ORGANIZATIONAL ALTERNATIVES FOR LARGE PROJECTS

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ABSTRACT: Organizing large construction projects can be as confusing and challenging as managing them. Many organizational variations are possible. This paper describes five major organizational alternatives and reviews the advantages and disadvantages of each. The alternatives include: (1) Strong functional organization; (2) functional organization with area coordination; (3) functional organization wth area management; (4) area management with craft discipline staff; and (5) autonomous area organization. This paper also proposes a method for selecting a project organization that involves developing organizational criteria and using these criteria in an evaluation matrix. Such a process could aid managers in meeting the challenge of effective project organization.

INTRODUCTION

Large engineering and construction projects challenge managers attempting to organize them. Variations in goals, situations, and project phases make organizational requirements on each project unique. Managers of major projects in the industrial, heavy, and commercial construction sectors have many organizational alternatives open to them. These alternatives vary in their ability to meet different project goals; their number and complexity introduce confusion to the selection process.

This paper attempts to help industry professionals design more effective organization structures by outlining logical process for organization structuring. The first step is an analysis of the project situation—its goals and objectives, external influences, technology and phase. We then lay out seven criteria managers can use to assess their organizational structure requirements. This is followed by a review of five organizational structures found on major projects. We describe their significant characteristics, their advantages and disadvantages, and the types of project situations most suitable to each. Finally we illustrate the organizational structuring process with practical applications to assist managers in organizational structuring for engineering and construction projects.

SITUATIONAL ANALYSIS

Goals.—Owners or the firms they engage to manage engineering and construction projects generally state overall goals in terms of quality, safety, cost and schedule objectives. These goals are highly interrelated and external pressures may force changes in their relative emphasis. Several other types of goals may also strongly influence project organi-

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zation and management. Examples include: (1) Maximizing local procurement content; (2) strictly complying with regulations or licensing commitments; (3) controlling disbursements of funds and maintaining clear audit trails; (4) satisfying special owner requirements such as specific design features or informational need; (5) developing assigned subordinates and (6) building company or personal reputations.

A precise statement of project controls is essential for the accurate evaluation of structural alternatives because some stuctures will serve certain goals more effectively than others. Therefore, the clear statement of project goals recognizing their interdependencies provides valuable input for effective structuring. The question of who establishes integrated project goals is significant in organization. The conflict among individual subunits regarding the ranking of their priorities in support of project goals is one of the most significant challenges to effective project management.

External Influences.—External organizatons and special interest groups influence project organizatinal structuring. Identifying and describing these external influences on a structure is an important prerequisite to reviewing structural alternatives. Major categories or organizations influencing the project include: (1) Owners; (2) operators; (3) the architect/engineer and the design contractors; (4) fabricators and suppliers; (5) construction contractors; (6) craft labor unions; (7) regulatory agencies; and (8) others unique to individual projects.

Design and Work Technology.—Construction projects involve two distinct types of technology. Design technology defines what is required; work technology describes how it is done. For engineering and construction projects, design technology defines the coordination requirements, the conceptual or process design, and the detailed engineering for the planned facility. The plans, specifications, design and construction standards, and other special requirements constitute the design technology. Design technology may define complex and diverse special requirements for work technology. Examples include precise tolerances, special processes and operations, unusual materials, high levels of physical congestion, and special inspection and testing requirements.

Three major characteristics—complexity, uncertainty and interdependency—can be used to describe work technology and identify the influence of work operations on organization structure (3). Complexity indicates the number of work activities or information items handled by the organization in performing its fundamenal work operations. It also establishes information processing requirements. Uncertainty indicates the risk of failure in performing individual work activities. Interdependency characterizes the extent to which changes in one work operation introduce changes in another. Collectively these elements influence structure by determining the operations which should be grouped in order to lessen coordination requirements (4). They also influence information processing (1).

Work technology for engineering activities varies in uncertainty, complexity, and interdpendency depending on the type of project. For example, engineering analysis techniques may range from the traditional design methods used on many types of projects to state-of-the-art procedures involving finite element analysis. Similarly, the level of com-

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plexity may vary from low to high, depending on the project scope and the number of disciplines involved in design activities. On large projects involving design activities by multiple disciplines, interdependency reaches high levels. For example, equipment selection provides necessary input for building general arrangement, structural design, electric power supply, piping and instrumentation systems design, and performance requirements for building ventilating systems.

Work technology associated with construction also varies in uncertainty, complexity, and interdependency. When the design technology defines familiar and proven work activities such as welding conventional materials, the uncertainty is low. At the opposite extreme, the potential for successful completion of many operations in marine construction, for instance, is highly uncertain because of the variable conditions.

Project Phase.—The phase of an engineering and construction project also influences work technology. Projects pass through a life cycle that includes planning, conceptual engineering, detailed engineering, construction, and start-up. Each of these phases involves different major work operations that may require extensive changes in organization to meet new demands for decision-making and coordination. For example, the transition from the civil/structural phase to the systems phase imposes quite different organizational requirements on the project.

Selecting an Organizational Structure

Goals, external influences and work technology together define the project situation. The situation in turn will dictate which organizational structure is most suitable to the project. Certain basic principles guide this choice of an organizational structure. To be effective, the organizational structure should:

1. Establish clear responsibility for external interfaces with engineering, purchasing and operations.
2. Provide single point of responsibility at lowest practical level.
3. Integrate craft, engineering, planning, and materials resources at the lowest practical level.
4. Establish and enforce craft discipline priorities consistent with the construction phase of the project.
5. Limit manageable spans of control.
6. Assure clear and effective reporting relationships.
7. Assure most effective utilization of available management, support and craft resources.

While many other criteria could be employed, and should be employed in certain cases, these seven are applicable to virtually all projects. The remainder of this paper describes the major organizational alternatives in use and their advantages and disadvantages in light of these seven criteria. These alternatives range from the traditional functional structure to the autonomous project organization approach. This paper focuses on the site manager's portion of the organization for a large construction project. The alternatives outlined encompas the elements normally required to manage site activities for large scale projects.

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Organizational Alternatives

The following sections discuss each major organizational structure in turn. In our discussion, we emphasize two elements of structure: the grouping of functional units, and the process used for coordination. Two other variables in Mintzberg's classification of structure, the decision-making system of the organization and the design of positions (2), are mentioned only as they relate to unit grouping and coordination. For each alternative, we include a brief description, a review of advantages and disadvantages, and a summary of conditions favoring its use.

Strong Functional Organization (Alternative A)

Functional organizations are traditionally found in the construction industry. They are characterized by a clear division of the work that corresponds to the disciplinary specialization of supervisory and engineering personnel, e.g., civil, mechanical, electrical, instrumentation and controls. Functional structures clearly define authority, responsibility, and accountability. This structure allows managers to divide work into distinct functional subunits and assign personnel to perform these tasks for the entire project (Fig. 1). Each subunit retains a single focus and has specific responsibility for the performance of its own work.

Evaluation.—This traditional structure presents many significant advantages for certain project situations and phases. Because of their clarity and familiarity, functional structures:

1. Establish single-point functional and administrative accountability.
2. Require minimal numbers of managers and subordinates with multiple-discipline experience and knowledge.
3. Provide greater training and career path opportunities for centralized groups of specialists who therefore work in a more comfortable environment.

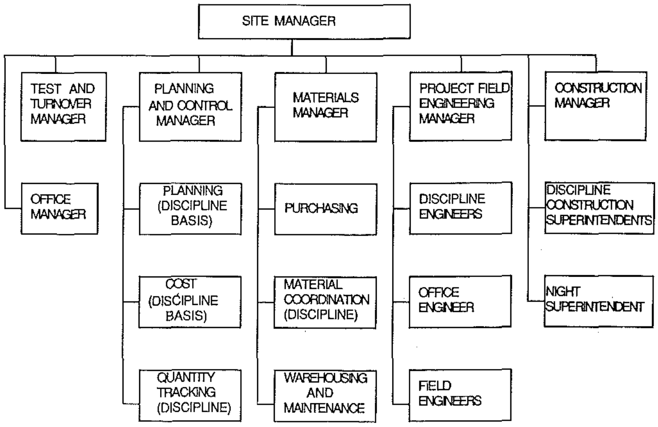

FIG. 1.—Strong Functional Organization

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4. Maintain consistency in each functional activity across the entire project.

5. Simplify reporting relationships, avoid conflict regarding work responsibility for functional activities, and allow rapid decision-making for problems involving a single discipline.

The strong functional organization therefore satisfies our second and third criteria (single-point responsibility at lower level and interface at work prerequisite) extremely well. It also provides excellent utilization of management resources (our seventh criterion).

The rigid work division of functional organizations, however, can cause problems in certain project situations and phases. Functional organization structures may not be well-suited for work involving numerous interfaces between multiple disciplines. This condition results in extensive coordination requirements. For large projects, functional structures may not reduce the scope and responsibility of individual tasks or subunits to manageable size. In functional structures, the site manager must ultimately integrate the diverse work activities. Overload may delay decision-making.

Goals may not be consistent across the various subunits, which creates conflict and less than optimal resources. In addition, the high fragmentation of functional organizations can create confusion and inconsistency in dealing with external interfaces.

Thus, this structure is likely to violate several of our effectiveness criteria, particularly the first (establishing clear responsibility for external interfaces); the fifth (limiting span of control); and the sixth (effective reporting relationships).

Conditions Favoring Functional Structures.—Smaller projects with limited external influence and well-defined technology favor the use of the functional organization. These conditions minimize coordination requirements and allow functional activities to proceed independently. Highly specialized work operations also favor the functional organization because it groups the scarce resources necessary for these activities.

Functional structures are also more appropriate when the project plan calls for distinct functional phases, such as civil, mechanical, or electrical, because such an arrangement lessens requirements for interdisciplinary coordination. Traditional fixed price contracting illustrates this condition. Fast track construction, involving concurrent engineering, procurement, and construction activities, does not.

Managers group elements of the functional organization based on type or discipline of activity, geographic work area, or plant process system. These frequently relate to project phase. The contracting philosophy of the project, if it maps a functionally structured environment, may also favor this alternative. For example, construction subcontracts generally conform to the industry structure contractor specialization by trade. Finally, the functional structure may support the plant operator more effectively because of the role of functional action requirements in the solution of plant start-up problems.

Functional Organization with Area Coordination (Alternative B)

This first step in departing from rigid functional organization is to add

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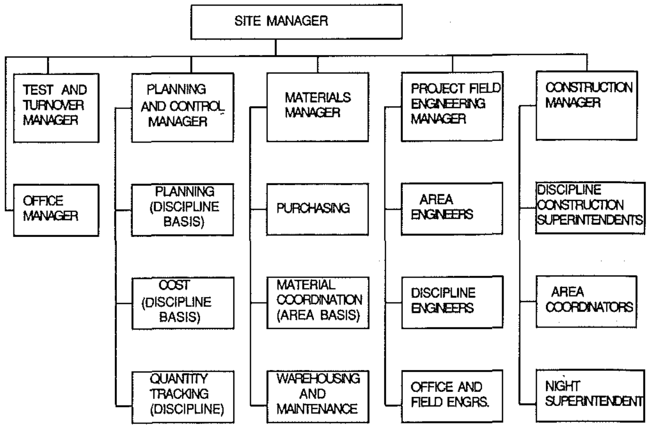

FIG. 2.—Functional Organization with Area Coordination

a staff of area coordinators under the construction manager. Area refers to a specific region of the plant, such as a building or a defined section of the plot plan. Managers using this form seek to coordinate functional activities, implement project priorities, and monitor at the more detailed level of project geographic segments.

Unlike the strong functional organization, the functional organization with area coordination shown in Fig. 2 alters unit grouping in the subunits headed by the construction manager, the project field engineering manager, the planning and control manager, and the materials manager. For the construction subunit, area coordinators perform three major functions: establish priorities among disciplines, develop plans for their assigned geographic areas, and provide greater area visibility and integration capability. Supplementing the technical specialists in the field engineering subunits, area engineers expedite technical support on an area basis. The planning and control manager then structures work activity on both a discipline and an area basis. The materials manager also divides material coordination activities by discipline and area.

Evaluation.—The functional organization with area coordination provides several benefits under certain situations and phases:

1. The specific assignment of construction, engineering, planning, and materials personnel at an area level improves the integration of these functions.
2. This alternative reduces involvement of the project manager and the construction manager in lower level integration of disciplines and activities.
3. The addition of area coordination improves area focus and visibility.
4. Assignment of support resources to construction areas increases decision-making responsiveness.

Its outstanding strength is providing single-point responsibility at the lowest possible level (criterion 2).

On the other hand, the overlay of area responsibilities in four key functional areas has the following disadvantages:

1. The area coordination activity adds both confusion and conflict with respect to roles, responsibility and authority, assignment of resources, and external interfaces.
2. In both the construction and the field engineering subunits, the combined number of discipline specialists and area personnel reporting to the subunit manager increases the span of control.
3. The lack of decision-making authority by the area-oriented personnel may limit their effectiveness.
4. This organization requires more personnel with multiple-discipline skills.
5. Successful performance of the area coordinator role requires unusually well developed interpersonal skills.
6. Career path uncertainty limits the interest of qualified personnel in the area coordinator position.

This organizational alternative is quite weak on clear and effective reporting relations (criterion 6) and clear responsibility for external interfaces (criterion 1).

Conditions Favoring Use.—Projects of moderate size and complexity are suitable for this organizational alternative. On projects where precedent strongly favors the functional form, and the situation does not differ substantially from previous experience, this alternative can improve coordination without extensive disruption of normal work approaches.

By introducing dual responsibility in a specific and limited way, this alternative allows for an evaluation of the possible use of stronger matrix forms, as included in Alternatives C and D. Therefore, if project conditions indicate that these structures may be necessary as the project further develops, the functional organization with area coordination provides an interim solution. Managers can then evaluate the potential acceptance of other structures by the project personnel.

Functional Organization with Area Management (Alternative C)

This next departure from functional structures introduces matrix management. Responsibilities for direction, coordination, and support of construction activities within an area of the project are split between the general superintendent and the area manager (Fig. 3).

In a functional organization with area management, the area manager acts as a project manager for a specific portion of the facility. His major responsibilities include development of the area plan, coordination of craft disciplines within the area, cost and schedule monitoring, reporting and problem identification, and management of planning, engineering and material support personnel. The general superintendent directs the line construction effort. He staffs the construction organization, assigns disciplines superintendents and crafts for work performance in accordance with the area plan, and maintains responsibility for craft performance. The managers of the project field engineering, planning and con-

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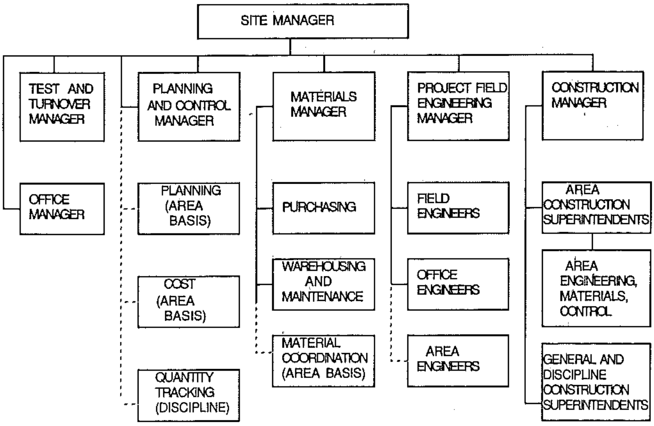

FIG. 3.—Functional Organization with Area Management

trol, and materials management subunits then matrix (assign) support personnel to area management.

Evaluation.—In this matrix structure, the area manager has responsibility for total performance in a specific portion of the project. This yields the following advantages:

1. Consolidating the support functions within the area increases the level of functional support.
2. The area manager establishes overall area priorities which encourages adoption of project priorities by individual disciplines.
3. This alternative retains specialization and consistency of craft construction activities under the general superintendent.
4. The area management structure increases accountability and responsibility for both progress and functional support within the construction manager's subunit.
5. The multiple discipline perspective of the area manager allows him to focus on major goals or milestones.
6. This structure provides earlier problem identification through more specific monitoring.

This structure fulfills our sixth criterion quite well (clear and effective reporting relationships) but it has several serious drawbacks.

The functional organization with area management rates poorly against criteria 1, 4, 5, and 7 (responsibility for external interfaces, discipline priority consistent with phase, span of control, and resource utilization). Its primary flaw is that it increases the number of management and support personnel required compared to the functional structure. It is also possible for conflict to arise if personnel familiar with functional structures resist the use of the matrix. This structure also increases the potential for conflict regarding production responsibility below the construction manager level. Finally, the assignment of line responsibility for support functions to the area manager introduces a high potential for role confusion.

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Conditions Favoring Use.—Moderate-size projects with intermediate levels of complexity and requirements for coordination favor the matrix introduced by the functional organization with area management. For example, a cogeneration project with physically separated work areas might be a good candidate for this structure. Area management would enable the work to be divided into more manageable subunits while still maintaining the advantages of centralized construction craft grouping.

Area Management with Craft Discipline Staff (Alternative D)

The area management with craft discipline staff structure introduces dual reporting of construction crafts (Fig. 4). In this organization, the area manager assumes total responsibility for planning, directing, and supporting all functions within the area. He controls all resources. The general superintendent:

1. Provides craft discipline supervision and crafts to the area.
2. Manages resources among the areas.
3. Provides construction and methods support and maintains methods consistency between the areas.
4. Provides common services such as concrete placing, scaffolding, cleanup, and temporary facilities.
5. Assists in resolving specific area problems when requested.

Evaluation.—Transferring total construction responsibilities to area management personnel and providing a discipline staff offers some advantages. This structure lowers single-point accountability and responsibility to the area manager to allow him to focus on a more manageable scope of work. Assigning craft resources to the area manager improves coordination and information flow for construction activities. Concentration of support resources in the areas further improves the functional support of the construction activities. However, while this structure sat-

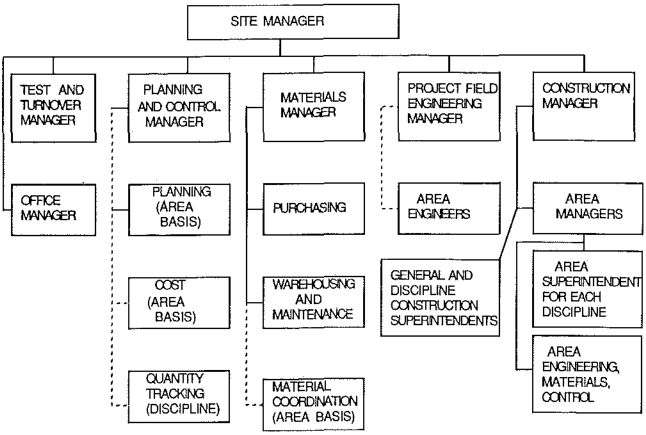

FIG. 4.—Area Management with Craft Discipline Staff

isfies our second and sixth criteria moderately well (single-point responsibility at lowest level, clear reporting relationships), it has some disadvantages. This alternative includes direction from management with both area and function specialty. This introduces potential confusion and conflict by changing the traditional single reporting of the craft superintendent and the general foreman. This may also lead to hoarding resources within the areas and inefficiency in resource allocation among the areas of the project.

Staffing and coordination problems are also potential problem areas. This structure increases the number of craft supervisory personnel required and may lead to difficulties in staffing the organization. Full area management introduces coordination difficulties for those activities that cross area boundaries.

Conditions Favoring Use.—In general, this structure scores poorly against most of our criteria, but it has value in certain situations. Large and complex projects on which the breakdown of work activites into discrete areas is feasible favor the use of area management with a craft discipline staff. If the work activities are physically separated and the facility design considers the interfaces between these distinct areas, this is an effective approach to managing costruction operations.

The type of project best fitting this alternative would combine a large ize with a strong need for technical consistency over the entire poject. For example, the scope and scattered layout of a major synfuels project would require a breakdown into area subunits. However, the need to perform several specialized tasks, such as concrete placement or cable installation, in each of the areas could call for the craft discipline staff provided under alternative D.

Autonomous Area Organization (Alternative E)

The autonomous area organization (Fig. 5) breaks the project into multiple work areas, each with distinct geographic separation.

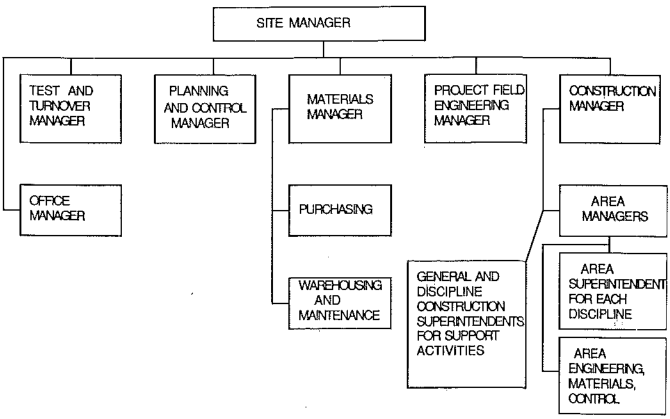

FIG. 5.—Autonomous Area Organization

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Evaluation.—The creation of a separate functional organization for each area of the project offers the following advantages:

1. Separate organizations for each area of the project divide large work scope into fairly manageable segments.
2. The autonomous structure eliminates the confusion of dual reporting by construction crafts.
3. This alternative assigns full responsibility and accountability by area.

On the other hand, the separate project organizations of the autonomous area structure result in the following disadvantages:

1. Duplications of functions, personnel, and other resources.
2. Elevates interarea coordination and resource allocation to the construction manager level.
3. Provides no centralization or consistency of discipline methods among the separate work areas.
4. Increase the difficulty of planning career paths.

Conditions Favoring Use.—Very large projects with substantial geographic separation between major elements or facilities, interdisciplinary complexity and "fasttrack" construction favor the use of the autonomous area organization. There must be well-defined interfaces on the project. In order to benefit from the use of this structure long-term, the firm employing it should be planning a series of separate projects for which it can define a progression of key managers. In addition, extreme schedule pressure which allows some duplication of resources supports autonomous area organization.

The Evaluation Process

Each of these organizational alternatives performs differently in different project situations. Earlier we introduced seven criteria for evaluating organizational structures. Table 1 presents a relative ranking of each of the alternative structures discussed here according to those criteria. Clearly no one alternative satisfies all seven criteria; each has strengths and weaknesses, as the above evaluations have indicated. Depending on the project requirements in terms of goals, work technology, etc., additional criteria may actually be more important.

For example, if the project is being undertaken in an area with a history of labor problems, a key criteria might be the ability to attract and retain qualified personnel. In such a case, the functional organization with area coordination might be rejected because it requires substantial numbers of personnel with multi-discipline skills. The area management with craft discipline organization might not be appropriate either because of the large number of craft supervisory personnel required. Another possible criteria would be the ability of management to implement the given structure.

Managers attempting to select the most effective organization for their project must make trade-offs among these criteria. They need to employ

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TABLE 1.—Organizational Evaluation Matrix

Criteria (1)	Functional (2)	Functional area coord. (3)	Functional area mgmt. (4)	Area with disc. staff (5)	Autonomous area (6)
Responsibility for external interfaces	3	3	3	3	3
Single point responsibility at lowest level	1	1	2	2	2
Integrate resources at lowest level	1	2	2	3	3
Discipline priority consistent with phase					
a. Bulk	1.5	2	2	3	3
b. System	2	2	3	3	2
Span of control	3	2	3	3	3
Clear and effective reporting relationship	3	3	1	2	3
Resources utilization					
a. Management	1	2	3	2	2
b. Non-manual	2	2	3	3	2
c. Manual	2	2	3	3	1
Total	19.5	21	25	27	25

a systematic process fot evaluating their project and assigning priorities to the various criteria. One method for doing this is to develop organizational criteria for specific performance attributes and establish an evaluation matrix like the one shown in Table 1. This method provides a consistent, systematic, and objective approach for organizational structuring. The organizational effectiveness development must be very specific to a given project and its completion phase. In developing the criteria, it is critical to clearly identify the major difficulties that the organization must address. This can be facilitated by using an organizational "diagnostic" approach that will clearly identify the project situation. This diagnostic must be objective and must be performed by qualified personnel in order to provide a sound basis for the organization structure criteria—a prerequisite, therefore, for evaluating the aternatives.

Conclusions

Managers of large projects face significantly different situations. Goals and objectives, external influences, technology and phase each create important differences among projects. These elements of situation dictate which organization structure is most suitable to the project.

Organizational alternatives used for large projects form a spectrum from a strong functional structure to one which involves grouping by autonomous projects. Five major alternatives used for engineering and construction projects include:

1. Strong functional organization.
2. Functional organization with area coordination.

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3. Functional organization with area management.
4. Area management with craft discipline staff.
5. Autonomous area organization.

For a given project situation, each alternative offers both advantages and disadvantages.

Organizational criteria—specific performance requirements—provide a means for selecting the appropriate alternative. These criteria, when combined into a matrix, allow for an improved qualitative evaluation. This method will also suggest tailoring the general alternatives that may be necessary to meet objectives for a specific project situation.

Practical application of the organizational alternatives described in this paper involve the process of defining organizational criteria (possibly through an organizational diagnostic), evaluating the alternatives against these criteria, and selecting the most beneficial structure. Differences in the situation on individual projects will require variations in both criteria and alternative structures. This process provides a starting point for organization design. As the project develops, and particularly at changes in phase, modifications to the structure will be necessary. The suggested process of evaluating alternatives by using organization criteria will also assist in making changes to organization.

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