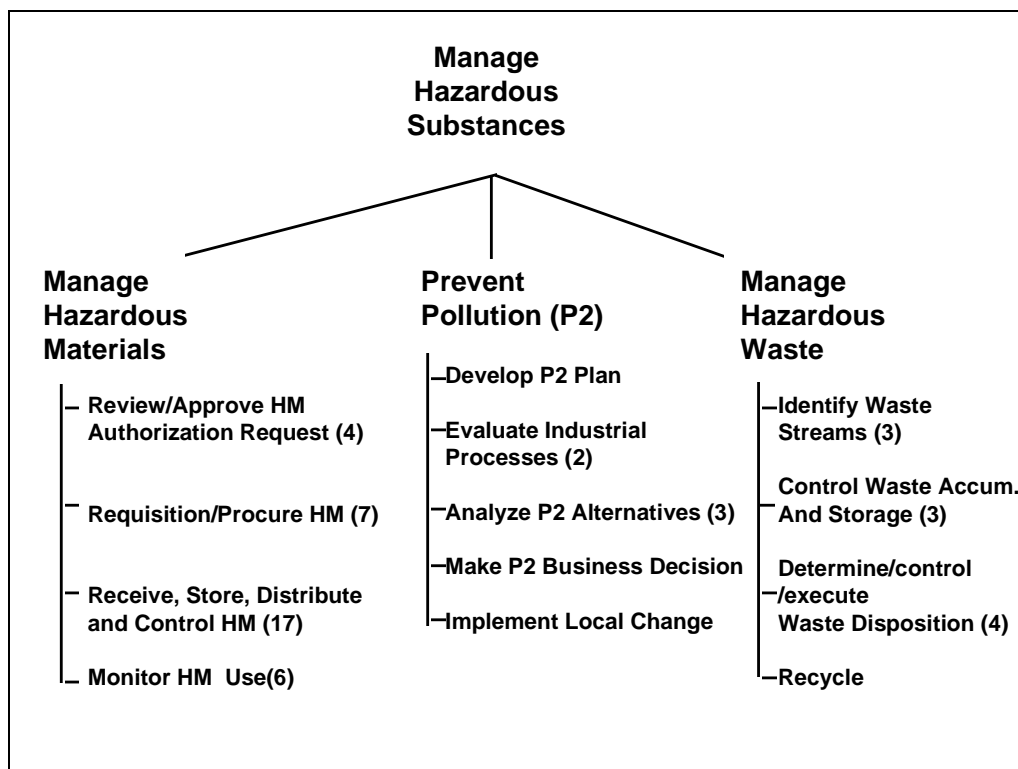


Figure 6. Node Tree View of IDEF0 Activity Model

The 17 activities under this activity are also hierarchically organized. SMEs generally agreed on the need to perform all 17 activities but they did not always agree on the leaf node activities at the bottom of the tree. For example, one activity that has to be performed is receiving the hazardous material at the point where the material arrives at a loading dock from a transfer agent (“Receive HM”). Figure 7 represents the activity and sub-activities associated with receipt of a shipment of hazardous material (e.g., cases of spray solvent).

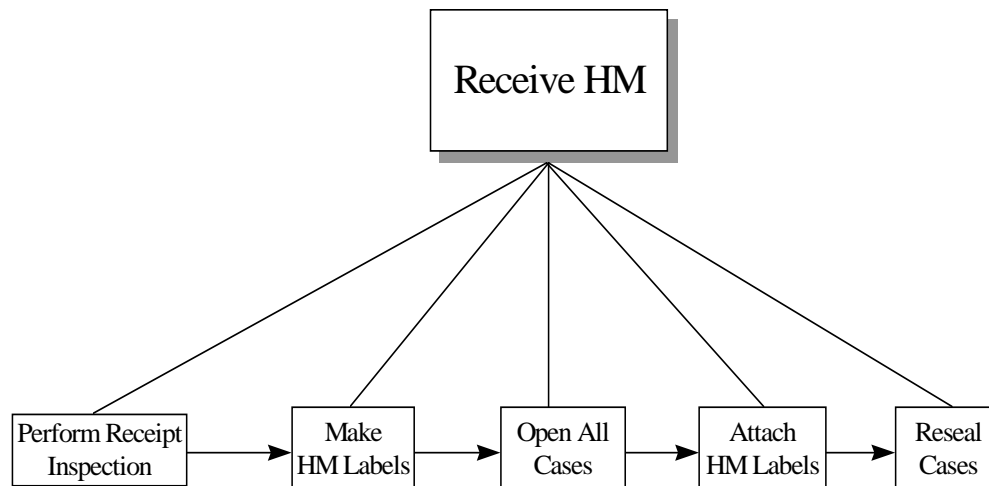


Figure 7. Conflicting Business Activity

The material needs to be inspected to ensure it matches a purchase order, contains the correct amount, and is in acceptable condition. Each installation tracks the HM by multiple characteristics such as type of HM, processes in which it can be used, who is authorized to use it, etc. Thus, each installation generates its own inventory tracking number and makes labels to attach to each container of HM. One version would have the receiver open all of the cases, attach the labels to each of the containers, and reseal all of the cases of solvent. A variation of this business activity would be to simply attach an envelope containing the labels to the case and attach them only when the case is opened just prior to issuing them to an authorized requesting user of the solvent.

In this example, SMEs agreed that each of the activities needed to be performed. They could not specify the order in which it should occur due to the various personnel resources available at the receiving docks of military installations. Thus, they ceased modeling the business when they came to the points where they “agreed to disagree.”

It was a significant accomplishment to get 24 representatives to agree on this model of 65 business activities. The conclusion of the April session is legendary within the DESCIM program. After nine days of activity and data modeling in the electronic meeting facility in Tucson, the SMEs had developed enough rapport to design and buy T-shirts for all participants and compose a song of 14 verses (to the tune of “Folsom Prison Blues”). They also self-selected a subcommittee to continue to the next stage of the project.

The purpose of the subcommittee was to select the best three existing information systems out of the over 300 systems that were supporting various aspects of hazardous substance management. These three systems were to be selected based upon their ability to support the functionality of hazardous substance management. The intent was then to place the three systems before a technical committee that would select one of the three as the best technical solution to be recommended for use as a migration system throughout the DoD until a new (“To Be”) system could be developed.

V. EVALUATING HAZARDOUS SUBSTANCE MANAGEMENT SYSTEMS

There are approximately 600 DoD military installations around the world. Each installation has an environmental coordinator of some capacity. The task of selecting the three best systems out of the 300 information systems supporting various aspects of hazardous substances in an objective manner presented a serious problem. In addition, since all funding for information systems development was stopped for the services and routed to supporting the DESCIM, program developers of the existing systems had financial incentives for their systems to be selected. This

made the task of selecting systems in an objective manner all the more important. It also tested the good will and rapport that was developed among the SMEs over the first three meetings.

DEVELOPMENT OF SYSTEM EVALUATION QUESTIONS

The 12-member subcommittee that was elected in the April meeting met for three days in June of 1993 in an electronically supported meeting. Since the Activity Model represented agreement across all of the services and agencies as to the business of hazardous substance management it should serve as the basis for judging information systems that supported that business. There were sixty-five activities in the model. However, since each lower-level set of activities is a decomposition of the parent activities we only needed to concentrate on the lowest level (leaf-node) activities in the model. The 36 leaf-node activities are listed in Table 3.

Table 3. Common Business Activities

| The 36 Lowest-Level Hazardous Substance Management Activities | |
|--|--|
| Manage Hazardous Material | Prevent Pollution |
| Validate HM Request | Develop P2 Plan |
| Identify Process/HM Waste Stream | Identify HM Processes |
| Review Process for Environmental Compliance | Prioritize HM Processes |
| Review Process for Bio/Environmental Concerns | Identify HW Generating Processes |
| Communicate HM Approval | Prioritize Hazardous Waste Processes |
| Determine Source for Procurement | Identify and Rank Alternatives |
| Release Material/Issue MRO | Test Alternative Materials and Processes |
| Requisition Material From Off-Activity Source | Select Change |
| Receive Material (New and Used) | Make P2 Business Decision |
| Store Materials | Implement Local Change |
| Issue Materials | |
| Request HM | Manage Hazardous Waste |
| Receive Material/Substance at Work Site | Sample Waste Streams |
| Monitor HM Use During Work Order Accomplishment | Analyze Waste Streams |
| Determine Disposition | Characterize Waste |
| Transfer to Hazardous Waste | Issue Containers for Accumulation |
| Transfer Unused Material | Monitor Waste Accumulation |
| | Monitor Waste Storage |
| | Determine Waste Disposition |
| | Prepare Waste for Off-Site Shipment |
| | Keep Records |

The leaf-node activities were loaded into an electronic meeting system group-outlining tool. Group members were asked to focus on one leaf node activity at a time and ask themselves if information systems support would be useful for that activity. If so, they should assume that the facilitator of the session had developed an information system that supported the activity. Questions should come to their minds such as “Does your system _____?” The group members were asked to enter their questions anonymously. Since the group members included experts in one of the three areas (hazardous material, pollution prevention, or hazardous waste), each member concentrated in those areas that he was most knowledgeable. Once group members entered a question it became “public”; other group members could read it, comment on it, or add more. With 12 people working in parallel, approximately 200 questions were developed in a short period of time. The facilitator then guided the group through each of the 36 activities to identify questions that the group felt would be useful in evaluating an information system that purported to support each activity. Table 4 shows examples of these questions.

Table 4. Sample Evaluation Questions

| Type | Question | Evaluation Score |
|----------------------|---|------------------|
| Global | Does the system provide pick lists, drop-down data, etc. to support validation of data input/editing? | 1 2 3 4 5 |
| Hazardous Material | Does the system provide for identification of approval to order a specific substance (Authorized User or Use List)? | 1 2 3 4 5 |
| Pollution Prevention | Does this system identify the engineering department (or code name) and individual in charge of the pollution prevention process? | 1 2 3 4 5 |
| Hazardous Waste | Does the system provide the ability to create and maintain a chain of custody for each waste sample? | 1 2 3 4 5 |

During the discussion several issues came up of a global nature. These issues were transformed into questions and included such things as “Does the system have the capability to use bar coding or similar material/waste tracking?” Fourteen global questions were created in addition to 182 questions specific to the leaf-node activities.

ASSIGNING WEIGHTS OF IMPORTANCE

A voting tool was used by group members to attach an importance of each question to the business of hazardous substance management on a 1 to 5 scale. The average of the 12 scores attached to each question was then used as a weighting factor of the question. Participants had a chance to review those questions for which the standard deviation among the scoring was high. During the discussion they could alter their voting if they so chose.

Since there was insufficient time to review 300 information systems the group decided to reduce the list of systems to be evaluated to only those that supported both hazardous material and hazardous waste management. The rationale behind this decision was that because of the desire to manage hazardous substances at a military installation from “cradle to grave” (from receipt of HM to disposal of HW) only systems that supported and integrated both major activities would be considered. This narrowed the selection of systems to twenty-nine. We then asked group members to prioritize the 29 with respect to systems that they felt should be observed at working installations and evaluated. From this list 15 systems were selected for evaluation and a schedule for group member travel was made.

Sites were visited and systems evaluated through July, August, and September of 1993. Each person doing the evaluation had a questionnaire and made an individual evaluation of the system at each site. In addition to the importance associated with each question, each question was scored on a range of 1 to 5 scale where the system was judged to perform the function very poor (1) to excellent (5). The DESCIM office collected the questionnaires after each evaluation and reviewed them. In particular, they noted very high reliability across the evaluators' scores. There was little deviation in the scores for any given system. Some partisan voting was expected but not observed. In cases where subcommittee members had been active participants in the system development they voluntarily abstained from the voting. The data from the evaluation questionnaires were entered into a spreadsheet with weighting factors attached to the questions and average scores by the reviews.

EVALUATION REFINEMENTS

While reliability among scores for any given system was good it was felt that interpretation of some of the questions on the questionnaire might have changed between the time of the first system's demonstration and the last system's demonstration (several weeks). In particular, team members' opinions were that the Pollution Prevention questions were most ambiguous. DESCIM decided that the team should validate the weights of the questions anonymously in an electronic meeting to make possible adjustments in the weights before the final summations were made. This meeting occurred in October of 1993.

The Pollution Prevention questions were placed into a matrix tool and team members voted on the importance of each with respect to the overall business of hazardous substance management. The new weighting factors were then placed into the spreadsheet containing the scores of the 15 systems. Table 5 contains the resulting scores.

Table 5. System Voting Outcome

| System | Total Score |
|---------------|-------------|
| McClelland | 360 |
| Portsmouth | 338 |
| Kelly | 295 |
| Tinker | 240 |
| New River | 160 |
| TobyHanna | 143 |
| JLSC | 130 |
| Aberdeen | 121 |
| Hill | 120 |
| Pt. Mugu | 99 |
| Alameda | 80 |
| AMC | 79 |
| Ft. Lewis | 76 |
| AEC/Waste | 67 |
| AEC/Materials | 18 |

The top three systems were recommended to the DESCIM technical committee for selection as a system to be used throughout the DoD.

VI. CASE DISCUSSION

The contribution of this case is that it provides a specific example of a business referent model that has aroused much interest in the information systems research literature [Chen et al. 2005; Fettke and Loos 2003b; Khatri et al. 2006; Osterwalder et al. 2005; Thomas 2005]. Analysis of this case raises several interesting issues: even in a politically-charged environment, it is possible to achieve consensus among business experts upon a business activity definition. The normal process involves business systems analysts interviewing experts. From these interviews, analysts generate data flow diagrams, entity-relationship diagrams, use case scenarios, etc. in minute detail and in a format that causes business experts' eyes to glaze over when they are asked to approve them. Domain experts know their businesses but, instead of Joint Application Design (JAD) or prototyping sessions, they need facilitated modeling sessions that document the as-is business activities. Our experience in this case and similar cases was that these models were not really as-is business models but "should be" business models. Because we were modeling one DoD model using the Air Force, Army, Navy, Marines, and Defense Logistics Agency, we were combining at least five as-is models into one to make it a "should be" model for use throughout the DoD. The fact that we could achieve consensus upon one business activity definition among these five agencies would seem to suggest that it is feasible to define one business activity model within any single organization.

The project was politically charged in several ways. The branches of the DoD had a "200 years tradition of disagreement." From the earliest days of the existence of U.S. military components, competition for funding made the components more adversarial than collaborative. Several factors helped representatives from the branches reach consensus upon one model. We used electronic meeting technology to provide anonymity and externalize the process of specifying activities. We had them initially brainstorm on the activities that they felt needed to be performed followed by another brainstorming session on activities that they felt were unique to each branch of the DoD to demonstrate how much commonality there was in the overall business activity of managing hazardous substances. It was widely known that the responsibilities of the SMEs who participated in the modeling were to keep their respective base commanders "out of jail" by making sure that no activities on the military bases violated Environmental Protection Agency rules. Because this had happened to at least one base commander, participants felt compelled to learn what other SMEs knew and practiced. Finally, we housed all of the participants in the same suites-style hotel with a free happy hour each evening. We found that modeling occurred not only in the electronic meeting lab during the day but also on napkins at the happy hour into the late evening.

While very abstract, the resulting business model can be used as a referent business model by business experts to provide specific information systems requirements. Our case demonstrates that it is easy to generate and use those resulting requirements to evaluate the functionality of existing systems in supporting the business activity referent model. We infer that existing information systems have a business activity model "hard-coded" into them via the interpretation of a rationalized referent business model created by the original systems analysts and developers of the system.

Several political forces were present during the construction of the HSM model. DoD members informed us at the beginning of the research that we were attempting to interrupt a 200-year tradition of disagreement among the DoD services. There was competition among developers of hazardous substance management systems even within each of the individual organizations. The task of selection of one system was referred to as a "best of breed" contest where the winning system obtained the right to continued existence while all others lost all DoD-level financial support. DoD managerial forces were also represented since the team included "front-line" managers of hazardous material at the military base level up to major command-level DoD

officers. Motivation for working together on the model included the “threat of non-compliance” which was DoD-speak for “keep our base commanders from being put into jail because of pollution from base operations.” These business experts focused on defining what activities were required to support hazardous substance management in the DoD. Focus was first placed on “what” activity or set of activities was essential before focusing on the “how” each of those activities was completed. Consistent with systems’ thinking, each activity served as the context for its decomposition.

The resulting business activity model is at a much higher level of abstraction than that depicted in most business process modeling literature (e.g., [Green and Rosemann 2000], [van der Aalst et al. 2003]). Most information systems textbooks speak of business process decomposition into sub-processes but seldom provide examples. “Process Customer Order” is a typical example that gets decomposed into individual activities. The activity model developed in this case was five levels deep.

The HSM model is a static model. It identifies activities and their interrelationships. It does not show “flows” or “swim-lane processes.” However, it served as a referent model for both managing people (supervisors could be assigned business activities with clear scopes of responsibility) as well as determining information systems requirements. Research and support literature of SAP (Enterprise Resource Planning Systems Software) speak of a referent model [Blain et al. 1997]. This is the business model that is locked into the SAP software by the systems designers and their views of the real-world business. The gap between the business expert’s model of business activities and the system’s referent model can be quite large. We refer to this gap as the “gulf of ambiguity.” We were able to demonstrate how this gap might be measured from the business-side of the gap. It is interesting to note that a “perfect” system would have scored 629 points. The best system out of approximately 300 systems scored 320 points — 57 percent of the functionality possible as viewed by business experts. This might suggest a loose fit between the business task and the best technology identified to support it. Further, directions on how to tailor the system to fit the task better are suggested in identifying those business activities that are most important but more poorly supported by technology.

Finally, the business referent model provides a basis for discussion of what business activities are required and how those activities should be performed. This model suggests that how activities are performed may be dependent upon what technologies are introduced. How a given activity is decomposed will depend upon the technological mechanisms that are implemented for a given activity.

VII. CONCLUSIONS

This case study presents a real-world instance of using a business activity model to support an objective selection of information systems that best support the business activity. The selection process was difficult due to the competitive relationships among the Air Force, Army, Marine Corps, Navy, and Defense Logistics Agency in addition to the large-scale economics involved (eventually only one systems developer would be selected from over 300 development efforts). DoD estimates include a savings of \$600 million (\$1 million for each of the 600 military installations) at a cost of \$25 million to implement the model. An electronically supported business activity modeling process resulted in a benchmark model that was supported by all of the services. Service members ignored their affiliations and created a business model that captured the concept of hazardous substance management at any DoD military installation. By focusing on the lowest level activities in the model and assuming a vendor was offering a system that supported any given activity, service members were able to develop questions concerning what a system should be able to do to support those activities. These questions served as functional requirements of an information system. The questions were weighted with importance to the business model and evaluations of existing systems were made.

This process is generalizable for situations in which multiple, overlapping information legacy systems exist for the same business process. It could also be used to evaluate new information systems.

The business referent model in this case is unique in the literature along four dimensions. First, the model was created by the business experts themselves using modeling software that allowed them to develop one model simultaneously. Secondly, the business activities in the model were both more specific and more general than that found in the business referent model literature. Thirdly, the viewpoint of the model is a business context viewpoint (problem-space) instead of an information systems conceptual model viewpoint (solution-space). Finally, the model is a hierarchical breakdown of business activities which is useful for managers to communicate what it is that must be done instead of a linear representation of activities which is useful for communicating how something must be done.

CAVEATS

Details were missing even at the lowest level of the model. The process of Preventing Pollution had the most ambiguity. This was supported by the need to re-evaluate the pollution prevention weights at the October 1993 meeting. Between the time of the first meeting in October 1992 and the evaluation of systems in July of 1993 developers were working hard to adapt their systems to support the model. There was still a great deal of subjectivity in interpretation, which became evident after the ultimate system was selected and implementation began throughout the services. An often-heard complaint was that the model did indeed capture what needed to be done but the information system did it in a way that raised some objections. This suggests that further decomposition of the leaf-node business activities affected by an information system is needed to define "how" those activities should be performed.

The modeling process does not capture general business viewpoints that may be essential for understanding the business. Two particular managerial issues resulted from the modeling exercise: the pharmacy concept and the tying of hazardous material and hazardous waste to installation industrial processes. The pharmacy concept meant that a centralized hazardous material distribution system should be made operational to improve management of the hazardous material inventory. Tying the use of hazardous material and the creation of hazardous waste to installation industrial processes meant that environmental coordinators at military installations have a better understanding of those activities requiring the use of hazardous material and/or generating hazardous waste; the tracking of HM and HW should be based upon the industrial or other process that uses or generates the material or waste. These global concepts are not specifically captured in the model, yet the consensus of agreement among the service representatives for these concepts contributed to their cooperation.

While the decision-making process was sound, Air Force members felt that the changing of the weighting scheme in the October 1993 meeting should not have been allowed by DESCIM. The controversy over this decision caused an eighteen-month delay in implementing the resulting DESCIM-approved system (the Portsmouth system).

EPILOGUE

The activity model continues to be the benchmark of agreement among the services. The Portsmouth system continues to be implemented throughout the Army and Navy. The Air Force "non-concurred" with DESCIM. They selected one Air Force system to be used throughout the Air Force. However, it is interesting to note that the Air Force used the DESCIM model and the questionnaire to select their system.

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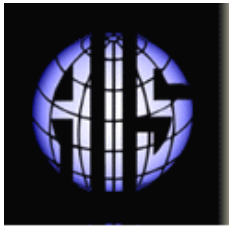
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ABOUT THE AUTHORS

Richard E. Orwig is assistant professor of Information Systems in the Sigmund Weis School of Business and Economics at Susquehanna University. He has published in the *Journal of Management Information Systems*, *Journal of the Association of Information Science & Technology*, *Journal of Visual Communication and Image Representation*, *IEEE Computer*, and *Group Decision and Negotiation*. His research interests are in organizational modeling for measuring business and information systems fit as well as automated document categorization.

Douglas L. Dean is associate director of the Information Systems Department and associate professor in the Marriott School at Brigham Young University. He has published in *Management Science*, *Journal of Management Information Systems*, *Journal of Association for Information Systems*, *Information & Management*, *Electronic Commerce Research*, *IEEE Transactions on Man, Systems, and Cybernetics*, *International Journal of Cooperative Information Systems*, *Expert Systems with Applications*, *Communications of the AIS*, and others. His research interests relate to technology to support e-business, requirements analysis, collaborative tools and methods, software project management and metrics, and creativity methods and measurement methods.

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