Integration and Adaptation in Architectural Process: Strategies for Project Organization, Planning, and Communication

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INTRODUCTION

"Monsters be here."

So wrote the 17th century mapmaker to fill the void of uncharted waters (Fig. 1). In architecture we have adopted a similar attitude toward construction planning. Architects have, to varying degrees, distanced themselves from the execution of their design concepts. However, we are starting to confront the monsters, some of us by choice, and some by force of economic necessity. Two market forces driving us to reconsider our role in the construction process are collaboration and concurrency. Collaboration is an interdisciplinary approach to project organization – architects, engineers, contractors and clients working together to create a building. Design-build is one contractual manifestation of collaboration between disciplines because it requires architect and contractor to work together, liberating the client from the role of referee too often required in design-bid-build. Design-build has become so popular with clients that more than one third of all non-residential projects in the US are now delivered in this way, and the number is growing every day (HBE Blueprint 1999). The other force drawing architects into construction planning is the fast-track nature of today's project schedules. Schedule compression, driven by clients demanding quicker project delivery, requires that construction begin well before design is complete. In contrast to the traditional "over-the-wall" method of project delivery in which the architect completed the design drawings and handed them over to the contractor for execution, we now see an overlap or concurrency of design and construction activities as the project proceeds.

Collaboration and concurrency complicate the architectural process already exhibiting high levels of complexity and uncertainty. This paper defines several strategies for coping with an architectural project environment characterized by collaboration, concurrency, complexity and uncertainty. It describes global strategies of integration and adaptation, and presents several specific methods for project organization, planning and communication. By educating students and practitioners in integrative, adaptive models and methods of architecture, we prepare them to traverse the uncharted waters of construction planning and lead the collaborative teams that will design and build tomorrow's projects.

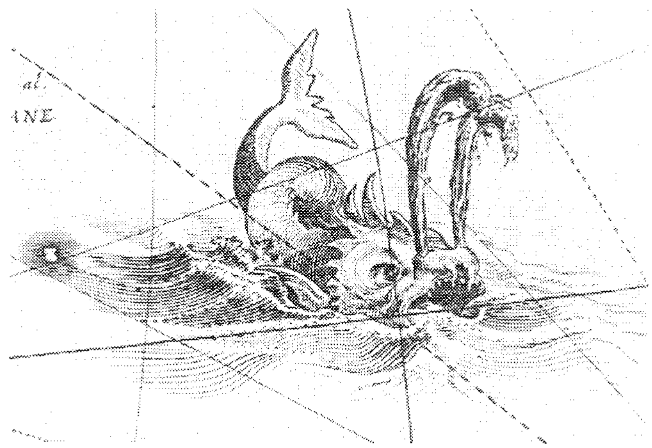

Fig. 1. The 17th century mapmaker filled uncharted waters with serpents. Architects are beginning to explore the uncharted waters of construction planning and face some of the monsters in this expanding area of practice (Blaeu 1618).

INTEGRATION

The specialization and separation of disciplines in architecture which have evolved over the last hundred years have had their benefits in an effective division of labor and development of expertise. What has been lost is the master-builder's ability to synthesize the diverse aspects of design, construction and project management into a holistic model of integrated architectural practice. The mechanistic mental model that accompanies specialization and separation has also had certain benefits in the organization and planning of construction, but mechanistic models are ill-suited for application in an environment characterized by high levels of complexity and uncertainty (Jantsch 1980).

An alternative process model emphasizes the interrelationship between disciplines and the integration of project activities. Concurrency and collaboration imply that

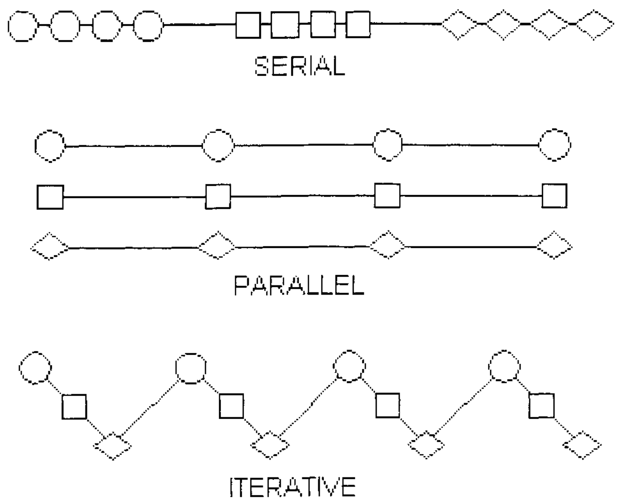

Fig. 2 Types of relations between activities. In a serial process (top) all activities of a certain type are completed before activities of another type can begin: in parallel process (middle) activities occur simultaneously but not necessarily in interaction with other types of activities: in an iterative process (bottom) different types of activities not only occur simultaneously, but are related by an iterative exchange of information.

design and construction activities occur more iteratively than in the past. Figure 2 shows three different types of relationship between activities. In a serial process (top) such as the over-the-wall paradigm of design-bid-build, all the activities of a certain type are completed before activities of another type can begin. Parallel processes (middle) occur simultaneously but not necessarily interacting with other types of activities. In an iterative process (bottom) different types of activities not only occur simultaneously, but are related by an iterative exchange of information and the opportunity for feedback.

A well-established body of research in industrial management has addressed the benefits of feedback, as in Deming's "Plan-Do-Check-Act" cycle of continuous process improvement (Deming 1982). Feedback can only be utilized in an integrative process where information outputs from each type of activity can serve as inputs to other types of activities. Of course, the majority of design activities still occur at the front end of the project, followed by the bulk of the construction activities, but an integrated model of design and construction provides two advantages over the more commonly held serial model. First, it more accurately reflects the changing nature of project delivery characterized by fast-track collaboration and concurrency. Second, it gets us thinking about the opportunity for continuous design improvement during construction that an iterative feedback cycle might hold.

ADAPTATION

Integration requires increased communication and coordination between disciplines, adding to the complexity and uncertainty of the project environment. In the natural environment, one way that organisms cope with complexity and uncertainty is to adapt to changing circumstances and unforeseeable ends. "Adaptation," writes John Holland, "is the process whereby an organism fits itself to its environment." (Holland 1995). Adaptive organization, planning and communication in architecture respond to changes in the project environment rather than relying on overly rigid pre-established policies and procedures. While self-organizing systems in nature may not always provide transferable lessons for the realm of human organization, many authors have argued for flexibility or adaptability in the policies and procedures that govern communication and coordination in the complex, uncertain environment of construction planning (Yamazaki and Ibbs 1995, Pietroforte 1997).

Historically, architects have welcomed change during construction if it meant an opportunity to improve design. The builders of the Parthenon (Fig. 3), for example, took down the great marble columns beneath the entablature and moved them *four centimeters* to accommodate the addition of the Panathenaic frieze (Korres 1994). This shows how seriously the architects took the opportunity to make design improvements during construction. Without this flexibility and openness to change they could never have achieved the perfection of design that is the Parthenon. Today, architects fear change, and not without good reason. The cost of change during construction has been estimated at $60 billion per year in the U.S., and change orders are the leading cause of conflict in the construction process (Ibbs 1997, Ibbs et.al. 1986). But is change inherently costly, or are our methods for dealing with it simply inadequate? Change is the essence of nature, and organisms in the environment are structured to adapt quickly to changing circumstances and uncertain ends. Clearly we need to plan ahead, but policies and procedures that deny change during architectural process at least miss the opportunity to improve design and may ultimately lead to the extinction of overly rigid and inflexible organizations.

A comprehensive procedural model of an integrated, adaptive architectural process is well beyond the scope of this article. However, a conceptual model is of little value if it does not lead to new procedures (and a critical reevaluation of old ones.) Following are three brief examples showing how a model of integrative, adaptive practice could be implemented. Three procedures are briefly described, one from each of three critical areas of practice: project organization, planning and communication. The specific practices are a strong matrix team, an evolutionary project plan, and early downstream information user input.

ORGANIZATION: THE STRONG MATRIX TEAM

There are probably as many alternatives in project organization—the composition and interrelation of project participants—as there are projects. Each is unique. However, some organizational structures are undoubtedly better than others at integrating design and construction smoothly and adapting to an ever-changing project environment. Many

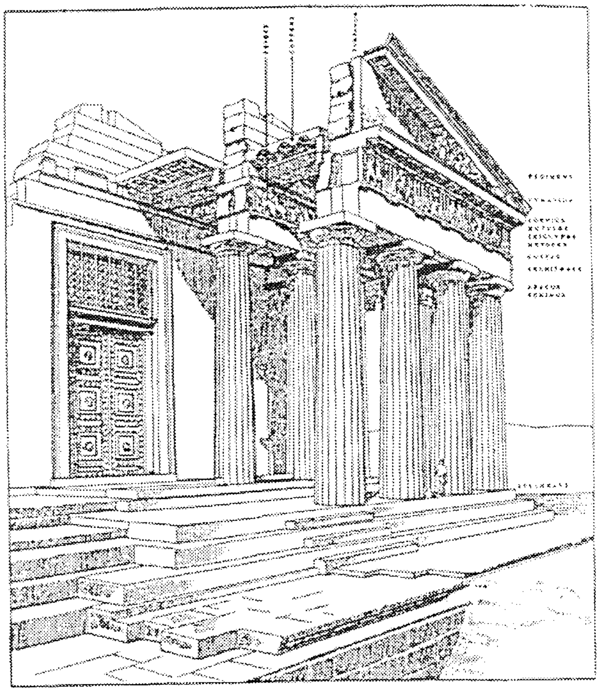

Fig. 3. The builders of the Parthenon took down the great marble columns beneath the entablature and moved them four centimeters to accommodate the addition of the Panathenaic frieze (Korres 1994).

firms use project teams as the basis of their organizations because in architecture, more than almost any other field, the work of individuals within the firm centers on one specific project after another. However, when we look beyond the makeup of individual firms at the multidisciplinary organizational structure of a whole project, the team approach tends to break down. Because of specialization (not to mention liability,) the different disciplines generally continue to operate not in multidisciplinary teams, but within their own "professional bureaucracies" (Mintzberg 1993). Professional bureaucracies maintain strong functional control over their employees at the expense of multidisciplinary team autonomy. They have been found inherently unsuited to today's projects because they lack the flexibility and rapid response capability demanded by complexity and uncertainty (Ahmad and Sein 1997, Jaafari 1997). Most aptly, they have been called "Newtonian organizations in a quantum world." (Wheatley 1992).

Effective coordination and communication in the collaborative, concurrent project environment are strongly enhanced by a multidisciplinary team organizational structure (de la Garza et.al. 1994). Flexibility and rapid response require that the team have substantial autonomy in its decision-making. On the other hand, individual firms cannot be expected to grant total autonomy to independent, multidisciplinary teams. Individual team members must still be accountable to the goals and policies of their employers. These goals and policies, however, should leave room for independent project teams to make important decisions on

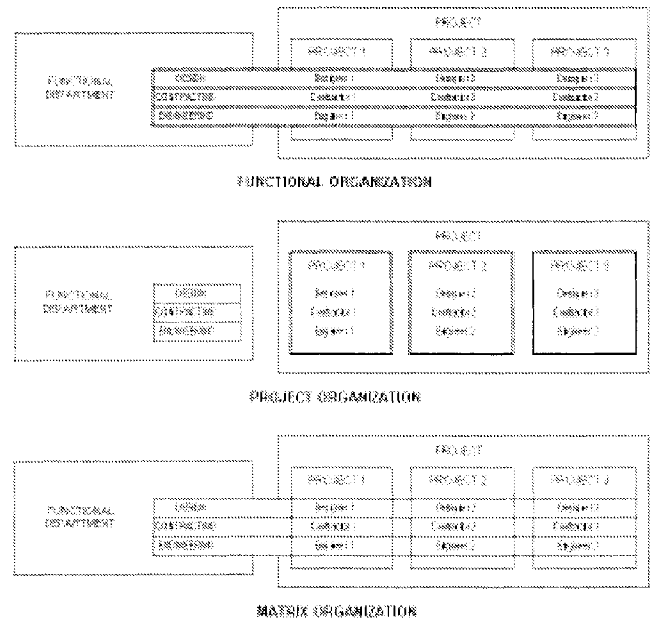

Fig. 4 Organizational structures in architecture. A strong matrix organization may foster innovation and autonomy.

their own and respond quickly to project-specific circumstances without fighting through layers of bureaucratic red tape.

An effective organizational structure for the dynamic environment of architectural projects may be the "strong matrix" (Stuckenbruck 1979). A matrix organization uses project-specific teams whose members maintain ties to functional departments within their home firms. Figure 4 places the strong matrix (bottom) within the spectrum of organizational structures ranging from pure functional (top) in which the professional separation of architects, engineers and contractors and owners is strongly maintained, to pure project (middle) where completely independent multidisciplinary teams are created for each project. Like Mintzberg's "adhocracy," the strong matrix approach "is able to fuse experts drawn from different disciplines into smoothly functioning ad hoc project teams." (Mintzberg 1993). These experts maintain loose functional ties with their home firm while working in independent project teams. Some of the advantages of the strong matrix approach include the opportunity for innovation through interdisciplinary interaction, encouraging team autonomy by bringing decision points closer to the source of information and action, and developing project focus while maintaining functional ties.

PLANNING: THE EVOLUTIONARY PROJECT PLAN

When design and construction activities overlap in the fast-track world of collaborative, concurrent architecture, the nature of project planning is changed in two fundamental ways. First, the principles of integration and adaptation require continuous iteration and feedback in the definition of project form, organization, and the work to be done. In other words, it is understood that the building breakdown structure (the definition of form usually embodied in plans and specifications,) organization breakdown structure (the roles and relationships of team participants,) and assembly breakdown structure (the work plan,) all interact with and have an affect upon each other. Second, planning evolves in stages, the most critical components and interrelationships of each of the three breakdown structures being defined early in the life of the project, with finer levels of detail emerging as the project proceeds.

The principles of iteration and evolution are consistent with the nature of today's projects, whereas more rigid planning procedures attempting to define too much in advance are doomed to failure by the reality of complexity and uncertainty in architecture. At the same time, however, we need to organize the building process and define predictable outcomes and expectations for the form of the building. Otherwise, accurate scheduling and budgeting become impossible. One way out of this dilemma is to employ procedures which make a distinction between the *macro* organizing principles establishing the overall character of the project and the *micro* specification of its geometric structure. It is the interaction of macro principles and micro structure which guides biological development from a single cell to a complex, mature organism (Fig. 5) (Weiss 1969).

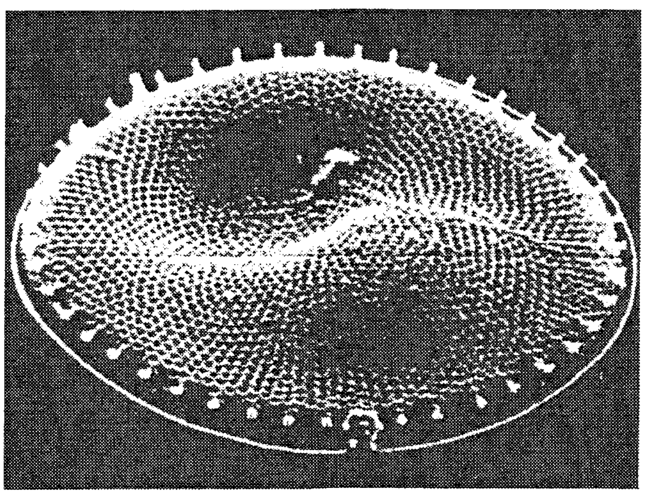

Fig. 5 Interaction of macro principles and micro structure defines the growth of living organisms like this single-cell alga (Schrader in Jantsch 1980).

In architecture, projects with fairly certain outcomes may have their form, organizational structure and work plan well articulated in advance. But in projects where uncertainty is high, organizing principles may drive the articulation of these structures. Organizing principles define the quality sought in the outcome rather than the details of structural configuration. This is the principle behind performance specification in defining building form. Performance

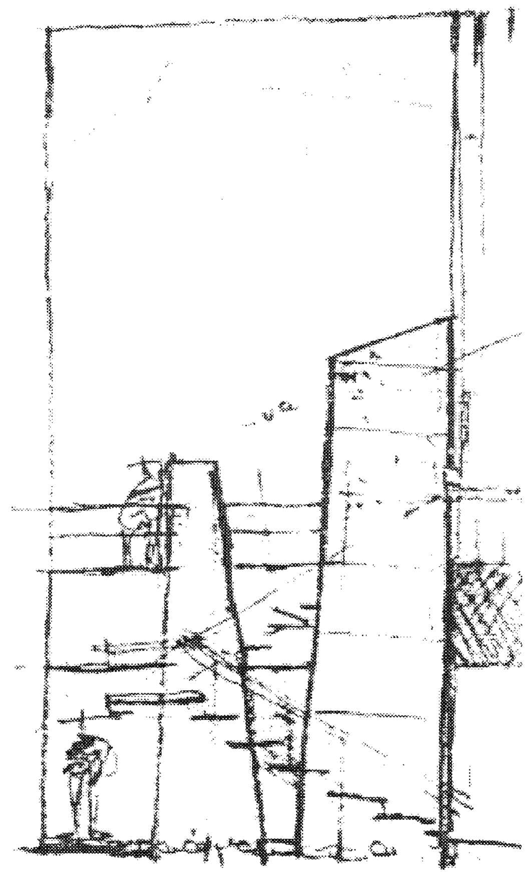

Fig. 6 The window design shown in this sketch was improved based on the architect's direct experience on site (Line and Space 1998).

specifications give the project team an agreed-to measure for evaluating project performance, without committing to intricate design details too early in the project (Construction 1999). They are a critical component of design-build project delivery. As Los Angeles architect Michael Keating has said, "An architecture competition entry in design-build is more about a set of principles than it is about saying 'this is the building you're going to get." (Keating 1995). Examples of organizing principles driving project development can be found in Rheinfrank and Evanson's "design language" (1996), Walz, Elam and Curtis' "scenarios of use" (1993), and Alexander's "pattern language" (1977).

COMMUNICATION: EARLY DOWNSTREAM INFORMATION USER INPUT

When the relationship between design and construction activities changes in concurrent, collaborative architectural process, the flow of information changes with it. In the traditional, "over-the-wall" paradigm, almost all design activities are completed prior to the start of any construction activities. This is a case of *sequentially dependent* activities because the construction activities depend on information generated by the design activities which precede them sequentially. In a concurrent, fast-track project, however,

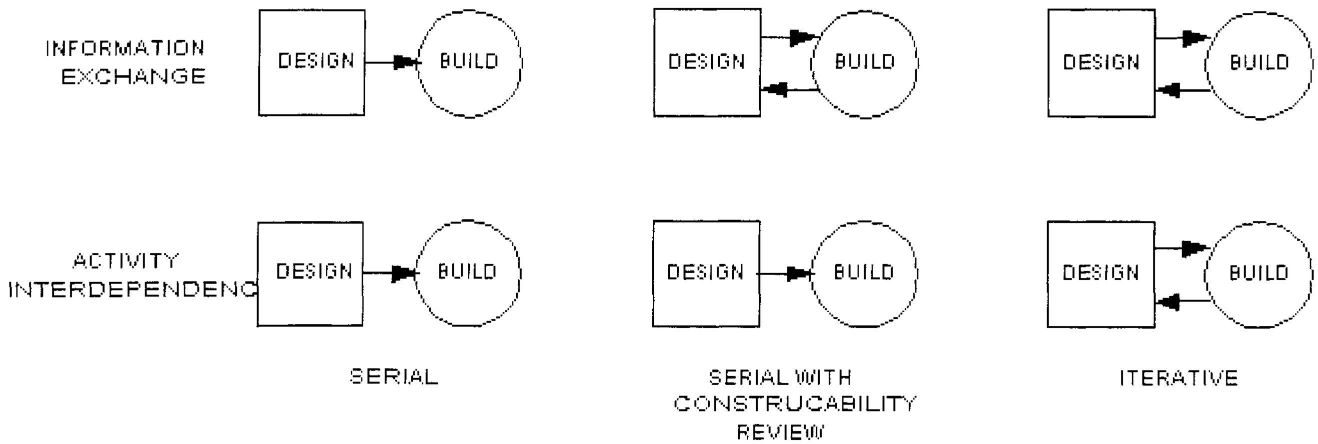

Fig. 7 Information exchange and activity interdependence in architectural process. The importance of feedback increases with the interdependency of tasks.

design and construction activities become *reciprocally dependent*—construction activities still depend on design activities, but as construction begins before design is complete, some design activities also depend on information outputs from construction activities, creating a reciprocal dependency.

On-site design is a case of reciprocal dependency between design and construction activities. On a building site in Tucson, Arizona, architect Les Wallach described to me how he employed information generated by construction to improve design. "This evolved during the construction phase: That window got raised three feet. That was done when we excavated and grade was in. We started looking at the views, and when you're inside it's a nicer view out with it raised." (Fig. 6) (Elvin 1998). Design improvements like this cannot occur unless the project is structured to allow the architect to use feedback from construction activities as input to design activities.

When design and construction are sequentially dependent, constructors are "downstream" of designers in the flow of project information. In these cases, early downstream information user input has long been advocated in the form of constructability reviews. A constructability review allows the contractor to review design ideas early in the project with the aim of improving the constructability of the architect's designs. In a concurrent process, however, the designer is also downstream of the constructor because she or he relies on information produced by the act of construction to complete the design, as in the window example above. Figure 7 shows the flow of information and activity interdependence in serial design-bid-build, design-bid-build with constructability review, and integrative architectural process. In an integrative architectural process, construction activities produce information that must be extracted and organized by the designer. Designers unaccustomed to their new role as downstream information users of construction activity outputs will need to learn what questions to ask, when to ask, and who to ask in order to elicit the information they need to continuously improve design during construction.

CONCLUSION

Perhaps increased specialization and separation hold the answer to complexity and uncertainty in architecture. However, in this paper I have argued that the key to improving architectural process is contained in integrative, adaptive models appropriate to the dynamic, ever-changing world of collaborative, concurrent architectural process. Through these principles and methods, the obstacles of project organization, planning and communication in an uncertain world may ultimately be turned into opportunities by integrative, adaptive organizations in architecture. Through education, we can build the knowledge and skills that enable students and practitioners to confront the monsters of construction planning and discover new frontiers in architecture.

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