The Engineering Project Organization Journal (March–June 2012) **2**, 5–14

A contingency approach to designing project organizations: theory and tools

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Received 7 September 2011; accepted 10 November 2011

Many firms have increasingly come to rely on projects as a fundamental approach to organizing work. Yet understanding the best way to organize projects is a challenge, given the various contingencies that impact project success. We focus here on three contingency-based project organization design tools (the design structure matrix, OrgCon™ and SimVision™) that help to manage project complexity and ensure project success by identifying misfits or misalignments between organizational elements. We discuss the application of these models to a large National Aeronautics and Space Administration project as an example. We conclude with a consideration of how the existing tools are useful, and where they fall short.

Keywords: Contingency, organization design, project management.

Introduction

Many firms have increasingly come to rely on projects as a fundamental approach to organizing work (Sydow *et al.*, 2004; Maylor *et al.*, 2006). As projects become more prevalent, the manner in which they are managed likewise takes on more importance. Since the organization of projects is a critical determinant of project success, project managers are concerned with getting the organizational elements right. Yet understanding the best way to do so is a challenge. Part of this challenge is that not all projects are fundamentally similar (Shenhar, 2001), therefore project managers must understand the impact that organizational factors such as project goals, task characteristics, and coordination methods have on each other (Andres and Zmud, 2001). And even if project managers appreciate that the right organization design is contingent on other factors, 'ambiguities, uncertainties, and interdependencies among activities, their results, and tools' (Browning and Ramasesh, 2007, p. 218) make projects and all organizations complex and difficult to understand, and thus difficult to design (Burton and Obel, 2004; Burton *et al.*, 2011).

Project organizations focus on tasks which must be completed in a semi-ordered sequence. The completion of the tasks and the ordering requires coordination in the optimal utilization of resources to complete the project in an efficient manner (Levitt *et al.*, 1994). Of course, engineering technology is fundamental to successful completion of a project. But there are other organizational contingencies which are important in the project organization: the project goals, the availability of resources in quantity and time, the leadership style of the management team, the climate and culture surrounding the project, control, and IT tools available to the management, the incentives that drive the personnel on the project; all of these elements should be designed well to complete a successful project. Further, these contingencies must fit together, e.g. the management incentives of low costs may not fit with the shortest time project completion goals of the client.

Despite an appreciation for the need to establish an effective organization design, project failures are numerous in practice (Tatikonda and Rosenthal, 2000). While projects may fail for a number of factors (Pinto and Mandel, 1990), organizational reasons are often part of the cause (Keider, 1984; Wallace *et al.*, 2004). Thus, tools and methods to manage the various contingencies that determine the best approach to project organizations are especially valuable.

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The Engineering Project Organization Journal
ISSN 2157-3727 print/ISSN 2157-3735 online © 2012 Taylor & Francis
http://www.tandfonline.com
http://dx.doi.org/10.1080/21573727.2011.641118

While organizational design concepts (and tools to aid it) at the macro-level of the firm (Burton and Obel, 2004) have been developed more extensively than at the project level of analysis (Shenhar, 2001), there are contingency-based project organization design tools that can help to manage the complexity and ensure project success. We report here on the application of three exemplar models: the design structure matrix (DSM), OrgCon™ and SimVision™—each created to identify misfits or misalignments between organizational elements such as: goals, task requirements, coordination issues, personnel characteristics, and organization attributes. In a later section, we explore some research challenges for these comprehensive contingencies for projects, including a National Aeronautics and Space Administration (NASA) project design as an illustration.

The paper is organized as follows. We begin by introducing an example of a complex engineering task—the NASA Project Constellation initiative. Next, we highlight key studies in organization design and contingency theory. In the following section, we look at the application of tools designed to help project managers design successful project organizations. We end with a consideration of how the existing tools are useful, and where they fall short.

Example: designing a project organization at NASA

The project constellation project challenge

NASA routinely faces the challenge of designing effective project organizations. One example was the work of the Systems Analysis Integrated Discipline Team (SAIDT), formed in 2005 as part of Project Constellation. Founded in response to the US Space Exploration Vision (National Aeronautics and Space Administration, 2004b), Project Constellation aimed to explore our solar system, including a return to the Moon followed by human exploration of Mars and beyond.[1]

Constellation included the development of spacecraft (including a crew capsule and a lunar lander) and booster vehicles. The components of Constellation were developed in a modular fashion. The large number and complexity of the design options for the components themselves were compounded by the additional need for these components to work together (Carroll *et al.*, 2006). For example, it was critically important that the Crew Exploration Vehicle, its launch vehicle, the lunar lander, and other equipment which share functional interfaces with the Crew Exploration Vehicle all share a robust, interoperable software architecture. This architecture had to be 'open' in the sense that it be structured to accept gracefully the inevitable upgrades in software applications that would be produced over a 20-year programme life cycle.

The challenge was the design of an organization that integrated the engineering systems and further integrated the organizational units building the components. As a further challenge, the staff responsible for developing software applications resided in multiple, geographically distributed organizations. The boundaries that were spanned across these interfaces included not only geographical boundaries, but also government-industry boundaries, and multiple, often competing, contractors within industry.

The resulting organizational design challenge then was to create a high performing organization characterized by wide open communication across the many interfaces, strong motivation to cooperate in spite of competing profit motives, and strong goal orientation to ensure astronaut safety and mission success.

Constellation organization design

Early on, the NASA Constellation organization design analysis team needed to decide whether to group personnel on the basis of products (Integrated Products Teams) or skills/disciplines (IDTs). Because the Constellation Systems mission had just been created and no products or work plan had been identified (i.e. no critical path method (CPM) existed), the team decided to organize around skills/disciplines areas. A total of 14 IDTs were eventually formed and staffed. These teams began work in October 2004, and successfully provided Constellation Systems with access to 200 full time equivalent (FTE) personnel across eight field centres to initiate the complex system design process (Carroll *et al.*, 2006).

One of the IDTs, the SAIDT, is emblematic of the broader NASA challenge. The SAIDT was established to perform technical studies and systems analysis tasks in support of the design, development, test and evaluation of Constellation systems. The SAIDT tasks focused on issues and requirements that affect the interoperability of the Constellation systems. As part of their work, the SAIDT would need to perform studies that required the technical expertise of personnel from all 14 IDTs staffed from up to eight field centres. Thus, the challenge for the SAIDT Design Team was to design a cohesive organizational unit that would span these discipline and geographic boundaries to execute the above tasks. The initial establishment of the 14 IDTs and the organization design of the SAIDT in particular, were aided by the use of three design tools: the DSM[2]—a tool used to identify and model interdependencies (Steward, 1981), OrgCon™[3]—the organizational consultant expertise system for organizational design (Burton and Obel, 2004), and SimVision™[4]—

a simulation of the project and its organization for implementation (Levitt *et al.*, 1994, 1999). The process and outcomes of using these tools will be detailed later.

The NASA project goes beyond the examination of the project only in terms of tasks and sequencing, but includes numerous contingencies which were given by the larger NASA organization: personnel and resource availability, incentives for success, IT support for multiple locations—all of which dictate a complexity beyond the standalone project. We examine Contingency theory-based tools that go beyond our intuition, experience, and CPM type tools: the DSM for basic mapping of the coordination requirements; the OrgCon™ to examine the larger organization implications; and SimVision™ for a more detailed project level analysis. These analytical studies together provided NASA with understanding and insight that would not have been evident from experience alone.

Research on organization design and contingency theory

The management of a complex project is an information intensive challenge. In order to complete the project in an efficient manner, massive amounts of data are analysed and information is exchanged. The information processing view of organization focuses on two general areas: calculations or who analyses which data; and communications or who talks to whom about what (Burton and Obel, 2004, 2011b). The analyses of data include: engineering calculations, assignment of resources to tasks at an appropriate time, monitoring of costs, among numerous other calculations. The communications is the exchange of information among the managers and the project personnel which can take the form of face to face conversations, phone conversations, email and texting, formal project plans and charts which are shared by everyone, among countless exchanges using advanced IT. An organization uses information in order to coordinate and control its activities in the face of *uncertainty* where uncertainty is an incomplete description of the world (Arrow, 1974, p. 34). By processing information, the organization observes what is happening, analyses problems, and makes choices about what to do, and communicates to others. Work involves information processing; individuals conduct information- and knowledge-based activities. They talk, read, write, enter information in databases, calculate, and analyse. The information processing model of organization examines the project management processes and information that are at the heart of project planning and implementation. The information model of organization then focuses on the coordination of project tasks to realize the project completion. At a fundamental level, organizational design involves two complementary problems: (1) how to partition a big task of the whole organization into smaller tasks of the subunits and (2) how to coordinate these smaller subunit tasks so that they fit together to efficiently realize the bigger task or organizational goals. It is the information processing model of organization which focuses on the coordination of the project tasks to achieve the requisite coordination.

The basic design problem is to create an organizational design that matches your organization's demand for information processing with its information-processing capacity. Galbraith (1973, 1974), in his seminal work, put it this way: 'the greater the uncertainty of the task, the greater the amount of information that has to be processed between decision makers' (Galbraith, 1974, p. 10). Task (or work) uncertainty can arise from a firm's technology and the business environment in which the firm operates (Thompson, 1967), as well as other sources. Organizations thus face a trade-off: they can either reduce their need for information processing or increase their capacity to process information (Galbraith, 1974). These are the two managerial options.

The first option is to reduce the organization's need for information processing by increasing available resources and creating more self-contained units. NASA did not have this option as resources were scarce and self-contained units would not yield the needed coordination for the complex and highly interdependent tasks. The second option is to increase the organization's capacity to process information. This was NASA's challenge as described above. With the high interdependencies across the multiple units and locations, it had to increase its coordination capacity to achieve the project goals.

The organization design challenge then is to manage multiple contingencies in order to create greater information processing capacity. Burton and Obel (2004) extend the information processing view of organization as a basis for their multi-contingency model for organizational design. Burton *et al.* (2011) developed a step by step approach for the practical implementation of the information processing approach. In each chapter of the book, diagnostic questions measure the above elements for your project or firm. First, elements such as the goals, strategy and environment are assessed for their diagnosis and strategic (internal) fit. Second, the configuration, complexity of the firm and the distributed nature of the organization are measured and placed together with the goals, strategy, and environment to assess their contingency fit. This step-by-step approach places the project or firm into a category, e.g. exploration or exploitation strategy or functional, divisional or matrix configuration. Once the project or firm is assigned a category, misfits are identified. Then third, the task design, people, leadership and organizational climate are examined and further assessed for fit. Finally, the coordination, control and information systems, and incentives are examined for overall fit with all of the above elements. Misfits or misalignments among these design elements lead to a decrease in organizational performance, either today or in the future. The identification of misfits thus is the starting point for the implementation of change. As such, misfits are the engine of the organizational design process. Each chapter contains an extensive discussion on how to fix the misfits and improve the efficiency of the project or firm.

The multi-dimensional contingency approach includes both structural and human components. Structural components of organizational design include goals, strategy, and structure. Human components include work processes, people, coordination and control, and incentive mechanisms. Together, these components provide a holistic approach to the organizational design challenge. This model is depicted in Figure 1.

NASA managers recognized that organization design, and the ability to evolve the design over a long duration programme, would be critical to success. Thus, NASA managers sought better methods to model and analyse the characteristics and performance of their units, including their structure, cost, internal and external interactions (with industry partners, for example), and overall effectiveness. For the Constellation project, NASA proceeded with theory based and empirically validated design tools which are consistent with the multi-contingency step by step approach.

The role of design tools

Applying the design tools to NASA

Contingency theory identifies relevant factors and relationships, but there is still a high level of complexity and difficulty for the project manager to understand all the interactions. Here, we focus on theory based-organizational design tools: the DSM, the OrgCon™, and SimVision™. Again, we refer to the NASA study for the three tool applications. See Table 1 for an overview and comparison of the tools used by NASA.

Phase 1: the DSM

The DSM is a project management tool designed to manage the information needs and requirements, sequence of tasks, and task iterations in a complex project (Steward, 1981). It allows for easy graphical representation of project tasks, including tasks that are iterative or require feedback. The DSM can also be applied as a system analysis tool that utilizes expert experience as input for quantifying the dependence between organizational elements. In this way, it reveals the underlying interrelationships within the system that can then be used to design an organization.

The DSM is essentially a square matrix. It is formed by first identifying the project or system elements and listing them along the rows to the left of the matrix (which are mirrored across the top columns). Each cell represents a potential interaction between the project elements. For any given element, the row that lists that element identifies which other elements provide inputs or interactions. The aim is to iteratively reorder the elements to produce clusters of interdependent elements which provide the basis for organizational units. The logic of organization is that more interdependent elements

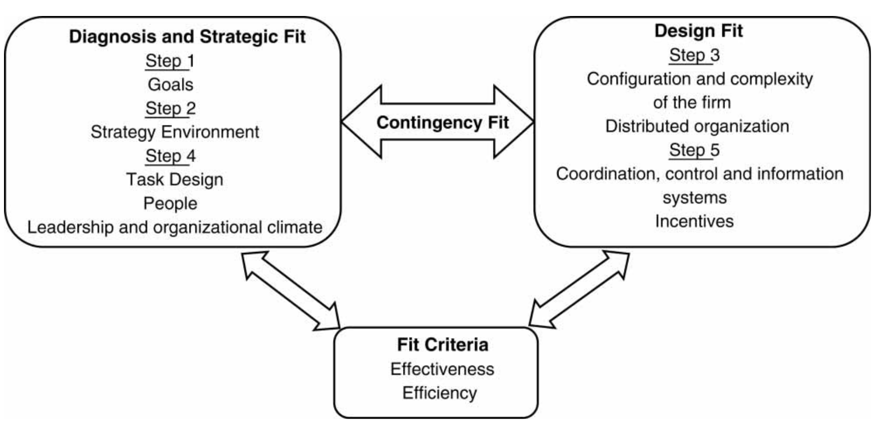

Figure 1 Strategic organizational diagnosis and design fit (Source: Modified from Burton and Obel (2004) (Figure 3.1) and the Burton *et al.* (2011) step-by-step approach)

Table 1 Comparison of contingency-based project management tools

Comparative characteristics	DSM	OrgCon™	SimVision™
Data requirements for the model	Level of interaction between tasks or activities, communication among organizational actors; generated by relying on documentation (design manuals, project schedule, etc.), and structured expert interviews	Approximately 60 questions to be answered by the user on the multi-contingencies: goals, environment and strategy, structure, processes and people, organizational size and age, coordination and control	Interviews with project leaders and personnel identify data on the project task requirement, the sequence of tasks, the actors in the organization and their skills, the project organization and connections among the actors
Focus of the model	Grouping together tasks with the highest degree of interaction	Identifying misfits between organizational design elements	Identifying project problems (project duration, cost and quality), which often result from ‘hidden work’ such as coordination and rework
Form of the output recommendations	A matrix showing the coordination links and their intensity in the organization	A report that highlights misfits and opportunities for addressing them	Numerical and graphed outputs for time, schedule and quality (among other measures)
Source of the theoretical support	Coordination as a core property of organizational processes	Multi-contingency theory based upon information processing	Micro-contingency theory of project management
Illustrative applications	New car design; software development	NASA; software development	Lockheed missile test; oil platform design
References	Steward (1981); Browning (2001)	Burton and Obel (2004); Burton *et al.* (2011)	Levitt *et al.* (1994); Levitt *et al.* (1999)
Online reference	http://www.dsmweb.org	http://www.ecomerc.com	http://epm.cc

should be in the same organizational unit with fewer interdependencies between the organizational units. This is similar in concept to Galbraith’s (1973) creation of independent subunits—if possible.

Because the Constellation Systems mission had just been created and no products had been identified, the team decided to organize around skills/disciplines areas. NASA uses a ‘Workforce Competency Dictionary’ (National Aeronautics and Space Administration, 2004a) as a means of categorizing the capabilities of an employee, the knowledge requirements of a job position, and the workforce requirements for a project. Using the Dictionary as a reference, team members picked all the skills listed in the dictionary they thought would be required. The organization design team then worked with expert input from the field centres to group the interactions between the skill requirements. The results of this effort were accepted and the IDTs were subsequently implemented. A total of 14 IDTs were eventually formed and staffed.

The DSM measures the coordination requirements in an organization; simply, it maps who talks with whom about what. As such, it captures coordination requirements as they have emerged in an organization. With this information, coordination issues become clear with information bottlenecks evident. These bottlenecks can then be addressed and mitigated to increase the information flows needed for coordination. At a more subtle level, it may be possible to identify coordination oversights, i.e. coordination which is needed, but not taking place. With oversights evident, it is then possible to correct them by indicating that certain individuals should be coordinating with others. In short, two design changes are emergent: bottlenecks and coordination oversights.

In terms of the fundamentals of contingency organizational design, the need for information and the capacity are brought into balance or fit. NASA began its analysis by creating a design matrix which gave information about potential bottlenecks and oversights in the initial design proposal. For the Project Constellation design team, using the DSM made clear that the project was not comprised of highly modular and discrete clusters of activities. Rather, there were a high number of interdependencies. Thus, in addition to identification of the core IDT’s, the design team decided to build a final IDT (SAIDT) that would work to coordinate and integrate the work of the other teams. Several of the core organization design team members transitioned to work on the SAIDT.

DSM is an information processing tool which measures the coordination connections in a project and captures coordination, communications, and control mechanisms of the multi-contingency design model.

The coordination matrix spells out 'who talks with whom about what' in the management of the project. Coordination of interdependent activities is fundamental to achieve good performance for the project.

For NASA, the DSM was a beginning phase of the process.

Phase 2: the OrgCon™

The second phase applied the OrgCon™, an expert system programme that assessed the fit between multiple organizational and environmental contingencies for NASA as a whole (Burton and Obel, 2004). Using OrgCon™, NASA developed a baseline model. Next, the organization design team explored alternatives and assessed the robustness of the baseline design. This was a top-down view of the project organization analysing all of the elements in a total design discussed above. This complemented SimVision™, which gave a 'bottoms up' view of the task flows, actors, and interdependencies to predict time, cost, and quality (Levitt *et al.*, 1999). These tools fit the culture of the organization, as NASA relies heavily on engineering and computational techniques, especially simulations.

OrgCon™ is an expert system informed by multi-contingency theory. It provides a top-down assessment of the 'fit' between environmental, organizational, and strategic elements. In an OrgCon™ analysis, users input information on the organization's environment and organizational design choices and OrgCon™ computes the fits and misfits between contingencies such as the organization's strategy, structure, incentives, management style, climate, and environment (Burton and Obel, 2004). The OrgCon™ assessment follows eight steps which follow the same logic and sequence as the step by step approach in Burton *et al.* (2011). The first three steps set the stage for the organization analysis. Step 1 begins by identifying the organizational unit for analysis. It could be the whole organization, or only a part of an organization such as a division, department, agency, or team. The organizational unit can be large or small, but it requires a clear delineation of its visions, goals, boundaries, and environment, i.e. what it does, and what is on the inside and what is on the outside. In Step 2, a design team needs to be chosen. This design team includes individuals from the organization who are vital to the design process. It may be the management team or a special design task force, and it may also include some knowledgeable individuals from outside the organization. Implementation must be considered from the beginning; the design team must be able to implement changes or be important to the implementation of changes, resulting from the design process. In Step 3, the organizational design team is briefed by the consultant on the diagnosis and design process, the OrgCon™ technology, and the purpose of the interviews and plenary session. In the first meeting, the OrgCon™ logic is presented and discussed with the design team to develop an intuitive understanding of the diagnosis and design process.

For the NASA organization design team, the first three steps of the OrgCon™ analysis were relatively straightforward. The design team sought to find an acceptable organizational design for the Constellation SAIDT. At a general level, SAIDT was established to perform technical studies and systems analysis tasks in support of the design, development, test and evaluation of Constellation systems. The SAIDT tasks focus on issues and requirements that affect the interoperability of the Constellation systems.

To accomplish these tasks, the SAIDT needed to perform studies that required the technical expertise of personnel from all 14 IDTs staffed from up to eight field centres. Thus, the task for the SAIDT Design Team was to design a cohesive organizational unit that would span these discipline and geographic boundaries to execute the above tasks.

This required the SAIDT chairperson and his core leadership team to identify the personnel requirements, estimate the resources required for the team, and scope the roles and responsibilities of individual team members. In order to facilitate the organization design process for SAIDT, the organization design team needed to develop an understanding of the internal division of work and coordination mechanisms, as well as their likelihood of meeting project goals (time, resources required, and quality). These were design aspects that the DSM did not explicitly address.

The first of three sets of organization design questions related to the best way to draw on the expertise located in geographically distributed field centres. The second set dealt with coordination mechanisms. The third set related to performance. How likely would the SAIDT be able to meet schedule, cost, and quality goals?

In Step 4, the members of the executive group are then interviewed individually by the consultant, using the 68 questions in the OrgCon™ questionnaire. The consultant translates the OrgCon™ vocabulary into concepts and meanings relevant to the particular organization under consideration. The validity of the data inputs depends upon a clear and common understanding of the questions and the meaning of the responses in the current context. Frequently, an individual gains great insight about his/her organization during this query phase of the diagnosis and design process.

The process of developing the baseline OrgCon™ model actually answered the main organization design questions for the SAIDT Organization Design Team, before the simulation itself was run. After discussing these options and developing the model inputs, the

Organizational Design Team (ODT) members decided that in reality, the two main options under consideration —the Core Team (personnel drawn from a small number of field centres) and Distributed Matrix Team (personnel drawn from a wide variety of field centres) were not equally plausible discrete options, given the NASA context. For instance, the SAIDT chairperson recognized that his projects would be temporary, somewhat foreseeable, relatively high priority efforts. In all likelihood, he would have to negotiate with functional line managers in the field centres to get their personnel allocated to his projects. Thus, the Core Team Option where the SAIDT chairperson could simply assign personnel as he needed was not a realistic option.

Since most of the SAIDT work involved studies that looked at issues involving multiple IDTs, the plausible option was a project matrix organization where the study leads would receive direction from the SAIDT core managers. These leads would be located across the NASA field centres. These study team chairpersons would direct their study team members, also located across NASA. The study team members then would answer to the study team chairpersons (for the duration of the study only, typically a few months at most) as well as their local, functional or project manager (who directed them normally).

Since the major organization design choice was made prior to the OrgCon™ analysis, the analysis phase (and subsequent phases) was used to test the robustness of the organization design that had been chosen for SAIDT. In the normal OrgCon™ process, the main analysis of the input data profiles occurs in Step 5. The OrgCon™ software tool is used to analyse each individual profile and then examine the similarities and differences among the input data and the implications for design changes. Step 6 convenes a Plenary Session, which is a presentation to the design team and the executive group of the data analysis and the implications for design changes. Here, there is an emphasis on common understanding of issues and the implications for design and change in the organization. At the same time, differences in interpretation and understanding of the organization and its challenges are highlighted and discussed. The goal is to achieve a common understanding about the organization, its challenges and possible changes for the future. If differences remain they are further analysed, and the outcome is presented to the executive group alone for further consideration and final resolution.

The OrgCon™ analysis process identified the most plausible design option for the SAIDT. In addition, it provided a reassurance that the proposed design would not create contingency misfits. In the wake of the Challenger and Columbia shuttle disasters, NASA was keen to avoid an organization design that permitted the same organizational issues that led to those disasters. In particular, the Columbia Accident Investigation Board report (Gehman, 2003) identified a number of organization design flaws, including unrealistic goals and schedule pressures, lack of adequate oversight, and poor information exchange across a large, distributed organization.

The choice of organization design occurs in Step 7. Based on the results from the Plenary Session decisions are made on strategy and design as well as on the change process. Finally, in Step 8, the details of the lower level organizational design process are usually a bottom-up process. Key people within the various organizational units are asked to design the work processes inside and between the units and the external and internal units.

Phase 3: SimVision™

The SAIDT Organization Design Team next analysed the baseline model, using SimVision™, a system modelling, project design, and discrete event simulation tool (see Levitt *et al.*, 1994, 1999). The Organization Design Team developed a baseline organization structure, a corresponding schedule of tasks and milestones, and a set of programme risk factors. Similar to the OrgCon™ process, the organization design team held review meetings with SAIDT members to develop and validate the SimVision™ models.

SimVision™ is an information processing tool which was first developed by the Virtual Design Team researchers at Stanford University's Center for Integrated Facility Engineering (Levitt *et al.*, 1999) and later refined by ePM Corporation. Similar to DSM, SimVision™ models 'who talks with whom about what' including: project and the task requirements, the actors in the project and their skills, and the communications links for the needed coordination. Levitt *et al.* (1994, 1999) developed SimVision™ using a micro-contingency framework where the best project design is a function of these contingencies. The project elements are the multi-contingencies which must be composed for good project performance. After creating a base model, SimVision is then a platform for experimentation to consider alternative project designs.

The SimVision™ program allows an organizational designer or researcher to specify the tasks, personnel (known as actors), activities, and linkages between them in order to simulate project team performance. SimVision™ is based on the information processing theories of Galbraith (1974), March (March and Simon, 1958; March, 1988), and Simon (1976). SimVision™ views the project team as an information processing and communication system, composed of (boundedly rational) limited information processors (either individuals or groups) who strive to achieve a specific set of tasks. The researcher or manager may specify the decision-making characteristics of the organization (such as high, medium or low levels of centralization and formalization), the number, skill set, and experience levels of actors (or encapsulated teams of actors), and the process workflow (including dependencies between actors or activities). Higher complexity tasks require the actors to cope with increased information processing demands, given finite time and attention. The accuracy of the predictions made by Virtual Design Team (VDT) and SimVision™ have been validated on hundreds of projects in industries ranging from construction, capital equipment, and aerospace through consumer products, semiconductors, and software development (Levitt *et al.*, 1994).

The outcomes of SimVision™ simulations, just like real projects, are intimately dependent upon the specifics of the work process and the organization. The task for the organization designer in practice is to match the information-processing requirements of the task, technology, and environment with the requisite organizational information-processing capacity, both in quantity and in its functional and organizational locus (Burton and Obel, 2004). From prior work (Thomsen *et al.*, 2007; Levitt *et al.*, 1999), SimVision™ has been shown to be a reasonable representation for medium-sized projects (involving between a few tens and about 100 workers and managers) and for technologies that are neither highly innovative, nor extremely mature.

The SAIDT Baseline Model combined elements of a functional and a matrix organization. The initial baseline model (Case 0) captured actors, tasks, and milestones for the SAIDT project. The essence of the tasks and SAIDT deliverables was a cyclical execution of a planned set of complementary engineering analyses and trade studies to characterize the capability and functionality of the exploration system. The Case 0 model is essentially a CPM version of the project that does not include the effects of 'hidden work' such as coordination and rework. The Case 0 model was validated by SAIDT personnel by comparing the SimVision™ schedule and manpower data against the SAIDT Project Schedule. Upon validation that the Case 0 model was accurately representing their planned project, a more articulated and realistic baseline model (Case 1) was developed which incorporated many more details on the actors (skill types and levels, FTEs), tasks (communication and rework links between tasks), and project parameters (such as centralization, formalization, matrix strength, and team experience).

The SAIDT Case 1 Simulation predicted the impact of rework and communication failure on several of the project's original performance objectives. It indicated that the project would likely miss its schedule completion date by two months and require more total work days than forecast. From a quality standpoint, the results were satisfactory. The key result of this effort was the recognition that after adding in realistic project details beyond the CPM model, the simulation demonstrated that the SAIDT team was unlikely to achieve their scheduled completion date. The focus of Phase 3 then was developing an organization design that would be more likely to achieve the performance goals established for SAIDT.

From a macro-contingency theory perspective, the baseline SAIDT organization was projected to perform reasonably well, based on the OrgCon™ analysis. The only misfit occurred between the developmental climate and the high level of organizational complexity. From an information processing viewpoint, however, the baseline model was projected to miss the schedule goals by over two months based on the SimVision™ analysis. As the Columbia Accident Investigation Board Report (2003) points out, schedule pressures, resource constraints, and organizational culture issues such as barriers to effective communication and a lack of a functioning chain of command were all factors in the shuttle disasters. Thus, the Design Team continued the organization design process by considering several alternative designs, seeking to reduce completion time while preserving quality standards and minimizing misfits.

Alternative options explored included adding resources (personnel), limiting the scope of work, and changing the level of centralization (high centralization or high decentralization). The tools allowed the organization design team to explore project organization alternatives, model the proposed changes in OrgCon™ and SimVision™ and assess the likely outcomes. Typically, the alternatives improved project performance in one measure (e.g. time) at the cost of another outcome measure (e.g. cost). The alternatives also produced contingency misfits, highlighting that the complexity of project organizations often do not permit simple changes. A change on one dimension (such as centralization) often creates misfits in other areas, such as working style or managerial preferences.

Lessons and next best steps for project management research

Project organization is an ongoing challenge for managers and executives. Projects are organizations by themselves with all of the challenges of larger organizations. The information processing contingency theory of organizational design has focused more on the larger organization, but not to the exclusion of the project. For projects, we need to expand the design considerations beyond the technical requirements as demonstrated in CPM charts and engage the total project design which includes issues related to the organization's goals, strategy, resources, environment, people, leadership, climate, control and IT and incentives—all issues which have been developed for the total organization. We have discussed the current state of the research; yet this is the future challenge for project organization.

Project organization is fundamentally an information processing challenge to have the right information at the right place at the right time to make a coordinated decision for project efficiency and effective implementation. Galbraith laid out the fundamentals that a balance of information processing needs must be balanced or fit with information processing capacity of the project organization. Burton and Obel (2004) developed the multi-contingency theory of organizational design which incorporates these concepts for the total organization. The micro-contingency theory for project organization has been developed by Levitt *et al.* (1994); they also build their ideas upon an information processing model of organization.

We suggest that the next best set of research challenges for project management is the further development of the context or environment of the project, which includes culture and institutions where the projects are undertaken. This research focus would address a number of topics which need further development.

We suggest that design tools are needed which are future oriented to understand better the world of what might be (Burton and Obel, 2011a). The world of what might be can begin with project managers thinking through the future possibilities; yet we know that experience and intuition as evidenced in the NASA study are limited. Organizational design tools are the intermediary between design theory and project practice. Tools provide the means for better project design. Here, we reviewed the DSM, the OrgCon™ and SimVision™ organizational tools using a real application for NASA as an illustration. These design tools gave NASA the capability to go beyond experience and intuition to design a better project design in a very complex environment. Without these tools, experience and intuition are limited; NASA would have adopted a project design which would have been infeasible by going beyond the project time and budget. Yet, there remains a need and an opportunity to develop other design tools for practice. But we caution that these 'new' tools need to be theory based and validated with project managers and executives. Experience, intuition, and rules of thumb can be the basis of good design, but theory-based design can go further to provide good design—particularly for new and exciting projects which have never been seen before (Burton and Obel, 2011a). It is the new and future projects where theory has its greatest benefit. The multi-contingency model of organization with its questions and design rules to imagine what that future might be and how to operate in it. SimVision™ forces us to think about the more micro-detail and how the project might operate to enhance our understanding and help eliminate costly surprises in novel situations, e.g. where implementation time must be cut by one-half. Simulations of projects are powerful decision aids in the development of projects where the challenge includes extensive analysis of not just what exists but also what might be. The OrgCon™ and SimVision™ are two such design tools. Going beyond these tools, there is a challenge to incorporate global issues as discussed above. Global issues involve multiple projects, firms, nations, laws, and cultures. It is a significant challenge to understand these complex interfaces and what might be simulations of the future that can advance both theory and practice.

Projects are part of the larger organization; each has its own goals, strategy, environment, control and information technology, leadership and climate, resources, and incentives. The fit of the project with the larger organization is not well developed and needs research effort. Burton *et al.* (2011, Chapter 12), outline issues on interorganizational coordination that need greater specification for the project—organization interface. This is a promising area for future research and tool development.

This coordination and interface challenge occurs at a larger scale as well. Projects are always a part of a larger external environment. Going beyond the project—there is the larger environment outside the firm which calls for an examination of project interfaces with its environment (see, for example, the work of the Collaboratory for Research on Global Projects at Stanford University for one promising approach to this research area). Many of today's projects are global, involving many nations where different cultures have deep implications, particularly as coordination is required across norms of behaviour and implicit expectations. These behavioural issues are in addition to the technical issues of the integration of different technical standards.

What do we need; what can we expect? The need for better theory is a continuing challenge and we believe that the information-processing approach provides the fundamental framing for that better theory. Further, design tools provide the bridge to practice; and validation by project managers and executives makes the theory relevant. (Some may argue that research should take the best practice and codify it; but we argue that this works well for a future that is like the past. Our best guess is that is risky, if not wrong.) Can we expect these advancements? The challenge is clear for researchers to advance the theory and for practitioners to support these researchers with their questions, ideas, and validations. This journal is a testament that it can happen.

Notes

1. The Obama administration cancelled Project Constellation in October 2010. However, the project organization design challenges detailed here remain for NASA in its development of new projects.
2. For details on DSM and its application see: http://www.dsmweb.org.
3. Further description of the OrgCon™ is available at: http://www.ecomerc.com.
4. SimVision™ is the commercial version of VDT—the virtual design team. See: http://www.epm.cc.

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