AN INTEGRATED FACILITY PLANNING PROCESS MODEL

By

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FOREWORD

The Computer Integrated Construction (CIC) Research Program at Penn State was started in 1987 with a large grant from the National Science Foundation. This grant enabled the research team to develop the fundamental process models defining the scope of the activities required to provide a facility. The research team comprised up to twenty researchers at various stages of its life. It included faculty and research assistants from Architectural and Industrial Engineering, an academic advisory board from five of the leading research schools in the country and a five member industrial advisory board representing experts in each of the phases of the facility life cycle.

In this report, Moris Guvenis and Mohammed Al Muallem have defined the roles and essential functions required to plan a facility. This report is a stand alone document focusing on planning, in the architectural sense, but also complements the other six technical reports defining the remainder of the research undertaken by the team to provide the facility as a whole. Parts of the report are extracted from Mohammed's thesis.

The six major Planning activities, divided by similarity in process, are: assign the planning team; study / define the user's needs; study the feasibility of alternatives; develop the program; develop the project execution plan; and finally, select and acquire the site. It is envisioned that this cornerstone piece of basic research provided by Moris and Mohammed, will lead to many future applications in the areas of planning strategy and methods, information systems, organizational design, software development and process integration.

Other complimentary work resulting from this work will be detailed in subsequent technical reports issued by the CIC research program.

Victor Sanvido
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ABSTRACT

This report presents a generic process model of the activities required to plan a facility. The model starts with the idea that initiates the provision of a facility, describes the functions required for planning a facility at various levels of detail, and ends with the acquisition of the site on which the facility will be located.

The first two chapters give an introduction to the Computer Integrated Construction Research program (CIC) and an overview of the selected modeling tool (IDEF_0), and orient the reader to understand the structure and the content of the report. The literature review provides a background to the reader on the previous efforts on modeling the owner-related aspects of construction. This is followed by the process model itself which describes the functions at different levels and ties them to each other with information elements. The model is then tested on an actual construction project (The Agricultural Science and Industries Building, The Pennsylvania University). This case study and its application to the process model are detailed in Chapter 5. The report is concluded with a discussion on the potential uses of the model, and on how the construction owner can benefit from it.
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Special thanks to Professor C. H. Wheeler for his advice and for providing valuable literature. Thanks also to the CIC research team, all the individuals who supported this work at Penn State, Mr. D. C. Johnson, and Mr J. Starling.

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Chapter 1

THE COMPUTER INTEGRATED CONSTRUCTION PROJECT

1.1 INTRODUCTION

The National Science Foundation has funded a fourteen member interdisciplinary team together with ten advisors, to explore methods to enhance the use of computers in all phases of the life of a constructed facility. The objective of this Computer Integrated Construction (CIC) project is to provide an open information architecture to support the provision of a facility. The team comprises Penn State Architectural and Industrial Engineering researchers together with McDonnell Douglas and selected industry professionals. The intent is to benefit from the pioneering work related to Computer Integrated Manufacturing (CIM) done at Penn State by applying similar approaches to construction.

As the first major thrust of the project, we are developing an integrated process model that accurately represents the essential functions required to manage, plan, design, construct, and operate a facility. To date, the models have been successfully used on four different projects.

The second half of the project is to define the information and its attributes that are required to drive the system. The major benefit of this exercise is the development of a generic dynamic process and information model that can be applied on a specific project to develop and link the everyday models used to provide a facility. Examples of these models are: the architectural program, schematic drawings, CAD detailed drawings, contracts, CPM schedules, budgets, space planning models, energy management simulation, organizational charts and contracts.

IDEFO [3] was selected as the most appropriate modeling tool. A schematic representation of the drawing format (figure 1.1), and a graphical representation of how the model is decomposed (figure 1.2) is included.
FUNCTION: An activity, process, operation, or transformation.

INPUT: Elements (resources or data) that are transformed through a process or an operation to form the outputs.

OUTPUT: Elements that result from the function being performed.

CONTROL: The elements that influence or determine the process of converting input to output. May limit the activity or allow the activity to occur without being affected.

MECHANISM: The elements used to perform a process or operation, such as a person or machine.

Figure 1.1: Schematic representation of the IDEF₀ drawing format (adapted from ICAM Function Modeling Manual, June 1981).
1.2 AN INTEGRATED BUILDING PROCESS MODEL

The Integrated Building Process Model (IBPM) is explained in two drawings. The first drawing (figure 1.3) is an overview titled "Provide Facility" that defines the boundaries of the model in general terms. The second drawing (figure 1.4) divides "Provide a Facility" into five sub-processes. These drawings offer increasing levels of details. Figure 1.3 has the least detail and is known as the level F model.

The model was drawn from the perspective of an observer outside the whole process. It is an abstraction from observation of many building projects by the project team, advisors and other reviewers. The actual mechanisms used in the execution of the functions will depend on the project delivery method. This generic model, when completed with the appropriate mechanisms, should account for all delivery options.

1.2.1 The Level F Model "Provide Facility"

The level F process flow model (Figure 1.3) consists of a single block showing the inputs (facility idea, resources), the controls (external, and project participants constraints), the mechanism (free enterprise economic system and facility champion), and the outputs (operational facility, facility experience, and the impact on environment). Three elements will be tunnelled, shown as an arrow with parentheses on one end. In this case they are the free enterprise economic system, the external constraints, e.g., weather, and the impact on the environment. This tunneling of arrows means that they will not be shown at the next level of detail - they essentially add nothing to the model and clutter the drawing. These will reappear when their influence is specific to an activity.

1.2.2 Components of "Provide Facility"

The level F model breaks down the process of "Provide a Facility" into the five sub-processes shown in Figure 1.4. These are: Manage Facility, Plan Facility, Design Facility, Construct Facility, and Operate Facility. Detailed definition of these sub-processes follow.
Figure 1.3: F.0. "Provide Facility"

Purpose: This model describes idealized owner's functions and their relationships in a construction process.

Viewpoint: The owner / User

Node: F-0

Title: PROVIDE FACILITY

- PROVIDE FACILITY
- OPERATIONAL FACILITY
- FACILITY INFORMATION
- IMPACT ON ENVIRONMENT
- FREE ENTERPRISE ECONOMIC SYSTEM
- FACILITY CHAMPION
- FACILITY RESOURCES
- FACILITY IDEA

OWNERS NEEDS/CONSTRAINTS
EXTERNAL CONSTRAINTS
FIGURE 1-4: F. Provide Facility
Manage Facility includes all the business functions and management process required to support the provision of the facility from planning through operations. These activities focus on converting a facility idea, time and money into a facility team, facility management plans, documents and contracts, and resources to support the project. This function runs for the duration of the facility life. It is controlled by two major factors - performance information about the facility as a whole and information to optimize sub-processes within the facility e.g., constructibility information.

Plan Facility encompasses all the functions required to define the owners needs and the methods to achieve them. These activities translate the facility idea into a program for design, a project execution plan, and a site for the facility. Major controls are constraints imposed by project participants (e.g., the owner or engineer), the facility plan, the contract and optimization information. Other outputs include facility planning knowledge and information on the performance of the team.

Design Facility comprises all the functions required to define and communicate the owner’s needs to the builder. These activities translate the program and execution plan into bid and construction documents and operations and maintenance documents that allow the facility to meet the owner’s needs. Controls or constraints include program and site information, the contract, facility planning knowledge transferred to the design team, the PEP and the design plan. Again, facility design knowledge and information on the performance of the design team is another output.

Construct Facility includes all functions required to assemble a facility so that it can be operated. These activities translate resources (e.g., materials) in accordance with the design into a completed facility. Typically appropriate facility operations and maintenance documents are generated. As a result, facility construction knowledge and information on the performance of the construction team is generated. Controls include bid and construction documents and criteria, the PEP, facility design knowledge transferred to the team, the contract and the construction plan.
Operate Facility comprises all of the activities which are required to provide the user with an operational facility. In addition, operating knowledge, and information on the performance of the team is generated. This process is controlled by the facility construction knowledge available to the team, the facility operating and maintenance documents, the PEP, the operating plans and the contract.

1.2.3 Evolution of the Model

The IBPM has been developed through extensive interviews with experts and practitioners; eight site visits; and multiple reviews by each of a five member academic panel and a five member industry panel. Over 40 experts have reviewed this model for its completeness. The model has been extended four levels below the F level model. This has led to simplification and verification of the upper levels presented in this paper.

While the drawings may seem obvious and simple, they differ radically from those first assembled by the project team. The first model included technical and management functions and was heavily influenced by who performed the function. A second model treated each of the four functions, viz. planning, design, construction and operations & maintenance as combined business and technical functions. The third revision, on the other hand, separated the management functions for each group and combined them into one generic management function called "management of the facility." The other four functions named above, focus on technical functions only. Finally, at lower levels, the model recognizes that there are planning and control, service acquisition and resource acquisition functions that are done at both the facility level and the sub-function level.

The following chapters of this report focus on planning a facility. The "Plan Facility" function which is referred to with the node "P" (see figure 1.6) is decomposed into its sub-functions at two more levels. The "Plan Facility" model is presented with explanations regarding its components, as well as case studies which were used to build and modify it.
Chapter 2

SCOPE OF WORK / METHODOLOGY

2.1 OBJECTIVES

The primary objective of this technical report is to develop a process model of the planning phase of providing a facility. It is intended to show the owner the role of the planning function in obtaining a facility. This report will enable the owner to understand:

a. how the scope of the project is defined,
b. how the planning tasks are defined, and
c. how elements (including information) flow between the tasks.

The model is also intended to show the owner the various functions which take place in accomplishing the above mentioned items of the planning process.

2.2 SCOPE AND LIMITATIONS

This report will cover part of the construction project life cycle, starting with the facility need recognition and ending with the provision of facility plans, ready for the design, construction, and operation of the facility.

The scope of work is limited to large owners such as corporate or government organizations. However, the model is generic enough to be applicable to a
variety of facilities, ranging from small and simple projects to large and complex ones. Integration of the processes within the model is done by focusing on the performance of the given tasks rather than who or which organization performs them.

Three basic assumptions were made for the model:

1. A group of in-house owner's project management professionals assume the responsibility of understanding, planning for and achieving the owner's / user's project objectives. This group is known as the owner's Project Management Team (PMT). Typically, the PMT seeks professional help from external consultants when necessary.

2. The owner wants to minimize the life cycle project costs, i.e., construction and operations (including maintenance) costs.

3. Compliance with owner's administrative and technical requirements such as administrative procedures and technical standards is strictly enforced.

2.3 METHODOLOGY

The following steps describe the research process used to build, modify, and validate the "Plan Facility" model.

2.3.1 Gathering Information

Three sources of information were considered. The first source was a review of the existing construction literature. This included books and current issues of construction journals and periodicals. The purpose was to be informed of the
current construction and planning research. Here planning refers to the architectural process whereby user needs are specified in a program and a project execution plan. The second source was a number of interviews with selected owner project management members. These interviews were conducted to identify major problems faced by owners. The third source was a review of latest project management procedure and documents as practiced by Aramco, an oil company operating in Saudi Arabia.

2.3.2 Development of a Preliminary Model

In this step, a preliminary IDEF₀ model of the construction process was developed. This abstract level model covered the whole project life cycle covering planning, design, construction, and operation and maintenance.

2.3.3 Review of Model by Experts and Modifications to the Model

The preliminary model developed was reviewed by industry experts. These included five key management personnel (members of the industry advisory board of the project) who are involved in design, construction and management of major facilities from five different organizations. These experts reviewed the model for its conformance with the best current practice in the industry.

Based on the comments of the experts, the model was modified and expanded to show more detail.
2.3.4 Consolidating the Model

An "as built" model was developed for case studies in order to validate and consolidate the proposed model. Initially, three cases were planned to be studied. However, due to the following reasons, two of the cases are not included in this report:

**Turner-Harwood Ventures, Virginia:** Due to its small organizational structure, it was noticed that the planning tasks in this company were highly integrated with the whole project management process. Therefore, it was decided to include this case study in the "Manage Facility" technical report (Technical Report No. 2).

**Building Technologies Corporation, Ohio:** Building Technologies Corporation (BTC) is a leading manufacturer of metal buildings and their components. Due to the integration of the firm with the project team, it was decided to conduct a case study on the role of BTC on providing a facility, covering the overall Integrated Building Process Model (IBPM). However, since the planning function was not within the business scope of the firm, the only possible observation was the influence that the metal building industry had on facility planning. This is detailed in Technical Report No. 8.

**Agricultural Sciences and Industries Building, the Pennsylvania State University, Pennsylvania:** This technical report validates the "Plan Facility" model by applying it in its full detail to one project. The Agricultural Science and Industries Building (A.S.I) was selected based on the following criteria:
size and complexity,
access to information, and
project status (at time of selection).

The following steps describe the methodology used for conducting the case study.

a. An interview with owner's project manager was conducted. In this interview the project manager explained owner's construction management approach.

b. An overall review of the project files was conducted. This was done by reviewing project documents and design drawings to get an overview of the project, i.e., its scope, size, status etc.

c. A list of questions was developed to test the project conformance with the model. The questions had the following general form:

- What was included in this function? (Scope of process)
- What was needed to perform the function? (Inputs)
- What was the product of the function? (Outputs)
- What influenced the flow of the function? (Constraints)
- Who performed the function? (Mechanism)

d. Consistency of the case with the model was then tested. This was done by starting at the lowest level diagrams (i.e., diagrams with no further decomposition), and collecting data. Each box was tested for consistency with the model. Consistency was recorded on the diagrams where evidence was found.
e. Each higher level box (i.e., the parent) was tested using results from the previous step. Agreement was shown at this higher level diagram where a minimum of 67 per cent consistency was observed (i.e., consistency in two out of three boxes). The above approach was continued up to the highest level, i.e., "Plan Facility".

f. Areas where lack of consistency was found are then reviewed for possible justification. This was done by referring back to the project files, by consulting the project manager or by both.

More detail on the case study and its conclusions are given in Chapter 5.
Chapter 3

REVIEW OF RELATED LITERATURE AND PREVIOUS MODELS

This chapter summarizes a literature review and previous construction related models. It is divided into two parts. The first discusses the owner's role in construction and highlights the need for project integration. The second part is an overview of some previous attempts to model the construction process.

3.1 THE OWNER'S ROLE IN PROJECT MANAGEMENT

The owner's role in construction project management has not been well defined. Different approaches have been used in practice. Some owners choose to be closely involved in managing their projects, yet others prefer a remote role (Thrush, Diekmann and Wilson 1987). Many researchers have, for a construction project, emphasized the design and construction teams' functions (Clough 1986, Bonny and Frein 1973, Stitt 1985, Sanvido 1984, Halpin and Woodhead 1976 and 1980, Parker and Oglesby 1972). Very little attention, however, is given to the owner's role. This is probably due to the fact that, in many cases, construction from the owner's viewpoint is a one-time operation.

The owner's role was highlighted in reports published by the Business Roundtable (BRT 1983) and the Construction Industry Institute (CII 1987a, b). These documents describe the high impact that the owner has on the construction project, which in many cases may determine the project success or failure.
Thrush, Diekmann and Wilson (1987) concluded, from a research project in project control, that owners who exercise close involvement seem to be the most satisfied with their project results. They stated that even designers agreed that heavy client involvement (but not micro-management) was a key factor in successful projects.

Wheeler (1978) emphasized the importance of the owner:

"The most important people in a construction project should always be the client and his organization. The architect-engineer-constructor team serves its client just as the doctor and lawyer serves their clients. The client should always get what he wants. The client should have a genuine feeling that he not only has a very fine building but has participated in an efficient, well-managed and well-coordinated program of design and construction." (Wheeler 1978)

3.2 THE NEED FOR INTEGRATION


"In no other important industry is the responsibility for design so far removed from the responsibility for production."

This refers to the interface between design and construction functions, and highlights the need for constructibility. Walker (1984) emphasized the need for integrating project functions. Referring to the owner he wrote:
"A member of the client's staff who is intimately involved with the particular project may have authority over most matters. This should result in close integration of the client organization and the construction process." (Walker 1984, p.76)

Halpin and Woodhead (1980) highlighted what they called the "segmental nature" of the total building process:

"In [the] traditional organization of the building process, the construction process is totally separated from the feasibility, engineering and design processes. The contract documents usually do not refer to specific construction methods and leave the selection of these and the solution of related field engineering problems to the contractor. Thus the design basis and its implied construction rationale are not readily communicated to the contractor. In some cases project design details are formulated without consideration of construction methods and costs." (Halpin and Woodhead 1980, p. 6)

### 3.3 PREVIOUS MODELS

Seven attempts to model the construction process are presented.

#### 3.3.1 A Project Initiation Model

Cumberpatch (1983) modeled project initiation within a typical owner's organization. Figure 3.1 shows ideas are initiated by individuals in different divisions of the owner's organization. Of these, promising ideas are developed in project proposal form. Proposals with strong justification go through review and approval cycles and hence become projects.
Figure 3.1: Project Initiation Model (Source: Cumberpatch 1983)
3.3.2 Vanegas’s Early Design Model

In a design-construction integration research project, Vanegas (1987) modeled the initial phases of the design process, i.e. pre-design and preliminary design. This model consisted of schematic and verbal models. Figures 3.2 and 3.3 show parts of Vanegas’s model. His purpose was to improve the constructibility input to early design, and hence did not define the project life cycle.

3.3.3 Wheeler’s Project Life Cycle Model

Wheeler (1978) developed a comprehensive model for managing architectural construction projects. In this model, Wheeler divided the project life cycle into nine sequential phases (figure 3.4). He then divided each phase into several sub-phases; he called them steps. He considered the execution of a phase a primary milestone and the execution of a step a secondary milestone. He then divided each step into several activities. The result was presented in a matrix format showing the project phases, steps and activities as performed by each of the project participants, namely, the owner, the project manager, the design manager, the construction manager and the contractors. Figure 3.5 is a typical segment of Wheeler’s matrix. Looking at the whole matrix, one can see how the project responsibilities are assigned to project participants. Of particular interest to this thesis are all the activities assigned to both the client and the project manager as highlighted in figure 3.5. However, this model does not show the interrelationships between activities.
Figure 3.2: Vanegas's Model (Level 1). Principal Systems and Processes of the Model for Design / Construction Integration (Source: Vanegas 1987)
Figure 3.3: Vanegas's Model (Level 2) Principal Processes of the Pre-design System (Source: Vanegas 1987)
Figure 3.4: Phases and the Steps of the Building Process
### 6.1 PLAN AND SCHEDULE

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<td>6.2.7 engineering sys. confirmation</td>
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<th>6.2.9 building sections</th>
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<th>6.2 50% CHECK</th>
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</thead>
</table>

**Figure 3.5: Wheeler's Project Matrix (partial) - (Source: Wheeler 1978)**
3.3.4 Sanvido's Conceptual Construction Process Model

Sanvido (1984) presented a conceptual model of the construction process. Part of the model defines all influences on the construction process as shown in figure 3.6. Another part describes a hierarchical model of the construction process (see figure 3.7). The model is a generic time independent representation of the project site operations.

3.3.5 Sanvido's Project Management Model

Sanvido (1986) developed an input-process-output model for the design and construction phases of a project. In this work, Sanvido modeled the functions of the designer, the constructor and the project manager (figures 3.8 and 3.9). He then prepared a checklist for each of the three functions (i.e., design, construction and project management) and used it as a tool to audit performance on actual projects. This model is the basis for the life cycle modeling on the CIC project.

3.3.6 Walker's Model of the Construction Process

Walker (1984) presented an input-process-output model of the project delivery process. He modeled the construction process as one that is parallel to the owner's management process (figure 3.10). In this model, he viewed project resources as flow of inputs to the owner's project team. These resources are then diverted as inputs to the construction process itself, i.e. the design and construction processes. The output of these is then fed as input to the owner's project team's process. Walker (1984) also modeled the construction process...
Figure 3.6: Influences on the Construction Process (Source: Sanvido 1984)
Figure 3.8: A Project Management Model (Source: Sanvido 1985)
Figure 3.9: Project Management Function Outline (Sanvido 1984)
as three sequential systems which he called conception, inception and realization. In this model, he divided each of these systems into sub-systems. Key decisions and operational decisions mark the boundaries of systems and sub-systems as shown in figure 3.11. The end product of this breakdown is a series of task sub-systems consisting of group of tasks similar to CPM activities.

3.3.7 Project Definition Model

Salapatas (1983) presented a project definition model in a flow chart form (figure 3.12). The starting point of the model is the need for providing a facility,
Figure 3.11: Hierarchical Model of the Construction Project
(Source: Walker 1984)
Figure 3.12: Project Definition Model (Source: Salapatas 1983)
and the end of the flow chart is the execution of the project plan. The process is represented as a series of functions, the critical decision making points and issues, and the resources needed to accomplish them. He claimed that the model could be used as a framework for project analysis.

3.4 CHAPTER SUMMARY

This chapter summarized a review of related literature and models. Literature reviewed shows that poor project integration is a major problem in the construction industry. The reviewed literature also yields several models developed by many researchers for different applications. These models all serve their own purposes and represent pieces of the project life cycle, their processes, inputs and outputs. Salapatas, Vanegas and Cumberpatch each describe early project phases, Wheeler addresses the project life cycle while Sanvido models both design and construction phases, and Walker presents a decision making model of projects. However, no single model which defines the functions required to integrate projects has been found in the literature. The next chapter will describe the "Plan Facility" process model.
Chapter 4

THE "PLAN FACILITY" MODEL

This chapter presents the "Plan Facility" model. The model describes the planning process from the viewpoint of the owner's project manager. It consists of a series of related diagrams with supporting explanations and a glossary of definitions (see Appendix B for Glossary). The model will expose details of "Plan Facility" in a gradual manner, both in the graphical part of the model as well as the textual explanations. This will maintain the same level of detail among the model's three components: boxes, arrows and text. Therefore, it is suggested that the reader refer to the 'child' diagram (i.e., next level down) and its textual explanations for details.

4.1 AN OVERVIEW OF THE MODEL

4.1.1 The Importance of Planning in Providing a Facility

"Plan Facility", driven by the owner's constraints, represents the development of the facility idea into plans (i.e., the program and the project execution plan) and into site information. These two are significant for the other functions in the overall Integrated Building Process Model (IBPM). They drive "Design Facility" which produces the "Design" that includes design calculations, construction documents and operations and maintenance (O&M) documents in addition to the associated undocumented information such as concepts developed and
assumptions made by the designers. The "Design" and the "Plans" control the "Construct Facility" function which consumes construction resources to produce the operational facility and the related post-construction information (i.e., O & M manuals, as-built documents).

4.1.2 The Role of the Owner in Planning a Facility

"Plan Facility" starts at the facility idea stage and ends with the plans and site information. Typically, this function is performed by the owner. Depending on the nature of the facility and the owner's experience, external planning services may be acquired as needed. The planning function is very critical for the owner due to the following reasons:

a) The owner is closely involved in the planning function. As a minimum, the owner participates in clarifying the project requirements and his critical concerns.

b) In the planning function the owner makes the project's major decisions. These may include the decision to (or not to) proceed with the project. Other decisions include the option to rent, buy, remodel, or build the facility.

c) The chance for a major influence on the project cost is higher at the planning stage.

4.2 "PLAN FACILITY" - The Model

The parent IDEF₀ diagram of the "Plan Facility" function is shown in figure 4.1. The inputs, outputs, and the constraints (control arrows) of the function at its
broader level are shown in this diagram. Figure 4.2 shows the node tree which details the functional decomposition of "Plan Facility". The six sub-functions at the first level of breakdown are (the first level of "Plan Facility" is the second level of the overall IBPM):

P1 Assign Planning Team;
P2 Study / Define Needs;
P3 Study Feasibility;
P4 Develop Program;
P5 Develop Project Execution Plan (PEP); and
P6 Select and Acquire Site.

Figure 4.3 shows the IDEF0 diagram which relates these functions to each other by means of inputs, outputs and constraints. Brief explanations of each of the above sub-functions are given in the following sections.

4.2.1 Assign Planning Team (P.1)

This refers to establishing the planning team which may be assembled with in-house personnel, external planning professionals or a combination of both. Acquiring planning services may include: qualifying potential professionals, requesting proposals, evaluating proposals and issuing the planning services contract. This node is not expanded further in this report.
Figure 4.2: "Plan Facility" Functional Breakdown
4.2.2 Study / Define Needs (P.2)

This function starts with the "Facility Idea" and generates the plans for meeting the user's needs. To be successful, this function should be performed with user participation. Figure 4.4 divides this function into the following sub-functions.

Study User Requirements (P.2.1): The planning team studies the requirements set by the user and seeks clarification of these requirements from the user representative.

Evaluate Existing Facilities (P.2.2): The compatibility of existing facilities with current and future operations are evaluated. The cost of maintenance and associated expenses (e.g., operational shutdowns) might be of interest. Facilities with high O&M costs or those unsuitable for current or future operations should be either modified (i.e., remodeled or expanded) or disposed of: by sale, by transfer to another user, or by demolition.

Determine Users' Needs (P.2.3): By comparing facilities requirements against available facilities, the planning team defines the necessary facilities, or facility modifications.

Generate Alternatives (P.2.4): Providing a facility is normally possible by different means (e.g., buy, rent, build). This function explores such alternatives.
4.2.3 Study Feasibility of Alternatives (P.3)

The feasibility study includes economic feasibility, technical feasibility and environmental feasibility studies. These aspects which are shown in figure 4.5 are also detailed below.

Study Economic Feasibility (P.3.1): As detailed in figure 4.6, this function includes estimating the funding requirements, performing the project cost/benefit analysis and allocating and securing the project funds and their sources. The outcome of this study should answer the question: "Given owner's financial status, is it financially and economically possible to build the facility?"

Study Technical Feasibility (P.3.2): A breakdown of this function to its sub-functions is shown in figure 4.7. This study should answer the question: "Given the available technology and resources is it possible to build the proposed facility?" Technological constraints such as material properties (e.g., structural, chemical) should be considered as they present challenge to the construction process.

Study Environmental Feasibility (P.3.3): A breakdown of this function to its sub-functions is shown in figure 4.8. In this study the potential impact of the project on the environment (as enforced by regulatory authorities) and those of the environment on the project should be considered (Williams and Massa 1983). The consequences of these impacts may be sufficient to stop the project.
Figure 4.5: Study Feasibility of Alternatives (P.3)
Communicate Results / Decisions (P.3.4): This function synthesizes the technical, economical and environmental studies, concluding with a decision to proceed with the project. If a decision to proceed is made, a plan of action which sets constraints such as the budget, schedule or scope of the project, will be issued.

4.2.4 Develop Program (P.4)

The purpose of developing a program is to define, in detail, the project scope and size or capacity. According to AIA Document B141 (AIA 1977), the program should include the owner's design objectives, constraints and criteria, including space requirements and relationships, flexibility and expansibility, special equipment and systems. If the site is not predetermined, the program will include site criteria. Programming, as defined in figure 4.9, includes:

Gather Information (P.4.1): The function includes collecting and understanding all the available information that describes the proposed facility. Different approaches may be employed including user interviews, questionnaires, literature research and visits to similar facilities.

Define Scope (P.4.2): Based on the information collected and the applicable constraints (e.g., budget, schedule) the scope of the project is defined.
Develop Design Criteria (P.4.3): The design criteria are the sole guidelines that define the expected quality of the facility design. They describe functional relationships between facility components, and specify desirable facility characteristics such as image, flexibility, operability and expansibility. The design criteria also include outline specifications of facility systems and components such as structural requirements (floor loading), environmental requirements (e.g., HVAC, acoustics, lighting), power distribution, telecommunication, security and safety requirements.

Develop Site Criteria (P.4.4): Site criteria are developed to guide site selection. Only the key site characteristics should be included in these criteria. These may include the funds available, size, topography, location with respect to the owner’s business market, and to the availability of infrastructure.

Communicate Program (P.4.5): This refers to transmitting the program document and other undocumented programming information to other project functions including design, feasibility study, execution planning, and site acquisition. Undocumented information may be transmitted via informal correspondence; i.e., meetings, telephone calls etc.

4.2.5 Develop Project Execution Plan (P.5)

The Project Execution Plan (PEP), also called the project master plan (Wheeler 1978, GSA 1972), defines owner's approach to project delivery options and strategy for acquisition of services. The PEP is the project’s front end plan which covers the whole project life cycle, i.e., planning, design, procurement, construction, operations and maintenance and disposal (if required).
Developing the PEP includes the following functions which are also shown in figure 4.10:

**Identify Required Services (P.5.1):** This includes the recognition of necessary services such as planning, design, construction, construction management and O&M.

**Study Market Conditions (P.5.2):** This includes studying present and projected level competition between service organizations, and the availability and cost of key resources (e.g., skilled labor, special material or equipment).

**Develop Project Plan (P.5.3):** The project plan describes the owner's approach to project execution such as project packaging and phasing. It includes the project master schedule with established major milestones including the owner's key review and approval points. The project plan also includes a budget that serves as the project cost control tool. It also describes the responsibility and authority of each of the project participants.

**Develop Contracting Plan (P.5.4):** The contracting plan describes:

a. Contract types (e.g., lump sum, reimbursable, unit price);

b. Contracting methods (e.g., competitive, negotiated), and

c. Project delivery strategy (e.g., fast track approach, design-build or sequential traditional approach).
Communicate the PEP (P.5.5): This refers to the process of communicating applicable PEP information to other project participants, affected parties such as those involved in related projects, and utility entities such as power, sewer and water organizations.

4.2.6 Select and Acquire Site (P.6)

In many projects the site is a predetermined factor. But, if this is not the case, the site has to be properly selected in order to provide the best advantage to the proposed facility. Williams and Massa (1983) have developed a structured approach for siting major facilities. They identified many to be considered in selecting the site. Some of these factors are: (Williams and Massa 1983, Molnar 1983)

- Geographical location
- Suitability of size and configuration
- Expansibility
- Cost of land
- Environmental factors
- Applicable codes and regulations
- Local infrastructure
- Existing land use and conditions
- Future area development
- Availability of construction resources
- Local traffic conditions
"Select and acquire site" is divided into four tasks as shown in figure 4.11.

These tasks are:

**Identify Candidate Sites (P.6.1):** Using the site criteria developed in the programming function, the planning team will identify some potential sites.

**Evaluate / Select Site (P.6.2):** This refers to the process of evaluating the candidate sites using the site criteria, and ranking them in order of preference. The product of this process is information about the selected site.

**Acquire Site (P.6.3):** This process includes all the activities required to acquire the site, including negotiation with the site owner(s) directly or with the help of a real estate agent. The output of this process is the site (i.e., site ownership title). It may be necessary to conduct geotechnical analysis in order to assure that the soil condition is suitable for the proposed structure. This function, however, is considered a part of "Investigate Site."

**Investigate Site (P.6.4):** This function includes all investigations (prior to and after purchasing the site), that determine the properties of the site. Site properties include site topography, soil bearing capacity, ground water level and sub-surface formation. This function is sometimes conducted after the acquisition of the site. However, the scale is contingent upon results of the site investigation. For example, if poor soil conditions were not expected, but found, the price of the site may decrease, or the sale may be void.
4.3 CHAPTER SUMMARY

This chapter presented the "Plan Facility" model as a series of related diagrams and textual explanations. Terms appearing on the model are defined in the Glossary (Appendix B). To test its validity, the proposed model was applied to an actual project. The results of that case study are presented in Chapter 5.
Chapter 5

A CASE STUDY

This chapter presents a detailed case study that tests the model on an actual project. This is done by describing the project and how it fits the model. The methods used in the case study are detailed in Chapter 2.

5.1 PROJECT DESCRIPTION

The project is a four-story building comprising laboratories, classrooms, a 200-seat auditorium, faculty offices, administration offices and supporting facilities, including animal holding rooms, cold rooms, instrumentation rooms, constant temperature rooms, etc. The following list presents additional information on the project.

Project Title: A.S.I. Facility
Owner: A major university
User: Three departments within a college in the university
Building size: Approximately 100,000 square foot.
Location: North eastern U.S.A., rural setting.
Funding Source: Federal Government
Total Estimated Budget: US$ 18,000,000
Design completion (planned): April, 1988
Construction projected start: May, 1988
Expected completion: February, 1990

5-1
Figure 5.1 shows the schedule for the planning (actual), design, and construction (as planned) phases.

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<tr>
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Bar Chart

Figure 5.1 Project Schedule
5.2 MODELING THE CASE STUDY

In order to check the model in a simple and rapid manner, the results are documented graphically as an overlay on the IDEF0 drawings. Figures 5.2 through 5.11 (pages 5-5 to 5-14) show the results of mapping the case study onto the diagrams of the model. Thicker boxes and arrows represent those found to be consistent with the model. If a function is not found to be performed, the related box is left as it is. Explanatory labels and notes are written in italics on the diagrams.

5.3 CASE STUDY RESULTS

The following observations result from the case study:

a. General agreement with the model was observed. Specifically, the case study shows agreement in task definition, i.e., the model included all tasks observed in the case study (disregarding names used to describe tasks).

b. Areas showing inconsistency with the model may imply any of the following:
   1. The function was irrelevant to the project, and hence was not performed.
      For example, "Study Technical Feasibility" was not required since no new building technology is involved in the project.
   2. The function was performed, but no evidence was found to indicate such conclusion.
   3. The function was needed but was not performed.

   In reference to this case study, however, items (1) and (2) above are found to be the norm. No evidence of item (3) was found.
c. The case study highlights the need for more attention to interfaces and feedback loops. Although many feedback loops are shown, some were performed better than others.

d. The procedure followed in measuring the consistency with the model does not give a good indication of quality of task performance, nor does it allow for different weight values for tasks and sub-tasks.

e. Difficulty was faced in attempting to separate planning and design functions due to their overlap: some tasks which are considered as part of the planning function are performed by the designer as part of design contract (e.g., detailed program). This is not considered to contradict the model since the model does not show time, responsible party or organizations.

f. It was observed that in specific cases, planning was reactive. According to the model planning output is supposed to control/direct the design, construction and O&M functions. In some cases, planning tasks were not performed on time. As a result, some design tasks would either proceed on assumptions (possibly wrong), or it would trigger the need for the planning task. For example, the structural designer needed soil investigation results in order to finalize the design of the foundations. This requirement when highlighted by the designer drove the owner to perform this task, i.e., expedite the soil investigation contract.

In conclusion, the case study results did not indicate a need to change the model. The case study, however, presented good examples for explaining the model's components.
Figure 5.2: Plan Facility Function (parent diagram) for the A.S.I. Project
Figure 5.3: Plan Facility (P) - Case Study
Notes:
1. Facility idea has evolved over the last twenty years (according to the User representative).
2. User needs are a refined version of user requirements that is developed taking in consideration applicable constraints such as owner's standards and available funding.
3. An alternate plan considered by the feasibility study team was to renovate, upgrade and expand existing facilities.

**NODE:** P2  **TITLE:** STUDY / DEFINE NEEDS

Figure 5.4: Study / Define Needs - A.S.I. Facility
Figure 5.5 Study Feasibility of Alternatives - A.S.1. Facility

Notes:
1. The project feasibility study emphasized funding justification for Congress approval. (Reference: Feasibility Study Report, April 18, 1986)

Legend:
- ACTUAL
- MODEL
- External Constraints (Financial constraint)
- Execution Planning Feedback
- Site Info
- Alternate Plans
- Codes and Regulations
- Owners Constraints
- Resources
- Study Economic Feasibility
- Study Technical Feasibility
- Study Environmental Feasibility
- Study Feasibility Information
- Communicate Results/Decisions
- Feasibility Study (Feasibility Report)

Node: P3
Notes:
1. The project was justified on the basis of the college's urgent need for modern research and educational facilities.
2. $18 million federal funds was issued on condition that the State matched the funding. A total of $36 million was needed for the college proposed facilities.

NODE: P31  TITLE: STUDY ECONOMIC FEASIBILITY

Figure 5.6: Study Economic Feasibility - A.S.I. Facility
Notes:
No evidence of technical feasibility study was found. The building is a fairly common type for the owner.

NODE: P32  TITLE: STUDY TECHNICAL FEASIBILITY

Figure 5.7: Study Technical Feasibility - A.S.I. Facility
Notes:
1. The study of the physical impact of the facility on the vicinity included impact on parking space, a flood hazard statement, and planned relocation and/or demolition of some existing facilities.

NODE: P33   TITLE: STUDY ENVIRONMENTAL FEASIBILITY

Figure 5.8: Study Environmental Feasibility - A.S.I. Facility
Notes:
1. A detailed program was developed by the Architect/Engineer with the user's participation. "Gather information" function included site visits to few modern research facilities.
2. User's needs were formalized in a document called "Program of Requirements", dated 1-7-1986.

NODE: P4    TITLE: DEVELOP PROGRAM

Figure 5.9: Develop Program - A.S.I. Facility
OWNERS CONSTRAINTS

Feasibility Study Information
(e.g., University Academic Calendar, Owner's Project Management Procedures)

Program

Identify Services

Study Market Conditions

Develop Project Plan

Develop Contracting Plan

Communicate Project Plan

Actual

Function

Model

Function

Legend

Contracting Procedures
(See Note 2)

Project Plan

Financial Plan

Project Mgmt Procedures

Notes:
1. Construction Market Information is the owner's project management knowledge about the construction market conditions.
2. These refer to contracting methods for construction and design services. (Schedule, Budget & Contracting Approach)

Node: P5  Title: Develop Project Execution Plan

Figure 5.10: Develop Project Execution Plan (P.E.P.) - A.S.I. Facility
Notes:
1. Site selection was confined to space available around existing college facilities. Site information refers to its conformance with the area master plan.

NODE: P6        TITLE: SELECT AND ACQUIRE SITE

Figure 5.11: Select and Acquire Site - A.S.I. Facility
5.4 CHAPTER SUMMARY

This chapter presented a case study used to test the model. The case study results were presented graphically as an overlay on the model. The results show high consistency with the model especially in defining project tasks. The need to emphasize feedback loops and interfaces between project tasks was highlighted.
CHAPTER 6

CONCLUSIONS

This report has presented a model of the facility planning process taken from the viewpoint of the owner. The model defines the tasks involved in the planning process and describes the flow of information between them. The model consists of interrelated diagrams, function definitions and a glossary. The model was developed to serve as an owner's tool to understand the significance of planning and how it interacts with the life cycle of a facility. Using this model, the owner can understand what factors influence different tasks, and can then address them before they occur. The model also improves the owner's understanding of the necessity for efficient flow of project information within the planning process as well as between planning and the other functions required for providing a facility.

6.1 Benefits of the Model

The model has numerous opportunities for implementation offering many potential benefits to the construction project owner. Some of these opportunities are:

a. The model can be used in analyzing current project management procedures for improvement. A similar (As-Is) model of current operations should first be constructed. This actual model can then be compared with the ideal model. Such comparison will offer many opportunities for
improvements. Similarly, a futuristic model can be constructed to serve as a tool for integration.

b. The model can be used to improve the communication between the owner's team members and between the owner and other project participants.

c. The model can help in defining task boundaries and responsibilities, and thus help the owner in scoping and writing contracts.

d. The model can serve as the basis for designing a facility information system. This may be implemented using a facility data base that contains selected facility information including those produced by the planning, design, construction and operation functions. Such data base would serve project management in managing the on-going planning, design and construction as well as in managing future facility modification projects. The data base would also provide the information needed to operate and maintain the facility.

e. The model can be used for teaching purposes. It can be used to demonstrate the significance of planning, and how the owner and other project participants may influence the flow of the overall project.

f. The model can be used to determine what owner's decisions will be required, when these decisions should be made, and what information will be needed to support these decisions. The model can also be used to highlight the implications of the lack of timely decisions, information or other resources.

In summary, the model will serve as the single mechanism to unite the scheduling, budgeting, contractual, organizational and other tools used to represent the project as a model. However, it does not attempt to freeze any variable, such as time, or cost relationships. On its own, it is conceptual and
generic. When used in conjunction with these other tools, it can be very powerful.

6.2 Limitations of the Model

Two of the model's limitations are:

a. It does not assign values or priorities to tasks. Thus, it shows all tasks as of equal value to the project.

b. It shows no sense of time nor does it show task sequence relationships (The IDEF₀ methodology describes a process as a series of functions tied together with a number of inputs, outputs, and constraints; no time concept is introduced). In many areas of the construction process, timing of tasks and information has a high impact on the project success.

Nevertheless, these limitations can be overcome by using other models in conjunction with this model. For example, the model can be cross referenced to identify key activities on a schedule network (e.g., CPM) and key cost budget items, thus providing collection of tools for the user. This model then complements and fits with current tools used in the industry.

6.3 Future Research

Some issues which were faced during this research require solution in future research. Some of these are:
a. Database design: One possible area for research is to use the model as a starting point for designing a facility database and testing its potential uses.

b. Relating the model to other project management tools: An effort is needed for relating this model to other project management tools such as CPM schedules and budgets.

c. The "arrows" in the model need further development. They can be decomposed into information elements at further levels of detail in accordance with the terminology accepted in the industry today.
Appendix A

BIBLIOGRAPHY


APPENDIX B

GLOSSARY OF TERMS

Alternate Plans: Alternate options for meeting user's need for facilities such as: buy, modify, expand or build.

Acquisition Information: Detailed information on the physical condition of the required site, its size, location, purchase/lease price, etc.

Availability of Sites: This relates to how soon and how easily a site can be acquired. When there are more than one alternative site, availability becomes an important issue for the owner and its business.

Business Market Conditions: These are the characteristics of the environment in which the owner's business exists. They will indirectly affect the decision of the owner about the recognition of the need for a facility. The facility will potentially improve the owner's business market share.

Candidate Sites Information: A description of the site's attributes such as topography, size, location and soil characteristics.

Codes and Regulations: Statutory requirements imposed by various governmental bodies. These requirements can cover safety, environmental, operating systems, and other building codes as imposed by local authorities.
Constructibility Information: The information used to integrate the construction experience on the project into the earlier design phases to optimize the provision of the facility.

Construction Market Conditions: As the need for a facility is recognized, the construction market conditions such as availability of contractors, availability of materials, costs, construction type trends, etc. become significant.

Construction Market Information: Information about the availability, quality and cost of resources (e.g., labor force, material), and service organizations (e.g., designers, contractors, construction managers, material vendors). This may include information about on-going and future projects that may influence the competition for the subject project.

Construction Performance Evaluation: An owner's evaluation of services provided by the constructor.

Construction Planners: The individuals who are responsible for material take-offs, schedules, methods plans, and start-up plans that govern the construction of a facility.

Contract: Legal document between two parties used to arrange for services to be performed and to establish the business relationship.

Contracting Plan: An owner's approach to service procurement that specifies selected contract types (e.g., lump sum, reimbursable), contracting method (e.g.,
competitive bidding, negotiated) and project delivery strategy, e.g., fast track, design-build or traditional approach.

**Contracting Procedures:** (A subset of "Owner's Constraints") Owner's standard rules that control the management of contracts, e.g., contractor selection, contract types and clauses.

**Cost Estimate:** The initial quantification of the expenses for the construction project. It is used to evaluate the funding requirements and to conduct financial analyses.

**Current/Future Operational Conditions:** The requirements of the the owner from the facility regarding its compatibility with the users' needs as well as the facility's intended purpose(s).

**Design and Construction Feedback:** The information regarding the status of the actual design or construction (if the project has to be re-planned during its later stages, or if part of it is still being planned while the design and/or the construction of other parts are already in process).

**Design Contract:** Legal document between the owner and the designer, used to constitute the design services to be performed and to establish the business relationship.

**Design Criteria:** Tools used to audit the quality of the design output. They describe the proposed facility, e.g., its image, flexibility, expansibility, and operability. They also include functional description of the facility components.
(spaces, structural elements, HVAC system, etc.), and the relationships between those components.

**Design Performance Evaluation**: An owner's evaluation of design services.

**Design**: The product of the "Design" function that includes design documents (i.e., drawings, specifications and design calculations) and other undocumented information such as as concepts and assumptions evolved throughout the design process.

**Designability Information**: The information used to integrate the design experience on the project into the earlier planning phase to optimize the provision of a facility.

**Detailed User's Needs**: The requirements for maintaining an efficient working/functioning environment in a facility, as viewed not at the company/owner level, but at the user level.

**Economic Feasibility Information**: Information describing the financial aspects of the project including cost/benefit analysis, project financing plan and project cash flow.

**Environmental Project Impact Information**: This term refers to all information pertaining to the interaction between the proposed facility and the environment (both physical and non-physical).
Existing Facilities Evaluation: Owner/user's facilities evaluation for compatibility with current and future use.

External Constraints: Parameters and variables in the environment that impact the facility and that are beyond the control of all project participants. These include weather, codes, economy, technology, etc.

Facility Idea: The initial thought or instance that recognizes the need for a facility and its description.

Facility Information: A collection of all information generated throughout the process of providing the facility.

Feasibility Feedback: (A subset of 'Feasibility Information') Information based on various feasibility studies, which can be of significant consideration when recognizing and understanding the needs for a facility and the possible alternatives.

Feasibility Information: Information pertaining to project economical, technical and environmental feasibility.

Feasibility Study Information: (A subset of 'Feasibility Information') The part of the feasibility study product which is used in developing the project execution plan.

Feasibility Study Team: Group of individuals who analyze the technical, economical, and environmental aspects of the project feasibility.
Financial Plan: The owner's best approach to project funding. The financial plan establishes source(s) of funding (i.e., internal, borrowed) and project life cycle cash flow.

Financial Resources: Means of acquiring the necessary funding for the construction project. Major financial resources are banks and insurance companies.

General Programming Information: All the elements of information which describe the proposed facility. These are used for developing the design criteria and communicating the overall information to the designers and the contractors.

Impact on Environment: This includes all influences on the environment associated with the process of providing the facility, such as physical (e.g., pollution, noise) and non-physical impacts (e.g., economic loss/profit impact on project participants).

Impact on/of Infrastructure Information: This includes the impact of the facility on the conditions of the infrastructure as well as the impact of the infrastructure conditions and limitations on the facility.

Non-Physical Impact Information: Information describing the influence of providing the facility on the community (employment, local business, population, etc.).
Opinions, Facts, and Information: The set of information elements which include details about the scope of work and the design criteria.

Owner's Budget and Schedule: The financial plan or the fund expected to be set aside for providing the facility, and the time allocated or the required date for the facility to function.

Owner's Constraints: Constraints set by the owner organization and are subject to owner's influence such as owner’s strategic and operational plans.

Owner's Standards: Specifications describing the owner's needs in terms of quality, procedures, or codes that exceed minimal regulatory standards.

Owner's Strategic Plans: Long range objectives and general approaches of the owner used to meet company or project goals. These include preliminary schedules, facility manager's long term requirements and owner's priorities for time, cost, quality and safety.

Performance Information: Owner's evaluation of contracted organization's performance.

Planning Execution Plan: A plan that sets the methods, schedule, budget for the facility / project planning function.

Planning Feedback: Information about the project execution plan which can be used for studying the technical feasibility of parts of the project.
Planning Team: A team assembled by the owner to plan for the project. This team may include representatives of the owner, the user, operation and maintenance entity and planning professionals.

Plans: A collective term used to label the product of the planning function. It covers the information used to guide the work and to keep the overall goal of providing an operational facility which meets the requirements of the owner. It comprises the program and the project execution plan.

Post-construction Information: All information generated, introduced or modified by the construction function such as as-built documents, shop drawings and O&M manuals.

Program: A document that describes owner/user's requirements comprising spatial, operational/functional aspects, design basis and criteria for the designer to meet. The program is used to define the project for the designer and is used as a design review and evaluation tool.

Programming Team: The group of individuals and the equipment that carry out the programming function.

Project Execution Plan (PEP): Owner's plan for procuring all resources and services that are required to provide and manage the facility. A PEP includes schedules, contracting strategy, milestones and budgets.
Project Management Procedures: (A subset of "Owner's Constraints") Owner's standard rules that provide guidelines for managing the construction project.

Project Plan: Owner's selected approach to providing the facility. This includes overall project budget and master schedule with established major milestones.

Resource Availability: The quality, quantity, and accessibility of resources to support the functions within the facility.

Resources: This term includes all resources provided for the facility by all participants (building materials; time and man-hours; energy; money, furnishings, supplies, utilities, etc).

Scope Requirements: Essentials of the scope of the project as prepared for the programming of the facility.

Site Analysis: (A subset of "Site Information") Elements of the study which covers the topographic and geological conditions of the site, its present and future value, accessibility of materials and equipment to the site, etc.

Site Criteria: A selection tool that sets recommended facility site characteristics such as geographical location, accessibility, traffic load, site physical conditions, cost, surrounding environment, utilities etc.
Site Evaluation and Conditions: The end product of the review of the candidate sites usually in the form of one selected site and its general attributes (size, price, availability, etc.)

Site Information: A description of the site’s attributes such as topography, size, location and soil characteristics.

Site Investigation Funding: The capital which is required for executing the site investigation.

Siting Requirements: Essentials of the site conditions as required for the programming of the facility.

Site: The physical location of the facility. (usually a plot of land)

Strategic Plans: The subset of owner’s overall constraints, which includes his business limitations and plans.

Technical Availability Information: Data pertaining to the accessibility and the serviceability of the technical details of the project.

Technical Feasibility Information: Information describing the technical aspects of the project including the technical availability of resources and technology, technical properties of the project, and the physical execution feasibility of the project.
**Technical Properties:** Essential attributes of the project which relate to the technical aspects of the construction.

**User Operational Plans:** Plans describing current/future user's operations (e.g., Business Calendar, operations expansion plans)

**User Requirements:** A description of facility requirements that matches owner's/user's current and future operations.

**User's Needs:** Description of the user's functional and environmental requirements from the facility.