BUILDING CONSTRUCTION PRIMARY TASK MODELS

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ABSTRACT: This paper provides a foundation for developing an integrated conceptual data model for managing information during the life cycle of a building. The Soft System Methodology (SSM) was used to develop Issue Based (IB) and Building Construction Primary Task (BCPT) models. The IB model was found to be an effective system for presenting a conceptual organization and the interrelationships among the different subsystems of the organization. The BCPT model provides a practical framework for building construction process analysis. It defines the minimum and necessary tasks required to support the subsystems of the IB model. These two models have formed a foundation for development of a conceptual data model for information integration utilizing the IDEF1x technique.

KEYWORD: building, construction, IDEF, information, model, system.

INTRODUCTION

The integration of design and construction has been proposed and considered to be the optimal approach to successfully reducing fragmentation and eliminating some of the major problems in the architectural, engineering, and construction (AEC) industry. This approach involves the use of computers to manage and manipulate both geometric and non-geometric data, thus facilitating the planning, design, construction, and operation of constructed facilities as one integrated process. In order for this process to be completely successful, integration must be achieved on both horizontal and vertical dimensions. Horizontal integration must involve all disciplines at each stage of the process, and vertical integration must involve them throughout the life span of the building.

Providing information or knowledge to the parties involved in a construction project today is done much the same way as it has been done in the last few decades. Although many aspects of the process such as cost record keeping have been computerized, the industry does not yet have a working integrated information system model. The format as well as the nature and flow of required information at each stage of the process is based on either loosely defined terms in the contracts made among stakeholders or the laws and regulations governing the process. Contracts are often drawn up in a subjective manner, often at the whim of one construction team member, and the responsibilities for executing the work are delegated through these contracts. However, the responsibilities of acquiring and providing feedback as well as controlling information are generally not clearly defined.

On every construction project, a vast number of data are generated and distributed to the involved parties; however, this process does not always take into account the three most important attributes of data, i.e., quality, integrity, and timeliness. Nor does it define standards, proper guidelines, or a model for generating, collecting, storing, and providing feedback about these data. Currently, the project designer or the owner acts as a clearinghouse for information processing; however, because of contractual arrangements or adversarial relationships existing among the owner, the contractor, and the designer, this procedure is neither efficient nor accurate; in addition, existing standard contracts do not precisely define areas of responsibility for each party nor the type, format, and quality of information that each participant should provide or collect.

The objective of this paper is to develop a conceptual model for analyzing the process of building construction, to identify the types and the attributes of data generated throughout the life cycle of a building, and to develop a framework for an integrated conceptual data model for managing information during the life cycle of a building. The scope of this research takes into consideration the owner's point of view on building construction projects using a competitive bidding project delivery method. The boundary of the scope is from inception of the idea of the building to initiation of the construction.

MODEL DEVELOPMENT

The proposed integrated information system consist of four phases: 1) the Problem Situation Expressed Model; 2) the Development of Issue Based (IB) model; 3) the Development of Building Construction Primary Task (BCPT) model; and 4) the Development of Building Construction Entity Model (BCEM). Due to space limitations, only the first three phases are described in this paper. Readers can refer to Sadri (1993) for more detailed information on the last phase.

Development of the proposed model started with defining the problem situation (the Problem Situation Expressed model) based on the Soft System Methodology (Wilson 1990, and Checkland et al. 1990). This method was found to be appropriate for describing ill-structured problems such as the process of building development. The model illustrates the stage at which the problem is first identified. Based on the analysis of the Problem Situation Expressed model, an issue-based model has been developed.

The Issue Based (IB) model is a system for presenting a conceptual organization and the interrelationships among the different subsystems; such a system is required in any enterprise involved in building construction projects. Comparing the organizational structure with the model will reveal if all the subsystems exist in the organization and if their positions and relationships are arranged in an efficient, effective manner. The model can be used for either evaluating existing organizations or re-engineering the systems within the enterprise. Then the issue-based model is transformed into a primary task model.

The Building Construction Primary Task (BCPT) model defines the minimum and necessary tasks required to support the subsystems of the IB model. Mapping the organizational structure onto this model will identify the responsibilities of the managers of different operations, expose the gray areas of responsibility or any overlap of authority in the operation, and identify any deficiencies (i.e., tasks having no assigned responsible manager) and inefficiencies (i.e., tasks involving more than one decision-maker). The BCPT model and the information required to support the tasks can be used to determine the information systems needs of an enterprise. The concept of considering each task as a transformation process will enable analysts to evaluate the performance of the designed information system in any organization by comparing the required input of different information categories and by grouping the data into information categories. Comparing the output of all the data transformation processes may reveal any duplication in the process, thus contributing to a more efficient design of the data transformation process. Utilizing the BCPT, a conceptual building construction entity data model for information integration has been developed.

The Building Construction Entity Model (BCEM) is a conceptual data model that provides the information analyst with a readily available framework for the design of an information system that

can satisfy the needs of the enterprise. Incorporating the concepts of product data modeling into the BCEM allows the various disciplines involved (e.g., the designer and the constructor) to prepare their data based on this format and use the related entities as an interface to the model. As a result, an integrated information system which can be used by project participants has been developed (Sadri 1993). The following section describes the first three phases in more detail.

PROBLEM SITUATION EXPRESSED MODEL

Investigating the process of building development was the first step toward developing the model. The methodology chosen for solving a problem of information management in the development of buildings depends on the way this information is generated, monitored, and controlled. The Soft System Methodology (SSM) and several different modeling techniques such as SADT, SAMM, NIAM, IDEF0, Data Flow Diagrams, the Entity-Relation Model, and Jackson's Diagrams have been evaluated based on the following criteria suggested by Chung (1989): Technical merit for representing functions and interrelationships of the investigation; ease of use and understanding by all project participants; availability to all members of the project; compatibility with the major efforts in this area; and proven robustness through use in the industry. Based on these criteria, the SSM was selected as the methodology to be used in modeling the building construction process. Since one of the goals of this study was that the methodology conform to the STEP standard guidelines, methodologies for the development of Application Protocol (AP) suggested by STEP were investigated, and the similarities and differences between the AP methodologies and the SSM were evaluated. The outlook of developing a conceptual data model using the SSM for implementation in conformance to the STEP standard guidelines is discussed below.

The STEP modeling methodology suggests the use of IDEF0 (ICAM 1983), a process modeling technique for the Application Activity Model (AAM), (Trapp 1993). Within the context of this research, IDEF0 has been considered a good tool for modeling processes that are specific to a building type. Because control and mechanism factors must be defined for each process, this technique is rigid compared with that of the primary task model, which has more flexibility for developing a generic model--the goal of this investigation. In addition, the SSM is designed for the development of an information system, and a validation mechanism is built into the methodology; however, such a mechanism is not a part of the IDEF0. On the other hand, one of the techniques that STEP recommends for the Application Reference Model (ARM), is IDEF1x (in addition to NIAM, EXPRESS, and EXPRESS-G), an information model based on IDEF0; but the SSM does not have a formal conceptual data model. The final decision, therefore, was to use a hybrid approach: to implement the SSM for the development of the functional model and then transfer information to an IDEF1x information model, which can easily be converted into EXPRESS for the development of the STEP Application Protocol.

Building Development by Soft System Methodology

Development of a building has been considered as a human activity system based on the concept of the Soft System Methodology. The SSM is a seven-stage process of analysis which uses the concept of the human activity system as a means of going from *finding out* about the situation to *taking action* to improve the situation (Wilson 1990; and Checkland et al. 1990). This methodology is used for developing functional models for building development processes as described in the following section.

In order to develop an activity model, several resolution levels have been developed. Activities on each level are a set belonging to a system at the previous level. At each level of resolution, a minimum, necessary set of required activities are identified, and through a root definition (a root definition attempts to capture the core or essence of the system being considered), each system will be expanded to the higher resolution level. Smith and Checkland (1976) suggest that a well-formulated root definition should be prepared by consciously considering the following six elements (called CATWOE):

Customer (C):	The victims or beneficiaries of the transformation process.
Actors (A):	Those who would do the transformation process.
Transformation process (T):	The conversion of input to output.
World-view (W):	The world-view which makes this transformation process meaningful in context.
Owner (O):	Those who could stop the transformation process.
Environmental constraints (E):	Elements outside the system which it takes as given.

The core of CATWOE is the pairing of the transformation process (T) and the world-view (W), which makes it meaningful. Based on the CATWOE structure, the simplest version of a root definition can be defined as "a system to do *X* by *Y* in order to achieve *Z*."

Model Development

After the activity list is developed, related activities must be grouped to form a system with distinct input and output. For this purpose, boundaries and responsibilities were defined based on an investigation of current practices in the construction industry, a comparison of suggested managerial styles, functional analyses and organizational structures, and various documents and standard forms published by organizations such as the American Institute of Architects, the Associated General Contractors of America, and the Construction Specification Institute. As a result, several issues of concern were identified and a list of primary tasks involved in the process prepared. At this point, the SSM was followed for the development of the model. Work responsibilities in each operation were analyzed to ensure that all aspects of contractual agreements were met.

Prior to the study of the problem, the following issues were investigated: What is taken to be the boundary of the area under study? What interactions are assumed to exist in relation to this particular boundary? and What kind of activities are likely to be present within this area? These questions are answered by defining the developer's organization boundary, the planning and construction management unit, and the major interactions both internal and external to the developer's organization.

This model uses the SSM methodology to illustrate the stage in which the problem is first identified. The model reveals a system called Project Planning and Construction Management (PPCM), a system within the developer's organization that will strongly influence both the developer's organization as well as its environment.

The PPCM is the first resolution level model which provides a global view of the problem situation expressed. The goal of this model is that it serve as a basis for the development of higher resolution models (issue-based and primary task models) by exploring the nature of the projects, the relationship between the units, environmental constraints, market demand for quality, and others.

Therefore, the definition (root definition) of the PPCM is "a developer-owned system for the effective and efficient procurement of site; design; and management of construction by the PPCM unit for the development of building construction projects to meet market demand while meeting the developer's expectations for performance within developer and environmental constraints." The analysis of this system definition resulted in the following elements:

Customer (C):	The market producing the demand.
Actors (A):	The project planning and construction management unit (PPCM).
Transformation (T):	The procurement of site, design, and management of construction.
World-view (W):	The efficient and effective construction project management that will ensure that developer expectations are met.
Owner (O):	The developer.
Environment (E)	The developer and environmental constraints.

Definition of these six elements will be used for developing the second resolution model (on issue-based model as described in the following section) which defines the role of the developer on building construction projects. This model will then be used to define the information needed for the planning stage of the development of a building.

THE ISSUE-BASED MODEL

Analysis of the PPCM model and its interactions with the other units of the developer's organization resulted in the development of the Issue-Based (IB) model. This model is a higher resolution of the PPCM model. It is a system for presenting an organization and the interrelationships among its

different subsystems; such a system is required in any enterprise involved in building construction projects.

After the analysis of the responsibilities, five major systems essential to the efficient operation of all construction projects are identified. The following lists the five major systems of an enterprise with their root definitions and their elements.

Business Strategy System

This is a system that considers all constraints in planning the growth and direction of an enterprise to achieve long-term goals. In this system, the six elements are defined as follows:

C:	The management team
A:	The policy-making body (e.g., the board of directors)
T:	The policies on current and future directions of the enterprise

W: The need to have a strategic plan in order to achieve goals successfully and stay competitive in the market place
O: The enterprise
E: Statutory regulations, industry norms and standards, and technology

Planning System

This system analyzes market needs, project requirements, cost benefits, and the developer's capabilities for acquiring the site and commissioning a design that meets the developer's objectives. In this system, the six elements are defined as follows:

C: The land owners, the designers, the construction management system, and the technology and resource development system
A: The planning system staff
T: A plan of action based on market needs
W: A belief that the venture is economically feasible
O: The enterprise
E: The plans, policies, and capabilities of the enterprise

Construction Management System

This system implements Constructability, selects contractor(s), and monitors and controls the construction process so that it conforms to established requirements and specifications. In this system, the six elements are defined as follows:

C: Contractors and suppliers
A: The construction management staff
T: The conversion of material and other resources into a building
W: The use of modern technology and the feasibility of development using available resources
O: The enterprise
E: Regulations, codes, norms, and standards

Technology and Resource Development System

This system is based on the defined strategic mission of the enterprise and acquires or develops the necessary technology and resources and allocates them to appropriate systems in order to achieve the desired performance, ultimately creating a competitive edge for the organization. In this system, the six elements are defined as follows:

C: The planning and construction management systems
A: The technology and resource development staff
T: The availability of technology and resources to the customers of the system
W: The feasibility and effectiveness of available technology and resources
O: The enterprise
E: The economic aspects of the technology and resources

Control System

This system for defines the strategies and policies of the enterprise, establishes the goals and measures the attainment of these goals, and initiates a system to monitor and control the processes and outcomes of the above systems by comparing them against standards, specifications, and pre-defined requirements to ensure that necessary resources and services are provided to each subsystem and if necessary, that corrective action for improvement of overall system performance is taken. In this system, the six elements are defined as follows:

C:	All other systems in the enterprise
A:	The management team
T:	The feedback from other operations
W:	The achievement and maintenance of goals through constant monitoring and control
O:	The enterprise
E:	The organizational structure and management philosophy of the enterprise

Since the developer (enterprise) is the owner of all of these systems, a statement of ownership has been deleted from the root definitions. In order to determine if each transformation process was successful, the following evaluation criteria suggested by Wilson (1990) were considered:

Efficacy:	Does the means work?
Efficiency:	Is the ratio of the amount of output divided by the amount of resources used satisfactory?
Effectiveness:	Is transformation meeting longer-term goals?

The evaluation criteria were considered and answered in each instance of the application of the model. When the answers to the evaluation criteria were not satisfactory, a review of the issues and the organizational structure were conducted. In most cases, another iteration of the organization into the model revealed the problem area.

THE PRIMARY TASK MODEL

The primary task model is a higher resolution of the issue-based model described in the previous section. The five major sub-systems of an enterprise with their root definitions are described in the following section.

Business Strategy System

This sub-system involves the strategic plan of the enterprise and reflects the basic "road map" of the company, guiding all other related systems in the direction of the strategic plan. The system includes five primary tasks:

Task 1:To know about the future development policy of the developer and its implications for development capabilities. This task relates the construction management unit (i.e., project management is a function of the construction management unit) with the strategic plan and involves

identifying future needs. According to the root definition, this task is a system for determining development policy and requirements for implementing that policy.

Task 2:To prepare a long-term plan for the development of planning and project management capabilities. This task involves managing available resources and complying with the strategic plan identified in task 1. According to the root definition, this task is a system for identifying the needs and requirements for implementing a business strategy for planning and project management capabilities.

Task 3:To know about current developments in the business of building construction. This task includes keeping the construction management unit informed about current innovations and future trends in the field. According to the root definition, this task is a system for collecting and analyzing important information that relates to all aspects of development in the building construction field, and for ensuring that this information will contribute to the strategic decision-making capabilities of the management of the enterprise.

Task 4:To monitor the achievement of plans. This task requires a system in which the progress of the plan can be continuously checked against established goals, and any deviation from the plan can be reported to the control business strategy system. According to the root definition, this task is a system for observing and evaluating the implementation of the business strategy system.

Task 5:To control the business strategy system. This task involves a system for receiving information from the monitoring mechanism (task 4) and for correcting or modifying the operation or business strategy to assure that the final result is compatible with the objectives of the business strategy. According to the root definition, this task is a sub-system for measuring any deviations from the plan and implementing corrections or modifications necessary to remedy the problem.

Technology and Resource Development System

This system ensures the enterprise's competitive edge in the global market place. The significance of this system arises from two basic premises: that innovations in means and method of construction as well as the development of new technology are of utmost importance to an enterprise; and that expertise of human resources either through recruiting the best in the business or by training existing personnel can ensure quality and satisfaction with the existing project and secure future business. The technology and resource development system consists of the following seven different tasks:

Task 1:To know about existing resources and their capabilities by performing an operational analysis and evaluating all resources. This evaluation must be based on a benchmark identified as the best in the industry and include the identification of criteria and constraints required to achieve that benchmark. According to the root definition, this task is a system for continuously evaluating and improving efficiency and effectiveness of the enterprise's resources and technology.

Task 2:To know about major developments in building construction and associated industries. Specific knowledge of research areas and state-of-the-art developments in the field is required for future growth and competitiveness of the enterprise. According to the root definition, this task is a system for identifying new technology and required resources for successful execution of projects.

Task 3:To decide what capabilities need to be developed to meet the requirements of various projects. Selecting the appropriate technology and personnel that will best meet the goals set by the enterprise's business strategy is of utmost importance to the organization because this is the blue print for the success or failure of the enterprise. According to the root definition, this task is a system for making decisions about the capabilities required to accomplish business strategy goals.

Task 4:To plan an acquisition or development program for the capabilities. After the decision about the required capabilities is made, the capabilities must be developed or obtained. This system may require, along with task 3, several iterations with the previous system. According to the root definition, this task is a system for planning the acquisition or development of the required resources to accomplish the objectives of the enterprise.

Task 5:To acquire and commission new capabilities. Proper allocation of resources is the objective of this system. According to the root definition, this task is a system for obtaining and allocating resources and technology to the other systems and ensuring their efficacy, efficiency, and effectiveness.

Facility Planning System

In accordance with the business strategy of the enterprise, the planning system is responsible for identifying and implementing projects which can enable the enterprise to achieve the objectives of the organization socially, financially, and technologically. This system will initiate the project and give direction to the other systems for its implementation. The tasks of this model are:

Task 1:To know the existing market. This system always includes a research division. Some source (either formally or informally established) of general and specific information about the market must exist within the organization. According to the root definition, this task is a system for collecting and analyzing information related to the objectives of the enterprise.

Task 2:To identify the needs of the market. The purpose of this task is to match the needs of the market with the capabilities of the organization. According to the root definition, this task is a system for determining market needs in accordance with the objectives of the enterprise.

Task 3:To decide whether the conditions in the market warrant a building project. The purpose of this system is to analyze the information acquired in task 2 and determine if market conditions and the objectives of the enterprise are compatible. According to the root definition, this task is a system for comparing and identifying the market needs that the enterprise can achieve within the confines of its resources and objectives.

Task 4:To know the present and the planned capabilities of the developer. The purpose of this system is to evaluate the capabilities and determine the strengths and weaknesses of the developer. According to the root definition, this task is a system for analyzing current capabilities and future capabilities that are compatible with the strategic plan of the enterprise.

Task 5:To perform a cost-benefit analysis. The purpose of this task is to make a final determination

as to whether to undertake a project or not. According to the root definition, this task is a system for transforming economical and technological opportunities into the use of resources over a specified period of time to produce an expected return that the enterprise can feasibly achieve.

Task 6:To prepare the program. The purpose of this task is to determine a framework for the architectural programmer. Regardless of whether the programming is done in-house or by a consultant, this system is responsible for approving and making final decisions about the program. According to the root definition, this task is a system for preparing a program that solves the problem of required functions and space for the feasible development of a building project.

Task 7:To acquire the site. According to the root definition, this task is a system for selecting a site based on the cost-benefit analysis and program requirements.

Task 8:To commission the design. According to the root definition, this task is a system for selecting a project designer who will convert the architectural program to the building design.
Task 9:To arrange for project funding. According to the root definition, this task is a system for obtaining funding based on a cost-benefit analysis.

Construction Management System

This system is responsible for transforming the resources of the enterprise into a physical structure of a building in a manner which is compatible with the objectives of the enterprise. The tasks of this system are:

Task 1:To plan and implement Constructability. The purpose of this task is to ensure that the construction management team and the design team establish a close working relationship from the inception of the project in order to maintain the efficient, effective use of resources. This task measures the effectiveness of the design by using the following criteria as recommended by the Construction Industry Institute (Constructability a Primer 1986): The accuracy of the design; the usability of design documents; the cost of the design effort; the Constructability of the design; the performance of the design; and the ease of start-up. This evaluation must take into account the objectives of the enterprise rather than absolute or independent criteria. According to the root definition, this task is the same as Constructability, a system for ensuring the optimum use of construction knowledge and experience in planning, engineering, procurement, and field operations to achieve overall project objectives.

Task 2:To receive the design documents and initiate the bidding process. According to the root definition, this task is a system for obtaining the best project delivery method within resource and time constraints.

Task 3:To select a contractor. According to the root definition, this task is a system for evaluating contractors based on pre-defined criteria.

Task 4:To know about the project management tasks that must be undertaken. This system determines the resources and expertise required for each specific project and directly relates them to the Work Breakdown Structure (WBS) and the Organization Breakdown Structure (OBS). According to the root definition, this task is a system for determining project management tasks

and allocating these tasks to the proper sub-units within the organization.

Task 5:To manage the construction of the building. This system provides the core of the operation of the enterprise. According to the root definition, this task is a system which consists of professional staff that transforms resources and materials over a specified period of time to produce a building according to plans and specifications in order to achieve the objectives of the organization.

Task 6:To control the project management tasks, standards, and quality of the project. This task is part of the overall control system assigned to the construction management system. According to the root definition, this task is a system for establishing a procedural system in which processes and products are checked to ensure that they conform to established standards and specifications.

Task 7:To complete the construction of the facility. In the construction industry, this task is referred to as the project close-out. According to the root definition, this task is a system for assuring both compliance with all of the contractual provisions of the project and the removal of temporary facilities.

Control System

The control system includes two basic systems: a system of controlling performance processing; and a system of decision-making. The former has been divided into three subsystems: accounting and financial analysis; personnel performance; and productivity control.
The Performance Processing Control System

The root definition of this system is a system for setting goals and defining the appropriate measures of both quantitative and qualitative performances for evaluating all the systems in the enterprise. It includes the following systems:

The Accounting/Financial Analysis System processes financial data and evaluates the quantitative measures of the success or failure of the organization in terms of accounting procedures, such as cost accounting and financial analysis, based on accepted principals of the industry and in conformance with regulatory and enterprise constraints. According to the root definition, this is a system based on accounting principals for determining, at any given time, the financial status of the company and of each project and the overall use of resources to ensure their compatibility with the strategy of the company and with regulations and company policies.

The Personnel Performance System collects information on performance data and formulates personnel policies based on the strategic plan and standards of operation of the organization. According to the root definition, this is a system for defining and measuring the performance of personnel according to company policies, and then initiating an appropriate course of action to correct a performance problem.

The Productivity Control System measures the overall achievements of the organization in terms of the efficacy, efficiency, and effectiveness of the final product. According to the root definition, this is a system for determining if the operation of a company is efficient and effective and if it conforms to the requirements of the organization.

The Decision-Making System

This system encompasses the managerial levels in the enterprise and relates directly to the organizational structure. For this system to be implemented, the Organizational Breakdown Structure (OBS), including the roles and responsibilities of each manager, must be defined. According to the root definition, this is a system for producing company polices and procedures, setting standards of performance and requirements for operation, and determining the control action necessary to achieve the goals set by the enterprise's policy-making body.

The decision-making system consists of three subsystems: defining measures of performance; comparing measures of performance to the productivity analysis; and taking appropriate control action. Their root definitions are basically explained by their task definitions.

THE BUILDING CONSTRUCTION PRIMARY TASK MODEL

Building Construction Primary Task (BCPT) model represents the integration of the primary task models of five identified issues and their relationships with each other. This model is a higher resolution of the issue-based model developed in the previous section.

Following the SSM methodology, the model assumes that regardless of the organizational structure of the developer, he has to acquire a site and construct a building in order to be in the business of building development. This is referred to as "global" consensus. Thus, the global consensus would be a system for acquiring a site and constructing a building. The second assumption is that some legitimate activities are necessary to achieve the global consensus. These activities may have different perceptions or formats in various organizations. This is called "local" consensus. The local consensus for this model was presented by the Problem Situation Expressed model of the PPCM system. The third assumption is that the activities identified are desirable for the efficient and effective achievement of the global consensus as presented in the IB model.

Since the purpose of the primary task model is to represent a consensus of the problem situation, the activities of the model should reveal "how" the task is performed to achieve either global or local consensus. At this stage, an analyst is not concerned with whether the "how" is appropriate or not; therefore, for the process of building development, one should expect such activities as acquiring the site, commissioning the design, providing the resources, and so on will be included in the model. If it is not, the building, which is the final product, will not emerge from the process. Validation of the model is done by examining that such a "how," in fact, exists for each activity by determining what the output of each activity is and assuring that the output exist. For example, the output for the activity "commission design" would be "design documents," the existence of which, as required information, will validate its inclusion in the model.

The scope of this study was limited to the information required by the developer from the inception of the project idea to the start of the construction of the facility. The process of design, considered a system outside of the developer's own systems, is considered according to its relationship with the developer's systems in the "commission design."

In order to achieve the goal of this study, the BCPT model was reviewed and the boundary of the

scope was plotted to the model. This boundary contains two systems: planning and construction management, for which operational activities were analyzed for information requirements. The rationale for choosing only operational activities for further analysis is based on the fact that the primary concern of "know about" activities are external interactions with the system.

SUMMARY AND CONCLUSIONS

Building construction is an area of the construction industry with unique characteristics, as its means and methods are quite different from those in other segments of the industry. After an assessment of the common practices in the industry, it was concluded that investigating the process as an integrated system of planning, design, and construction would be necessary to identify the interrelationship among these processes. Based on the principals of systems theory, creation of a building as a system is feasible. Considering systems theory in view of the management of information led to the concept of "soft systems," which is an appropriate methodology for the analysis of information required to support the construction of a building.

Based on the SSM, modeling the *making* of a building as a system is useful in the following ways: (1) It is an aid to clarifying the thinking about one area of concern--the process of planning and managing a construction project; (2) it illustrates a concept for the flow of information in these processes; (3) it is an aid for defining the structure and logic to show the interrelationships among the various tasks; and (4) it is a prerequisite to designing a conceptual data model. Developing a conceptual model which represents the system of the *making* of a building is based on the basic concept that this system is a transformation process, and the set of activities contained in the model represent the interconnected set of actions necessary to transform some input(s) into some output(s).

The strategy for the development of the model was based on a review of the literature, an investigation of the documents most frequently used in the building construction industry, and expert views. The scope of this research includes information required by the owner of the building project for the planning, commission of the design, and start of the construction process. The owner (i.e., the developer), as the initiator and executor of the building project, has control over the entire process and can set standards and requirements of performance for all the disciplines involved.

This paper provided a foundation for developing an integrated conceptual data model for managing information during the life cycle of a building. In this paper, the Soft System Methodology (SSM) was used to develop a set of functional models from the owner's viewpoint. This was accomplished by developing Issue-Based and Building Construction Primary Task models.

The proposed Issue-Based (IB) model was found to be an effective system for presenting a conceptual organization and the interrelationships among the different subsystems; such a system is required in any enterprise involved in building construction projects. Comparing the organizational structure with the model would reveal if all the subsystems exist in the organization and if their positions and relationships are arranged in an efficient, effective manner. The model can be used for either evaluating existing organizations or re-engineering the systems within the enterprise.

The proposed Building Construction Primary Task (BCPT) model provided a practical framework for building construction process analysis. It defined the minimum and necessary tasks required to support the subsystems of the IB model. Mapping the organizational structure onto this model identifies the responsibilities of the managers of different operations, exposes the gray areas of responsibility or any overlap of authority in the operation, and identifies any deficiencies and inefficiencies.

The methodology of analysis of the BCPT model and the information required to support the tasks was used to determine the information systems needs of an enterprise. The concept of considering each task as a transformation process provided a framework for evaluating the performance of the designed information system in an organization by comparing the required input of different information categories and grouping the data into information categories. Comparing the output of all the data transformation processes may reveal any duplication in the process, and thus contribute to a more efficient design of the data transformation process.

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