Designing Project Organizations: An Expanded Process

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Abstract: To the traditional elements of structure, expanded views of organization add means of coordination, location of decision-making, and requirements for positions. This paper describes these expanded views of organization, illustrates significant diversity in organization structure with data from eight industrial projects, and develops a method for practical application of expanded views in the systematic design of project organization structures. The conclusions highlight the benefits of designing an organization rather than letting it evolve.

Introduction

Organization frequently demands manager attention. Some managers call it their forte. However, experience and habit may limit this attention to organization charts. Other elements of the structure that may then evolve exist only as the "informal organization." But these additional variables are important in meeting project objectives. Expanded views of structure, which are based on organization theory, provide benefits in the analysis of existing structures and in the design, rather than evolution, of new organizations. In both analyzing situation and designing structure, greater effectiveness can result from a systematic approach.

This paper presents a method for organizational design. Its purpose is to describe an expanded view of organization structure, to illustrate its use with data from eight projects, and to develop practical applications for the design of project organizations. The data used to illustrate and analyze organization structure are from eight industrial construction projects.

The subject is developed in four parts. First we describe the expanded view of organization structure. Next we review the research method and present data regarding organization structure from eight project organizations. Then we develop a process for practical application of this framework to design structures. This process uses inputs from analysis of project situation, as described in a companion paper. Finally, we draw conclusions regarding the differences indicated by expanded views of organization, the use of this framework to design project organizations, and the need for future research.

Expanded Views of Organization Structure.—Mintzberg (2) proposed four major parameters for describing organization structure: (1) Basis for grouping the elements of the organization and determining their size; (2) means of coordination between the major units; (3) location of decision-making within the organization; and (4) requirements for key positions. See Table 1 for a summary of these elements.

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J. Constr. Eng. Manage., 1986, 112(2): 259-272

TABLE 1.—Elements of Organization Structure

Group (1)	Design parameter (2)	Related concepts (3)
Design of positions	Job specialization	Basic division of labor
	Behavior formalization	Standardization of work content System of regulated flows
	Training and indoctrination	Standardization of skills
Design of superstructure	Unit grouping	Direct supervision Administrative division of labor Systems of formal authority, regulated flows, informal communication, and work constellations Organigram
	Unit size	System of informal communication Direct supervision Span of control
Design of lateral linkages	Planning and control systems	Standardization of outputs System of regulated flows
	Liaison devices	Mutual adjustment Systems of informal communication, work constellations, and ad hoc decision processes
Design of decision-making system	Vertical decentralization	Administrative division of labor Systems of formal authority, regulated flows, work constellations, and ad hoc decision processes
	Horizontal decentralization	Administrative division of labor Systems of informal communication, work constellations, and ad hoc decision processes

Note: Source is Mintzberg (2).

Grouping the Elements.—Subunit grouping, the portion of the structure indicated by conventional organization charts, involves dividing the work activities, arranging the resulting groups, and determining their staffing. Selecting this grouping is the central focus of organization design using traditional views of organization structure. Managers may base this on one of several characteristics of the groups: specialized knowledge, work process performed, time or sequence in the work flow, type of output, client, or place of work performance. Grouping also involves determining unit size which defines the span of control (number of persons reporting) for individual managers and the shape of the organization. Multiple levels in the hierarchy produces a deep structure; a large span of control produces a wide structure.

Means of Coordination.—Managers determine the means of coordination (also termed lateral linkages) within the organization by selecting planning and control systems and by establishing coordination devices (2). Requirements for coordination or lateral communication within the organization stem from the grouping. Coordination devices encourage

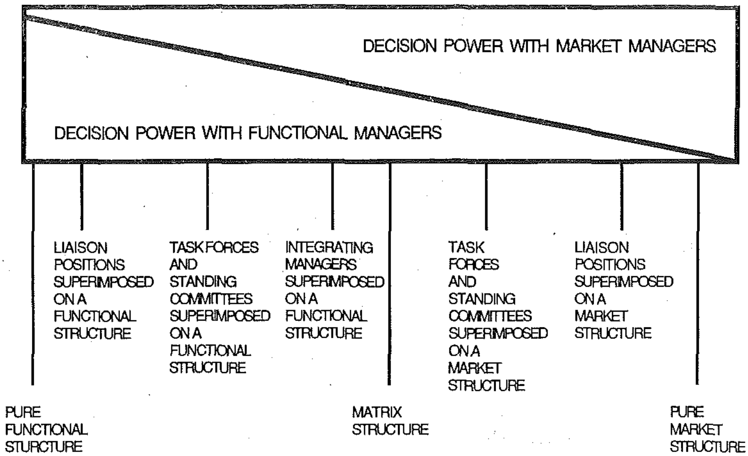

FIG. 1.—Continuum of Liaison Devices

cooperation between individuals to resolve common problems. The range of these devices (see Fig. 1) includes four types: (1) Liaison positions with coordination responsibility but without decision authority; (2) task forces and standing committees to resolve specific problems on a finite or an ongoing basis; (3) integrating managers with specific authority for *decisions involving multiple activities; and (4) matrix structure (involving dual reporting).*

Although not normally considered a part of organization structure, control systems provide further means of coordination. The first major type of planning and control system, performance control, imposes general performance standards over a period of time, e.g., complete all concrete work in the water treatment building by July, 1985. Action planning systems, the second type, define specific decisions, actions, and schedules. For example, such a system might require that the Piping Superintendent install valves A and B to allow hydrotesting of subsystem 44 on the second shift tomorrow.

Locations of Decisions.—The decision-making system determines the degree of vertical and horizontal decentralization within the organization. This relates to delegation of authority in traditional views of organization structure. Vertical decentralization establishes the location of decision-making authority witin the hierarchy of line management. For example, delegating the authority to approve purchase orders under a specified dollar value to the General Superintendent defines the degree of vertical decentralization for this type decision. Horizontal decentralization refers to the extent to which staff personnel control the decision-making process. Giving power to the analysts, to the experts, or to members of another organization creates horizontal decentralization. For example, a requirement for approval of contract administration, design engineering, quality control, the owner's accounting group, and the public relations staff for execution of a contract change order with a small value

J. Constr. Eng. Manage., 1986, 112(2): 259-272

as compared to total project cost indicates high horizontal decentralization.

Requirements for Positions.—The final design parameter identified by Minztberg (2), which is design of positions, includes job specialization, behavior formalization, and training. This expands the information traditionally included in position descriptions. Job specialization takes place in both the horizontal dimension (division of labor) and the vertical dimension (separation of work administration from work performance). For example, the position of owner's Project Engineer on a large industrial project with responsibility for broad overview of design activities by all disciplines in the *A/E* organization is described by low horizontal specialization and high vertical specialization. Behavior formalization involves the standardization of work content for both prediction and control. Training standardizes work skills.

These four variables provide an expanded view of organization structure and a basis for the design of organizations. They include the traditional views of structure, or "what you see on the chart." They also force attention to two key elements of how the organization operates: coordination and decision-making. This expanded view pinpoints important differences in structures. An investigation of eight project organizations illustrates these differences.

Projects Investigated and Research Method

The writer used this expanded view of organization to analyze structure on eight industrial construction projects. This investigation used interviews, document reviews, and site observations to collect data regarding the project situation, the organization structure, and the process of organization design. Four of the projects were hydrocarbon processing facilities; electric generating plants made up the other half of the sample. Both project management and construction management organizations formed the unit of analysis; the decisions studied included initial organization structuring for four of the projects and a major reorganization for four projects. The research also included how managers decide to structure project organizations (6).

Organization Structures for Eight Projects.—Using the expanded view of organization, the structures for these eight projects differed significantly. They also varied from the organizations previously used by the key managers involved. This experience provided a basis for comparing the individual elements of structure. The projects also varied significantly within this group of eight. Analysis using each of the variables described above highlights these differences.

Unit Grouping.—Managers of projects in this sample used both a functional and an area basis for grouping the engineering elements of the organization. Area or geographic segment provided the primary basis for grouping the construction elements, as shown by Project A (Fig. 2). However, the sample also included examples of grouping by construction discipline, such as piping and electrical, during the bulk installation phase (see Fig. 3 for Project E) and during the plant start-up phase (see Fig. 4 for Project F). Managers generally grouped support

J. Constr. Eng. Manage., 1986, 112(2): 259-272

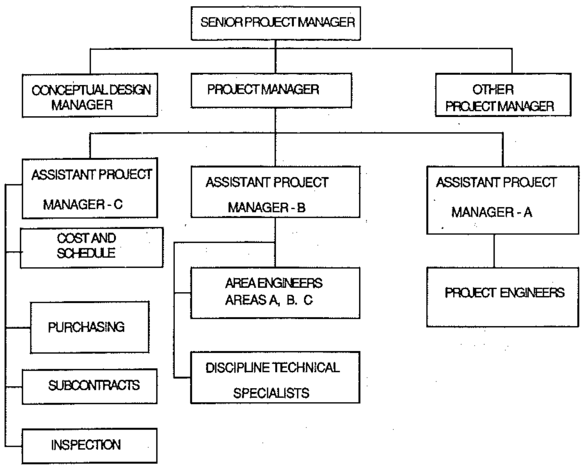

FIG. 2.—Project A Organization

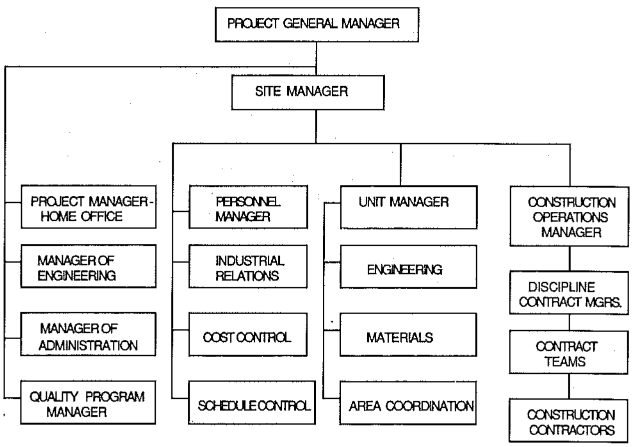

FIG. 3.—Project E Organization

elements, such as contract administration or project control, by functional specialization. See Fig. 5 for an example of this on Project B.

Unit Size.—The project organizations displayed large diversity in the elements that make up unit size: total staffing, span of control, number of units in the hierarchy, and percentage distribution of staffing. The staffing levels peaked at an average of 75 persons for the project management structure on the process plants, and approximately 850 persons for the site construction management organization on the power plants. Span of control for the project manager or the construction manager heading each organization ranged from 3–11 sub-units; levels in the engineering and construction segments ranged from 2–5.

J. Constr. Eng. Manage., 1986, 112(2): 259-272

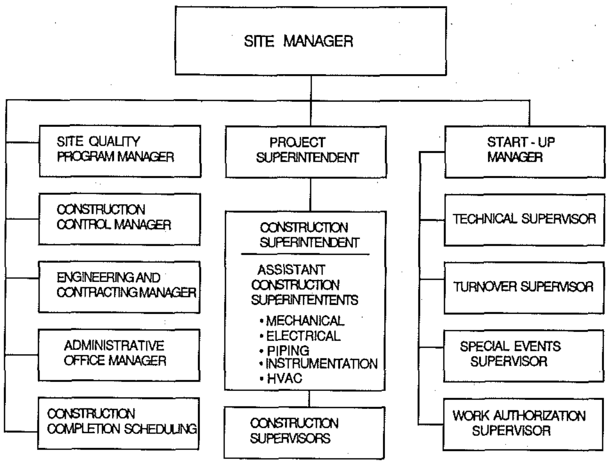

FIG. 4.—Project F Organization

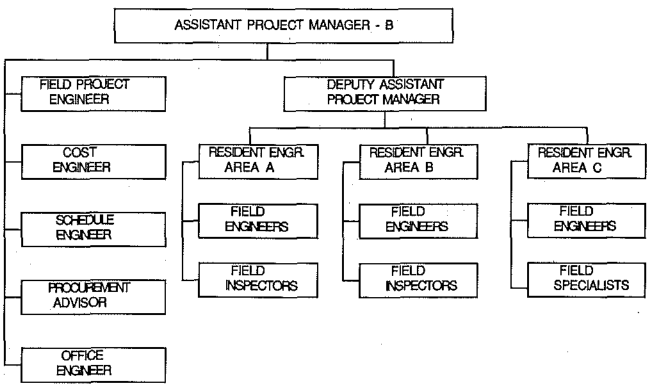

FIG. 5.—Project B Organization

For the process plants, engineering staffing averaged nearly 25% of the total organization, and construction management staffing 35%. For the power plants, site engineering staffing averaged 35% and the construction management sub-unit averaged 15% of the total. The expanded size of all support activities on the power plants accounted for this difference, and required an average of 50% of the staffing, as compared to 40% for the process plants.

Means of Coordination.—The projects also varied substantially in the two means of coordination, lateral linkages and planning/control systems. The functional structure dominated this sample of projects but many examples of the liaison positions, the integrating managers, and the matrix structure devices for coordination (1) were included. Differences in means of coordination for the three organizational elements (engineering, construction management, and support) required separate

J. Constr. Eng. Manage., 1986, 112(2): 259-272

analysis. Both the project engineering organizations for the process plants and the field engineering organizations for the power plants used functional structures. Liaison positions coordinated procurement and inspection activities on the process plants and technical support to construction on the power plants. The construction sub-units employed functional structures with superimposed liaison positions and integrating managers. Matrix managers directed inspection activities within multiple plant regions; area managers integrated discipline activities throughout the bulk production phase. The start-up organization, which expanded during the final project phase, typically consisted of an integrating manager with many liaison positions responsible for system coordination.

Implementation or alteration of planning and control systems formed a major element in each of the reorganizations. Two of the initial structuring decisions implemented performance control systems with monitoring based on overall milestones, such as large concrete placements. On three projects, the reorganizations shifted from performance control based on bulk commodity installation to action planning systems that defined and monitored the detailed actions necessary for process system completion. Managers of one project substituted a detailed control system for a schedule basis of monitoring. This shift in emphasis corresponded to a project phase change from structural to bulk production.

Decision-Making System.—*With few exceptions, managers on the* projects struggled to determine who should make decisions. Key concerns included budgets, design criteria, and change approval. Construction managers consistently attempted horizontal centralization of key operational decisions, with mixed results. Approaches to vertical centralization varied with the individual manager's style. In distinguishing among types of centralization, this analysis used a base of vertical levels below the project manager or construction manager and horizontal elements outside the line construction organization. The organization differed for operational, technical, and financial decisions.

On both the process and the power projects, managers generally centralized technical decision-making vertically and decentralized this activity horizontally by concentrating it in either the engineering sub-unit or with an external project manager. Quality assurance programs mandated this for design control on the power plant projects. Managers generally centralized commitment and dispersement of funds vertically and decentralized this activity horizontally to specialist financial sub-units. Three projects illustrated extreme restrictions on decision-making by limiting the level of delegation from external organizations.

Design of Positions.—The sample ranged from low to high specialization in the design of individual manager position. External influence increased normal specialization on one process project; reorganization decreased specialization on three power projects.

The projects illustrated various degrees of formalization by job and by procedural rules. Because of its extensive project experience, the company managing the process plants developed standard operating procedures. These formalized the design of positions. However, differences in project situation and the individual manager's approach to implementation caused a range of position formalization as compared to this standard. Of the four project reorganizations studied, three increased the degree of formalization and one decreased this variable.

The design of positions on each of the projects included specific training and experience requirements. Managers made experience on similar projects a prerequisite for assignments to senior positions. On the process plants, training required experience in the company. On the power plant projects, managers sought experience in construction craftwork or in the system completion and start-up phase of the project execution in filling key positions in the line organization.

Implications of Project Differences.—The descriptions of organization structure on eight industrial construction projects indicate a diversity of states for each element of structure. Managers paid much attention to organization charts indicating size and grouping of the major elements. Position descriptions, procedures, signature authority delegations, and planning and monitoring systems captured some of the other variables. But many were not defined. Also, the projects changed rapidly and other demands for the manager's attention prevented consciously designing many elements of structure. A systematic design process, considering all variables in the expanded view of organization, would result in more specific definition of structure, greater fit between structure and project situation, less evolution of the structure and, possibly, more effective organization. This process provides an alternative to adaptation of past organizations, the primary process of organizing described by managers of these projects (6). The following section describes practical application of expanded views in a process to design organization structure.

Applying Expanded Views of Organization Structure

The process described in the following sections uses systematic decision-making to custom design an organization for a specific project situation. It follows from analysis of the project situation, as described in a companion paper. In addition to the expanded view of organization, the process uses relationships between situation and structure suggested by contingency theory (1,3,5). Much of this theory relies heavily on the ideas presented by James Thompson (8). The objective of this process is to tailor each variable in the expanded framework of organization to unique project requirements. The resulting organization design will require change as the project advances or as the manager obtains more information, but this process provides a starting point.

Define Objectives.—Defining all project objectives and establishing a tradeoff between them is the starting point for this process. It involves quantifying objectives whenever this is possible and making difficult choices between conflicting objectives.

Project objectives normally include cost, schedule, quality, and safety (both during construction and in plant operation). Quantification is difficult; tradeoff is even harder. Despite this, setting priorities between conflicting objectives is necessary to design effective organizations. Priorities between objectives influence each of the elements of organization. For example, schedule priority over cost implies providing greater resources for coordination, such as increased staffing or a more extensive planning and control system and increasing the vertical decentralization of decision-making. Each increases cost but also improves the responsiveness of problem solution to better support the schedule.

Policy statements provide a starting point in defining project objectives. However, they are generally not quantified. For cost and schedule, budgets and milestones set specific objectives. Objectives for quality and safety are more difficult to define. Requirements for conformance to designated codes and specifications, which include both quality methods and acceptance criteria can define quality objectives. Accident statistics and comparisons with national averages provide one means to quantify safety objectives. Certain other objectives, such as local procurement, can be quantified by percentages or monetary values. Others, such as control of funds, require subjective assessment.

The key question in the tradeoff of objectives is: "What governs in cases of direct conflict?" Ranking objectives using this question provides an essential basis for designing the elements of organization structure. These objectives serve as criteria in making individual design decisions.

Define Line Management Organization.—Structuring the line organization, that element responsible for the key tasks to meet the project objectives, begins with probing the work operations required. Understanding how these operations differ from the manager's experience is essential. Possible differences include: (1) Higher risk of not meeting project objectives, such as uncertain engineering analytical or construction techniques (e.g., high risk rigging operations, welding dissimilar metals); (2) greater numbers of work objects and tasks, indicating a greater project scope; and (3) greater dependency on either other disciplines or outside organizations. These differences imply both priorities in grouping the elements of the organization and staffing requirements for these groups.

Identifying alternatives to group the highly dependent units of the line organization is the first step in grouping the elements of the structure. Minimizing the cost of coordination between elements of organization is a key criteria suggested by Thompson in (8). Galbraith suggested grouping to minimize information processing requirements (1). The alternatives for grouping range from traditional single responsibility organizations to the matrix (9). The single responsibility structures may group elements by function such as engineering discipline or by individual project as in the task force form. In the matrix, function and project generally provide the dual reporting points for engineering; discipline and area are the equivalent for construction.

To structure the lowest level of the line organization, group the units with the greatest degree of interrelationship and the greatest need for coordination (8). This generally means those groups which pass work tasks or objects back and forth to each other to complete work activities. For example, piping system engineers and designers or area planners and area superintendents may depend on the work of each other to an extent which merits their grouping in the organization. As a second level of the organization, group those elements which work in sequence. This lessens difficulty in the coordination of work turnover, such as from instrument installation crews to electrical connection crews. Finally, group those elements whose only common tie is meeting overall project goals.

For example, grouping accounting and engineering would receive the last priority. The elements do not require frequent communication to complete their respective work activities.

Information processing requirements provide another criteria for grouping elements of the line organization. Galbraith defined uncertainty as the amount of additional information required to complete a task (1). He suggested that, in designing organizations, managers should first group those elements of the organization with the highest need to exchange information.

Provide Additional Means for Coordination.—The next step in designing the organization involves adding individuals or groups responsible for satisfying the remaining coordination requirements. Galbraith (1) identified two major options. First, managers can assign additional personnel with various types of roles in coordinating the work of separate groups in the organizations. Examples of these integrating managers or liaison positions from construction projects include: material coordinators, startup system coordinators, or area superintendents. Second, a greater investment in planning and monitoring systems can increase coordination. Use of this approach in construction organizations involves planning, monitoring and reporting in greater detail. This decreases the need for coordination by obviating problems.

These two fundamental steps in designing the line management organization point out deficiencies in the current organization theory. How do we measure coordination? How much is enough? The current state of the theory requires intuitive judgements regarding coordination and the key variables. More precise measures would greatly benefit practical application of this theory.

Select Size of Each Unit.—After selecting a grouping for the units, consider several factors in determining their size. Units with a strong relationship to the project objectives and those with large scope, high complexity or great uncertainty in the tasks they perform merit special attention. These may require staffing in excess of the norms in the manager's experience. Many managers use staffing ratios, such as one project engineer per 200,000 engineering workhours, to determine the size of specific groups. Differences in the tasks performed may require modification of these ratios.

Together, the grouping of the units and their size determine the depth and breadth of the organization. The objectives also guide this decision. Where control is a high priority, limited breadth is desirable.

Design Staff Groups.—The first step in designing staff groups is identifying important external influences. Organizations in this category generally control resources critical to the project (4) or otherwise present a key uncertainty in meeting objectives. Other key influences stem from control of critical decisions, such as the committment of funds, by external organizations. Considering the project as the unit of analysis, key external organizations could be within the same firm as the project organization.

Designing staff groups for these external influences first requires selecting a strategy for dealing with the influence. Options include: (1) Buffering the technical core by preprocessing inputs or leveling disturbances from the environment; or (2) bridging to other organizations

J. Constr. Eng. Manage., 1986, 112(2): 259-272

through bargaining, contracting, or joint-ventures. Based on the degree of uncertainty presented by the external influence and the strategy selected for response determine the structure and staffing of the responsible staff unit. Locate the staff units in the organization adjacent to the line segments with the greatest interaction.

Two examples illustrate the design of peripheral staff groups. If uncertain supplier performance for critical values threatens the project schedule, a greater number of senior expeditors may be required. When supplier performance in meeting key delivery dates for structural steel depends on timely project review of fabrication drawings, the organization might include a coordinator with the knowledge and authority to perform this review.

Experience on previous projects generally provides a basis for design of staff units not subject to external influence. If analysis of the situation does not indicate substantial differences from past projects, adaptation of past structures may provide an adequate basis for structuring. Higher level departments responsible for the activity in the parent organization may also provide guidance.

Add Planning and Monitoring System.—Both the project objectives and the descriptions of the work operations provide input to selecting the planning and monitoring system. These systems may specify only general performance requirements and objectives (such as place all concrete in the pumphouse by a certain date) or they may define specific actions in detail (such as schedules for rebar, embedments, formwork, and curing). Data from the eight projects indicated use of general systems during early project phases and detailed approaches for construction completion and startup.

Selecting the size of the staff unit responsible for the planning and monitoring system is the next step. This decision is influenced by several elements of the project: its objectives, the coordination needs of the work operations, its information and reporting requirements, and its need to increase information processing capability. If a specific work operation involves high uncertainty, or if it requires action by several groups within the line management organization, the project may require greater staffing for planning and monitoring, compared to the manager's previous experience.

Locate Decision-Making within Organization.—With the size and grouping of the units defined and the means of coordination established, the next design step is delegating authority to locate decision-making within the organization. This requires fundamental choice between two conflicting project goals: control and schedule responsiveness. Several types of control decisions, such as compliance with budgets, limiting design change, or protecting the environment, may also cause this tradeoff. Each element of the situation influences this decision.

The work operations and overall coordination requirements, compared with the degree of coordination provided by other means such as unit grouping, coordination positions, and planning and control systems, provides a further input to the location of decision-making. The extent of influence, the authority retained by external organizations, and the involvement of others in decision-making each constrain delegation.

J. Constr. Eng. Manage., 1986, 112(2): 259-272

Considering this, differences in the locations of various types of decisions (e.g., operational, technical or financial) may be necessary.

Locating decision-making requires two steps. First, select the level of the line organization required for each type of operational decision. For example, this may involve designating who stamps drawings in an engineering office or who allocates cranes on a jobsite. Second, designate those types of decisions that are reserved for specific staff groups and assign authority for these decisions. Possible examples include: design change, commitment of funds above a designated level, or signature of a local labor agreement. Implement the locations selected for specific types of decision-making by authority statements, procedures, or other means that fully define this element of structure.

Define Requirements for Positions.—Work operations, grouping of elements within the structure, coordination requirements, and location of decision-making each influence the specifications for filling key positions in the organization. Designing the positions first involves selecting horizontal and vertical job specialization. Grouping the line management organization initially defines the division of labor. The extent of specialization for individual positions within these groups further defines this element of structure. Determining position specialization also involves selecting the separation of work performance and work administration. For example, a piping superintendent who supervised the work of several general foremen whose positions were highly specialized horizontally would involve high vertical specialization. The superintendent would plan, coordinate, and support the work of the specialized general foremen.

The second step involves the formalization of positions. Procedures and other detailed instructions create formalization by describing the individual job in detail or by specifying each individual step in the work flow. Issuing rules to cover all situations also formalizes positions.

The final step in designing positions involves specifying experience and training requirements. For example, key management positions on engineering and construction projects may require similar project management experience, an engineering background, or supervision of field construction operations.

Once position requirements are defined, implementing the organization involves assigning managers who meet the requirements of the positions. This seldom happens. In fact, the actual experience and capability of available persons may require some changes in the design, perhaps several iterations. This matching between positions and other elements of structure may alter the grouping and size of the units, the means of coordination, or the location of decision-making. These iterations should result in a balance between the requirements of positions and the persons assigned. Otherwise, it won't work.

Applications.—Project managers and construction managers face the task of organization design and redesign over the life of each project. Few tools exist to help. Although the steps described above lack the quantifiable measures managers seek for difficult decisions, they do provide a starting point for a systematic process. Considering each variable in an expanded view of organization structure may avoid some problems with organizations which evolve. Despite these potential benefits, other demands on managers' time normally prevent attention to each of the steps in this process for organization design. Making the process more precise and the tools more usable remains a formidable research challenge.

Conclusions

Organizing large and complex projects presents a major management challenge. Differences in work operations, impacts of external influences, and numerous options for organization each complicate these decisions. Faced with this ambiguity and constrained by multiple demands for their attention, many managers adapt organizations used on past projects to the current demands.

Expanded views of organization structure, based on organization theory, provide a means for the systematic design of structures. This view supplements the elements of organization traditionally shown on the chart (the grouping and size of units) with means of coordination, location of decisions and requirements for positions.

Investigation of eight large construction projects indicated variation in each element of organization structure. Although they were all from the industrial construction segment, the projects differed extensively in each of the expanded elements of structure. More importantly, the expanded elements highlighted substantial variations from the manager's experience. This indicates the risk of adaptation.

Applying expanded views of organization in designing structures for specific projects requires eight steps: (1) Define the objectives; (2) define the line management organization; (3) provide additional means for coordination; (4) select the size of each unit; (5) design the staff groups; (6) add the planning and monitoring system; (7) locate decision-making; and (8) define requirements for positions.

Using these steps results in several benefits for organization design. First, the expanded view identifies differences between the project situation and the conditions faced by managers on prior projects. Second, applying this framework results in a systematic process for the design of all elements in the expanded view of organizations. This produces a structure custom tailored to the specific project situation. It also substitutes conscious design of elements of structure for their evolution in an "informal organization."

As described here, existing theory is not adequate to support a fully developed procedure for organization design. We need refined measures of existing variables, such as coordination, and new elements of structure to capture the dynamics of project organizations. Increased understanding of relationships between situation and structure is also necessary to further develop methods for organization design. To help pressured managers, expanded views of organization will have to recognize the "real world" demands for frequent alterations to structure in anticipation of and response to ever-present change.

According to contingency theory, design of organizations to maximize fit with the situation should also maximize performance. Further research is necessary to verify this. However, the systematic design of organizations should result in the same benefits for organizing decisions

J. Constr. Eng. Manage., 1986, 112(2): 259-272

as rational analysis and evaluation of alternatives produce for other decisions. As a start, it should help recognize and understand the problem.

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