Preproject-Planning Process for Capital Facilities

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Abstract: Preproject planning is defined as the process of developing sufficient strategic information for owners to address risk and decide whether to commit resources to maximize the change for a successful capital facility project. Preproject planning—also known as feasibility analysis, conceptual planning, and front-end planning—is at the interface between business and engineering. It is an owner's responsibility that it be performed adequately; however, many preproject-planning functions are performed by engineering consultants. Members of the engineering profession must be aware of its implications and requirements. This article presents results from an on-going investigation of preproject planning. The concept and definition of preproject planning are discussed. A validated process map describing the major subprocesses of preproject planning is presented and a brief narrative describing each is given. Key preproject-planning principles discovered during the course of the research project are outlined and conclusions concerning the preproject planning process are presented.

INTRODUCTION

Preproject planning is defined by the preproject-planning research team of the Construction Industry Institute (CII) as the process of developing sufficient strategic information for owners to address risk and decide whether to commit resources to maximize the chance for a successful project (Gibson et al. 1993). Preproject planning is often perceived as synonymous with feasibility analysis, conceptual planning, programming, front-end loading, and front-end planning. The planning stage of a project begins once an initial idea for the project sets it in motion. Preproject planning is an important subset of project planning; it begins after business leadership deems the project concept as being desirable and continues until the beginning of project execution, when detailed design and construction actually begin. The purpose of this article is to define the functions involved in the preproject planning of capital facilities, as well as to relate key points concerning preproject planning that have been discovered during the research.

Note that a capital facility can be defined as a new or renovated facility that is designed and constructed to meet a business or societal need as part of a capital budget. It can be a building, road, dam, manufacturing plant, and so on, and is typically tax depreciable for private companies.

Preproject planning is the project-development interface between business and engineering in terms of capital expenditures. It is the facility owner's responsibility that it is performed adequately; however, many of its functions are performed by engineering consultants. As major domestic-facility owners downsize their central engineering staffs and decentralize engineering functions, much of the preproject-planning effort currently being performed by owner organizations may be contracted in the future. Members of the engineering profession must be keenly aware of the implications and requirements of preproject planning.

CII initiated a research project to investigate preproject planning in July 1991 by setting up a research team with a charter "to find the most effective methods of project definition and cost estimating for appropriation approval." The research team has subsequently modeled the preproject-planning process to identify the important functions that must be accomplished to successfully meet this charter. Development of this process model satisfies the first objective of a three-phase research project investigating the process of, utility of, and requirements for performing preproject planning. The following sections will discuss this research effort in more detail.

BACKGROUND

Many experts within the construction industry believe that planning efforts conducted during the early stages of a project have a significantly greater effect on project success than efforts undertaken after the project is under way. Fig. 1 graphically illustrates this concept. The curve labeled "influence" reflects a company's ability to affect the outcome of a project during its various stages. As the diagram shows, it is much easier to influence a project's outcome during the project-planning stage, when expenditures are relatively small, than it is during project execution or operation of the facility, when expenditures may be significant. As shown in Fig. 1, the four distinct stages of the project life cycle are business planning, preproject planning, project execution, and facility operation. The project-planning stage includes both the business planning and preproject-planning functions.

Early in the research effort, the research-team members struggled to understand the preproject planning process. The differences between the research-team participants' views of the preproject-planning process in terms of semantics, functional abstractions, and industry-specific paradigms were hard to overcome. The writers realized that they needed a methodology to help organize the research team's efforts and sub-

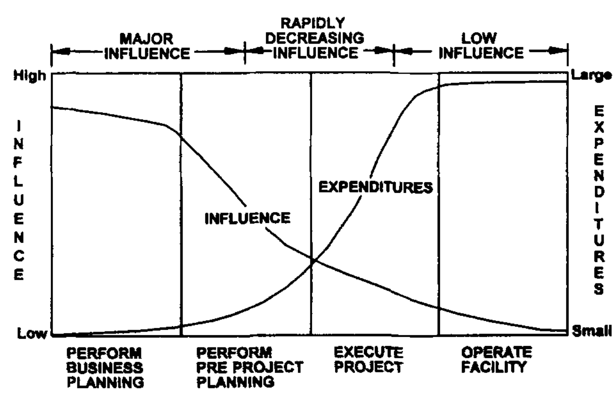

FIG. 1. Influence and Expenditures Curve for Project Life Cycle

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Note. Discussion open until February 1, 1996. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on January 24, 1994. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 121, No. 3, September, 1995. ©ASCE, ISSN 0733-9364/95/0003-0312–0318/$2.00 + $.25 per page. Paper No. 7723.

J. Constr. Eng. Manage., 1995, 121(3): 312-318

sequently proposed the IDEF0, Structured Analysis and Design Technique (SADT) methodology (March and McGowan 1988). This methodology was developed for the U.S. Air Force in the early 1980s to model the functional relationships of manufacturing processes involved in defense weapons procurement contracts (Softech 1981). The methodology was adopted by the research team and provided a structured, graphic tool to organize their thoughts in a group setting.

The result of using IDEF0 was a validated, generic model that describes the basic preproject-planning process for all construction projects. This model provides common industry terminology, a basis for measurement of the cost and effort of preproject planning, a basis for developing or refining the preproject-planning process within a company, a graphic method for sharing ideas and concepts, and a useful training tool for engineers and planners. The following sections will discuss the literature review, research methodology, and process model, as well as present key findings discovered during the course of the model development and validation.

LITERATURE REVIEW

Very early in the research project, it was determined that little published research had addressed the process of preproject planning. The literature review therefore focused on two areas. First, descriptions of process modeling methodologies including the IDEF0 modeling methodology were reviewed. Second, several previously developed planning models were identified and analyzed.

Process Modeling Methodologies

Chung (1989) provides an excellent evaluation of modeling methodologies for the computer-integrated construction (CIC) research project at Pennsylvania State University. He examined several modeling methodologies and determined that the methodology, to be useful for modeling construction processes, should be hierarchical, modular, standardized in structure, and capable of representing the complex processes of the construction industry. IDEF0 was chosen for the CIC project because it best met these requirements.

During the investigation described in this paper, the research team discovered that a CII member company also uses IDEF0 to model manufacturing-plant operations prior to beginning detailed design and construction. Also, all U.S. military branches have adopted IDEF0 to functionally model military procurement manufacturing programs.

The researchers and research team chose the IDEF0 modeling technique to model preproject planning for a variety of reasons: (1) The research team was comfortable with IDEF0 and considered it to be a good modeling method, and the writers were familiar with the methodology; (2) the methodology has been used previously for planning industrial construction projects and manufacturing processes; (3) IDEF0 has been used in academic literature related to construction in the past (Sanvido and Medeiros 1990); (4) IDEF0 is highly structured and hierarchical and is therefore well-suited to modeling the construction process; and (5) a commercial software package, Meta Software's Design/IDEF, was available to automate the design process.

Preproject Planning Models

An extensive literature review revealed several attempts to model the planning function. In previous research, CII targeted preproject planning as a key to project success and set forth a simple model of the process for constructing a project (CII 1986). Sanvido (1990) produced an IDEF0 model of the construction process for the National Science Foundation's CIC Research Program. His integrated-building-process model divides the construction process into five distinct phases: manage facility, plan facility, design facility, construct facility, and operate facility. Jewell (1986) outlined a seven-step process for planning and design: definition of problem; gathering of data; development of evaluative criteria; formulation of alternatives; evaluation of alternatives; choosing the best alternative; and final design/plan and implementation. Tompkins and White (1984) produced two models that relate to facilities planning. The first model locates facilities planning in relation to the other functions that occur during the facility-design process. The second model is a more detailed explanation of the facility-planning process itself, and stresses that the planning process is iterative.

Five other proprietary, corporate-developed preproject-planning process models were identified by research-team members and reviewed. In general, these models are very specific to the particular operations of the models' developers and tend to be significantly more detailed than the preceding five examples.

Several similarities exist between the nine models just described. However, it is also clear that the models are frequently very specific to the developers' operations or industry segment. In some cases, the models were lacking in detail. Therefore, the writers continued with development of a model to meet the needs of the research investigation.

METHODOLOGY

The writers, along with members of the research team, have developed a functional model of preproject planning as part of this research project (Gibson et al. 1993). The research team consisted of experienced industry professionals representing 16 companies, which ensured expertise for model development. Two faculty members and four graduate students were also involved in this process. Table 1 shows the companies represented on the research team, their origin, job position, and the industry that each represented.

Early in the development process, the research team decided that the model should not necessarily mirror a single company's planning procedures, and every attempt was made to keep the model as generic as possible so that it can apply equally to different project types and companies. Therefore, the model as presented refrains from going into so much detail that it becomes specific to one company, industry segment, or project type. As part of the research effort, the research team also developed detailed checklists of the important steps in the preproject-planning effort that can be used to insure

TABLE 1. Research-Team Representatives

Number of participants (1)	Type of firm (2)	Job position (3)	Company market (4)
3	Owner	Engineering and construction management	Power
5	Owner	Engineering and construction management	Chemical, petrochemical
1	Owner	Engineering and construction management	Manufacturing
1	Contractor	Architectural and engineering services	Commercial, institutional
6	Contractor	Engineering, procurement, and construction services	Power, chemical, petrochemical
2	University	Professor	Construction engineering education

J. Constr. Eng. Manage., 1995, 121(3): 312-318

that all the important planning functions are performed prior to beginning detailed design or construction.

The IDEF0-model–development process is very structured. Marca and McGowan (1988) refer to the iterative process of writing, evaluating, and rewriting an IDEF0 model as the SADT author/reader cycle. A completed model consists of the diagrams, a narrative describing the diagrams, and a glossary of all terms presented in the model. The following chronological discussion is given to illustrate the depth of the model, as well as the steps required to use this methodology for future development efforts.

The review process used by the research team was similar to Marca and McGowan's (1988) SADT author/reader cycle. However, the process varied somewhat because the model was developed primarily in a group setting. The first working versions of the context and first level diagrams were developed during a February 1992 meeting. The research team also began the development of definitions for the terms found in the two diagrams. Note that the writers drew and maintained the diagrams during this entire development process using Meta Software's Design/IDEF software package.

During the next meeting in March 1992, the research team reviewed the context and first-level diagrams and began work on the development of the second-level diagrams. After this meeting, the writers incorporated research-team suggestions into the model.

During the break between the March and June meetings, the research team developed more detailed definitions of the model terms. In addition, the writers held weekly meetings to refine the existing diagrams and developed draft second-level diagrams. The writers also received and incorporated definitions produced by the research team for inclusion in the glossary. Drafts of narrative descriptions of the model were reviewed and revised by the research team at the June meeting.

The research team reviewed and edited the updated model, glossary terms, and narrative descriptions at the August 1992 meeting. During the October meeting, research-team members developed and reviewed checklists of items required for a complete preproject-planning effort, which were included in the narratives. At the December 1992 meeting, the research team and writers finalized the model and narratives.

Although the model-development process was extensive and had input from a variety of sources, the writers felt that comparison with real-world projects would be valuable. Three CII member companies volunteered projects that were used to validate the preproject-planning model. The company and project types used for validation are shown in Table 2. Construction-planning professionals at each of the three companies gathered data from a specific project to compare their procedures with the steps described in the IDEF0 preproject-planning model. Validation site visits in which the researchers and the company representatives extensively reviewed the model and its relation to real-world practice were held in the spring of 1993 (Gibson et al. 1993). Overall, the model proved to be a good generic representation of the preproject-planning process; however, there were some company-specific differences dealing with semantics, teamwork, interim funding decisions, and the order that preproject-planning functions occurred. These differences, as well as other findings identified during these interviews, are incorporated in the section presented later in this paper dealing with key points. After review of the validation results, the writers and research-team members felt that the model did not need further modification and that it provides a good platform for subsequent research and industry action.

TABLE 2. Model-Validation Projects

Project (1)	Company type (2)	Project description (3)
1	Utility	$11,000,000 transmission line project
2	Utility	$100,000,000 power/steam cogeneration facility
3	Chemical/petrochemical	$250,000,000 petrochemical facility

PROCESS MODEL PRESENTATION

Early in the modeling effort, the research team and writers developed the context model for performing preproject planning, which is shown in Fig. 2.

Without going into detail about the IDEF0 diagramming methodology, the basic construction of the graphics as shown in Fig. 2 can be summarized as follows:

- Each box represents a specific function or process, and is named using an active verb phrase. Boxes have dominance based on position, with the upper left-hand box dominating or controlling the others.
- The arrows indicate "things" and initiate actions occurring in regard to the function boxes based on entry or exit points. They are named using nouns or noun phrases.
- Arrows entering the left of the box are inputs to the process and are transformed by the process.
- Arrows entering the top of the box are controls or constraints on the process.
- Arrows leaving the right are outputs of the process.
- Arrows entering the bottom are mechanisms needed for the process to occur such as people, machinery, and so on.
- The diagrams are hierarchical, allowing further detail as the diagrams are broken down to the next level.

Using the diagram shown in Fig. 2 as an example, the decision maker takes input in the form of a "validated project concept" and ensures that it is transformed into outputs in the form of a "project decision" and a "project-definition package." The input for the "perform preproject-planning" function, the "validated project concept," is the initial idea for the project that sets it in motion. The idea may involve a new profit opportunity or it may involve compliance with regulations or reductions of liability exposure. The first output of the preproject-planning function is a "decision," made by the "decision maker," concerning whether the project should proceed. The second output of the function is the "project-definition package," which is the information needed to execute the project successfully. "Constraints" take the form of available resources, regulatory issues, market conditions, and so on. "Objectives" would include financial goals, market goals, and site usage criteria.

Fig. 3 shows the first-level IDEF0 diagram that expands the context diagram (Fig. 2) and describes the major functions involved in preproject planning. Accompanying each of these

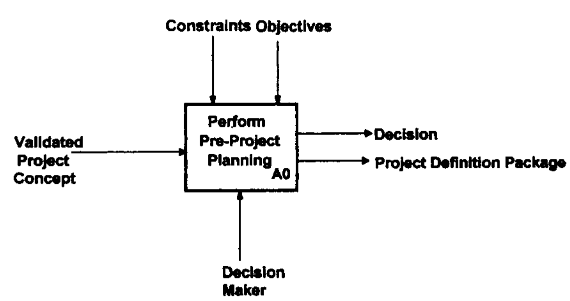

FIG. 2. Context IDEF0 Diagram—Perform Preproject Planning

J. Constr. Eng. Manage., 1995, 121(3): 312-318

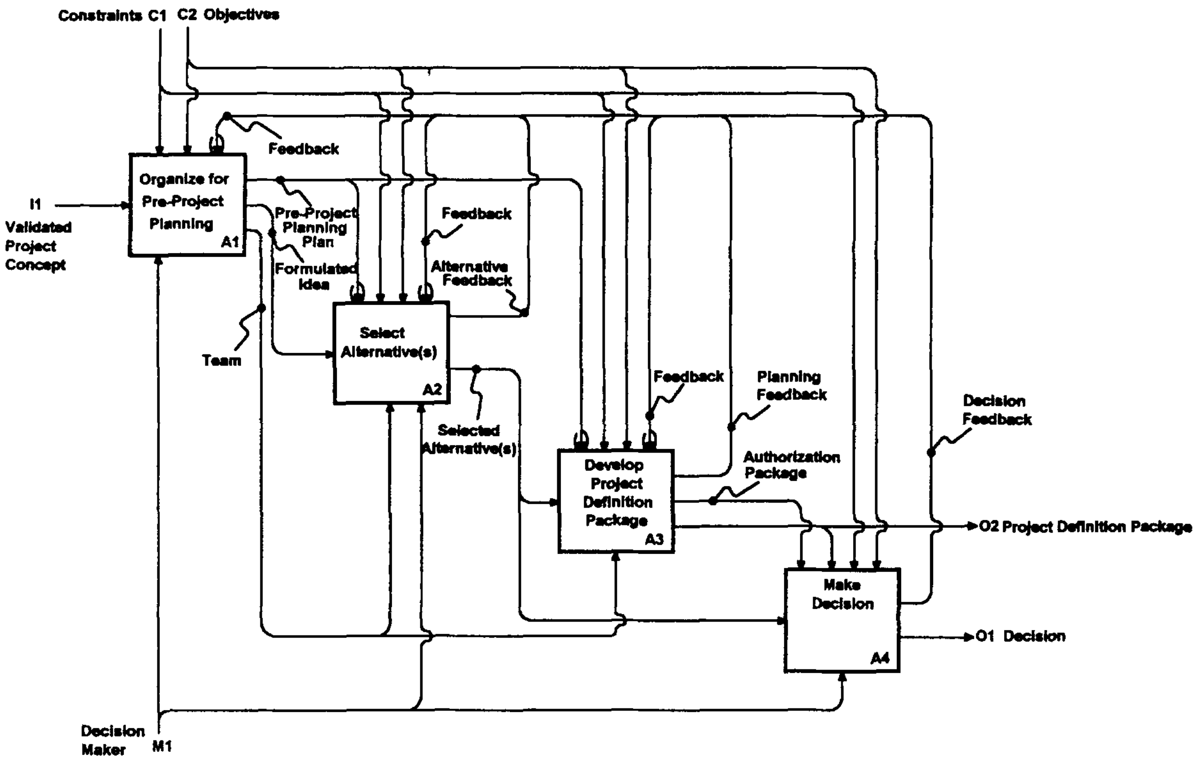

FIG. 3. Level 1 IDEF0 Diagram—Perform Preproject Planning

diagrams is a detailed glossary of terminology and a narrative describing the interactions within the diagram. As discussed earlier, the writers and research-team members identified the information flow between the various planning functions, as well as the major players (upward arrows) and the controls for each process (downward arrows).

As can be seen in Fig. 3, the major subprocesses of preproject planning are "organize for preproject planning"; "select alternatives"; "develop project-definition package"; and "make decision." Key points to note from this diagram are that (1) the processes are not linear and functions can occur concurrently; and (2) interaction and iteration are inherent within this process. A brief discussion of the major subprocesses identified in Fig. 3 is given as follows:

Major Subprocesses of Preproject Planning

"Organize for preproject planning" is the first major preproject planning subprocess of preproject planning shown in Fig. 3. It is further decomposed in Fig. 4 and consists of the following three major functions.

- "Select Team": In this function, the individuals responsible for preproject planning are selected and organized. The team should be composed of skilled and experienced members who can respond to the business and project objectives. The team may be dynamic in its membership, but should in any case have uninterrupted representation from business, project management/technical, and operations. Expertise required for the team may include project-management, business, legal, environmental, and safety fields.
- "Draft Charter": The charter defines the preproject-planning–team's mission and responsibilities and further refines the original project concept into a workable, project-based concept. This charter must be based on owner-sponsored guidance and would include elements such as a mission statement, quality requirements of the deliverable, and team member's responsibility and authority.
- "Prepare Preproject Planning Plan": Based on the charter and available resources, a plan is prepared documenting the methods and time schedule for completing the preproject-planning activities to be performed by the team. This plan would include the schedule, budget, physical location of the work, contracting strategy, and priorities for completing preproject planning.

"Select alternative(s)" is the second major preproject-planning subprocess shown in Fig. 3, and is itself developed further in Fig. 5. It consists of the following four major functions.

- "Analyze Technology": Existing and emerging technologies are evaluated for feasibility and compatibility with corporate business and operations objectives in terms of inclusion and usage within the project.
- "Evaluate Site": Alternate siting locations are evaluated to meet the client's needs in terms of relative strengths and weaknesses. Note that analyze technology and evaluate sites are typically performed in conjunction with one another.
- "Prepare Conceptual Scopes and Estimates": The team develops and assembles the required information on the various combinations of alternatives in a format that permits valid comparisons based on business/project objectives and constraints, including capacity, function, products, environmental, labor, legal, and logistics.
- "Evaluate Alternatives": The team and decision maker compare viable project options and choose the option(s) most advantageous to the business for further study.

"Develop project-definition package" is the third major subprocess of the preproject-planning process shown in Fig. 3, and is itself developed further in Fig. 6. Its five functions are given as follows.

- "Analyze Project Risks": The team identifies and analyzes risks associated with the selected project alterna-

J. Constr. Eng. Manage., 1995, 121(3): 312-318

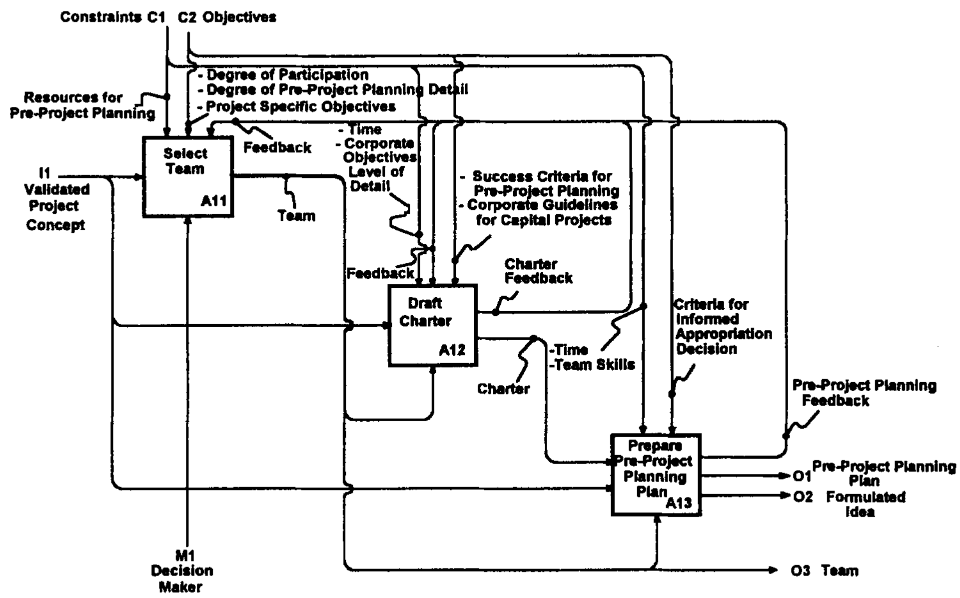

FIG. 4. Level 2 IDEF0 Diagram—Organize for Preproject Planning

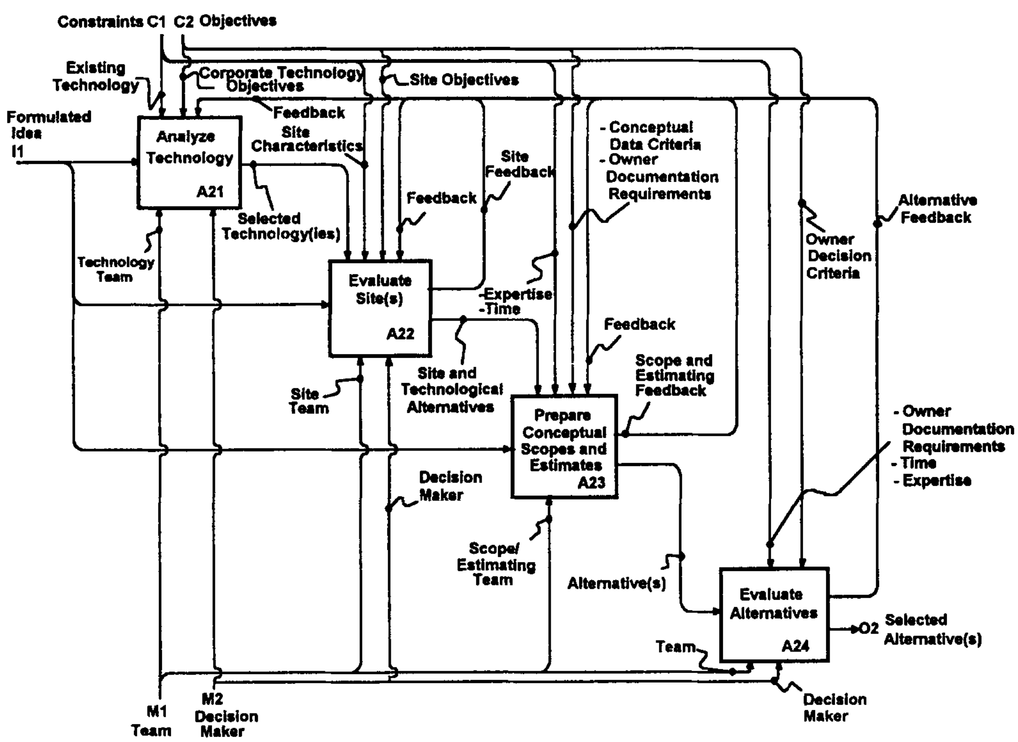

FIG. 5. Level 2 IDEF0 Diagram—Select Alternative(s)

tive. These analyses should include financial/business, project, social, and operational risk categories in order to proactively seek to minimize the risk's impact on project success.

- "Document Project Scope and Design": The team clearly identifies the commercial and technical intent of the project and brings the project design to the stage of completion that is necessary to reasonably minimize the risks associated with execution and operation of the facility. The scope analysis includes estimated project costs, project description, equipment lists, procurement strategy, flow diagrams, utility analysis, and operations and maintenance considerations, which form the "pre-authorization design basis."
- "Define Project-Execution Approach": This function involves addressing and documenting the methods to be used to perform the detailed design, procurement, construction, and start-up of the project, which together with other tasks form the "execution approach" to be taken for the project."
- "Establish Project-Control Guidelines": The team develops detailed procedures to manage execution of the project, including control guidelines such as milestone critical path schedules, procurement schedules, and safety guidelines, and a "control plan" that addresses such issues as planning, scheduling, change management, and management information systems.
- "Compile Project-Definition Package": The team compiles the information developed in the four functions listed above into a summary-form "authorization package" that allows the "decision maker" to determine the viability of the overall project. A more detailed "project-definition

J. Constr. Eng. Manage., 1995, 121(3): 312-318

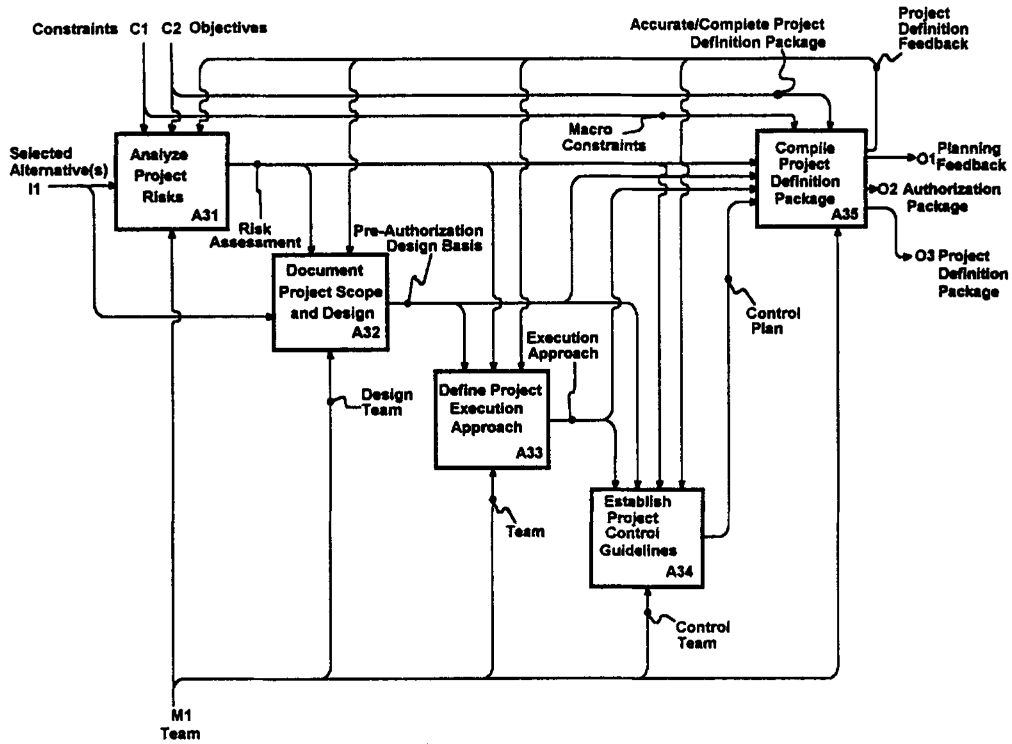

FIG. 6. Level 2 IDEF0 Diagram—Develop Project-Definition Package

package" is also compiled and provides the basis for project execution if the project is authorized.

"Make decision" is the final major subprocess of preproject planning, as shown in Fig. 3. No additional functional decomposition could be identified for this subprocess by the research team, therefore it does not have its own diagram. However, it is a very important subprocess. The "decision maker" must weigh the business objectives and risk of the project, and determine through evaluation of the "authorization package" if the project will meet the company's needs. The decision must be made with a thorough understanding of the project's objectives in mind. It also must take into account the impact of the project to society and community relationships, as well as the diverse groups who are stakeholders in the process. Finally, intangible issues such as intuition and the dynamics of the business environment must be considered, particularly if the project's chance of meeting objectives is questionable.

At this point, the "decision maker" can either approve the project for further execution, cancel the project, or send it back for further preproject-planning study. If the decision is made not to commit resources, feedback is used to modify the business planning of the enterprise and the project is canceled. If the decision is made to commit resources, the project is approved, with or without modifications, and the information generated during preproject planning is given to the project-execution team. Ideally, continuity is maintained between the preproject-planning team and project-execution efforts.

KEY POINTS

The research team and the writers feel that the model as presented in this paper is a good representation of what actually occurs in preproject planning. The following key points are given based on the research that has been completed to date and come from discussions and interviews held with research-team members and other industry representatives.

1. Preproject planning is an owner-driven process that must be tied closely to business goals. This conclusion was emphasized during interviews conducted for the purpose of model validation, as well as by members of the research team.

   - Business planning must be tied closely to preproject planning and the preproject-planning charter must be endorsed at a high level within the organization to be effective.
   - It is important that the corporate goals and guidelines for preproject planning, as well as the project, be well defined, and that there be key individuals involved in the process who are empowered by management to act on those goals, as well as be accountable for their actions.

2. Preproject planning is a complex process that must be adapted to the business needs of the company. Although the model presented in this paper is as general as possible, the researchers realized that each company has special requirements. Therefore, modifications may have to be made to the model so that the processes match the business needs of the individual company.

   - Membership and level of participation on the preproject-planning team is very dependent on the size and complexity of the project, as well as the expertise resident within the company. Consultants may be key to performing the process; however, the owner is still responsible for its accomplishment.
   - Interim funding decisions may occur during the process to fund specific portions of the process and allow cancellation of nonviable projects as soon as possible.
   - Projects are sometimes put on hold during preproject planning due to outside influences. It is very important to document preproject-planning progress so that the

project can be resurrected quickly with minimal disruption.

3. It is essential to have a strongly defined team developed during the early stages of the planning effort, again dependent on the size and complexity of the project.

   - It is important to include representatives from plant operations and maintenance (i.e., the facility users) on the planning team.
   - Continuity of personnel throughout the preproject-planning process is extremely important.
   - A specific deployment flow chart and responsibility matrix developed early in preproject planning for each project helps with the team process.

CONCLUSIONS

The IDEF0 methodology is an effective tool for process modeling using group techniques. The research-team membership eagerly embraced its use in both the research effort and also in their personal business activities. It allows easy review and combination of ideas from a variety of sources. It also facilitates communication because IDEF0 is graphic in nature. Future researchers and industry personnel may want to consider using the IDEF0 modeling methodology for developing definitions of functional processes. The discipline that the methodology brings to a group environment is very conducive to quickly arriving at consensus concerning complex processes. It requires that extensive documentation be maintained, which is very helpful to others using the model. Probably the major drawback to the methodology is its fairly limited usage at present in industry.

Preproject planning is a process that can be standardized. It can be broken down into discrete tasks that can be identified and organized in a structured manner. These tasks are represented by the function boxes in the preproject-planning model and describe the most important preproject-planning steps. Because of extensive industry participation and review, the writers feel that the model presented in this article is a good generic representation of the preproject-planning process. The model provides a foundation for discussion within the engineering and construction industry about the requirements of a good preproject-planning process, as well as a basis for developing or refining the process within a company. Since its development, it has been used in data collection measuring preproject-planning effort and as guidance for writing a detailed industry handbook outlining the process. The writers hope that it will help promote an awareness of the details of preproject planning.

The preproject-planning process is an owner's responsibility and must be closely aligned with the business requirements that dictate the project. The process is complex and must be adapted to the specific business and project needs of the owner's domain. Engineering professionals may perform significant portions of the process as consultants to owners and must understand the implications of their work. Organized, multidisciplinary teamwork is essential to the process, especially from the business, project management, and operations perspective. Continuity of team personnel also effects the preproject-planning effort.

ACKNOWLEDGMENTS

This research project was partially supported by a grant from the Construction Industry Institute (CII). The writers would like to thank the membership of the CII Pre-Project Planning Research Team for their guidance, wisdom, patience, and encouragement during this research project. The writers would also like to thank the many individuals who have contributed to this process through interviews and reviews. J. H. Kaczmarowski was formerly a graduate research assistant at the University of Texas at Austin.

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