PROJECT MANAGEMENT

QUEST FOR TEAM COMPETENCE
SOFTWARE PROJECT MANAGEMENT
ORGANIZATIONAL CHANGE AS A PROJECT
FACTORS IMPEDING PROJECT MANAGEMENT LEARNING

PROJECT MANAGEMENT ASSOCIATION FINLAND

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Management Across the Organisation

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Keywords: Project Management, Project Business, Project Company, Project-oriented Company, Corporation Management, Organizational Model for Project Management

A major new challenge in projectized industry will be how to organize project-oriented companies that apply projects as their major business vehicles. There is an increasing discussion of how projects relate to management of the company as a whole. The business aspect is emphasized. This editorial provides an organizational view on project management that widely covers aspects of managing corporate business. The organizational model is a new construct that puts project management in place and links it to related management activities in different organizational levels.

Management by Projects

A major new challenge in projectized industry will be how to organize project-oriented companies that apply projects as their major business vehicles (Artto et. al. 1998). While companies develop appropriate practices in project business, other organizations e.g. in the public sector develop either their project level activities to boost their temporary efforts, or whole organization level 'management by projects' related issues. 'Management by projects' as an organization's way to conduct its work and tasks in a project form is discussed in e.g. Turner (1993) and Gareis (1994, 1996).

Managing Business by Projects

There is an increasing discussion of how project management relates to management of the company as a whole. Both industries and the academic community has realized that projects must be linked in a concrete way to their context i.e., to company's strategy and entire management application of the corporation. This trend is reflected by selection of topics in three important events around the beginning of the new millennium: Nordnet'99 conference in 1999 in Helsinki, Finland; IRNOP 2000 conference in Sydney, Australia, and IPMA 2000 world congress in London, England. The whole 'Managing Business by Projects' theme selected for Nordnet'99 conference relates to the organizational business context (Artto, Kähkönen, Koskinen 1999). Similar orientation is reflected by the IRNOP conference interest areas: Global project collaboration; projectized companies; projects and strategic alliances; multi-project contexts; and working life in a projectized society (IRNOP 2000). Further, the management across the organization theme is also present in a stream of the IPMA world congress held in the beginning of the new millennium (IPMA 2000).

Introduction

The rationale for this editorial is to construct a concrete description of the business setting and project management setting in a project-oriented company. The specific discussion is directed to concern project companies that sell and deliver projects to their customers. However, the description can be considered as applicable to any project-oriented organization that conducts at least some fraction of its operations in project form. To provide a concrete basis of which issues project management must concern in order to cover the business in a project company, the paper constructs and introduces an organizational model for project management. The organizational model is a new construct with the purpose of positioning project management and its links to related management activities in different organizational levels.

Project business and management of project companies is a new area with only limited amount of reported studies. The purpose of this editorial is to introduce a new organizational model with appropriate company management issues at different organizational levels. The organizational model constructed enables understanding of different levels and dimensions of project-oriented management applications in corporations. In order to enable an analysis that can be linked to existing organizational levels and responsibilities in companies, the paper uses the basic organizational hierarchy defined in Artto, Kähkönen, Pitkänen (1999), but originally associated with the performance pyramid discussion of Lynch and Cross (1991). The four-level pyramid links strategy and operations by translating strategic objectives from the top down - based on customer priorities - and

measures from the bottom up. At the top of the pyramid, a vision for the business is articulated by senior management. To supplement the organization by projects, the organizational hierarchy is further extended by project processes at the operative level.

An organizational model is introduced that widely covers aspects of managing corporate business. By putting project management in place in the organizational context, the paper simultaneously discusses the diverse more narrow but well-known interpretations of project management content and related applications in companies. In order to supplement the organizational view by including projects to the organizational overview, an extended project process is introduced first. This editorial attempts to extend the perspective on project management from the conventional project management area in many respects.

Existing Definitions of Project Processes

The project management literature introduces different application area specific project processes - or project life cycles (see e.g. PMBOK 1996, Chapman, Ward 1997). The reported life cycles are typically illustrated by project processes that range from project initiation to project closeout. The perspective is often limited to effective management of project execution only. Many project companies follow the well-known project execution context by choosing development of project execution related procedures as primary targets for project-oriented business development. Development of project execution and project management is often justified as development of core procedures for manufacturing the concrete final deliverable that is finally handed over to the customer. However, for a project company that sells and delivers projects to their customers, just mere development of project execution or project management does not suffice. The wider business-oriented perspective on project process development is discussed in the following. Further, an organizational model of a project company is elaborated. Despite the specific discussion concerning project companies, the organizational model can be considered as applicable to any project-oriented organization that conducts at least some fraction of its operations in project form.

Extended Project Process

Adopting wide business-oriented perspective on project process is essential in any project company. The wide - or extended - perspective on project process can be illustrated by a process context covering pre-project phases related to project sales and marketing and post-project phases related to after-sales services (Artto et. al. 1998). Figure 1 illustrates such extended project process that covers the project sales and marketing and after sales services related phases relevant for the business context. Figure 1 also illustrates the project management process - as defined by current project management standards (ISO 10006 1997, PMBOK 1996) - positioned as a parallel management activity for the extended project process. The figure shows the interpretation of project management limiting itself to effective management of project execution only, excluding management of pre- or post-project phases associated with project sales and after-sales services.

Figure 1 emphasizes the feature of linking the extended project process tightly to the management of the organization unit as the owner of the project process. This feature is essential for any project company or other multi-project environment where projects serve as vehicles for the organization's operations. The full or partial ownership of the project process in the organization unit requires that the organization unit applies management processes that support effective management and opera-

tions at the project level. Concerning this supportive and direction setting role subjected to the unit's project portfolio, recording experiences from project processes and learning become important issues. Figure 1 illustrates in a simplified manner by arrows the dissemination of experiences from the project process to the organization unit for learning. However, the interrelation between the project process and the organization unit is not a one-way street only: Although there are no arrows back to the project process from the organization unit drawn in Figure 1, the organization unit level processes must be designed to distribute experiences from previous or parallel projects to the project process. Such distribution might occur in the form of company policies or instructions, guidelines, or suggestions for appropriate for project related procedures.

In order to adopt a wide learning loop that enables dealing with issues that related to the actual purpose of the project, the customer interface plays an important role. Linking of the project to customer's business is essential. The customer interface is better understood if the extended project process is adopted instead of using the traditional more narrow project execution oriented definition for project life cycle. The extended project process includes the project sales and marketing and after-sales services phases where the actual use of the purchased project product is the major issue. Accordingly, it is likely that the most relevant experiences for
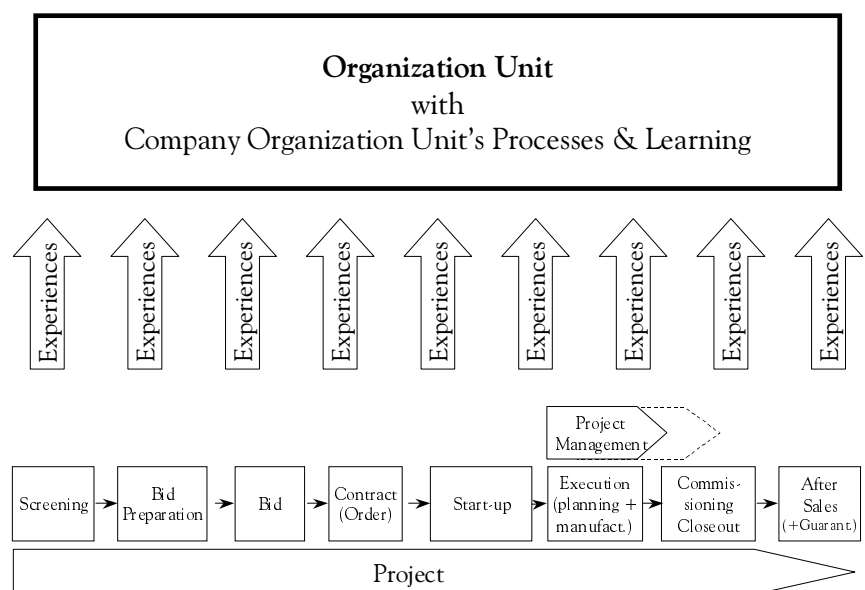
Figure 1. Extended Project Process with Links to the Owner Unit

learning purposes are available in the sales and after-sales phases of the project (or project product) where the project's purpose is considered in terms of customer's business.

Extended Organizational Hierarchy with Issues for Objectives and Measures

Project management relates to management of the company as a whole. The purpose of the following discussion is to enable an analysis that can easily be linked to existing organizational levels and responsibilities in companies. For this purpose, we start our analysis - to be continued in the following sections - by referring to performance pyramid illustrated by Lynch and Cross (1991). The performance pyramid is shown in Figure 2. The four-level pyramid links strategy and operations by translating strategic objectives from the top down - based on customer priorities - and measures from the bottom up. At the top, a vision for the business is articulated by senior management. At the second level, objectives for each business unit are defined in market and financial terms. The pyramid illustrates the principal relationships between lower level objectives to marketing and financial goals of business units at the second level: market measures are supported by both customer satisfaction and flexibility, and financial objectives are supported by flexibility and productivity. At the lowest base level of the pyramid, objectives are converted into specific operational criteria of quality, delivery, cycle time, and waste for each department. An operational control system of business operation systems must be based on tightly defined linkage between their objectives and measurements at the local operational level. The elements of this linkage are found in the four principal local operating performance criteria of quality, delivery, cycle time, and waste.

Kaplan and Norton (1996) provide the Balanced Scorecard management framework where the process starts in a analogous manner with the senior executive management team working together to translate its business unit's vision and strategy into specific stategic objectives. The Balanced Scorecard framework objectives and measures view organizational performance from four perspectives: financial, customer, internal business process, and learning and growth. Referring to AICPA (1994), Kaplan and Norton (1996, pp. 39-40) recommend that companies should adopt a more balanced, risk management oriented and forward-looking approach: "To meet users' changing needs, business reporting must:

- Provide more information about plans, opportunities, risks and uncertainties
- Focus more on the factors that create longer-term value …
- Better align information reported externally with the information reported internally …"

Extending the Organizational Structure by Projects

Figure 3 illustrates the performance pyramid in parallel with hierarchical organization structure. The performance pyramid shows the relevant management issues for each level of the organization. The organizational hierarchy is further extended by project processes. The basic message of the figure is to provide a view on which issues (or what kind of issues) are to be managed at which levels.

External delivery projects and other projects are basically owned by organization units. The ownership of projects is marked in Figure 3 by arrows that link the project process to the organization unit. The arrows indicate the organization unit where the project belongs to. The arrows also indicate simultaneously the organization unit where the profit of an external delivery project is accumulated to.

Artto (1998) develops the management accounting frame-
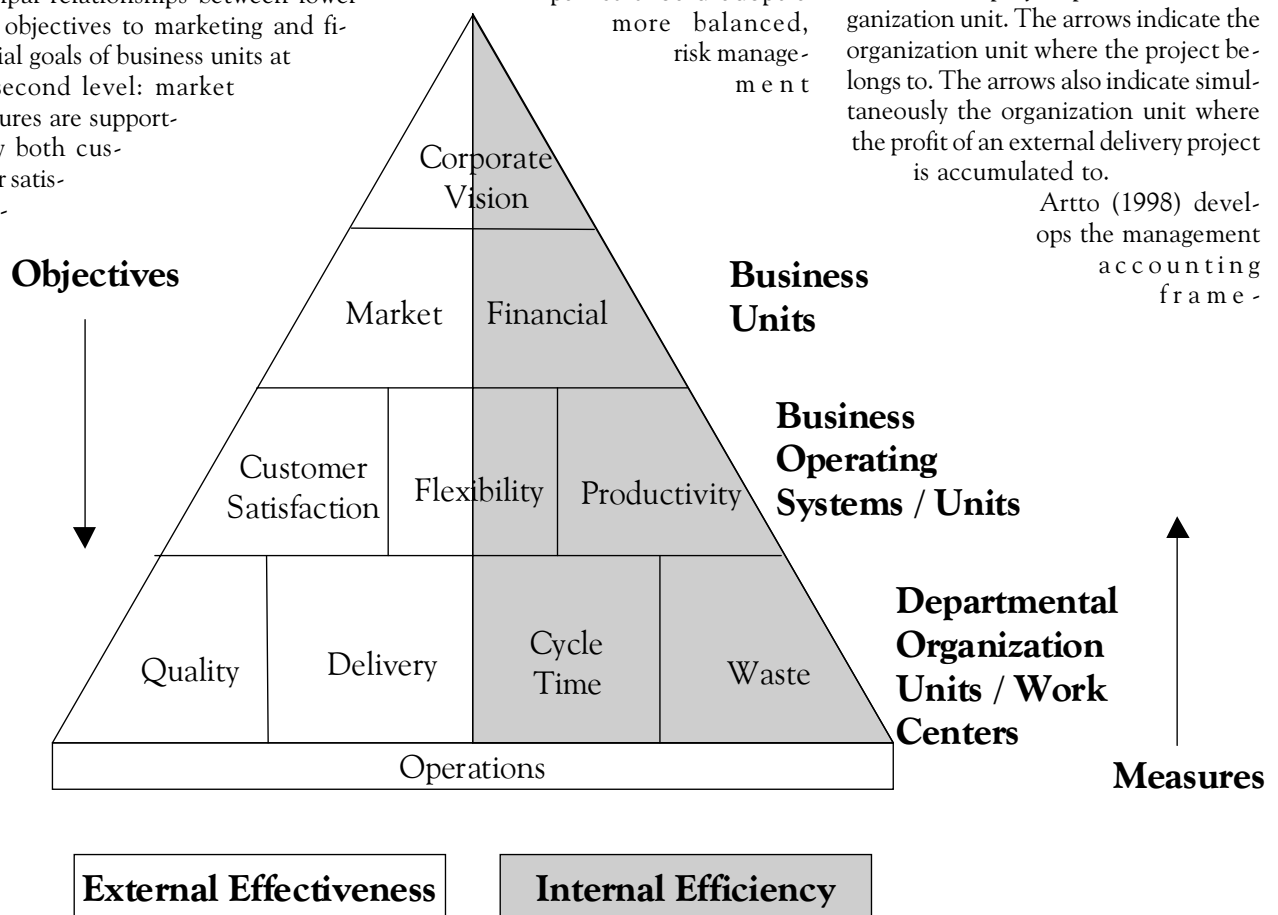
Figure 2. Performance Pyramid

work of a project company further; In the framework, projects are the basic structural building blocks for recording both costs and sales income. Company and business unit specific income statements can be derived by aggregating project income and cost information to organization units.

Project Portfolios

The project management discussion related to project contexts has mostly focused on managing single projects. As there are an increasing number of organizations - e.g. project companies - with several projects in their production lines, widening of the project management perspective to concern such a multi-project environment, is important in the future. Managing projects in a multi-project environment automatically refers to management of project portfolios - and not just management of single projects separately.

There are not many studies on project management developments associated with project portfolio aspects in the company. This is due to the fact that project management discipline concentrates on successful execution of single projects. Another reason is the fact that project business and management of project companies is a new area,

and there are only few publications in this area.

As far as the project management associated with project portfolios is concerned, there might be several aspects in analysing and making strategic choices associated with projects at the company or business unit level. For example, for a project company operating in international markets, the country and area specific local risks are important to take into account. The country risks affect not only one single project in the specific country or area, but the whole portfolio of bids and projects in that area. For example, for analyzing local creditworthiness of different project portfolio areas of a project company, Institutional Investor (see Shapiro 1997) provides global country credit ratings and analysis for ca. 135 countries, and separate ratings for North America, Eastern Europe, Western Europe, Africa, Middle East, Asia-Pacific, and Latin America.

In addition to particular geographical regions, also customers, product types, lines of business, or other important aspects may serve as criteria against which project portfolios should be considered. For example, Kaplan and Norton (1996, p.60) provide an example of Metro Bank that chose a finan-

cial objective to increase the share of income arising from fee-based services not only for its revenue growth potential but also to reduce its current heavy reliance on income from core deposit and transaction-based products. Thus, an objective to broaden revenue sources associated with different project portfolios served both as a growth and risk management objective for the whole business.

Bidding

Risk management associated with bidding provides an additional activity that can have an important relationship to the early pre-project management phases. Bids represent potential or hypothetical projects that pose some probability of becoming a business contract. The following discussion about bidding and adopting a wide business perspective is adopted from Artto and Hawk (1999).

As such, risk arises in two forms: there is a threshold risk associated with the likelihood of getting the order from the client, and then, if ordered by the client, there is the risk inherent in project execution. As is generally known, the probability of getting the contract can be easily increased, by lowering the bidding price and profit expectations, but this can also raise the prob-
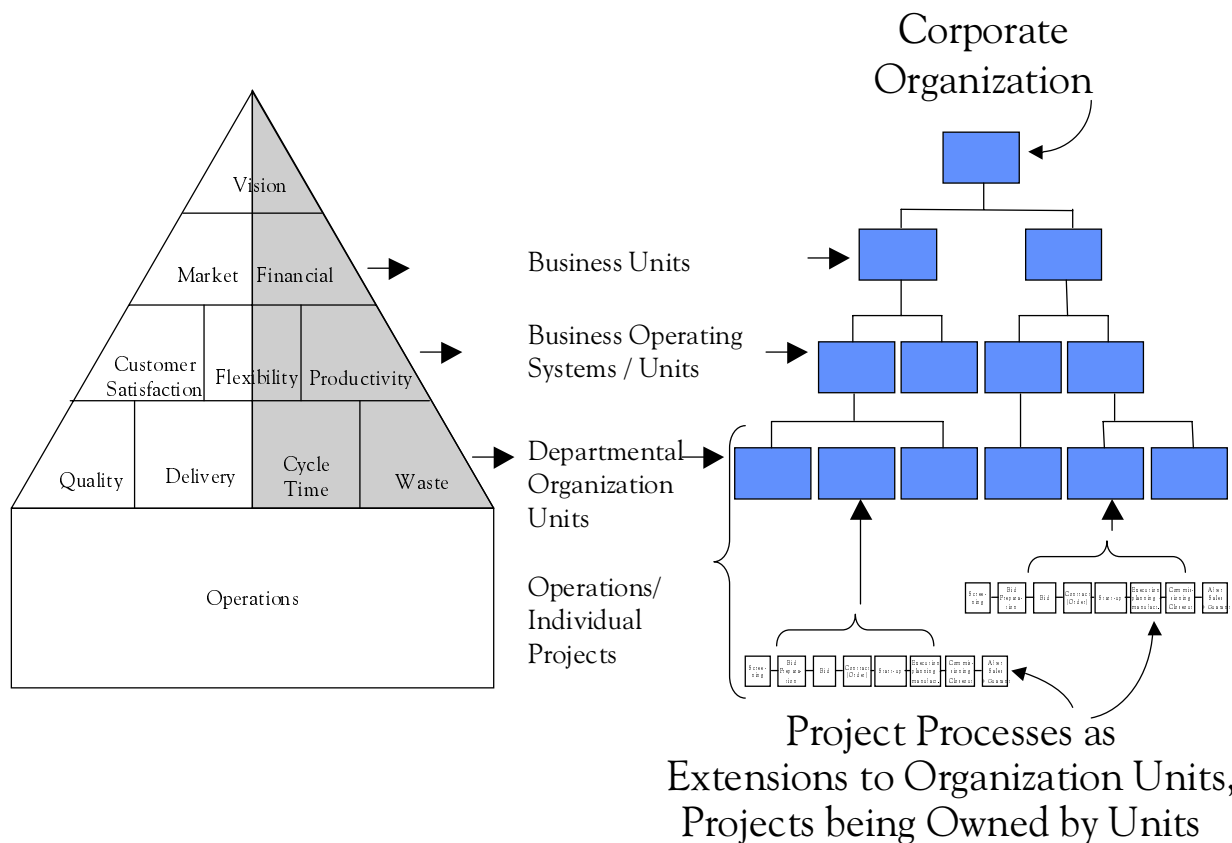
Figure 3. Extension of the Organizational Structure by Projects

ability of project failure in meeting financial and technical objectives. On the other hand, it is possible to find areas of potential cost savings due to new technologies and other innovations, which are theoretically encouraged in low bid strategies. Thus, the two apparently forms of risks are in fact closely tied to each other in the performance and execution of the project.

It is important to keep this connectedness in mind in the management of bidding activities as there are also important relationships between contingencies, contingency strategies, and strategic decision making as it is associated with the bid becoming a profitable project. Project simulation and project models can be helpful tools to support risk management in the pre-project phase.

Project simulation and project models are helpful supports to risk management in the bidding and pre-project phases. The management of whole pool of bids in a systematic way requires recording of bids based on bidding databases that provide information reflec-

tive of profit and risk expectations, as well as the likelihood of getting the contract. An additional dimension is seen in bid-related considerations that arise from future business prospects with the customer in question. Such information can assist decisions regarding level of effort and types of measures appropriate to selling a project. This also helps decisions as to which resources are appropriately reserved for execution of future projects that currently have only a bid status.

Finally, having a more comprehensive view of bidding and risk in the very early phases of a project requires considering the feasibility of a single project in light of the potential for future business. Figure 4 illustrates the project as viewed in a wider business-oriented context starting from pre-bid considerations. The important message in the figure is on emphasizing bidding in general and pre-bid phases as those relevant points in project sales and marketing. It should also be noted that this helps in consideration of the potential in a project's contribution to future busi-

ness as a whole. We should be reminded that only success with customers on the long run can guarantee a chance for successful project deliveries in the future. This takes us to the importance of finding an appropriate attitude for post-project - or after-sales - phases, where continuous customer care plays an important role. Appropriate customer care and good references from customers brings in new opportunities for future project delivery orders. It is often helpful for project companies to adopt the principle that customers are being managed instead of just projects.

Conclusions

To provide a concrete basis of which issues project management must concern in order to cover the corporate business perspective, this editorial constructed and introduced an organizational model for project management in company context. An extended project process was illustrated first. The extended process covers the project sales and marketing and after sales services related phases. The extended project process view

WIDE BUSINESS PERSPECTIVE, EFFECTIVENESS IN BUSINESS

WIDE BUSINESS PERSPECTIVE, EFFECTIVENESS IN BUSINESS

EFFICIENT PM

Pre-bid Phase   **Bidding Phase**   **Project Execution**   **Customer Care**   **Future Business**

Start-up   Execution   Closeout

Considerations of How the Potential Project would Contribute to Future Business

Considering the Customer as the Major Risk/Success Factor for Business

Success with Customers on the Long Run Guarantees Successful Project Deliveries in the Future

Manage Customers, not Projects.

Figure 4. Adopting a Wide Business Perspective

is relevant for adopting a wide view over the business context.

Project business and management of project companies is a new area with only limited amount of reported studies.

In general, the novelty of the discussion in this editorial lies in the following aspects. The literature on project management does not provide any analogous wide organizational management level framework. Project management literature and standards do not define similar extended project processes with sales and after-sales aspects clearly included to emphasize the business context. Instead, the implicit suggestion in project management literature is that project management processes would be applied in the execution of the project rather than putting the project management to the management context as a whole. In any successful project company, projects should strongly relate to phases of doing business with projects by selling and delivering them with appropriate customer care, rather than just executing projects efficiently.

For development of project business in a project company, it is essential to adopt a wider perspective where both the organizational context of the company organization is considered, and the project process is extended to include all project phases relevant for selling and delivering projects to customers.

From the project business viewpoint, learning from experiences and project failures for future projects is important: Knowledge transfer among projects should be guaranteed.

The management discussion related to project contexts has mostly focused on managing single projects. As there are an increasing number of organizations - e.g. project companies - with several projects in their production lines, widening of the project management perspective to concern such a multi-project environment is important in the future. This automatically refers to management of project portfolios - and not just management of single projects separately.

Concerning project company's activities, bids represent potential or hypothetical projects with some probability of them turning into a contract. As such, risk arises in two forms: there is a threshold risk associated with the likelihood of getting the order from the client, and then, if ordered by the client, there is the risk inherent in project execution.

A more comprehensive view of bidding and risk in the very early phases was presented, where the project was viewed in a wider business-oriented context starting from pre-bid considerations. The important message was to emphasize bidding in general and pre-bid phases as those relevant points where a project's contribution to future business as a whole must be considered. Further, besides considerations and decisions made in the bidding phase, also continuous customer care at post-project phases plays an important role for future business. It is often helpful for project companies to adopt the principle that customers are being managed instead of just projects.

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Quest for Team Competence

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Keywords: Project Management Competency, PMC, Team Competence

This paper reviews recent developments in project management competency (PMC). The evolution of Competency Movement is briefly traced to that of managerial competency. Much of the research surrounding project manager competency has its roots in managerial competency research. Generally, many of the authors who write about PMC suggest that if competency is improved, then the likelihood of project success is also improved. However, one area that has been neglected is that of team competence. It is the project team that performs the majority of project work yet has been neglected in much of the project management research.

Introduction

Project management is an evolving discipline where its participants are increasingly interested in the competency of its project managers (Kerzner, 1996; Morris, 1998). Some have related project management competence to project management effectiveness (Crawford, 1998); and project success (Jiang et al. 1996; and Lechler, 1998). However, project management competence research has been narrowly focused on project management skills - such as communication - and on the competence of the project manager. Soft competencies like traits and behaviors of both individuals and the team as a whole have received very little attention.

Competence

Many disciplines are concerned about competence. The engineering profession is concerned with improving the skills of its graduates as they enter the workforce (Anonymous, 1994, Ledsome, 1994 and Nelson, 1994). As well, business knowledge and skills like Total Quality Management and Just In Time practices are increasingly important to engineers (Hutchin, 1992). Engineers are also working toward maintaining and improving the professionalism of their discipline through competency-based qualifications (Lloyd, 1994). The engineering profession has recognized the importance of competence and is very active in its development.

Other disciplines, such as medical services are also working to improve the competency of their members. Many health care managers are interested in improving their knowledge and skills in the use of medical information systems (Mordue, et al. 1997). Technical personnel such as diagnostic medical sonographers are representative of the health care profession interested in competence (Curry, 1997, and De Lange, 1997).

Managerial Competence

One of the disciplines that has a long history of studying competence is that of business and management. Scientific management focused on task efficiency (Taylor, 1911, and Gilbreth, 1911). McClelland's research was on the achievement motive which can lead to superior performance (1961). The competence motive was identified by White refers to man's capacity to interact effectively with his environment (1959). Boyatzis (1982), and Spencer and Spencer (1993) rigorously studied managerial competence. They presented a multidimensional model of competence that goes beyond simple skills and knowledge.

Competence has been related to a firm's competitiveness (Nyhan, 1998), achieving the organisation's objectives (Tate, 1997), successfully dealing with change (Dingle, 1995), improving the firm's competitive advantage (Lei, 1997, and Hogg, 1993), and improving the organisation's performance (Martin, et al., 1994). Besides linking competence to outcomes, many have suggested that competence theories can be applied to improve human resource management processes.

When competence is understood by those in the firm, they can use this understanding to guide recruitment, skill assessment and development activities (Rowe, 1995). Human resource allocation decisions can be based on whether considered competencies are core to the strategic direction of the firm (Lepak et al. 1999). The firm can also use competency-based assessment methods to better understand required competencies (Boyatzis, et al. 1995, Guinn, 1996, and Chiu, et al. 1999). Many have recommended that training could be improved if linked to competence (Denton, 1995, and Strebler, 1995). Others have implemented competency-based compensation systems linked to achieving business objectives (Ashton, 1996) or competencies displayed (Jahja, et al. 1997).

While competency-based human resource management has gained momentum, it is not without its critics.

Some have suggested that managerial performance can not be adequately measured; and since the measurement of managerial performance is based on competence, competence-based human resource management is fundamentally flawed (Robotham, et al. 1996). Competency-based management development has been criticized for the possibility that it encourages conformity in the managerial ranks (Macfarlane, et al. 1994). The Competency Movement has also been criticized for not being context sensitive to different business strategies (Munro, et al. 1994) and ignoring the social context in favor of the technical component of work performance (Mansfield, 1993). Jubb and Robotham recommend that it is time to stop competency-based training and re-evaluate its approach (1997). Others have suggested that managerial competence research has been narrowly focused, fragmented and confusing (Stuart, et al. 1997). However, one of the most serious criticisms might be that the competence focus has been on manager skills and technical knowledge. Others have shown that technical knowledge and skills are but two characteristics of the multidimensionality of competence (Boyatzis, 1982, and Spencer, et al. 1993). Thus, while there seems to be great promise from implementing competence-based human resource practices, there are many hazards as well.

There are many parallels between business and project management research. Leadership, teamwork, success, risk, alignment and communication are some of the topic areas that have been examined by both project management and business researchers. However, business has long been looking at competence and those in the project management community only recently have begun to research competence.

Project Participant Competence

Competencies are commonly used by organizations and others to help guide decision-making regarding its human resources. Some simply define competence as skills plus knowledge (Brown, 1993). Parry suggests that a competence is a group of related knowledge, skills, and attitudes that influences performance (Parry, 1996). Ayer and Duncan (1998) expand the definition of competency to refer to a single specific, observable behavior or characteristic that

leads to superior performance. Boyatzis (1982) adds to the concept of competence the individual's motives, traits, and one's self-image or social role. Spencer and Spencer define competency as an "underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation" (1993, p. 9). (Criterion referenced implies that the competency actually predicts performance which is measurable and objective.)

The Infancy of Project Management Competence

Currently, there is very little rigorous research surrounding project manager competence. (Notable extant exceptions include Blackburn, 1998; Crawford, 1998; Morris et al. 1998, and PMI, 1999a). Lynn Crawford is in the final stages of a major research project to determine, among other things, competency profiles and competency standards for effective project personnel (Crawford, 1997). However, much of the practitioner literature surrounding project management competence is simplistic, anecdotal or theoretical. We do not know which competencies are most important for task performance and project success. One can only come to the conclusions that project management competence is not well understood. Further, the necessary competencies required for excellent performance by project participants, instead of the project manager, have not yet been identified and validated.

Competence is not only multidimensional, but also its focus and philosophical underpinnings can also be divergent. Blackburn (1998) delineates competence into two movements: behavior and standards schools. Both schools differ in their focus, purpose and orientation. Others write about a "qualified project manager" (Goldsmith, 1997) or the "capability" of an organization's people (Curtis et al. 1997).

Modeling Project Management Competence

One very simplistic model of project participant competence uses a familiar input-process-output framework (Skulmoski, 1999). While it is recognized that such a model likely does not portray the complexity of project participant competence, it provides a structured model to begin understanding project human resource allocation con-

siderations. The benefits of input-process-output frameworks for analysing human resource allocations for the firm have been recognized elsewhere (Grinold, et al. 1977, and Correa, et al. 1999). One can assess competence of others or one's self by examining inputs, processes and outputs. Input competencies are extremely varied and include knowledge, skills, traits, motives, self-image, social role, and behaviors.

Specific knowledge may be contained in AACE International's Certification Study Guide (AACE International, 1998) or in PMI's PMBOK Guide (Project Management Institute, 1999b). Certification from either of these organizations demonstrates that the candidate has acquired specific knowledge and skills related to cost engineering and project management respectively. Skills may include the ability to determine the critical path(s) in a network.

A trait is a characteristic way in which a person responds to a set of stimuli (Boyatzis, 1982). For example, people who believe they have control over their future have the trait of efficacy. In projects, when these people encounter a problem, they take the initiative to discover solutions. They do not wait for someone else to fix the problem or expect luck to take care of it.

Motives, on the other hand, drive behavior (Boyatzis, 1982). For example, people who are motivated to improve or compete against a standard are said to have the achievement motive. When people with a high achievement motive are given measurable objectives in the project setting, they are more likely to work to achieve the objectives.

Another dimension of competency is a person's self-image (Boyatzis, 1982). This refers to a person's perception of himself or herself. A self-image of competence will likely facilitate a person's work in a novel project even though the person has not previously performed the task. Social role is a person's perception of the social norms and behaviors that are acceptable to the group or organizations to which he or she belongs. Professionalism, punctuality for meetings, and preparedness are all behaviors that may be required by the norms of a particular project team. Thus input competencies are varied, multi-dimensional and broader than simply skills and knowledge.

Process competencies have been extensively examined in the project

Manage Time

Element	Performance Criteria
Develop Project Schedules	The duration and effort, sequence and dependencies of tasks are determined from the output of scope definition and with input from appropriate stakeholders, as the basis for the project schedule.
Manage Project Schedules	Ongoing analysis is conducted to identify and forecast variances and trends and to develop responses to achieve project objectives.

Table 1.

management discipline. Many have commented on the nature and use of particular processes which contribute to project success (Gareis et al. 1998; van Onna, 1998; and, Thamhain, 1998). Both the AACE International's Certification Study Guide and the PMI's PMBOK Guide contain processes which contribute to project success. Examples of project management processes include planning, controlling and closing a project (van Onna, 1998).

Outputs make up the final dimension of project management competence. Sattler and Neights call for performance-based project management competencies but do not provide assessment metrics (Sattler et al. 1998). Outputs can include project performance metrics such as budget and schedule compliance and project success criteria like customer satisfaction. An additional dimension is added to this model: contingency variables. Contingency variables are factors (i.e. project size, technical complexity, public visibility, etc.) that may affect which competencies are most likely to have the greatest influence on successful outcomes (Duncan, 1998).

Perhaps the most developed output-based competency standards are those developed by the Australian Institute of Project Management (AIPM, 1996). These standards contain, among other data, performance criteria which specify outcomes that demonstrate

competent performance. Table 1 illustrates a partial list of performance criteria for time management (AIPM, 1996). The assessor then determines whether there is evidence the candidate displays or has displayed the required performance-based competencies.

For example, the candidate would be required to prove that he or she involved the appropriate stakeholders to develop the project schedule. Thus the focus is on performance rather than on the acquisition of knowledge or the ability to follow a project management process. Performance-based competence is promising but lacks empirical support. That is, we do not know which performance-based project management competencies contribute most to project success. Lechler (1998) has concluded that project activities such as planning and control have a relatively small influence on project outcomes when compared with the human side of project management. Therefore, more work is required to better understand performance-based project management competencies.

The Project Management Institute is currently researching competence in their Project Management Competence project lead by Dr. Janet Szumal (PMI, 1999a). The purpose of this project is to develop a framework that will help direct project managers in their professional development. The framework will detail the clusters of

knowledge, skills, abilities, and other personal characteristics that are likely to be relevant to most, if not all, types of projects. A Preliminary Project Manager Competencies Framework (Figure 1) has been provisionally developed and is in the process of being validated (Szumal, 1999).

Project manager competencies may include, but are not limited to skills, knowledge, attitudes, abilities, behaviours, and personality. The project manager's competencies are influenced by past experiences (such as life experiences, formal education, training and work experiences). These competencies then influence project manager task performance. Project manager performance is the degree to which expectations are met regarding the project manager's responsibilities, duties and functions. Project performance includes outcomes such as customer and stakeholder satisfaction, goal achievement, quality of deliverables, and team leadership and direction. The strength of the relationship between task performance and competencies are mediated by contingency variables (for example project size and complexity). This framework is very much influenced by the work of Boyatzis (1982), and Spencer and Spencer (1993). What is unknown is if this project manager competence model will be appropriate for the project participant.

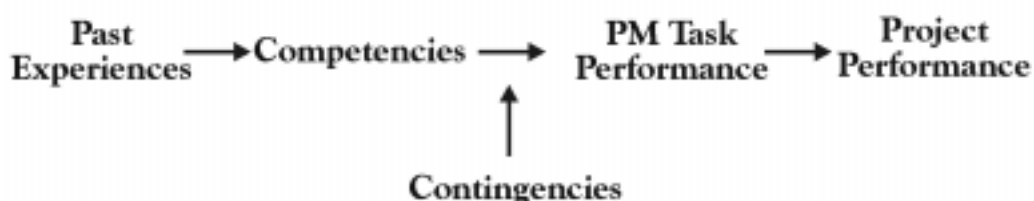## Preliminary Project Manager Competencies Framework

Figure 1.

Certification

Many professional organizations related to project management offer competence-based certification programs. The AACE International is a good example of a professional organization that has a well-established certification program. The purpose of any professional certification program is to provide recognition of the capabilities of an individual in a professional area. Certification from AACE International "indicates demonstrable expertise in the most current skills and knowledge of cost engineering." (AACE International, 1998) The Project Management Institute (PMI) also has a certification program similar to that of the AACE International (PMI, 1999c). The Association for Project Management is a UK based organization dedicated to the advancement of the project management discipline that also has a certification program: Certified Project Manager (APM, 1998).

Finally, there are the Australian National Competency Standards for Project Management. Project participants can become certified at one of three levels of project management competence (Australian Institute of Project Management, 1995). The major difference between the Australian project management certification and others is that the Australian model assesses performance or outcomes that demonstrate competence. The other models assess inputs such passing a certification examination on some specific body of knowledge. There is increasing interest in output competencies and certification based on performance (Sattler et al. 1998). Clearly, understanding output competencies better position the practitioner to deliver successful projects. Project management competence is like dentistry: a patient is not as concerned whether the dentist has the best tools or methods. Instead, the patient is most concerned about outcomes: that the toothache has gone away. Project management competence is a global concern where many national professional organizations certify its members. One question that has not been thoroughly answered is which competencies most contribute to project success? Another question that needs to be answered is does existing certification schemes signify true competence? As well, which competencies should be reflected in a project man-agement participant certification scheme?

Practical Issues

Above we have discussed the issues around certification and competence, as discussed in the literature. Little of this material deals directly with individuals who work in a project team, but are not - or do not see themselves as - part of the project's management. So we need to consider two issues: What does project management competence mean in practical terms, then what does this mean to the members of a project team?

Practical Issues of Competence

There seems to be a clear pattern in the literature surrounding the definition of project management competence that is emerging. The trend is towards a balance of knowledge and output-based competence. Some of the knowledge and output is based on process. Based on this extrapolation, and with some minor reshuffling, we can see that there is a need to address three components.

- Tools to help manage a project well

- Processes that allow us to pick the right tools and use them effectively

- Knowledge (experience and learning derived) that provides the safeguards against failure and promotes more reliable success.

This three-part model is consistent with the elements seen in established and regulated professions such as medical doctors, engineers, lawyers and accountants. In these professions, induction is based on distinct steps that start with rigorous "technical" education. Following a grounding in the theory - usually but not exclusively developed through a university based education at the bachelors or masters degree level - there is an internship period in the workplace. During this time the budding professional learns the processes and gains the wisdom needed to practice independently. Finally there is a test of some sort. This final stage varies in intensity and focus from one profession to another and between jurisdictions or countries. The end result is that the profession typically polices its membership through admission following a rigorous training program. It then normally is self-managing in terms of on-going competence and professional development, as well as conduct of the profes-sion itself. There is no direct or comparable equivalent in project management today.

The practical implication of this is that, in the absence of such a rigorous standard, we need to define competence at different levels. These levels are currently being influenced to a large extent by interests of established practitioners who may be disenfranchised by a certification model similar to other professions in its rigor. This means that the lowest common denominator is often the default standard. The term standard here is used loosely, as few formal ones exist. None exist internationally, few (notably Australia through AIPM, United Kingdom through APM and United States through PMI) exist at the national level and there are a number of standards or policies within companies.

The current situation is fragmented. This is being addressed by a group of researchers and practitioners at the international level. Many of the experts in this field identified above are participants. With the successful establishment of a baseline or benchmark for assessing competence of the project manager, we will have a basis on which to develop the competence needs for individual members of the project team. Some of these competencies can be identified without such a foundation on which to build, as we can use the extensive body of knowledge that exists on team effectiveness and other aspects of project and business management.

Competence for the individual project team member

The competence of team members can be considered from two perspectives. One view is of the skills needed for effective project team performance. The other view is from the practical application of project management principles to real projects.

Highly effective teams need seven ingredients to achieve exceptional levels of performance. These seven elements are based on empirical observation in the implementation of SMART Project Management on over a hundred projects. The implementation was based on use of a set of tools for project management combined with a series of processes designed to concurrently plan the project and build the team. Supplementary knowledge was used in a workshop style to add awareness of common project planning and delivery problems.

Note the three elements of tools, processes and knowledge that this contained.

These seven elements for effective teams are as follows:

1. Open communication: this is all about not hiding agendas and ensuring that there is enough information available to the team members for them to be able to fully contribute to the project.

2. Ownership of work: this attribute has to do with leadership style and the empowerment of the team. Specifically, the individual team members need to have a degree of control over the work they do, and some influence on the methods to be used.

3. Risk-taking: a propensity to take risk allows team members a degree of freedom that enables other critical things to take place. One aspect of this is that problems in delivering the project belong to the whole team, not one person or group within the team.

4. Creativity: this is the ability to solve problems with minimal restriction. The competence here is one that starts with the project sponsor or owner who needs to define the objectives of the project in terms of what is to be achieved and what the problem is, not what the solution is and how to arrive at the solution. This is partly a cultural shift and partly one of process and partly an issue of awareness by the owner and the project team.

5. Fun: this is all about recognition, reward and management of stakeholder expectations.

6. Tribalism: the best teams have their own code of behavior, hierarchy, traditions, language and other tribal attributes.

7. Trust: this is the confidence of individual team members in each others capabilities and in the team's commitment to the success of the project as well as the ability to rely on each other during the delivery process.

Implementation of effective project management with project teams on these numerous projects has always been more effective where the entire team has had the benefit of training in certain key elements of project management. The objective of this training has been to achieve the following:

1. A common language

2. Shared understanding of what the project is to achieve and what the management of that project entails

3. Basic planning skills

4. Basic risk management and mitigation skills

5. Project administration and reporting needs

6. Alignment on how the team will develop any other needed skills

7. Awareness of what each specialist or function contributes to, and needs from, the rest of the team and the success of the project.

Generally, when this training was provided to the entire core team for the project (completed over two or three days), the teams and their projects were consistently successful. There was no consistency in the results on the teams where this basic training was not provided. A discernible correlation between consistent success and training with the above seven objectives was noted.

Conclusions and Recommendations

The competence of a team is far more complex that this paper might suggest. The paper serves two purposes. First it identifies and provides a framework to consider the need for team competence in project management as well as the need for such competence by management. Second, it identifies at least at a cursory level, the type of competence that might be needed to improve the reliability and predictability of a successful project.

Significant effort is still needed to determine what project management competence entails. There is a need too, to extend this to understanding the need for project management competence at the team member level, as there is some need to train or educate all team members. The extent to which project management competence needs to percolate to individual members of a team is not understood. This need arises out of the requirement to balance effectiveness of the team with the cost and time required for the necessary skill training needed to achieve it.

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Applied Project Risk Management - Introducing the Project Risk Management Loop of Control

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The purpose of the article is to present an alternative comprehensive concept for performing project risk management in large-scale projects, and to demonstrate its application through examples in a hypothetical case. The case argues that risks can be managed by the suggested concept, leading to lower costs and shorter implementation for all parties and thereby increasing the credibility of international project management.

Introduction

Within the project environment many companies perform a sort of risk analysis that tend to be more crisis management of risks as they occur. A lack of adequate project risk management is a fact in many large-scale projects. International projects are full of risks. Risks can only be prevented by identifying their sources and managing them systematically. Risk elimination is a prerequisite.

The article deals with the application of a concept named the Project Risk Management Loop of Control. The aim of this article is to present a comprehensive and workable concept for project risk management techniques and demonstrate their application in a real international project management environment. The advantages of using the Project Risk Management Loop of Control are:
- Baselining for a systematically work approach.
- Controlling critical risks.
- Ensuring use of experience.
- Exchanging information between project participants.

Achievement of the advantages above are illustrated in a case study. The application of the methods in the project Risk Management Loop of Control is related especially to international projects that transfer process know how, equipment design and plant engineering from a domestic company to an overseas project environment. Even though the article describes the application of the project risk management in an international construction project, it can be applied to other complex and large-scale projects as well.

The paper describes the phases of the concept Project Risk Management Loop of Control (PRM Loop of Control), and how it can assist management in better decision making. The aim of the concept is to prevent risks from actually happening. Further, if risks occur, the model assists management with a systematic approach for reducing and controlling risks.

Figure 1. Project Risk Management Loop of Control

The Project Risk Management Loop of Control

The development of the PRM Loop of Control is based on an analysis of previously published risk management processes (Chapman,1997, Del Cano and de la Cruz, 1998, Godfrey, 1996, Isaac, 1995, Murray, 1998, Wideman, 1992, Turner, 1993). The PRM Loop of Control is a comprehensive model consisting of simple and applicable methods (Elkjaer, 1998). The PRM Loop of Control illustrates a dynamic and continuous process. It is a process where risks are continuously reassessed until they are prevented, reduced or accepted. The PRM Loop of Control, illustrated below in Figure 1, can be divided into four different phases: identification, assessment, response, and monitoring.

It is recommended to perform a PRM Loop of Control at the end of each project stage or when required by major change of circumstances. A natural part of a beginning of a new stage, say site mobilisation, is a new round of risk identification, assessment etc. as dictated by the PRM Loop of Control.

The Identification phase

The first phase of the PRM Loop of Control is identification of potential risks. The identification phase is the most critical to a successful risk management approach; risks that are not detected can not be managed.

There are some basic techniques for identifying risks. Interviewing key project staff and specialists is one of the obvious methods that can indicate where problems or unwanted events are hidden. Another well-known technique is brainstorming and creativity. Through workshops the project group reach a list with potential and current risks. An other method is the using of experience of similar projects.

Checklists are valuable for covering all areas in a project environment. There are many checklists available (Turner, 1993, Zhi, 1995, Lichtenberg, 1989). In order to apply risk management in project management it is important to classify and characterise risks in such a way, that users are provided with a unified classification system that facilitates appropriate communication and decision making.

The checklist below in Table 1 is based on experience from international overseas construction projects. The

Table 1. Checklist

MAIN GROUP	GROUP CLASS	CATEGORY
A. PROJECT	1. TECHNOLOGY	1.1 Raw material quality
		1.2 Packing materials
		1.3 Proces technology
		1.4 Quality Assurance
		1.5 Safety
		1.6 Environmental Protection
		1.7 Process Equipment
		1.8 Auxillary Equipment
		1.9 Transport Eqipment
		1.10 Utility Supply & Equipment
	2. PROJECT	2.1 Location & Plant Site
		2.2 Access to raw materials
		2.3 Access to utilities
		2.4 Availability of operating staff
		2.5 Availability of maintenace staff
		2.6 Logistics for plant operation
		2.7 Marketing & distribution of finished product
		2.8 Project Finance
		2.9 Project Approvals & Permits
		2.10 Other Project Risks
B. PARTNERS	3. OWNER/ OPERATOR	3.1 Shareholders
		3.2 Management
		3.3 Project Management
		3.4 Technical Management
		3.5 Financial Management
		3.6 Market position
		3.7 Financial position
		3.8 Change Readiness
	4. CONSULTANTS	4.1 Ownership
		4.2 Management
		4.3 Project Management
		4.4 Technical Competence
		4.5 Industry Competence
		4.6 Technology Experience
		4.7 Local Experience
	5. SUPPLIERS/ CONTRACTORS	5.1 Ownership
		5.2 Management
		5.3 Financial position
		5.4 Project Management
		5.5 Technical Competence
		5.6 Industry Competence
		5.7 Technology Experience
		5.8 Local Experience
	6. CONTRACTUAL ISSUES	6.1 Contract enforcement
		6.2 Scope of work
		6.3 Design requirements and approvals
		6.4 Equipment requirements and specifications
		6.5 Variation procedure
		6.6 Installation approval
		6.7 Precommissioning procedure
		6.8 Commissioning scope & procedure
		6.9 Acceptance testing scope & procedure
		6.10 Warranty obligation & procedure
		6.11 Documentation requirements
		6.12 Process guarantees
		6.13 Payments & security
		6.14 Time schedule
		6.15 Liquidated damages
		6.16 Contractual risk allocation
		6.17 Disputes & settlements
		6.18 Codes & standards
		6.19 Other:
C. POLITICAL-ECONOMIC	7. PROJECT COUNTRY	6.1 Political Situation
		6.2 Economic Situation
		6.3 Labour Situation
		6.4 Legal Situation
		6.5 Industry Situation
		6.6 Logistic Situation
		6.7 Market of Finished Product
		6.8 Construction Industry
		6.9 Codes and Standards
	8. REGIONAL FACTORS	7.1 Political Situation
		7.2 Economic Situation
		7.3 Labour Situation
		7.4 Legal Situation
		7.5 Industry Situation
		7.6 Logistic Situation
		7.7 Market of Finished Product
		7.8 Construction Industry
	9. GLOBAL FACTORS	8.1 Energy Supply/Prices
		8.2 Raw Material Supply/Prices
		8.3 Financial Situation
		8.4 Process Technology
		8.5 Market of Finished Product
		8.6 Competition

structure of the checklist is based on the literature (Klakegg, Lichtenberg, 1989, Zhi, 1995). Each group in the checklist is divided into categories. For each category a number of questions has been formulated in order to reveal potential risks. Further analysis based on questions will in such case confirm or negate the existence of risks. The risk potential only disappear when it can be ensured by a solution to the question.

The Assessment phase

Risk can be quantified through a separate assessment of probability and impact. The standard perception of quantification is that probability multiplies impact result in the risk level (Wideman, 1992). The risk level can be measured in quantified or qualified units. The PRM Loop of Control suggest a simple procedure for quantifying. A subjective assessment of impact and probability in either linguistic degrees and/ or a rating in percent or monetary units can be used. The suggested degrees are listed below in Table 2 and 3 in five categories and the conversion to quantified units is also shown to assist the assessment.

No.	Linguistic degree	Quantified unit
1	Unusual	0-1%
2	Most rare	1-2%
3	Rare	2-5%
4	Moderate	5-10%
5	Frequent	>10%

Table 2. The probability scale

No.	Linguistic degree	Quantified unit
1	Marginal	<10% of CM
2	Serious	10-50% of CM
3	Most serious	50-100% of CM
4	Critical	100-500% of CM
5	Catastrophic	>500% of CM

Table 3. The impact scale. (CM stands for Contribution Margin)

For selecting the most important risks, risk mapping is a practical tool. The risk mapping is illustrated below in Figure 2. The identified risks are assessed in two dimensions and the scales refer to the degrees in Tables 2 and 3. The risk mapping figure outlines suggestions for risk strategies.

The Response phase

The purpose of the response phase is choosing a risk strategy. The four possible risk strategies are briefly discussed below (Godfrey, 1996, Isaac, 1995,
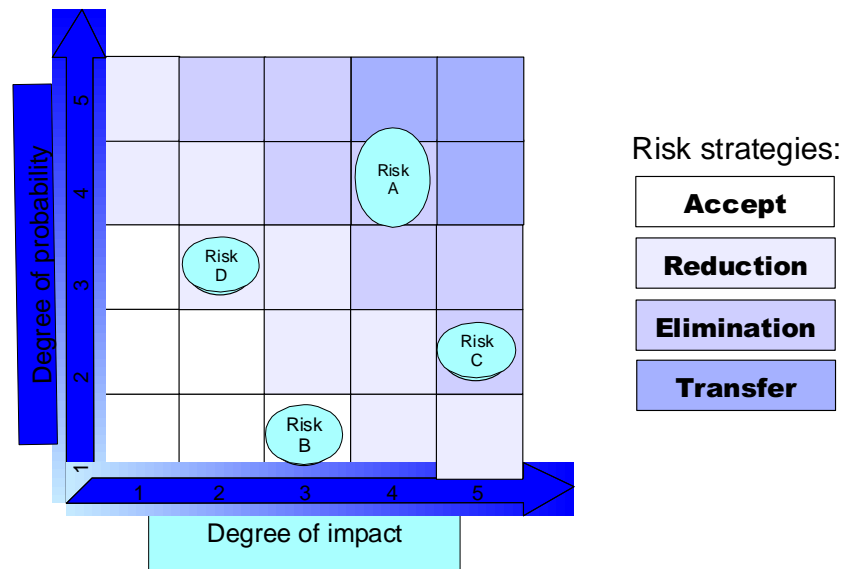
Figure 2. Risk mapping

Murray, 1998, Wideman, 1992, Turner, 1993).

Acceptance

When accepting a risk one normally does nothing because the costs of elimination are too prohibitive or the likelihood or impact of a risk is too small. Acceptance should only be chosen if impact is relatively insignificant. When accepting a risk the response is normally to make an allowance for it by adding a contingency in the budget or in time schedule.

Reduction

Reduction or mitigation requires immediate action that will either reduce the likelihood or the potential impact. One has to consider the cost of the reduction compared to the savings or benefit in doing so.

Elimination

Elimination means total removal of risks. If a risk is unacceptable i.e. it must never happen because of its impact, then prevention is essential. It is usually not cost ef-

fective to completely eliminate a risk. For elimination as well as reduction action plans are made in order to prevent the risks from influencing the project in a negative direction.

Transfer

Transferring risk is the last option. Passing risks on to other parties are typical done in the contractual phase, where risk management can help in defining who are most capable of managing a specific risk. Transferring risks does not necessary mean, that they are reduced or properly handled. Hence, the risk manager must not assume that those risks are out of business.
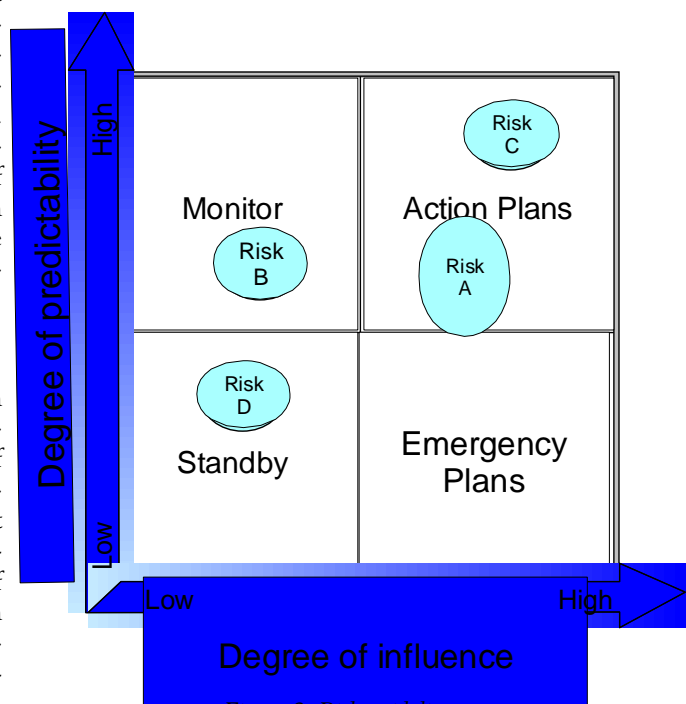
Figure 3. Risk guidelines.

There are two dimentions in choosing an appropriate attitude to the risk (Elkjaer, 1998). The first dimension is the degree of predictability. Some risks are impossible to predict i.e. it is unknown where and when in the project, they might occur. The second dimension is the degree of influence, which means that project managers have different degree of influence to control the risks. For instance a risk can be very difficult to handle because it is not within each own scope, and therefore the degree of influence is low. The two dimensions are integrated and four guidelines for responding to risks are then possible. The Risk guidelines are illustrated in Figure 3 with random placed risks.

Stand by

Stand by means that the project manager can do little to prevent the risk occurring. It is the worst and a most intolerable situation. There are basically two options for the project manager. Either to accept the situation, because the impact is low or increase influence by negotiation and/or increase predictability by further investigation.

Monitor

Monitor seems to be a passive response, however it is important to observe when and where risk could occur. Risks in the monitor area have a low degree of influence either because no one can influence them or because the influence rests with another party. Any possible precaution to reduce the impact should be considered. In the case of influence resting with another party risk preventing negotiations are a possibility.

Emergency Plans

With emergency plans influence is possible, but predictability is low. These are often called "Plan B", because they represent an alternative plan for an unusual situation. Emergency plans have a contingency character and are only implemented if certain events occur. If possible predictability should be improved, whereby the risk is moved towards the action plan area.

Action Plans

For risks that can be influenced and which are highly predictable, a proactive approach is possible. Therefore the PRM Loop of Control concept suggests use of action plans - in case of such risks.

The essential in managing impor-
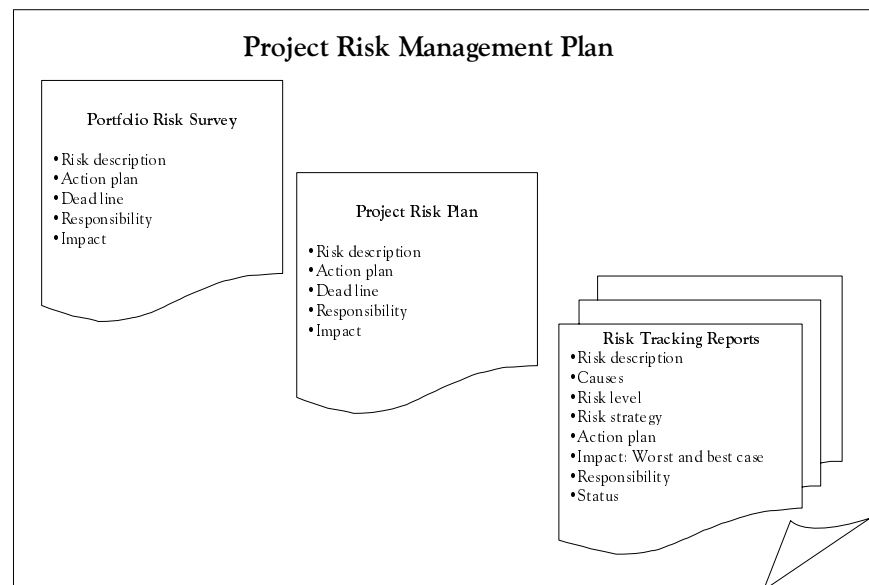
Figure 4. Project Risk Management Plan

tant risks is to clarify those risks that can be managed proactively and those risks that are not manageable. Risks that are placed in the monitor or emergency plan areas ought to be managed either by making risks more predictable, or making them more possible to influence.

The Monitoring phase

The last phase of the PRM Loop of Control is monitoring. By monitoring risks are documented and continuously reassessed in order to ensure proper action for prevention. Therefore the responsibility is defined for each risk. In the monitoring phase the most important issue is to keep up an updated plan for the potential risks. The plan is called the Project Risk Management Plan. The plan should be designed in consistence with the elements in every phase of the PRM Loop of Control. The project risk management plan can consists of three documents, which are the Portfolio Risk Survey, the Project Risk Plan and Risk Tracking Reports. The project risk management plan is illus-

trated in Figure 4 below:

The portfolio risk survey should be reviewed monthly at executive management meetings based on the information from project managers. An example of the portfolio risk survey is illustrated in Table 4 below.

The project risk plan is a project manager tool for monitoring the significant risks at project level. It is prepared by the project manager and should be reviewed monthly at project status meetings. The structure of the project risk plan is related to the portfolio risk survey.

For more information about specific risks, reference is made to Risk Tracking Reports. These are made for the most important risks. The reports follow risks through the project life cycle until they are adequately reduced or out of business. Table 5 illustrates an example of a risk tracking report.

The level of documentation needs to be carefully considered. For simplicity the project risk management plan contains only at the maximum of five risk tracking reports depending on

Project	Action Plan	Deadline	Responsibility	Expected Financial Impact	Reservation/contingency in Approved Accounts/Budgets

Table 4. The Portfolio Risk Survey

Project name/no./country/location	....
Client/enduser/consultant	....
Contract reference/value/contribution margin/completion date	....
Project Risk	....
Risk cause(s)	....
Risk strategy & relation to other Risks	....
Action plan/deadline/responsible	....
Present situation	....
Next action	....
Worst case expected financial impact(ΔTurnover, ΔCost, ΔCM; each year)	....
Best case expected financial impact(ΔTurnover, ΔCost, ΔCM; each year)	....
Prepared by/date/signature	....
Circulated/copied to (names & dates)	....
Reviewed at meeting/approved by (names & dates)	....

Table 5. The Risk Tracking Report

the scope and complexity of the project, and only those risks are continually revised and reconsidered at management meetings. An overview of the critical risks is documented in the project risk management plan.

An important part of the monitoring phase is the opportunity to transfer experience from one project to another. The action plans could be documented in a database. The documentation can be valuable for the next projects where similar problems might occur. By doing so the PRM Loop of Control becomes a dynamic tool for continuous improvement of the portfolio of projects and hence the whole organisation.

Case Study

The case study is hypothetical. However it is based on real project experiences (Felding and Kristensen, 1992). The risks presented are realistic for an international plant project. The parties are experienced and possess a rational attitude to risk management. The case description follows the below mentioned project stages and each situation emphasizes the different phases of the PRM Loop of Control.

- Project Development & Tendering (1. situation)
- Engineering & Procurement (2. situation)
- Construction (3. situation)
- Commissioning & Acceptance (4. situation)
- Operation & Maintenance (5. situation)

1. Situation: Project Development & Tendering

A medium-sized Danish food manufacturing company has decided to establish a baby food factory in Latvia in order to benefit from the cheap and abundant milk supply and to profit from the emerging Baltic Countries markets.

The project enjoys support from the Government and the authorities of Latvia. The Danish Baby Food Producer (DBFP) has made a feasibility study showing a sufficient cash flow and profit based on certain assumptions of the markets in the Baltic countries and on the assumption that export quality can be assured in production.

A local Joint Venture partner (with 50% ownership) has been identified and has participated actively in the studies and market research. Project financing is in principle in place pending the signing of the joint venture agreement. Consequently, the chairman of DBFP, who has been promoting the project with authorities and finance institutions, is very eager to get board approval at a forthcoming meeting in order to sign the joint venture agree-

1. PROJECT:

1.1 Scope of project: Plant for Baby Food production & marketing of 5.000 tons per year.
1.2 Investment: USD 18 million in Process and Utility Equipment and Buildings on Government leased land (30 years).
1.3 Profitability requirement: ROI after tax 12% after 5 years.
1.4 Time schedule:
    1.4.1 Design, construction & commissioning: 2 years.
    1.4.2 Local market penetration: 2 years.
    1.4.3 Production reach full capacity: 4 years.
1.5 Location: Industrial Estate of Riga

2. TECHNOLOGY:

2.1 Raw milk from farms and whey from cheese production.
2.2 Skimming and pasteurising
2.3 Demineralisation & vitamin adding
2.4 Evaporation & Spray drying
2.5 Blending & Packing

3. PARTNERS:

3.1 Danish Baby Food Producer Ltd. (in J-V with 3.2)
3.2 Latvian Milk Marketing Ltd. (in J-V with 3.1)
3.3 J-V: Danish-Latvian Baby Food Ltd. registered in Latvia

4. CONTRACTORS:

4.1 United European Food Process Engineering (UEFPE)
4.2 Riga Building Contractor

5. COUNTRY & REGION:

5.1 Population in Latvia: 2,5 million inhabitants.

Table 6. Case study facts

ment immediately. This will enable DBFP to close the project financing and order the basic design leading to tendering of building works and equipment supply. In Table 6 the case study reference facts are presented.

Risk identification

The managing director of DBFP realises that, although the project development has been smooth and quick, there are still potential risks involved in this large and first investment abroad. He also realises that there is more than 2 years of hard implementation work ahead. Consequently, he decides to prepare a risk analysis to be presented at the board meeting. At that meeting the board is scheduled to approve the joint venture agreement and the commitment of USD 1 million financing charges, design fees and other costs.

As small working group is formed to make a proper risk analysis of the project. Project Manager is asked to prepare the concept and checklist for the risk identification. The group decides to mark all risk categories with one of the following risk indications for probability and impact: low, medium or high. The replies reveal one common feature, namely a clear bias towards many low risks, few medium risks and hardly any high risks. Some of the participants realise that this method gives a wrong and too optimistic risk assessment because lack of detailed knowledge of the whole project and insufficient project experience to identify the potential risks and assess them objectively. It is realised that objective risk identification check-questions have to be formulated and answered in each category in order to get a more objective assessment. In Table 7, one category is further investigated.

Risk assessment

The three "No" in Quality Assurance reveals potential and serious risks as product quality is a very sensible issue for all products in general and for baby
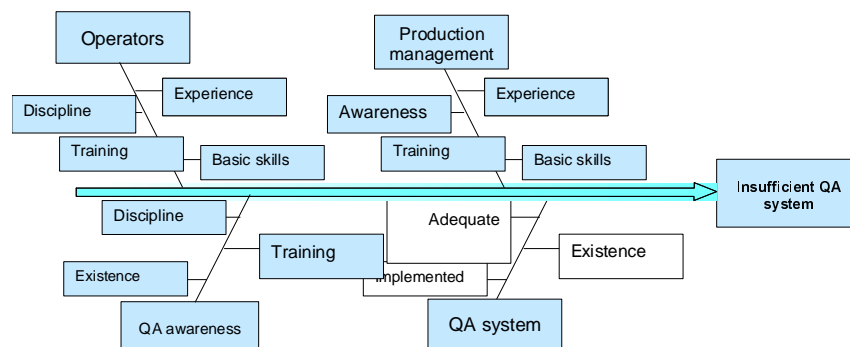
Figure 5. Cause and Effect diagram for Quality Assurance in production

food specifically. The following cause-effect diagram is drawn:

The cause-effect exercise reveals that the QA system is not adequate or sufficiently implemented and that operators are short of training and experience in the QA system. It is concluded that the risk probability is frequent and that the risk impact is catastrophic.

Risk response

It did not take a long argument to conclude that DBFP wants the risk to be eliminated beforehand, i.e. before commercial production starts. Consequently, the project manager and technical director are instructed to prepare a proper action plan to eliminate the risks

Risk monitoring

Requirements for approval, responsibility, action plans and reporting are agreed and documented in risk tracking reports and in the project risk plan for follow-up at monthly project status meetings.

Finally the managing director of DBFP can prepare his report to the board recommending the signing of the joint venture agreement. The recommendations is to proceed with the signing the joint venture agreement closely monitoring the progress on QA. Because he has a feeling that there might be other potential risks not yet identified he requests the whole risk analysis to be repeated in connection with management quarterly reports to the board.

The risk management plan will be reviewed at each monthly project status meeting.

The example demonstrates the necessity to perform a comprehensive risk identification and assessment as early as possible, and to close the loop by a renewed risk management plan.

2. Situation: Engineering and Procurement

After the Board approval and signing of the joint venture agreement the partners proceed with the tender procedure for the two major contracts, i.e. the process design and equipment supply contract and the building works contract. This situation deals with the award and of the process design & equipment supply contract from the contractor's point of view.

Three major suppliers of baby food process design and equipment are invited and their proposals are basically the same. They all accept the stipulated time schedule of 20 months. Although building works are not included in their scope of work the tender documents require the equipment contractor to co-ordinate building works with equipment installation to secure timely completion in 20 months.

In this situation the case study focuses on one of the suppliers, United European Food Process Engineering (UEFPE) called for the final round of negotiations in Riga.

The UEFPE sales manager in charge initially believes that he can talk his way out of an obligation to supervise building work. Thereby UEFPE avoids being solely responsible for its timely completion by instead promising a range of advisory services as planning and co-ordination free of charge. But he fails as the joint venture firmly requires the equipment contractor to take full turn-key responsibility for timely completion of building works as required by tender documents.

CATEGORY	RISK IDENTIFICATION CHECK-QUESTION	ANSWER (YES/NO)
3.5 Quality Assurance	3.5.1 Operator knows required standards?	NO
	3.5.2 Operator familiar with fulfilling & controlling standards?	NO
	3.5.3 Operator already has trainable staff?	YES
	3.5.4 Training programme for operator staff sufficient?	NO

Table 7. Risk Identification Questionnaire. Part 3 Owner/Operator. Cat. 3.5, Quality Assurance

CATEGORY	RISK IDENTIFICATION CHECK-QUESTION	ANSWER (Yes/No)
5.1 Ownership	5.1.1 Ownership stable?	Yes
5.2 Management	5.2.1 Management structure stable?	Yes
	5.2.2 Will relevant executives stay in office until project implemented?	No
	5.2.3 Have relevant executives past experience in similar projects?	No
	5.2.4 Do you know relevant executive personally?	Some
5.3 Financial position	5.3.1 Contractor Company profitable last 5 years?	No
	5.3.2 Contractor Company solidity above 50% after project?	No
	5.3.3 Contractor Company liquidity sufficient to cope with project?	Yes
	5.3.4 Contractor Company profitable after project implemented?	May be
5.4 Project Management	5.4.1 Project Management structure stable?	Yes
	5.4.2 Project Manager has past experience in similar project?	No
	5.4.3 "Assistant" PM can take over in case?	Yes
5.5 Tech. Competence	5.5.1 Sufficient basic technical competence existing?	Yes
5.6 Industry Competence	5.6.1 Contractor has references in this industry?	No
5.7 Tech. Experience	5.7.1 Sufficient applied technology competence existing?	Yes
5.8 Local Experience	5.8.1 Contractor has references in this country?	Yes
	5.8.2 Contractor has sufficient control of labour situation?	May be

Table 8. Risk Identification Questionnaire for Building Contractor

Risk identification

The new development is discussed with head office. After a short debate of the qualifications of the selected building contractor, management agrees to go ahead and in principle accept that UEFPE takes charge of building work progress on behalf of the joint venture owner, on the condition that joint venture accepts to sign a special agreement outlining the powers of UEFPE's project and site managers in this respect.

Sales manager and project manager are requested by management to prepare a risk analysis of the performance of the building contractor to be discussed and approved before any formal commitment is made. The risk analysis of the building contractor contains the following questionnaire in Table 8 filled in by sales manager and project manager.

The detailed analysis of the answers show the following weaknesses of the building contractor:
- Management has not yet adjusted to the change from the socialist central planning system to a market driven capitalistic system.
- As a result of above point the management structure and positions might change al-though no specific replacements can be foreseen.
- Profitability has not yet been firmly established although a small profit was made last year. The contractor's financial basis is still weak.
- In the socialist central planning system the contractor's main task was millitary construction work. The contractor has since then gained some experience in industrial building work, but has no experience in construction of high quality food plants.
- The labour market in the area is volatile and characterized by shortage of skilled construction workers, high staff turnover and many workers going abroad for better paid work.

The above 5 weaknesses lead to the following 4 main risks: management instability, financial weakness, lack of food industry experience and insufficient labour resources.

Risk assessment

The above risks are assessed in Table 9 according to Table 2 and 3. The equipment contractor UEFPE performs the assessment as if direct contract relation existed.

RISK	PROBABILITY	IMPACT	COMMENTS
A. Management	Rare (3)	Marginal (1)	Management changes are normally not as bad & risky as they look
B. Finance	Rare (3)	Critical (4)	This is by experience very critical for construction performance
C. Experience	Most rare (2)	Serious (2)	The will to learn advance ability
D. Labour	Moderate (4)	Most serious (3)	This is by experience critical for construction performance

Table 9. Risk assessment of Building Contractor

The risks are placed in Figure 6 in consistence with their impact and probability.

As seen in Figure 6 it is the labour and finance risks that have the highest risk level and therefore priority must be given to reduce these risks.

Risk response

The four risks are assessed according to the degree of influence and predictability and placed in Figure 7. Risk A is placed in the monitor area because the degree of influence is relatively low now the building contractor has been selected. Risk B is rather difficult to influence, so it is placed in the standby area, whereas risk C can be influenced by delegating supervisors on site assisting the building contractor's own staff. Therefore it is placed in the emergency plan area. As a precaution the project manager prepares an action plan of delegating overseas labour (risk D) to site if required. The labour authorities in Latvia are resisting such a plan but can accept a few working supervisors. However, the project manager maintains his plan.

Risk monitoring

UEFPE Management decides to review the performance of the building contractor at UEFPE's monthly project status meetings based on reporting from its site manager. Included in this report should be observations about the local building worker's employment situation.

Furthermore it is decided to strengthen the site team by employing a senior building construction supervisor.

Finally, the management agrees with the project manager's proposal to authorise that the equipment contractor UEFPE can delegate an assistant construction manager to work in building contractors site organisation free of charge in order to improve progress.

3. Situation: Construction

11 months later construction is almost completed and precommissioning testing has started. The parties are mobilising for commissioning and operation. Unrest among the 725,000 Russians living permanently in Latvia increases and becomes violent. The Latvian authorities still have the situation under reasonable control, but the plant site is unfortunately situated in a mostly Russian community experiencing riots from
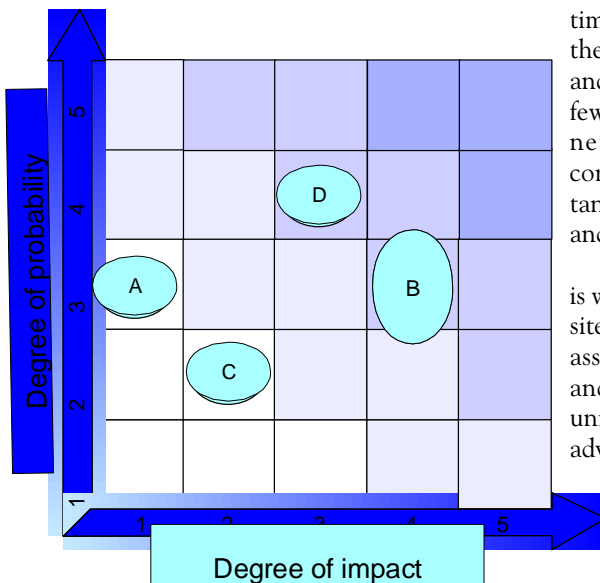
Figure 6. Risk mapping for building contractor
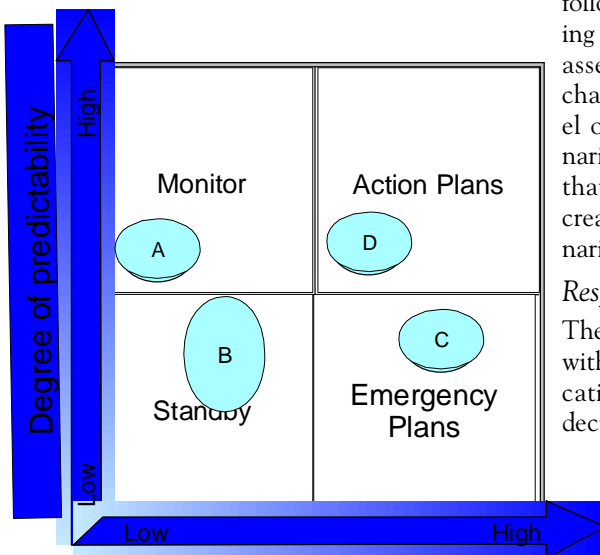
Figure 7. Risk Guidelines for Building Contractor
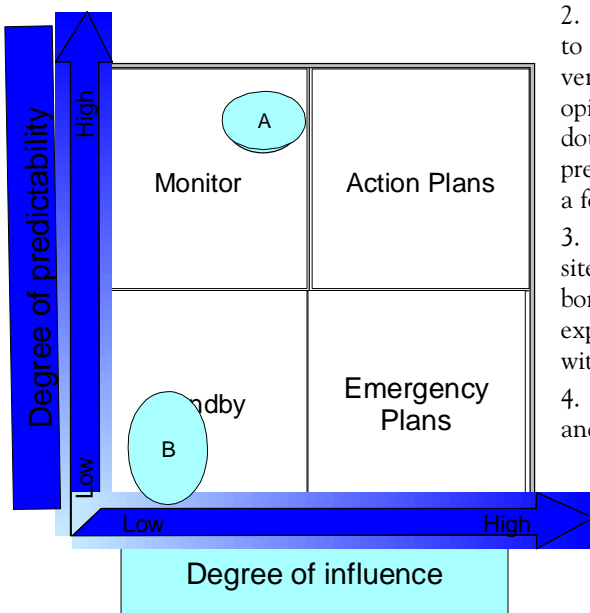
Figure 8. Risk Guidelines for unrest scenarios

time to time. Consequently, the expatriates from UEFPE and DBFP feel unsafe and a few replacements are imminent. Furthermore, new commissioning staff is reluctant to be stationed in Riga and work on site.

UEFPE Management is worried and requests their site manager to identify and assess the risks for UEFPE and its staff caused by the unrest. Site manager takes advice by the company's representative in Riga.

Identification and Assessment

The summary of the site manager's report is the following two tables describing two risk scenarios. They assess that there is a 6/10 chance that the present level of unrest continues (scenario A) and a 4/10 chance that the level of unrest increases to civil rebellion (scenario B).

Response and Monitoring

The project manager agrees with the above risk identification and assessment and decides to implement the following action plan subject to UEFPE management's approval:

1. Implement recommendation by site manager.

2. Notify "Force Majeure" to the client, the joint venture, although a legal opinion concludes that it is doubtful whether the present situation constitutes a force majeure situation.

3. Strengthen security on site and introduce a risk bonus of +30% for UEFPE expatriates after discussions with DBFP.

4. Visit Riga and discuss and "double-check" security and evacuation plans.

5. Daily site situation reports by site manager to project manager.

The project manager presents the reports and his action plan to management at its weekly meeting. Figure 8 shows scenario A (present unrest level) in the monitor area and scenario B (civil rebellion) in the emergency plan area. After a detailed discussion of the situation, management decides to approve the action plan. Management wants to follow the situation closely by receiving a daily site situation report and if required ask the project manager to attend weekly meetings.

4. Situation: Commissioning and Acceptance

The civilian unrest did not escalate and installation was only delayed by a few weeks. Pre-commissioning is now in progress and expected to be finalised in 2 weeks. Commissioning has correctly been notified and is scheduled to start shortly. The previously approved commissioning plan with a manpower requirement schedule is the basis for commissioning.

DBFP Project Manager finds out that the Latvian joint venture partner, LMM, is not able to staff the plant during commissioning with the stipulated number of staff already trained. The shortage of local operating staff is real and caused partly by internal promotions within LMM's organisation and partly by resignations caused by salary differences with new private companies.

Risk identification

The Risk Identification is rather simple because it is obvious that the risk is caused by insufficient operator recruitment. The volatile labour market could nevertheless have been predicted earlier.

Risk assessment

The joint venture has a clear obligation to provide 5 operators per shift during commissioning; altogether 15 operators. Only 10 trained operators are available and this shortcoming is a most serious risk for the full commissioning program. Joint venture proposes to adapt the commissioning program to the number of operators available but UEFPE refuses. The commissioning program is necessary for proper testing, adjustment and optimising of the plant in operation. UEFPE is willing to provide the missing 5 operators for an extra cost of USD 20,000 per man-month.

Risk scenario/risk factor	Probability	Effect on Site	Recommendations
1. Utility supply interrupted	5%	Reduced level of commissioning	No recommendation
2. Raw material supply interrupted	5%	Reduced level of commissioning	Building up stocks of raw material
3. Packing material supply interrupted	5%	Reduced level of commissioning	Building up stocks of packing material
4. Majority of local staff/workers absent	10%	Reduced level of commissioning	Replace local staff with expats
5. Distribution of finished products interrupted	15%	Can stop commissioning	Building up stocks of product also in temp. storage
6. Expert staff's welfare/safety jeopardised	10%	Expats leave site	Provide facilities for board & lodging on site
7. General site safety situation jeopardised	5%	Can stop commissioning	Emergency & evacuation plans prepared

Table 10. Site Manager's report on unrest situation;
Scenario A (unrest continues at same level)

Risk scenario/risk factor	Probability	Effect on Site	Recommendations
1. Utility supply interrupted	20%	Half level of commissioning	No recommendation
2. Raw material supply interrupted	10%	Half level of commissioning	Building up stocks of raw material
3. Packing material supply interrupted	10%	Half level of commissioning	Building up stocks of packing material
4. Majority of local staff/workers absent	25%	Half level of commissioning	Emergency commissioning program/few expats
5. Distribution of finished products interrupted	30%	Can stop commissioning	Building up stocks of product also in temp. storage
6. Expert staff's welfare/safety jeopardised	25%	Expats leave site	Provide facilities for board & lodging on site
7. General site safety situation jeopardised	10%	Can stop commissioning	Emergency & evacuation plans prepared

Table 11. Site Manager's report on unrest situation;
Scenario B (unrest increases to civil rebellion)

Risk response

The joint venture decides to accept UEFPE's proposal for 3 operators, whereas LMM makes an extra effort to recruit 2 locals going through a crash training programme. As a precaution DBFP delegates one experienced operator from its plant in Denmark. Commissioning can then go ahead.

Risk monitoring

The joint venture now decides to improve risk monitoring by preparing and reviewing risk tracking reports. Table 12 illustrates sample of a risk tracking report .

Furthermore, a project risk plan summarising the important risks, the related action plan and the possible consequences is prepared for regular review at management meetings.

This summary is in its compressed form a proven tool for continous management review of all major project risks. It is a comprehensive management status report of risks situations. The project risk plan is continuously updated and thereby demonstrates the loop aspect of the PRM Loop of Control. Once a risk is eliminated it disappears from the status.

5. Situation: Operation and Maintenance

Commissioning is finally in good progress with the agreed mixed operator staff working well together as one team. But the problem of recruiting operators permanently has not been solved.

The babyfood product produced meet the required quality standards and the guaranteed quantity. Preparation for guaranty tests and acceptance is in progress when a crack in the fluid bed machine appears. The crack is small although growing slowly and can easily be repaired. It does not yet influence production nor does it cause leaking of product or other safety problem. However, it makes the joint venture staff nervous about the equipment workmanship. Indirectly, it slows down the progress of preparing and executing the acceptance procedure. The joint venture management is keen on controlling equipment quality and puts no pressure on its staff for finishing tests and acceptance. The operator recruitment problem also takes time to solve.

The slow progress in commissioning tests and acceptance is on the other hand worrying UEFPE management, who is interested in solving the embarrassing technical problem and keen on making fast progress towards acceptance.

Risk identification, assessment, response and monitoring

The joint venture and the equipment contractor, UEFPE, then agree jointly to perform a technical expertise and quality control of all equipment. An independent expert in metallurgy reviews the investigation with no further comments except on the estimated probability of crack.

The parties then agree on the following action plan for solving the potential cracking problem:

1. The exposed equipment will be inspected weekly by UEFPE who will keep a maintenance engineer on site during the warranty period of one year.

2. Cracks causing operational or safety problems or being longer than 200 mm or wider than 0.5 mm will immediately be temporarily repaired by welding.

3. Before the end of the warranty period, UEFPE will replace all equipment parts with any cracks with approved new material not cracking. Equipment subject to such replacement will have a new warranty period of one year.

4. A procedure for handling warranty claims will jointly be agreed by the parties and the status will be reviewed quarterly.

5. Commissioning tests and acceptance procedure will proceed and cracks fulfilling point 2 above will be considered minor defects and do not prevent acceptance.

The above mentioned cracking problem is not only a technical problem but to a large extent a credibility problem for the equipment contractor, UEFPE, in this very critical phase of the project.

Consequently, it is very important that EUFPE's credibility is recovered. UEFPE's project manager fully realises this aspect and takes quick and strong action on the cracking problem. He also makes a serious effort to recover credibility by agreeing on a warranty procedure beyond the contract requirements to keep a maintenance engineer on site at its own cost during the warranty period.

A provision that might have been prudent to include in the first place.

Project name/no./country/location: New Baby Food Plant / 8976-23 / Latvia / Riga Contractors/Consultants: UEFPE and Riga Building Contractor / Latvia Consultants	
Contract reference/value/contribution margin/completion date: EBFP 1 - 12.4.99 - 5	
Project Risk: Shortage of Baby Food Plant Operators. Requirement: 5 per shift / 3 shifts per day	
Risk cause(s): Trained operators are offered 40-70% higher salary by other plant investors in Latvia or by foreign employers and 5 have left LMM. The remaining operators might be leaving although LMM salary level has been adjusted by + 20%.	
Risk Strategy & relation to other Risks: Adjustment of salary level and benefits for operators. This might come off on salaries of other technical staff.	
Action Plan/deadline/responsible: Recruiting 3 operators within 2 weeks and 2 more within 5 weeks. Technical Manager.	
Present Situation: 10 trained operators remain. Agreement with UEFPE to provide 2 operators during commissioning. LMM is presently recruiting 2 operators and later 3 more.	
Next Action: Interviewing 5 applicants.	
Worst Case Expected Financial Implication: D'Turnover: USD - 5 m.p.a., DCosts: USD - 0.5 m p.a., DCM: USD -5.5 m. p. A.	
Best Case Expected Financial Implication: D'Turnover: 0 p.a., DCosts: 0 p.a., DCM: 0 p.a.	
Prepared by/date/signature: Production Director/DBFP	
Circulated/copied to (names & dates): Members of Management & Technical Manager/DBFP/LMM	
Reviewed at meeting/approved by (names & dates): Management Meeting/ J-V Board	

Table 12. Joint venture Risk Tracking Report/Operator Recruiting

Conclusion

The article has presented a concept for project risk management as a systematic and cohesive management tool.

The case study demonstrates the applicability of the concept and indicates improved project performance by controlling risks systematically and continously. The repeated review of the risk plan demonstrates the loop aspect of the concept. Learning from previous risk situations is also an important part of the concept.

However, succesful implementation requires removal of three obstacles. First, a different management attitude to risk management is required. This implies recognition of early risk identification and assessment in order to improve planning and financial control. Second, training in risk management is necessary and thirdly, management must accept the extra time and costs required to implement project risk management mainly in early project stages.

When these obstacles are removed, the use of the Project Risk Management Loop of Control will strengthen project management and improve the performance and credibility of many engineering businesses.

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Risk	Action Plan	Deadline	Responsibility	Expected Financial Impact: Best Case / Worst Case (Million USD/year)	Reservation/ contingency in Approved Accounts / Budgets
Quality Assurance	QA Action Plan	Commissioning	Production Director	- 6.0 / 0	0
Unrest Latvia	Unrest Action Plan	Acceptance + punch list	Project Manager	- 0.5 / 0 (only year 1)	0
Equipment Cracks	Quality Action Plan	End Warranty Period	Project Manager	- 0.3 / 0 (only year 1)	0
Recruiting operators	5 new operators	Within 5 weeks	Tech. Manager	- 1.5 / - 0.2	0
Total Expected financial Impact				- 8.3 / - 0.2	0

Table 13. Project risk plan

Major Risks in ERP Implementation

Jari Välimäki, Andersen Consulting, Finland

The article discusses common risks that are damaging in the Enterprise Resource Planning (ERP) package implementation projects. The purpose is to present pragmatic experiences about these problems and appropriate project management practices.

Overview

The acronym ERP stands for Enterprise Resource Planning and it is used as a common name for those IT packages that intend to cover the majority of company's business processes with a single application. Well-known ERP packages include SAP, Baan, Oracle and PeopleSoft.

Due to their complex nature and the wide impact they make across companies' business, there aren't too many successful ERP stories available yet. This is not surprising because the majority of large IT projects are usually somehow unsuccessful (e.g. Keil, Cule, Lyytinen and Schmidt 1998). Johnson (1998) argues consequently that only 26 % of the major IT initiatives meet their schedule, budget and functional objectives, and ERP projects do not seem to be exceptions.

Approach

The main purpose of this study is to identify common risks that are extremely damaging in ERP projects. The research approach behind this article is very practical. The author has actually conducted about 20 face-to-face discussions with European business managers and consultants who have participated in these projects. All sessions were arranged at 1996 - 1998.

The following two risks were mentioned, in one form or another, in almost each interview, and they were thus selected for more detailed analysis:

- Management conflict between project tasks and deliverables
- Unsuccessful balancing of business processes and IT systems

Management conflict between project tasks and deliverables

A common problem in ERP implementation projects is that their management is too focused on project tasks and resource estimates without a good understanding of what should really be achieved with their execution. In certain cases, project teams had been assigned to implement work that did not produce any visible results to progress overall implementation processes.

For example, a team was asked to run a set of business scenarios with the system in order to define how the package is used in the company. However, they were not explained how the resulting change requests and workarounds are documented and communicated forward. The team went through their scenarios, but they didn't produce any proper deliverables. They were thus the only ones who knew how the system should be used in the company. This information is of course vital in the ERP implementation project, and it should have been shared with all other teams in a well-organised manner (i.e. with formal documentation and communication).

Similarly, quite often the management teams seem to lack comprehensive understanding on remaining work. Projects are managed on a daily basis without a long-term planning perspective, leading to a situation in which there is always some work, more or less surprisingly, undone.

Work Breakdown Structure is the key

Based on our discussions, in order to avoid these situations, project managers should actively change their management focus from implementation tasks to project's deliverables. The key is to illustrate an end-product oriented Work Breakdown Structure (WBS) for their projects. This WBS is then used as an iterative working tool throughout different phases, and eventually it should include all deliverables that are produced in the project.

A graphical Work Breakdown Structure is displayed in Figure 1. This simplified diagram presents a two-level structure, and some detailed deliverable examples on the tailored functionality element. Circles highlight those areas with which the interviewees had experienced their most severe problems. When graphically illustrated, the WBS models a hierarchical structure for the project's scope, similar in some respect to a production bill of material.

Deliverable orientation creates commitment

Following the creation of a WBS, each deliverable is assigned to a team leader for execution and delivery. They can then decide how these deliverables are produced. For example, it is up to them to define their own set of tasks, milestones and resource estimates, at least as far as those are in accordance with overall targets set at the project level.

Some of the interviewees argued that the most significant benefit in this approach is that the project teams are forced to go through a detailed planning process for their own part of the work. They claimed that it is the best way to achieve deep understanding of the work at hand, and a commitment to deliver it on time, in budget and to customer's expectations.
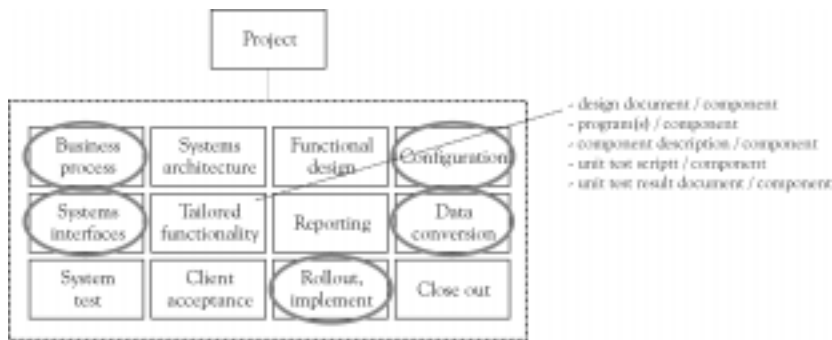
The project is on the right track

Figure 1. Managers should focus extra attention on the WBS elements marked with circles

when comments such as this are rare: "OK, I can see these tasks, but so what; what should I really do?" or "Does anybody know what else we should do in order to complete this project?".

Unsuccessful balancing of business processes and IT systems

This second risk is visible in two different ways. Firstly, in some ERP projects business processes that should be supported with a new IT application are considered when it is much too late. Secondly, in other projects too much effort is focused on the system independent process design. Companies can spend a lot of time and money on top-down process modeling without adding any real value on the software package driven business process implementation (Välimäki, Tissari 1997).

The following situations were mentioned:

- Constructed process models are too abstract, and it is thus impossible to define a meaningful link between these models and detailed processes imple-

mented with a software package.

- Constructed process models could not be supported with a new IT package, although its implementation has been already started.
- Constructed process models are very close to current as-is processes, although the objective is to achieve significant performance improvements with a new IT package.

An important fact organisations seem to be missing is that the best ERP packages comprise of very advanced business process models themselves. In adapting these processes companies would sometimes gain much greater performance improvements than with traditional top-down process design and system implementation approaches. It could also be a more cost-effective way to conduct major business changes.

Package independent thinking has a role

Software package independent thinking has also an important role in the ERP implementation work. A model on the projects' impact levels are presented in Figure 2. Based on interviews, best results are achieved when package independent considerations are focused on decisions related to two outer circles, and when business processes and workflows are almost directly adapted from a selected software package.

All decisions on detailed processes and workflows must naturally support, and be in accordance with, decisions made on the business strategies, structures and architectures.

This approach avoids a common situation in which putting very much effort on the
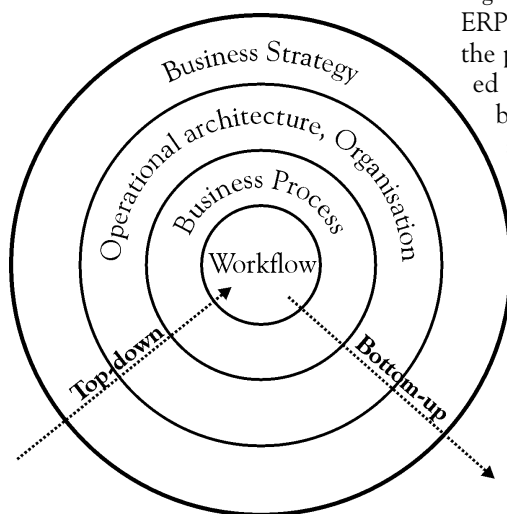
IT package independent process design exhausts key resources before implementation work has even started. Additionally, it takes full advantage of the current ERP packages' advanced process capabilities, and their ability to enable performance improvements in organisations.

Conclusions

This article focused on problems in ERP package implementation initiatives. Based on data obtained from a series of interviews, two major risks were identified and discussed. They are management conflict between project tasks and deliverables, and unsuccessful balancing of business processes and IT systems.

The key findings were that in order to be more successful, project managers should pay additional attention to deliverables, and to their own work allocation approaches. They should also let software packages drive and enable process changes to a greater extent.

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About the author

The author received the European project leader 1998 award from the ABT Corporation and the International Project Management Association (IPMA).

This award was handed over in Paris November 1998 (for more details, see www.abtplc.com/top5euro.htm).

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Figure 2. ERP implementation has impacts on different layers in an organisation

IPMA Research: PM-Competence of the Project-oriented Society

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As societies are becoming more project-oriented, the question arises how pm-competences in societies can be described, assessed and further developed. This paper describes an IPMA research initiative about pm-competences of the Project-oriented Society (POS).

Working hypotheses

The research about pm-competence of the Project-oriented Society (POS) will be based on following working hypotheses

- Societies can be defined by nations and by regions. Examples for regional societies are European Union, NAFTA, North America, Asia.
- Not just organisations but societies overall are becoming more project-oriented. Different national or regional societies have different project management competences. Differences in the project-orientation can be observed between OECD-, transition-, and developing countries.
- The question arises, how pm-competences at a macro-economic level can be described, assessed and further developed. Metrics for the description and the measurement of the pm-competence of a POS are the existence and the quality of formal pm-education programs, of pm-publications, of pm-associations, of pm-certification programs, of pm-events, of pm-advertisements in the newspapers, pm-awards, pm-norms and standards.

- The ideal POS defines project management as a profession. It has companies considering themselves as being project-oriented in all major industries, and has an explicit pm-education system. Further it has structures for the further development of project management as a competence of the society.
- The pm-competence of a society can be further developed. Instruments for this development are pm-self assessments, pm-benchmarkings, and significant pm-research initiatives (e.g. in Norway, in Finland, and in Sweden).
- Societies with similar pm-competences have high potentials for efficient cooperations with mutual benefits. Societies with a high pm-competence can transfer their pm-knowledge to societies with no or little pm-competence. An example for a pm transfer is EPROM, an EU-financed TEMPUS project to transfer pm-competence to Rumania.
- Organisations for the transfer of pm-competence are national pm-centers of competences.

IPMA research initiative: pm-competence of the POS

IPMA - the International Project Management Association sets a research initiative about the pm-competence of the Project-oriented Society (POS). A chain of projects is planned, within the time frame 1999 to 2002.

In "The POS Conception Project" the model of the POS will be constructed, metrics for the description and the comparison of POSs will be defined, pilot applications of the model will be performed. This project starts in May 1999 and lasts until June 2000.

In "The POS Benchmarking Project" the pm-competences of different POSs will be compared, commonalities and differences will be analysed and interpreted, strategies for the further development of pm-competences will be defined, and measures for the implementation of these strategies will be planned. This project is planned to start in September 2000 and is supposed to last until June 2001.

The implementation of the measures planned for the further development of the pm-competences will happen on the one hand side individual societies, on the other hand side cooperative efforts to transfer pm-competences from societies to other societies are planned. These implementation measures will be supported, documented, and interpreted in "The POS Im-

Figure 1. Project chain of the IPMA research initiative: pm-competence of the POS

plementation Project". This project is planned to start in September 2001 and is supposed to last until June 2002.

By putting project management at a macro-economic level the further development of pm-competences of societies as well as the development of pm-competences at the organizational and individual level will be stimulated.

The POS Conception Project

The POS Conception Project has following objectives:

- Construction of the model of the "Project-oriented Society" and definition of possible boundaries for societies (nations, regions).
- Development of metrics to describe and to measure the pm-competence of a society.
- Definition of restrictions and potentials for cooperations between societies with different pm-competences.
- Identification of initiatives for the development of (common) pm-competences and of demands for such developments.
- Evaluation of ongoing pm-knowledge transfers between societies (e.g. TEMPUS projects).
- Development of strategies and of instruments for the pm-

knowledge transfer.

- Ensurance of EU financing for the POS Benchmarking Project
- It is not the objective of the project to consider all societies or all industries within a society.

For the construction of the model of the Project-oriented Society literature analysis (e.g. pm-maturity models), interviews, and a questionnaire will be applied. For the pilot-evaluation of the pm-competence of a project-oriented society quantitative methods such as questionnaires, maturity models, and qualitative methods such as documentation analyses, project audits, delphi panels, will be applied.

The project is carried out by an international team of researchers and is steered by IPMA. Organization of the POS Conception Project is in Figure 2. Representatives of project management associations, project management experts of universities and as well as from project-oriented companies are invited to participate as project contributors.

Financing for the pilot research project POS Conception will be ensured by research contributions of project management associations and by sponsoring contributions of project-oriented companies. For the following POS Implementation project, funding from the European Union will be applied to supplement the above mentioned financing schemes.

Benefits

The benefits of cooperating in this research project for any national project management association and related parties are to participate in the initial evaluation of the pm-competence of the nation it is representating, and to learn about possibilities to promote the further development of the pm-competence in its society.

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Organization of the POS Conception Project

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- Project Manager: Roland Gareis, PROJEKTMANAGEMENT FACTORY, University of Economics and Business Administration Vienna, Austria
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- Project Team Members: Roland Gareis; Brane Semolic, University of Maribor, Slovenia; Sergey Bushuyev, Kiev State Technical University of Construction and Architecture, Ukraine; Joachim Ordieres, University of Rioja, Spain; Matti Ahvenkariju, Project Institute; Finland; Martina Huemann;
- Project Contributors: Representatives of project management associations, project management experts fromuniversities and project-oriented companies

Figure 2. Organization of the POS Conception Project

Software Project Management - Software by Committee

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John Ciccozzi, United States Patent and Trademark Office

The article presents a process of project management and comments on the business and legal foundations of this process. It is important to adopt a workable project management strategy. This is true not only from a project management perspective, but a legal perspective as well.

Introduction

Outsourcing is becoming more common in today's software development environment. As a result, providing software products and services is increasingly a cooperative effort between a customer and a vendor. Rather than being controlled exclusively within a single company, the success of many software projects now is dependent upon the political and legal relationships between two or more parties. These relationships significantly complicate an already complicated process.

This article presents a process of project management and comments on the business and legal foundations of this process. The legal issues are addressed in the boxes. It is unfortunate that many organizations fail to standardize policies and procedures regarding project management - or they have no project management process at all. In any event, it is vitally important that all organizations develop and adopt a workable project management strategy. This is true not only from a project management perspective, but a legal perspective as well. As a standard disclaimer, this article is for informational purposes only and not intended as legal advice. We simply want to increase awareness regarding potential problems that might arise.

Both authors have had many years of experience in software projects in various capacities. We have been involved in many successful software projects. Unfortunately, we have also been involved with some that were not so successful. It is from these experiences, as well as formal training in Project Management and Law, that we draw on for this article. The structure presented in this article can be used as a template to start the development, and the subsequent refinement, of a project management process. This process provides the checks and balances needed to grease the wheels for a smooth customer/vendor relationship as well as a successful software project (Box 1).

The Software Development Lifecycle - The Current State of the Art

This article deals with managing the software development process. There are most likely as many different software development processes as there are software development projects. There are certainly many reasons for this. On the one hand, each individual project has specific needs, and customizing a process to meet these needs is a logical and healthy exercise. On the other hand, many projects follow no process at all and this is anything but healthy.

There is a vast amount of literature available that speaks to the current state-of-the-art of software development. Almost all of these writings treat software development as an atomic process, suspiciously leaving out any political or legal interactions. However, today software developers must take these issues into consideration.

One of the most quoted models for software development is the Waterfall model. There are many incarnations of this model but they all follow the same principle: the model represents the flow from one phase to the next until the software is released. In short, the water flows from one phase to the next just like a waterfall. However, flaws in the model have been identified - not the least of which is the fact that the

Box 1

Even though the software development process may seem light years removed from the legal process, it is very important to conduct business in ways to ensure that your end customer gets what they want and that you are compensated for your software development efforts. Just as important, is that your clients do not reach a boiling point and cross over into territory where they believe (rightly or wrongly) that litigation is the only remaining option available to them. The problem with litigation is that it often results in a lose-lose situation for everyone involved. The following discussions should help you understand the potential legal landscape and how to navigate through it.
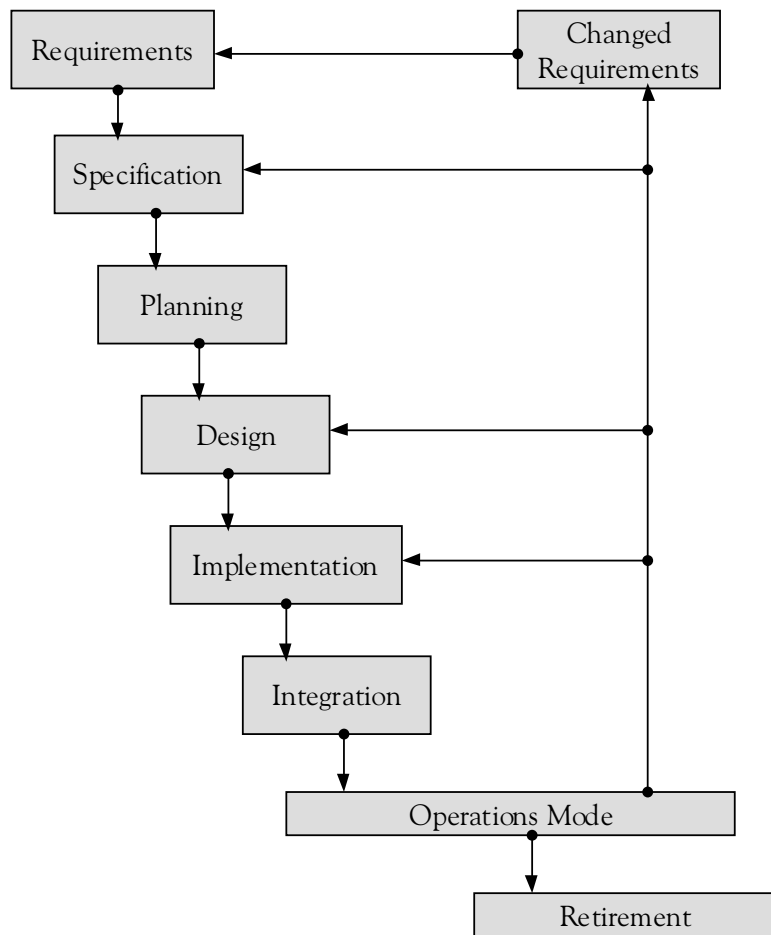
Figure 1. The Waterfall Model
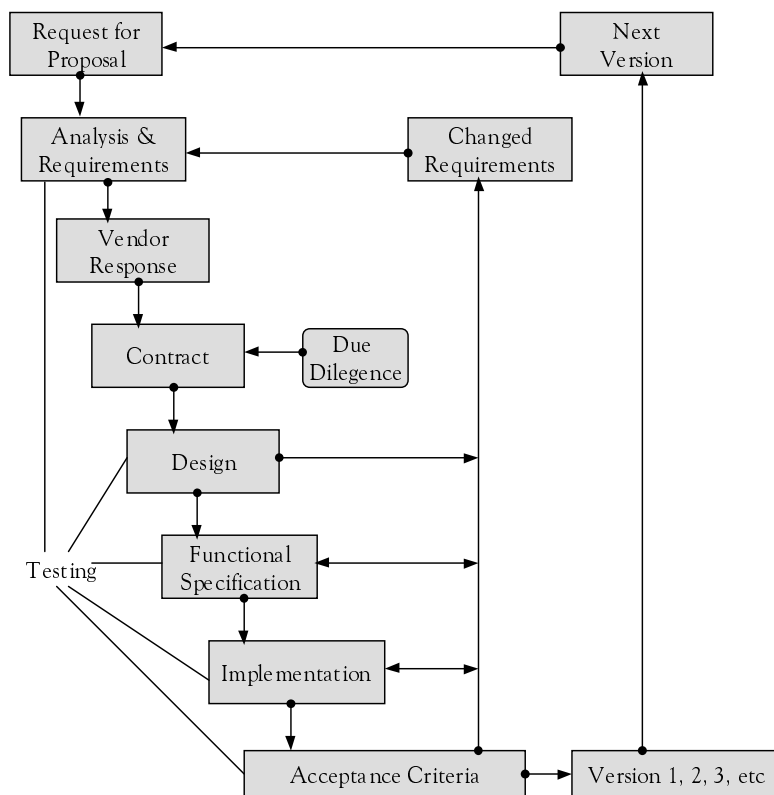
Figure 2. A Variation on the Waterfall Model

iterative nature of software develop-ment is not taken into account. Figure 1 illustrates one popular form of the Waterfall model (Classical and Object-Oriented Software Engineering, 3rd Edition. Stephen R. Schach. 1996 Richard D. Irwin). The lines of backward control represent maintenance.

In the best of all worlds, progressing from one phase to the other would signify the end of the previous phase. In reality, this is unrealistic. Thus, many other models have been devised; however, there is no single model that is considered the best one. In fact, most projects will use a combination of techniques. As far as this article is concerned, the technique(s) of choice is irrelevant. However, when dealing with legal contracts, it is advisable to delineate between phases and ensure that all parties agree to these transitions.

Project Management Life Cycle

While the Waterfall model focuses on the software development process, this article is concerned with modeling the software project management process. Rather than concentrating on building software, we explore a method of managing software projects. Unfortunately, just as a technologically inferior product may win in the marketplace due to superior marketing, a technologically superior software project may fail if the project management is lacking. In other words, a well designed and well built software product can fail miserably if the political, legal and business issues blow up in the software project manager's face. For example, if the deployment of the project gets stalled due to political bickering, or if one party sues the other, or if the project loses significant amounts of money, then, no matter how good the software and the other deliverables are, the project is considered a failure.

Figure 2 is a variation on the Waterfall model that approximates the project management model that we will discuss in the remainder of the article. Note the following significant changes:

1) The inclusion of the project management boxes (Vendor Response, Contract, Due Diligence).

2) The lines flowing backwards are not maintenance lines. They represent a true iterative process.

3) The explicit inclusion of testing in all of the development stages.

It must be reiterated that we are not advocating a specific software development approach - there are many proven techniques that are practiced successfully. We are simply advocating the integration of business realities into the software development process. The real issue is not which process to choose, but to have a process in the first place.

Request for Proposal

When an organization determines that it wants to outsource/contract with an outside party to create a piece of software, it traditionally broadcasts a Request for Proposal (RFP) to several vendors. The RFP outlines what the customer wants. If there is already a manual process (or even an outdated automated process) in place, this process must be explicitly detailed. All subsequent documents are derived from the RFP, and the RFP serves as the mutually agreed to basis for any work to be performed. It is crucial to note that the Request for Proposal is simply that - a proposal. The RFP is by no means a binding functional software specification (Box 2).

Box 2

The RFP serves as an advertisement that the customer is soliciting inputs for a job. In many cases, they are not aware of either the technology that exists or the feasibility of applying that particular technology to the job at hand. The level of detail that is submitted in an RFP is also a variable that depends upon the vendor and their interpretation of what the customer wants and how best to provide it to them. All further documents are derived from the RFP, and the RFP serves as the mutually agreed to basis for any work to be performed. The RFP is a high level document which is prepared unilaterally by the organization seeking the work to be done. For valid contract formation, you need the consensual agreement of all parties. The result of this agreement should be a requirements document that satisfies the expectations and business interests of each organization.

Analysis & Requirements

If a vendor is sufficiently interested in the work described in the RFP they must do the proper research and analysis to determine (1) the requirements

of the project, and (2) whether or not to make a bid for the job. Even though the level of detail does not need to be of a highly technical nature, the requirements must be specific enough to represent the true nature of the customer's needs for the end product. The vendor must analyze the current system and conduct extensive interviews. It is important for a representative of the customer's organization to be on the interview team. The requirements document that emerges from this phase must be of sufficient detail for the customer to make educated judgements about the completeness of the submitted proposal. It also must be of specific detail for a design group to take the document and proceed with the design phase. Heninger (1980) gives many guidelines for writing requirements, three of the most important are:

1) Specify only external behavior

2) Be easy to change

3) Serve as a reference tool (to developers, testers, etc.)

The requirements should be jointly developed by the customer and the vendor in order to establish co-ownership and buy-off between the contracting parties when the contractual phase is entered. The requirements must be very specific and all encompassing. In many software projects (in fact, many projects of all kinds) major problems are caused by implied from or read into requirements. These are requirements that the customer deems as so obvious that they are implied, even though they are not explicitly written into the requirements document. There must be no implied requirements. All requirements must be part of the requirements document.

Proposal

After completing the analysis and requirements phase, a vendor may decide to submit a proposal to build the software. This proposal must specifically outline how the vendor plans to satisfy the RFP. The requirements, derived from the analysis phase and included in this document, must be written in plain language since this is a user document - not a technical paper. The proposal must detail any areas of the RFP that the vendor feels cannot, or should not, be implemented and why.

Once the vendor submits the proposal and it is reviewed and accepted by the customer, a negotiation phase is

entered (Box 3). From these negotiations emerges the final, refined set of requirements. Note that the tone here must be one of cooperation - a team effort. Play to the strength of all parties. To simply take the stand that the customer is the customer and whatever they say goes is a recipe for disaster. In short, the customer approached the vendor for a reason - most likely because the customer does not have the resources or technical expertise to complete the project alone. For the optimal success of the project, it is vital that the two parties trust each other to make prudent decisions.

Box 3

It is very useful to keep track of the ongoing refinement of the requirements as the program evolves. This evolution is a natural consequence of learning more information about the project and working at a greater level of detail. There should be a give and take in the fine tuning and incorporation of adjustments to the requirements database. You want to strike a balance between reasonableness and the attainment of profit. Keep track of any changes in scope and publish them to both sides, to show all that you are doing. This helps to satisfy the legal requirements of good faith and due diligence in fulfilling your obligations under the contract.

Contract

The contract must outline all responsibilities for all parties involved. This includes defining the phases of the project, all project documents, the dates for all milestones, the exit criteria for each phase and the procedure for amending the contract. It is also important to enumerate what happens in the event that a part of the contract is breached (i.e. binding arbitration). Even though the customer is footing the bill, it is important that the customer accepts certain contractual responsibilities for the project. In fact, the customer may seek out this responsibility in an effort to save time and/or money. However, if the customer defaults on one or more of their responsibilities, then the vendor may not be able to deliver the product. The vendor must be constantly aware of this risk (Box 4).

In large projects, a contract may need to be written from scratch. However, in many cases an existing form can

Box 4

The classic definition of a legal contract is that a contract results when the following three elements are present: an offer, acceptance, and consideration. Using an easily understood house analogy, an offer is captured in the statement: "I want to buy your house." You are stating what you want from the other party in this contractual relationship. The acceptance is quite simply the statement: "I will sell you my house." It is an acknowledgment from the other party that they also want to enter into the transaction. Contract formation is a bilateral agreement between two or more parties, not a unilateral, one-sided one. Consideration is what one party is giving in exchange for the benefit being conferred by the other party. You get the house by paying money to its current owner for it. All of these three elements must be present, or else a legal contract was not formed and the contract does not become legally binding.

Box 5

Courts are on the lookout for the following types of things during their judicial inquiries. They like to see the involved parties conducting themselves as relative equals in the bargaining process (although absolute equality is almost never the case). They don't like to see one party using their superior bargaining position to take advantage of a weaker party. Several factors can contribute to an inequitable situation. One party can be smarter and more sophisticated than the other party. One party can have much greater resources than another. One party can be at a much higher level of technical know-how than the other. Courts also want to make sure that all of the contractual proceedings were performed in good faith, without any underlying fraud or deceptive intent by either of the parties. The courts will scrutinize the mental framework of the parties as they approached the business relationship very closely.

Of the three elements forming a contract (offer, acceptance, and consideration), consideration is the one that courts will not try to make a judgment regarding its sufficiency. In other words, if you want to sell your house for a hundred dollars, the law will allow you to do so. They will not say that you were out of your mind when you sold the house and should have charged $200,000. Sufficiency of consideration is left to the parties under the terms of the contract.

Box 6

From a project management perspective, it is important to structure software development programs into major program milestones or phases. This allows you to break down a larger project into manageable chunks so that your chances for success are much higher. Legally speaking, milestones are also very important for providing objective evidence that you and the customer have obtained buyoff for the preceding phase and are ready to enter the next phase. This buyoff transforms what could be perceived as a unilateral decision on the part of one party into a multilateral one. It helps to silence the complaint that you have not fully implemented what the customer believed was in the requirements. Neither party can say that they were not kept fully informed about all stages of the project, and the vendor will never be in the position of writing and implementing the code they erroneously believed was what the customer wanted.

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be used. In fact, many large customers will insist that they use their forms. Their reasoning is obvious - it is cheaper in both time and money. This may present a dilemma for a vendor, especially if they are small and cannot absorb the legal costs required to properly review the contract. How the contract is written or adapted is yet another issue that the parties must negotiate. Each contract will be different. It is important to have forms available as a starting point, but all parties must be flexible and sensitive to the needs of the others (Box 5).

Despite the fact that the requirements and the phases of a software development project are specifically defined by the contract, it is quite difficult, if not impossible, to keep from changing a requirement or crossing a phase boundary line from time to time. The contract specifically enumerates the required documents for the project. Whenever all involved parties formally accept a document, including the contract itself, any change requires a Change Order Request. A Change Order Request is an amendment to the contract. Though virtually unavoidable, any changes to the original document should be avoided like the plague. In short, if the change is not absolutely crucial, then postpone it until Version 2 of the software (Box 6).

Some formal development projects involving large capital intensive programs have Change Control Boards (CCBs). They are also called Configuration Control Boards. Their main purpose is to make sure that any baseline changes to the design are considered by all the parties involved, and that every change considered receives the project teams' authorization before final implementation. It is important that both sides identify one person that will serve as the focal point to transfer change information between the two parties. On the customer side, this individual needs to be very knowledgeable about ultimate product functionality.

Design

The requirements document is written so that the users understand what must be in the system, the design is the first step in migrating this plain language document to something that a programmer can understand and implement. Yet, the design document is still an abstract level away from the programmers.

The design specifies what needs to be done, not how it will be done. The major difference between the requirements and the design documents is that the requirements describe what the system must include while the design describes the system itself. It is important to understand the difference between the requirements, the design and the functional specification -the next iteration in the process. The design relies heavily on the requirements. Boehm (1984) addresses two major issues when writing requirements and creating the design:

1) Verification - building the product right.

2) Validation - building the right product.

At each step in the design, everyone involved in the project should be aware of these two important goals. Even though they may seem similar,

verification and validation are two totally different things. You can build the product right, but if you build the wrong product, then the project does not meet the user's needs and is a failure.

In many organizations the designers will have the luxury of direct access to the developers. However, in some, the design may be complete before the developers get involved. In the first case, the actual design will not be finalized until the developers get a chance to review it. In the latter case, this is not always true. Even if the developers do get to put their stamp of approval on the design, they may run into an unexpected technological constraint in the development phase, which will require a design change. In any case, the process must be controlled yet flexible (Box 7).

Box 7

On the supplier side, the individual must know the limits of the technology and what can be implemented effectively. They must also be very aware of the level of functionality negotiated in the initial contract so that the development activity can be focused and managed to an agreed to baseline. As in all business agreements, there is always room for some flexibility in trying to meet the customer's needs, but you must make sure that what you contracted for in the Statement of Work and then filtered down for implementation in your design specification, is what you are working towards.

Functional Specifications

The functional specification is the document that the developers are charged to implement. Too many times, at various stages of implementation, a customer will whip out the design, the requirements or even the RFP and ask why a certain feature was not implemented. All the documents listed in the previous sentence are ancestors of the functional specification. The functional specifications are the living, breathing documents that are destined to become the system. Sommerville identifies the following points that differentiate requirements from specifications:

1) The level of detail and abstraction [specifications are much more detailed].

2) Specifications impose additional constraints, but the user should have no way of knowing.

Of course, all documents are used as references to clarify issues and help the developers understand how to develop and implement the functional specifications. However, the functional specifications represent the true system according to the developers. It is critically important that all parties understand this, and invest the proper amount of due diligence into each phase of the project. It is all too obvious that a poor design will lead to a poor functional specification, which will lead to a poor system. It is the responsibility of both the customer and vendor to pay the proper attention to each phase (Box 8).

Box 8

Due diligence is conducting yourself in such a way that the reasonable person under the same circumstances would behave in the same or similar manner. It is not an absolute standard, but rather should be evaluated on a case by case basis in light of the surrounding facts of the case. The more things that you do to show that you have made a good faith attempt at considering many different factors helps to contribute towards the finding of due diligence in your case.

Again we visit the responsibility issue. To a large extent, it is the vendor's responsibility to learn the customer's business as best as possible. However, the vendor cannot ever be expected to understand the customer's business as well as the customer. In the spirit of teamwork, it is vital that the customer understand this. To get the best system, the customer cannot simply hand off the project and expect the vendor to create a great system. The customer must be willing to expend the time, effort and money to get the system done right. In many cases, the vendor will submit a design and the customer will not commit the necessary resources to review it. This leads to a rubber stamp of the design and it is only when the system is delivered that the customer realizes that the design was wrong. This is the fault of the customer. As with all phases of the project, this is a shared responsibility.

Implementation

The most important part of implementation is to make sure that any and all problems are caught as early as possible and are not allowed to propagate throughout the process. This means keeping the customer representatives and the entire design team involved throughout the entire project. The goal is to eliminate any surprises during implementation or otherwise. If the customer is involved in each phase of the project, then the surprises should be few - if any. As for the designers, even if the functional specifications are well written, the developers are bound to have many questions. The designers must be available to settle any potential confusion with the design (in many cases, the designers simply disappear - for any number of reasons). If the developers have to start making assumptions, big problems are inevitable. Again, the basic tenant must be - no surprises.

How are surprises kept to a minimum?:

- maintain clear and consistent communication

- practice incremental development and perform regular product builds.

- conduct regular status meetings (purposefully short and sweet)

- include a Version Description Document in all builds

- integrate a professional installation package into the build process

- place all project materials (including the status meeting minutes) on a secure Web Site

- make sure that more than one person is familiar with each part of the project

- don't forget the human resources on your project! They need maintenance too.

- implement a good configuration management plan.

- perform regular backups with offsite rotation.

- conduct regular fire drills to ensure that backups are valid

Integration of code is perhaps the most difficult aspect of the implementation. In a study by Basili and Perricone (1984), it was found that 40% of software errors were due to integration and interface problems. These problems are kept to a minimum if a proper design is

done and good functional specifications are presented to the developers.

If these procedures are followed during the implementation phase, the transition to the next phase, the alpha test, is much easier. If the customer and design teams are not involved in the implementation, then surprises are most certainly going to occur.

Testing

While the system requirements lead to the contract and the design, it is the test requirements that accurately represent the delivered system. Unfortunately, testing as a whole often gets shortchanged. Written properly, the test requirements can become the foundation for the remainder of the project. The test plan, acceptance tests, automated testing and even the user documentation can be based on the test requirements.

Test plans encompass everything that can be considered testing; however, most test plans focus on implementation and beyond. It must not be inferred that testing simply starts at implementation. A well-run project will identify the test team at the point of the initial design and include the test team in all reviews and milestones. The design should be tested by the test team every step of the way. In fact, it is quite desirable, if not a necessity, that the customer supply a permanent, full time resource to serve on the test team. The test team will be in place for the duration of the project - optimally even forward into Version 2 and any subsequent versions.

Alpha Test: The entire purpose of an alpha test is to have people other than the development team testing the product. The alpha test is a simulated environment that provides validation that the system is operating properly. By definition customer resources (i.e. people) must be included in the alpha test team. By the end of the alpha test all user functionality issues should be resolved and the customer must agree that the product meets the specifications. A mock site should be constructed to simulate the product's real world environment.

In short, by the end of the alpha phase, the customer must understand the delivered product completely and bring any deficiencies to the notice of the vendor. All documentation, user and otherwise, should be completed during the alpha phase. The complete system package, including the software and documentation, must be ready to move into the beta phase.

Beta Test: While the alpha test is really a simulated test, the beta is executed at a real-world site. The customer must allocate sufficient resources to rigorously test the product in a live environment. The test is a subset of the customer site and should be run in parallel with the current system. Again, without the proper customer participation, the beta test will fail - or the product will be accepted without the proper testing.

Acceptance Test: Acceptance tests must be in place as the final, legal exit criteria for each phase. This is especially important for the phases of testing. The customer and vendor must agree ahead of time on the acceptance test criteria. A phase is complete only when the acceptance test is performed and accepted by all parties (Box 9).

Box 9

> Does a vendor have a legal responsibility to do testing? No! LEGALLY they only have a responsibility to perform what is specified in the contract. However they have a responsibility to provide a product that works, and that is quite often only determinable if they do testing to prove to themselves that it does. To dispense with this testing would not be an example of due diligence, and it could be argued that it was negligent. Another way of saying this is that the vendor must supply something that works and the fact that it works can only be readily performed via testing.

One unfortunate reality is that no matter how well a product is tested, it is unfair to expect that the product will be bug free. While it is important to have no bugs as the goal, it is also equally important from a business perspective to realize that bugs will always arise. In fact, Goodenough (1979) has found that perhaps 50% of all errors may remain undetected even when the statement containing the error is executed.

Documentation Trail and Communication

Besides the obvious project documentation like requirements and design specifications, it is imperative that all supporting documentation, paper and electronic, be filed properly. It is unfortunate, but in today's litigious society, it is crucial that both the customer and the vendor keep a secure trail of all transactions regarding the project. It is recommended to:

- keep all paper and email correspondence (select key individuals to copy-don't spam)
- make periodic backups of all project materials, code or otherwise
- hold periodic fire drills to test the backups to ensure that they are indeed backing up
- have well defined communication channels (all contract changes must be approved)
- send out a brief synopsis of the meeting notes to all attendees
- send out a brief synopsis of all key phone conversations to key individuals

Deployment

For anyone working on a large project, the step from beta to deployment is a major event. In fact, this is the goal of the entire effort. In most cases, this step should be called Version 1. Some contracts may state that the end of beta signals the end of the contractual agreement. Some contracts may stipulate that the vendor must install the product at a certain number of sites. This all depends on the contract. Regardless of how the contract is written, there must be a hard cutoff for Version 1 somewhere soon after deployment begins. As with all the previous phases, scope creep must be avoided. Stick to the binding agreement (e.g. the functional specification) as the stake in the ground for Version 1. Anything else goes to Version 2 and a new contract (Box 10).

Box 10

> If a major rework or addition is deemed necessary (and as with any change in functionality this must be a painful process) it must be determined immediately whether or not the work is within scope or out of scope. If it is out of scope, then a Change Order Request is required. If it is within scope, the vendor must do the work pursuant to the contract. In any event, once any major work is done in the beta phase, the beta test itself should be re-started.

Conversions

Conversions are, simply put, a necessary evil. If humanly possible, avoid them at all costs. Unfortunately, in most cases a conversion of some sort is required. If this is the case, make sure that the conversions are part of the development effort and not simply an afterthought added on to the end of the project. The bottom line is to design the conversions into the project from the start. When the data model is being developed, take into account how the legacy data is to be converted and start the process early. Perform data conversions early and often, integrating them into the incremental build process.

Maintenance

While the concept of Version 1 is important, there is always the issue of maintenance to deal with. Deployment should signify the end of the project. If there are bugs and problems with the software that should postpone deployment, postpone deployment. Do not release software that is not ready for primetime.

The maintenance phase should be a totally separate phase that follows deployment. In fact, it should be a separate contract since maintenance is ongoing. In some projects, the customer may want to handle the maintenance themselves. In others, they may lack the expertise to handle the maintenance and thus need to farm the maintenance out. In actuality, maintenance and support can be a significant profit center to the vendor.

Conclusion

It is our experience that when a software project fails, it most likely fails as a result of business and/or political reasons. Technology is usually not the primary stumbling block. Ironically, it appears that in most cases the skills to manage the project actually exist; however, issues such as politics, marketing and departmental infighting, as well as other human factors, cause the downfall. While eliminating human factors such as politics is understandably impossible, there are ways to minimize their impact and run an effective and successful project.

The primary mechanism to circumvent these problems is to have a coherent project management plan that all parties agree, stick to the plan, and maintain good communication lines.

This article introduced a project management process with an emphasis on each phase of a project. Specifically, legal issues were addressed while discussing the process. Since it is our contention that many projects fail due to business or political issues, it is the responsibility of the business owner, department manager and/or project manager to manage these human factors properly to permit the effective use of the technical and project management talent.

It is safe to say that running a software project and worrying about all the potential business, legal and political issues is, in a word, daunting. However, ignoring these issues will put many projects, and companies, at peril. If you are a customer, do not assume that your vendor is practicing solid project management techniques. Make them prove it to you!! Require that they hold regular reviews that include one of your representatives. If you are a vendor, don't let the customer assume that you are using solid project management techniques. It is in your best interest to keep them informed so they do not bring up thorny issues late in the project.

With outsourcing becoming more and more prevalent, it is vital to have a consistent, yet flexible, strategy for running and monitoring software projects. A solid project management strategy will encourage all parties to practice due diligence and allow more time to concentrate on the more important, technical nature of the project.

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Development of a Project Simulation Game

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The paper describes use of simulation games especially in the implementation of change processes in Engineering-to-Order oriented companies. Simulation is used for introducing feasible scenarios for different project environments. The paper discusses experiences obtained during the development of PROSIGA (PROject SImulation GAme), with a learning aim concerning project planning, motivating the project team, and the decision making process. The paper suggests benefits of using both the implemented models and a seminar approach.

Introduction

Demand for training in the field of project management has increased. It is necessary to provide ways to experiment, make decisions and act in the project management context. Simulation techniques are used in a wide range of fields mainly for early pre-planning purposes. The fields include mechanical engineering to risk management or re-engineering (Haho and Smeds, 1996, Riis, Smeds, Johansen and Mikkelsen, 1996, Cano, 1994). In the learning process, these techniques give the opportunity to deal with virtual situations which bear resemblance to those we try to solve in real life.

Within the framework of the Leonardo da Vinci Programme, the CAESAR Project (Computer Aided Education with a Simulation Approach for the Redesign of Production Processes) appears as the result of the collaboration with the Universities of Karlsruhe (Germany) and Ghent (Belgium). The background of this paper relates to the development of a simulation game for project management training for this context. The basic purpose of this paper is to comment the development and the features of simulation games specifically for the implementation of change processes in Engineering-to-Order oriented companies.

Game description

The developed project simulation game, PROSIGA is focused on teaching the practice of project management. In the game, the participant takes part in the management of a project from the proposal preparation to the tests prior to the end of the project. PROSIGA provides a training experience devoted to the development, improvement and motivation of the work group, the decision making process and the skills of leading typical situations which appear when managing projects.

The example which is proposed by the simulator, is a project to set up a new bicycle plant in a country bordering the European Union (EU), supported by a technology transfer program of the EU. With this story line, the participants gathered in groups, and assumed the role of project managers, are obliged to make decisions in order to achieve the targets required by the board of directors of the company.

From the beginning they are under time pressure when trying to solve conflicts. The decisions made in the game influence the project development in different ways, the affected variables being such as costs, delays, team motivation, management support. By the means of simulation an interactive environment is created where management skills could be trained without any risk of failure. The game is applicable for:

- Engineering-to-Order companies that need to introduce project management skills.
- People who are interested in gaining experience in project management and need tools which reproduce real scenarios where decisions has to be made and conflicts solved.
- Companies which require specific simulation tools for training to deal with processes of fundamental change. These processes involve changing attitudes and encouraging new work methods, which form a part of the introduction of re-engineering and radical modification in internal organisation.

The game is a part of a seminar in which the participants should assume the role of project managers. The participants play with the simulator. At the end, they will analyse the results and draw appropriate conclusions. Each group will be made up of three participants. The seminar consist of two different phases (Figure 1) which complement each other.

Phase 1: Proposal Preparation

- Establishment of **work groups**
- Presentation of the **scenario**
- Theory of **Project Management** and Scheduling
- Tool handling presentation
- First proposal elaboration
- First proposal adjustment in costs and terms
- **End proposal** results analysis
- Results presentation for the Board of Directors

Phase 2: Project Development

- Theoretical analysis
- Tool handling presentation
- Game of the first half of the project
- First half result analysis
- Game of the second half of the project
- **Overall project** result analysis
- Results presentation for the Board of Directors
- Final debriefing

Figure 1. The Two Phases of PROSIGA

For the participants the aim of the phase 1 (see Figure 2 for an illustration of the screen) is to collaborate in the preparation of a proposal for a European Union programme. This programme handles the concepts of project scheduling, preparing an initial draft of the master plan and later, adjusting it to time limits and weighing up and choosing from the different available alternatives. The participants are first asked to prepare an overall plan for the installation of a new bicycle factory. Subsequently, participants have to optimise the time scheduling and the cost of the plan with assistance of PROSIGA. PROSIGA allows to carry out planning operations, such as the assignment of resources and the simulation of the effects of the decisions made. At the end of phase 1, participants have to carry out an analysis, in which their propose the master plan and the strategy to be followed with regard to costs, terms and resources allocation.

In phase 2 of the game, a series of situations will be experimented. These situations occur during the development of the project up to the commissioning and final completion of the plant. Therefore, participants should take a sequence of decisions which will be required as the project progresses. Impacts of these decisions on the project can be observed.

The project is divided into two halves. At the end of each half there is a feedback on the decisions taken, their impact on the results and how the project is developed throughout the considered period of time. In a limited period of time each participant has to decide on situations or conflicts that the system may raise (see contingencies in-
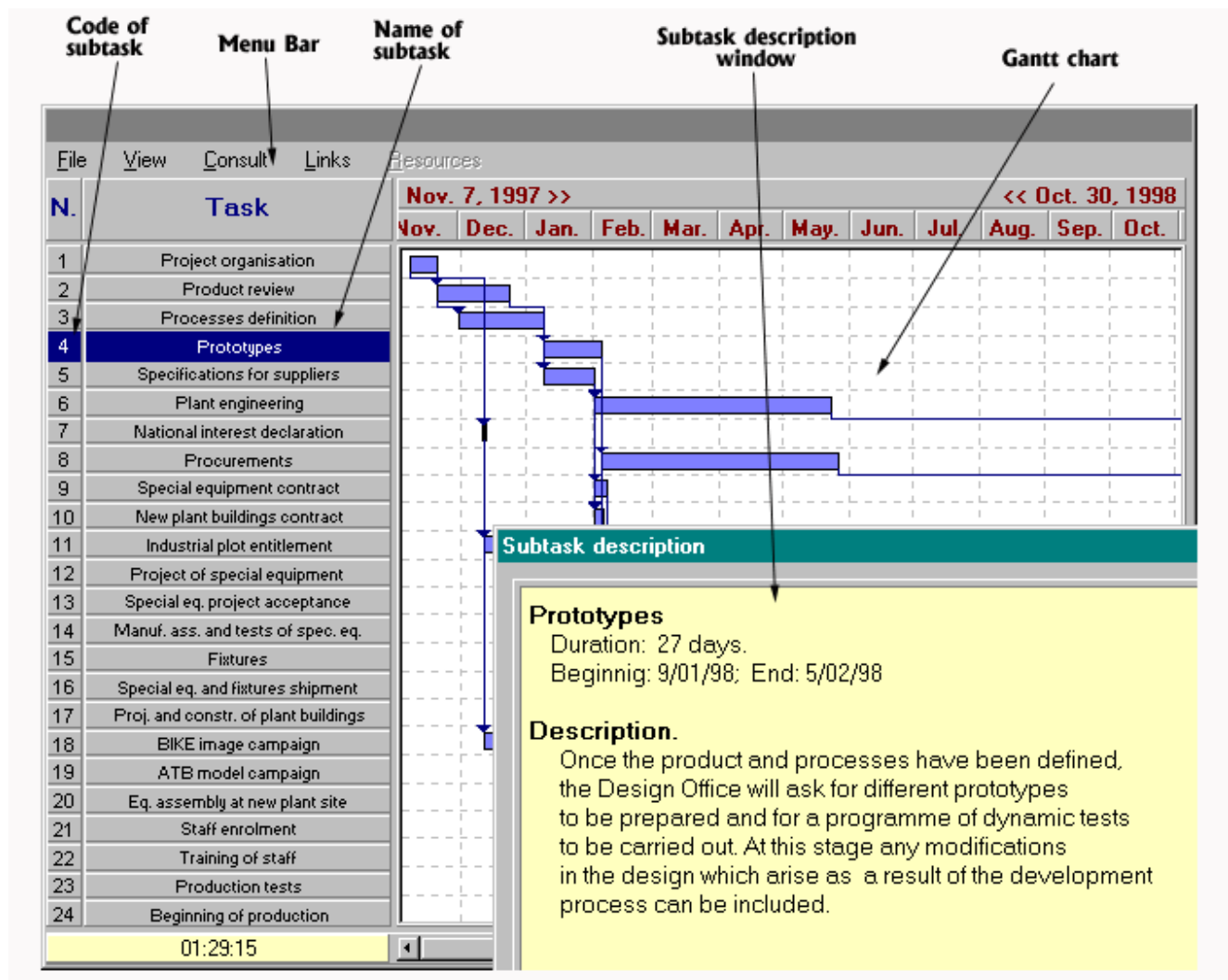
Figure 2. Main Screen of Phase 1

box in Figure 3). For instance, we might be informed that due to labour problems a supplier cannot deliver the required equipment on time. The system offers us a series of alternatives:

- To wait for the subcontractor to solve its problems and to let it deliver after the problems are solved.
- To cancel the order and to choose a more expensive equipment that is available immediately.
- To rent similar equipment for a period of time to replace the contracted one.
- To put the contractor under pressure in order to get it to speed up the delivery process.

The position adopted in this case will affect project state variables of quality, cost, duration, team motivation, management support, relationship with the stakeholders, and communication. Information about these variables is always available (see control screen in Figure 4) and you will be able to compare the work planned, in the terms of cost and time, to the work performed up to now in the so called S Curve (Figure 5).

For the participants the aim of the phase 2 is to introduce considerations of which option is the best among those the system offers. Obviously, among the different situations the group has to solve, some of them will be more attractive to the participants than others taking into account the experiences they have had in their companies or in their own working environment. They will discuss about the options to choose by simultaneously answering to questions such as: which option would be the best to consider in your company and which action should be taken to find an effective solution to this situation. When the participants have completed the course all of them should have an idea of how to implement these aspects in their own company. At the end of this part each group should explain and justify the results achieved by presenting the project for the Board of Directors.

Aspects to be considered in the PROSIGA development

When designing a game as a supporting tool for a specific training seminar, a wide variety of aspects such as the scenario, the control board of the game, the modules in which the game is going to be split, the project development model, the interactivity and the versatility achieved or the work group, ap-
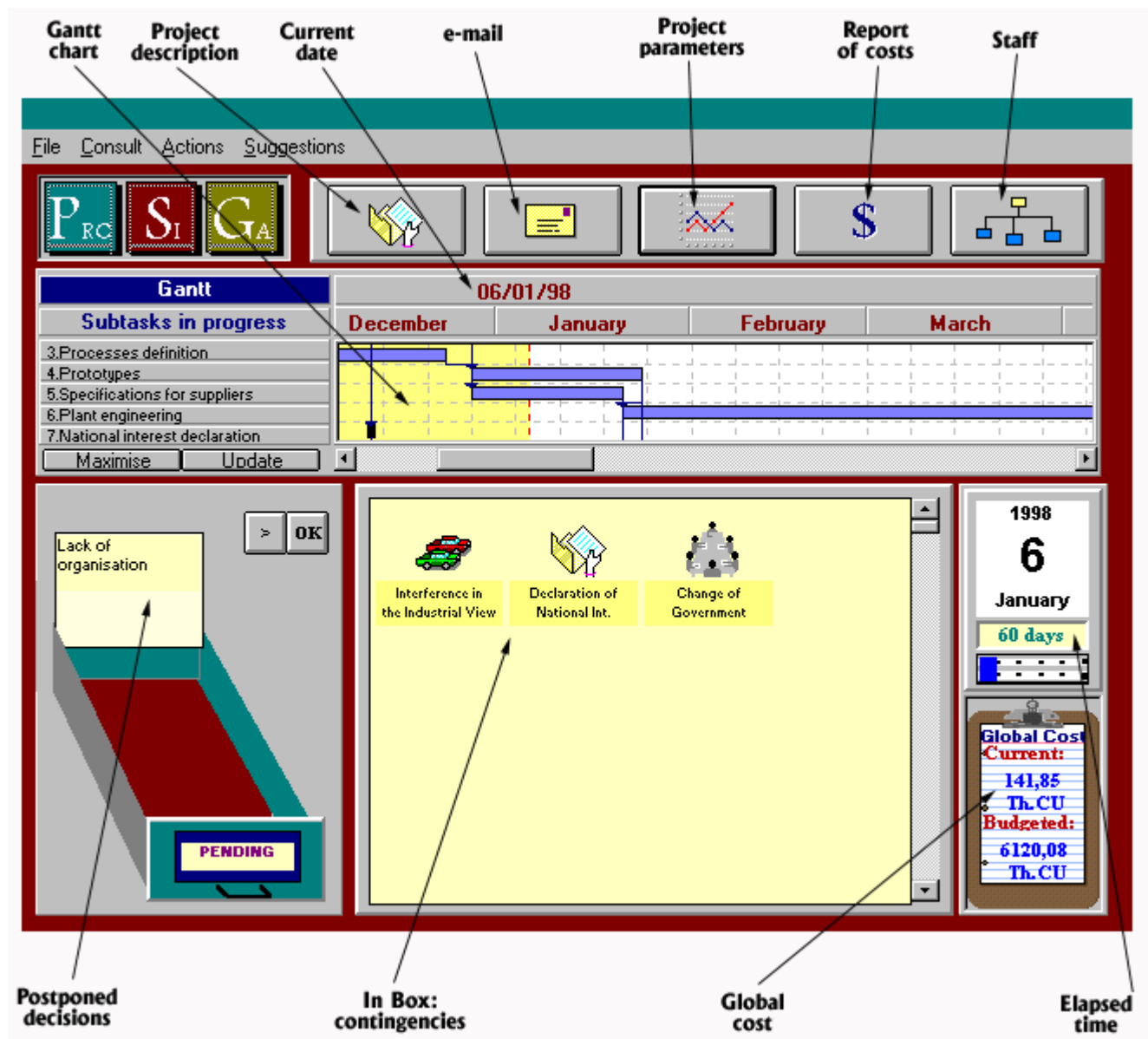
Figure 3. Main Screen of Phase 2
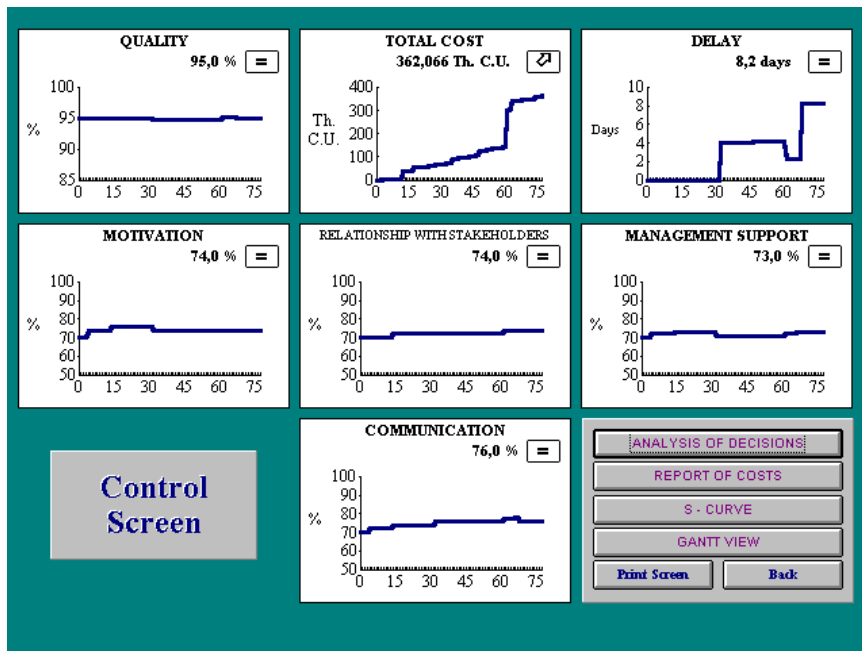
Figure 4. Control screen
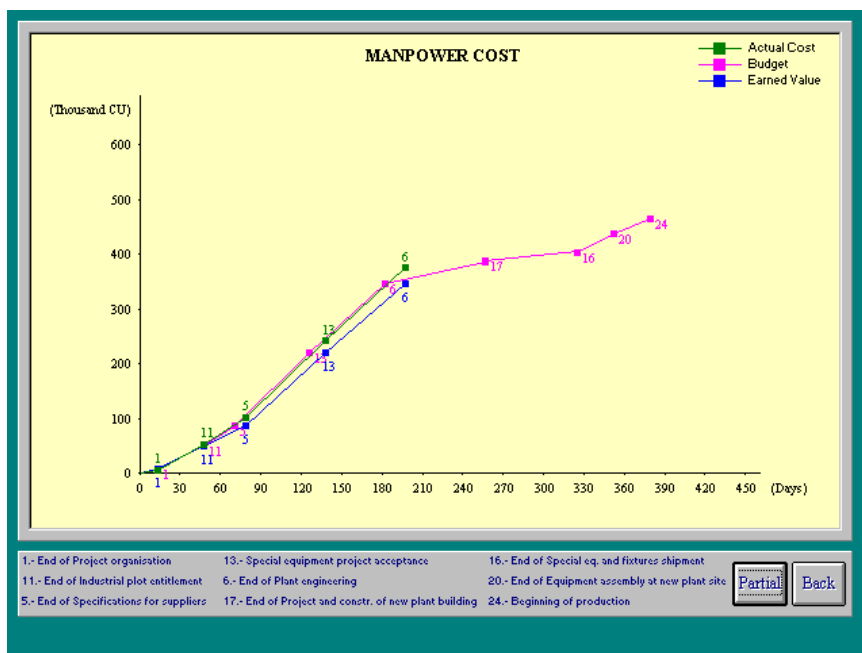
Figure 5. S-curve

pear as relevant factors. The development of the scenario is a key point. It is necessary for participants to be able to relate their own and their companies experiences with the particular situation in which the game is simulated. On the other hand, it allow the participant to assumes the role for himself. In this sense it is essential to perfectly define the frame situation with the sequence of scenes in which the action is going to be performed, the characters, with their abilities and limitations, and the tasks to be performed during the project development. In this scenario different

situations, conflicts and anecdotes, which will concern the evolution of the project, will occur.

The tool has to provide a control system of the evolution of the project state process so that, at every moment, it is possible to trace how the project is as a whole. This is enabled by an information control board. The system will have to present a steady range of running which contains a variety of decision-making behaviours. According to the decisions adopted by the project manager, the system modifies the value of the variables as it occurs in the real

world. Since it has been demonstrated in the seminars already performed, the global quantification of the variables as a single unit has been challenging for the groups.

The time sequence of the training seminar directly affects the structure of the game. Each part of the game and its duration will be delimited depending on the evolution of the seminar. A typical time distribution of the seminar would comprise 1/3 for the setting up the seminar, 1/3 for the computer simulation and 1/3 for the evaluation and presentation of the results obtained by the groups.

The project development simulation model used in the game is shown in the Figure 6. The project state is affected not only by the contingencies that could happen, but also by the results of the decisions made in the regulator, i.e. the function the participants play. The sensor of an information system gathers the project state, shown by different state variables, and compares them to the standard values adopted by the set point in the project - such as budget, master plan, supply quality specification. The difference between how it is and how it should be, triggers the regulator-function, which makes decisions concerning the project progress and the redefinition of new set points. The project development model is influenced by the project state variables which determine the next situation that will arise in our scenario based on probability laws and depending on the stage the project is going through. In this way, each group will experience different situations and different projects, depending on their decisions and the path they have followed.

The rules of decision / answer of the system require a certain degree of agility. So we do not have to wait for the system to react. The rhythm of the project (typical decision making process under the pressure of terms) has to appear at a reduced scale during each phase of the game. In addition, the system provides help and information about the project, so that participants manage, in their particular group, to interact with the tool and extract the most knowledge from the experience. The way of tackling the game design is significantly different if we try to adapt the game, with minimum modifications, to different scenarios. In this case, it would be necessary to implement a
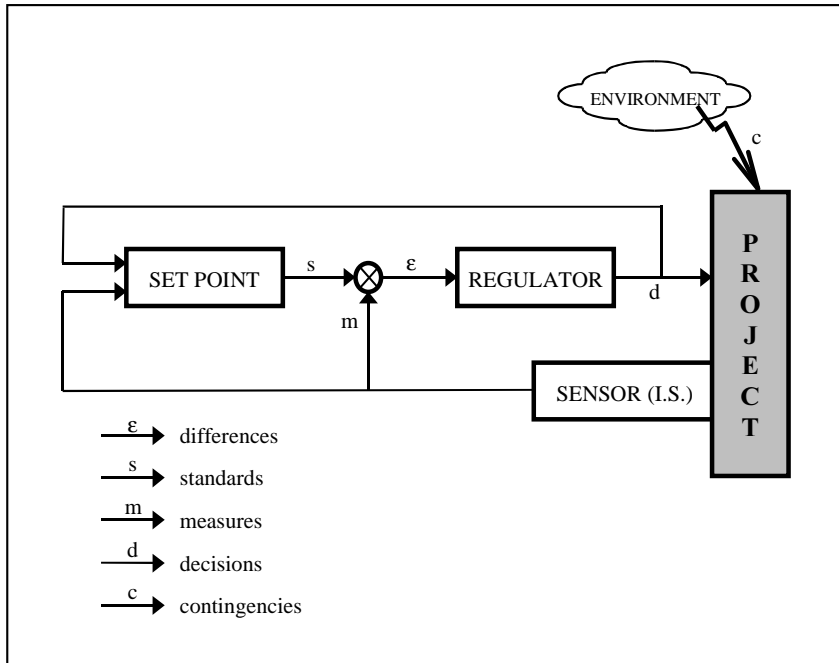
Figure 6. System Model for Project Development

macro-language which is open to a wide variety of scenarios and situations.

The game has to adapt to such a dynamic environment where the participant learns more from his partners than from the conductor of the seminar. The main interest of the seminar is based on the appearance of trade-off situations which can be tackled from different perspectives by each group. Generally the seminar could use different techniques so that different skills could be practised in diverse contexts. For instance, we are interested in dealing in groups with the different decisions which may be made with regard to the project progress. However, on the other hand, we want that the same people argue among themselves each one performing a different role, for example, to negotiate the terms of the commissioning of the equipment. In the first case we can use PROSIGA (development phase) and in the second one, games based on the role-playing techniques (Cano, 1994), (Passalacqua, 1990).

The designer of a game is obliged to carry out a huge quantity of tests where, with groups with different features, the attendants response to the application issues is monitored. It is crucial to prepare test seminars in advance during the tool development. We need to see how other people play with the simulator in order to be aware of the topics that require improvement. The interface design, the information shown on the screens, the menus, the error messages, the application help, etc. have been progressively modified through the different tests in order to achieve a high degree of usability in the application - a very important topic for the right simulation running. An independent group has been created in order to monitor the usability test of the successive PROSIGA issues.

The PROSIGA development has taken a period of 24 months with an overall effort of ten manyears. The phases in the PROSIGA development are the following: Game specifications, analysis and design in 1996, and application programming and, internal tests until 1998. 200 people (students and practitioners) have participated in seminars during the development until now.

Conclusions

All the experiences with the simulation game development have shown that a seminar approach is applicable. Simulation has been proved as useful and efficient tools with low level of risk, to improve the training in project management and allow to simplify and display the processes of internal change from a more objective point of view. Additional research is needed on how to contribute with simulation games to the project management field. At the same time virtual project environments are introduced where projects are managed through Internet applications.

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The Assessment of Client Satisfaction in the Client-Project Manager Relationship: An Expectations - Artefact Model

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The paper critically reviews the literature on customer service, service quality and customer satisfaction, identifying key issues and concepts relevant to the Client-Project Manager relationship. The project management service to the client is defined and related to the client satisfaction paradigms within the literature. A suitable model is identified, redesigned to meet the project management environment and submitted as a means by which practising project managers, after adapting it to their circumstances, may assess client satisfaction on an on-going basis.

Introduction

In the 1990's customer service has been widely recognised as providing the vital competitive key in the all-important retention of existing customers, through loyalty, and in the attraction of new customers. The general service literature highlights the importance of service as a business success factor in the 1990's, with authors such as Eccles (1994) stating "what quality was for the '80's, customer satisfaction will be for the '90's". Further, authors such as Anderson et al. (1994) posit that the extent to which a business is able to satisfy its customers is an indication of its general health and future prosperity. High levels of customer satisfaction are now seen as a means for an organisation to achieve a competitive edge, or, stated another way; service is the new competitive edge (Reicheld and Sasser, 1990; Lewis, 1990; Smith & Lewis, 1989).

Despite the widely perceived advantages associated with increased levels of customer service and satisfaction, relative to other non project orientated industries, there is a noticeable lack of project management literature discussing, relating to, or even acknowledging the fact. Such a deficiency proves all the more perplexing when we consider that as far back as 1978, researchers such as Rooley (1978) were prompted to conduct research as a result of an abundance of published adverse comment, together with "criticisms of the effectiveness of Project Management in the construction industry, expressed over a number of years, by many (clients) in influential positions". Any attempt to legitimise such reasons would seem futile in light of Levitt's (1986) comments that "there is no such things as service industries - only industries whose service components are greater or less than those of other industries....Manufacturing companies should think of themselves as also being in service....Everybody is in service".

Customer satisfaction and continuous improvement in service delivery is fundamental to total quality management. Juran (1999) believes strongly in the involvement of the client/customer in the service delivery process and that management must provide the framework, environment and culture for meeting them at the lowest possible cost. He argues that a 'triple role' concept applies to the service delivery process - namely 'the supplier, processor and customer'. He clearly sees that the output of one process may become the input of another process, therefore showing that there may be multiple internal customers and providers within a normal service encounter. The project management process is no exception and consequently emphasises the importance of securing customer input, both external and internal, into the planning stages of the project.

Jacobs (1999), drawing upon the work of Kano, states that the 'voice of the customer' must be brought into the design of the service as early as possible. Kano recognised that an important requirement in any new product or service is to 'maximise customer satisfaction while avoiding unnecessary extras that would add cost but with little added benefit'. To this end he developed a survey instrument to measure the level of satisfaction with a product or service

against customer requirements. Service attributes may fall into four categories of customer requirements. These are: exciting - where its absence has little negative effect but its presence generates excitement and high levels of satisfaction; desired - where more is 'better' and none is 'bad'; must be - considered necessary for the service to be acceptable or even considered and finally indifferent - where the attribute has no role in promoting customer satisfaction.

Whilst many service providers strive to deliver excitement attributes this is an on-going process due to competitors adopting similar services and that over time they become the norm, i.e. 'desired' or 'must be' attributes.

Thus, this research paper into client / project manager satisfaction shall attempt to redress the balance somewhat, through the adaptation and application of an appropriate model for client satisfaction measurement, identified by the author from the service quality and customer satisfaction literature.

For the purposes of this paper, the terms client and customer are interchangeable and refer to 'an individual, group, department, division or firm who require a project to be undertaken and has the ability and authority to instigate its commencement……. The client will 'own' the project or will directly benefit from its execution and is normally the ultimate arbiter of project success or failure', Browne (1997).

An Introduction to Customer Service and Satisfaction

A Definition of Service

While in marketing terms a service can be relatively easily defined as "an intangible product involving a deed, performance or an effort that cannot be physically possessed" (Dibb et. al., 1991), a convincing definition of customer service proves somewhat more elusive. Donaldson (1986) suggests customer service "means different things to different people" - sentiments which Bookbinder & Lynch, (1997) share, when they suggest that "every manager and customer will have their own definition of customer service".

Taking a general view however, perhaps we can consider an appropriate definition of customer service as: that service offered by a firm to its customers, high levels of which result in a

perception of service quality which, when recognised by the buyer is reflected in customer satisfaction, ultimately leading to its associated advantages.

Service Characteristics

Products (goods) are 'bundles' of attributes rendering satisfaction (Walker, 1995). Services too, are 'bundles' of attributes rendering satisfaction, yet they have been more aptly described as 'promises of satisfaction' (Levitt, 1986). Compared with goods, it is commonly accepted that services have unique characteristics that any service business must acknowledge (Dibb et. al., 1991; Parasuraman et. al., 1993). These are:

- Heterogeneity or Variability;
- Perishability, and,
- Inseparability.
- Intangibility;

Heterogeneity or Variability

Service performance is variable from producer to producer, as is the perception of that service from consumer to consumer and from day to day. The quality of the interactions that bank tellers, flight attendants and insurance agents have with customers can rarely be standardised to ensure uniformity in the same way that the quality of goods produced in a manufacturing plant can. The emphasis here is as much on the individual within the organisation as it is on competing organisations (Bell, 1981; Berry, 1980)

Perishability

Unlike products, services cannot be stored in inventory. Unused service time cannot be stockpiled for future time periods (Lovelock, 1991)

Inseparability

The simultaneous production and consumption of services render them inseparable (Berry, 1981). Quality in services

es primarily occurs during the service delivery in the provider / customer interaction, rather than being factory produced and delivered intact to the customer (Lewis, 1993). The luxury of a factory serving as a buffer between production and consumption is one not afforded to service providers, where their customers are seen by Parasuraman et. al., (1993) as being "in the service factory, observing and evaluating the production process as they experience the service". Such sentiments are echoed by Booms and Nyquist (1981), who highlight the consumer's role in service production as one that adds complexity over and above the production of a tangible product.

Intangibility

Services are primarily intangible - they cannot be seen, touched or tasted before they are purchased (Kotler & Armstrong, 1996). Services are performances and interactions as opposed to objects, thus precise manufacturing specifications concerning quality uniformity can rarely be set (Parasuraman et. al., 1991). What is really being delivered is purely a performance, hence the evaluation criteria that customers use is complex and difficult to precisely capture.

The Tangible / Intangible Continuum

As stated previously, services are primarily intangible (Kotler & Armstrong, 1996; Walker, 1995; Parasuraman et. al., 1992; Dibb et. al., 1991). It is widely acknowledged in the service literature that both goods and services are conceptualised to fall on a continuum, ranging from tangible to intangible (Figure 1).

This concept can be viewed in another way: Very few products are literally pure goods or pure services. Products are 'bundles' of goods and services, and vice versa. The concept of 'bundles'
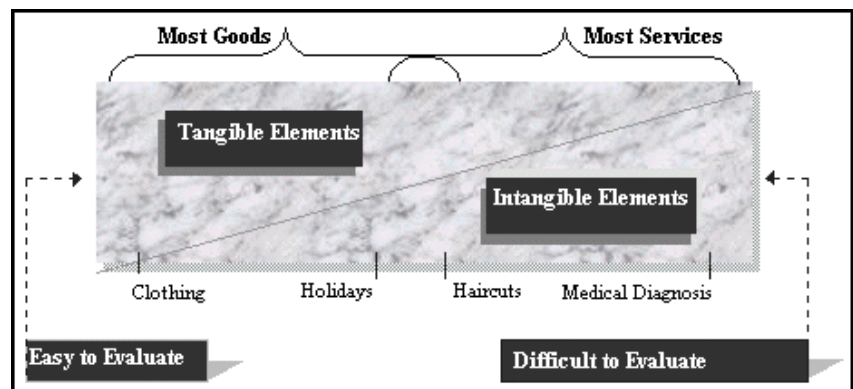

Figure 1. Rushton & Carson's (1989) Tangible/Intangible Continuum

was first introduced by Levitt (1986), when he suggested that "a product to the potential buyer is a complex cluster of value satisfactions" and is consistent with Kotler's (1988) view, that service production may or may not be tied to a physical product, and can constitute either a major or minor part of the entire offering.

When viewed in this light, one can begin to appreciate the sentiments behind Levitt's (1986) now famous statement that "there are no such things as service industries, there are only industries whose service components are greater or less than those of other industries - everybody is in service". Indeed various authors such as Payne (1993), Berry & Parasuraman (1991) and Shostack (1977), use similar tangible - intangible continuum models to Rushton & Carson's (1989) to suggest that defining services narrowly as only relating to service industries is clearly incorrect. Further, the concept of 'bundles' of tangible and intangible elements of products and services as perceived by the customer, goes some way in aiding in our understanding as to why certain industries appear more service orientated than others.

The Project Management Service to the Client

The use of project management services embodies a number of unique characteristics. The production and consumption of the project management experience are inseparable. The core benefit is primarily intangible, while the production process itself is complex and heterogeneous. In this way it is unlike many other consumption experiences (McLean, 1992).

Inseparability

In the inception and feasibility stages, both parties to the project try to come to an agreement concerning the client's needs, project parameters and conditions and terms of the service. Since the client must be present during the production of the service and work closely with the project manager to provide information on changing needs and circumstances, inseparability forces the client into contact with the production process (Carman & Langeard, 1980, cited by Johnson et al., 1996). In a dynamic view, the use of project management services may be described as having many experience qualities. A client

only begins to fully understand exactly what is being purchased during the course of the service production process; the perceived performance of the project manager in providing the service is, to a large extent, only observable once the service has been provided.

Physical and Mental Intangibility

Intangibility manifests itself in two ways. (Langeard et al., 1981) distinguish between physical and mental intangibility. Physically, the service provided by the project manager cannot be touched by the customer - it is impalpable. Project management services constitute performances rather than objects; they cannot be seen, felt, tasted or touched in the same way that tangible goods can be sensed (Zeithaml et al., 1985). Unlike a number of other services, such as taxi services or parcel delivery, project management services are also mentally intangible or difficult for customers to cognitively grasp. Amid an array of technical and complex processes, it is difficult for the inexperienced client to understand just what is being purchased.

This mental intangibility is enhanced by a rather complex project life cycle that includes, in such cases as financial services, up to eight different phases. However, most authors suggest five phases (Burton & Michael, 1991; McLean, 1992), which include: (1) inception, (2) feasibility and strategic review, (3) detailed planning and scheduling, (4) implementation, monitoring and controlling, and (5) completion and evaluation. This process involves a substantial amount of interaction between the project manager and the project's human resource element and is essential to the project's success. Yet a large part of the project does not involve the client directly; to the client much of the system remains invisible. The client is thus very dependant on the advice of the project manager to make successful project related decisions. Given that many clients have little project management expertise (McLean, 1992), it is a difficult service to evaluate.

Heterogeneity/Variability

Project management services involve a large amount of interaction with, and co-ordination of, human resources, which inevitably makes it rather heterogeneous. Langeard et al. (1981) point

out that because a project manager comes in contact with, and relies heavily on, project personnel for project success, problems of consistency of behaviour will inevitably ensue. The quality and essence of the service can vary widely from project manager to project manager, from client to client, and from day to day. This is critical because employee behaviour is an important customer criteria in service selection and retention (Parasuraman et al., 1988; Parasuraman et al., 1985).

Client Inexperience

Finally, for many clients, the use of a project manager is not a frequently 'purchased' service. With the exception of highly experienced clients, such as experienced developers or frequent business financial service users, clients rarely have the amount of experience necessary to turn a rather extended problem solving experience into a limited problem solving one or routine purchase (Howard, 1977). This suggests, therefore, that clients hold weak expectations, at best, for project management services. The expectations that exist are likely an output or artefact of the service production process which have a negligible impact on customer satisfaction. The basic argument here is that because performance information is complex and customer experience is limited, expectations are weak and unlikely to affect satisfaction (Johnson et al., 1996).

The Uniqueness of the Project Management Service

Contrasting this scenario with most other products and services - while some physical products may be complex, they are more tangible than project management services. Additionally, there is greater homogeneity in their production and customers have more experience with them. Other services, while physically intangible, are typically less complex, involve less dependence on the co-ordination of human resources, and are also more frequently consumed. In both cases, customers are likely to have stronger expectations prior to any given product or service purchase i.e. consumption experience.

Satisfaction Conceptualisation

A product or services' unique characteristics will of course determine how satisfaction is conceptualised. Of the

two conceptualisations introduced earlier, the author is of the opinion that, as a result of those unique characteristics displayed, satisfaction with project management services is best viewed as a cumulative construct. As is the case with project management services, where a service involves a high degree of inseparability, heterogeneity, complexity and a large amount of client involvement in the often lengthy project life-cycle (the 'production' process), satisfaction is best viewed as a cumulative construct that describes a client's total consumption experience, as opposed to a transaction-specific construct which is more suited to providing insights into 'short-run' service encounters (Anderson et al., 1994).

Viewing satisfaction within project management services as a cumulative construct, is also consistent with the views in economic psychology, where Van Raaij (1981) suggests that satisfaction is equated with the notion of subjective well being, and economics, where Meeks (1984, cited by Johnson et al., 1996) suggests satisfaction goes beyond expected utility to encompass post purchase consumption utility. Satisfaction, in this view, is not an ephemeral perception of how happy a customer is with a product or service at any given point in time. Rather, it is a customer's overall evaluation of their purchase and consumption experience to date.

Further, this approach is consonant with Gable's (1996) view, that an important construct in determining consultant / client relationship satisfaction, is client learning or improved client understanding. Churchman & Schainblatt (1965, cited by Gable, 1996) suggest that for management science (consultant engagement) to be effective, in addition to the scientist (consultant) understanding the manager (client), the manager must also understand the scientist. The manager needs to be educated about the scientist to understand what he is trying to do, and why he tries to do things the way he does. Views relating to the importance of improved client understanding as a construct of satisfaction are shared by many authors, including Kolb & Frohman (1970), who emphasise its importance "in order to increase the ecological wisdom of the organisation through improvement of its ability to survive and grow in its environment". Thus, in view of these comments, it is

clearly apparent that transaction-specific conceptualisation is inappropriate as a means of project management service satisfaction assessment, and is better suited to providing insights into 'short-run' service encounters.

Client Satisfaction Paradigms

The customer satisfaction literature suggests four general alternative model types. These models are referred to as; (1) The Disconfirmation of Expectations Model; (2) The Performance Model; (3) The Rational Expectations Model, and, (4) The Expectations Artefact Model.

The Expectations-Artefact Model

There is an emerging body of literature (Johnson et al., 1996, Fornell et al., 1996) positing a model to describe customer satisfaction, suggesting performance expectations are more likely an artefact of performance in such cases, and have no effect on satisfaction. Such scenarios differ from other products and services where expectations are a stronger predictor of performance and have a positive effect on customer satisfaction. This model is called the Expectations-Artefact model.

The nuances of project management services suggest that all three of the preceding models provide an inadequate description of customer satisfaction within the client / project manager interaction. At best, many clients, as a result of their inexperience (Masterman, 1992), hold weak expectations for project management services. Their expectations are more likely an output or artefact of a complex, intangible and infrequently experienced service production process, thus, the primary determinant of customer satisfaction should be perceived performance. Johnson et al. (1996) posit that expectations should have no positive or negative effect on satisfaction because they serve as neither an anchor, as in the performance model, nor a standard of comparison, as in the disconfirmation model, for evaluating satisfaction. At the same time, perceived performance should correlate with customers' stated expec-

tations. Performance gives rise to the expectations that customers report. The model, (Figure 2) posits a direct positive effect of perceived performance on satisfaction and a positive relationship between performance and expectations, without linking expectations directly to satisfaction, to capture these predictions. This model, of course, also holds important implications for those wishing to implement customer satisfaction and quality improvement programs. The argument that expectations are an output, or a by-product of the service production process means that it would be counterproductive to focus on expectations at all; service personnel should focus on improving performance rather than meeting or exceeding customer expectations.
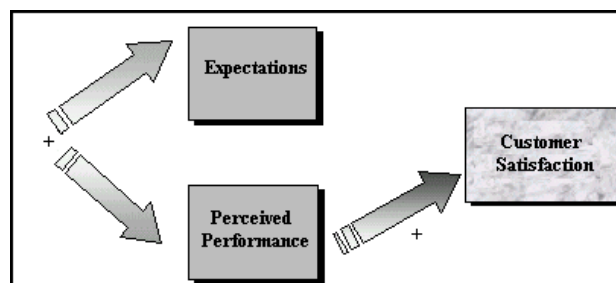
Figure 2. The Expectations-Artefact Model

Following a review of the four customer satisfaction model types suggested in the literature, it is proposed, that the Expectations-Artefact model proves the most suitable for the purposes of this research. It will act as a template for measuring customer satisfaction in the client / project manager relationship, a relationship in which it has been suggested that the client often has little or no previous experience with which to form expectations, and thus the primary determinant of satisfaction is perceived performance. Having chosen the Expectations-Artefact model as the model type, let us now turn our attention to the actual model selected, and its suitability for adaptation as a means of measuring client / project manager satisfaction.

The Multi-Dimensional Model for Client Success when Engaging an External Consultant - The Derived Model

Gable (1996) acknowledges several key issues, including firstly, the importance of distinguishing between the results of

the engagement (for example the 'goodness' of the consultant's final recommendations) and the effectiveness of, or satisfaction with, the consultant's performance in arriving at those results (the process). In other words, the Information Systems (IS) literature emphasises the importance of not only the end result but of the service delivery process in achieving customer satisfaction. Such a view is consistent with the general service literature, which widely acknowledges the fact that all elements of an encounter, for example the physical facility and service personnel, are involved in the production of satisfied customers (Zeithaml et al., 1990). Secondly, client learning or improved client understanding is an important objective or result of many consultancies. Argyris (1985), suggests that the consultant should help the organisation to achieve its objectives in such a way as to facilitate the organisation in continuing to do so with decreasing external help. Further to this view, Gable (1996) identifies an improvement in clients' understanding of their needs as one of the most important goals. Finally, the relevance of the additivity, mutual exclusivity, and completeness of the model dimensions were addressed.

Based on the literature search and case studies conducted, Gable proposes the descriptive measurement model shown in Figure 3. It predicts the existence of six important dimensions of engagement success, rather than being causal. Gable (1996) explains that the model makes a primary distinction between results success and performance. Results include the consultant's recommendations and improvement in client understanding.

These two results coupled with the performance of the consultant yield three main areas of assessing engagement success. These are: recommendations, understanding and performance. It is proposed that each of these three areas of assessment can be measured objectively versus subjectively. The objective measures for the three areas of success assessment are usage / acceptance of the consultant's recommendations, change in client understanding, and actual resource requirements versus those estimated. The more subjective measure for each of the three areas of success assessment is the client's level of satisfaction. Each of the six a priori model dimensions is now described.
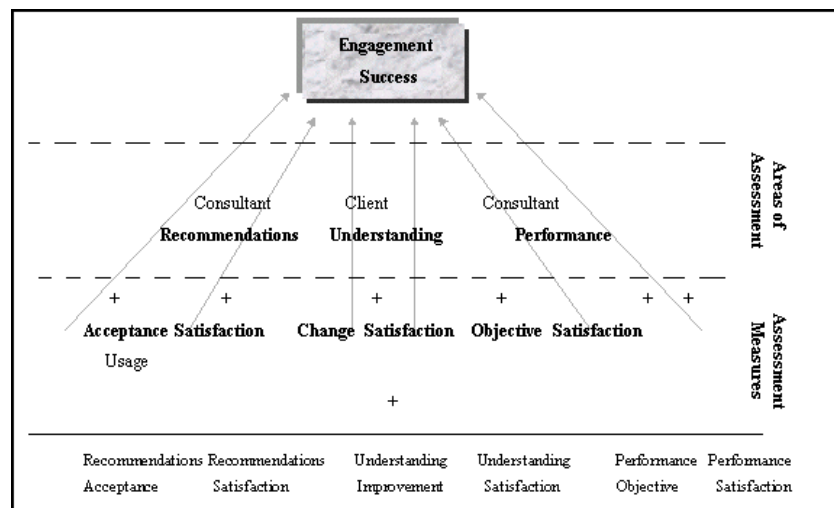
Figure 3. Dimensions of Engagement Success: The A Priori Model. (Gable, 1996)

Recommendations Acceptance

In the context of an Information system selection consultancy, usage refers to the extent to which the client 'uses', accepts, or intends on acting upon the consultant's recommendations (Gable, 1996). Ein-dor and Segev (1982), suggest that the study of usage itself is important - "we claim that a manager will use some of the (various other) criteria, and that use is highly correlated with them. Thus we choose use as a prime criterion of success".

Recommendations Satisfaction

A client may feel compelled to act upon the consultant's recommendations as a result of their investment (e.g. the consultant's fees and client resources), yet remain dissatisfied with the 'fit' of the solution recommended. Similarly, the client's inexperience and lack of knowledge of the technical aspects of the project can create a biased perception of the recommendations. This implies that usage or acceptance may not be entirely voluntary. Thus, Gable (1996) suggests the importance of also measuring the level of client satisfaction with the consultant's recommendations.

Understanding Improvement

As suggested in the literature, the importance of client understanding improvement is paramount. Improved client understanding can, as a result of a better appreciation of their needs, facilitate more effective implementation and an increasing level of general independence. Additionally, it is held that as the client is better equipped to conduct future projects with a decrease in required external assistance, they are better off.

Understanding Satisfaction

Irrespective of the degree of understanding improvement experienced by the client, they may subjectively be satisfied with the level of improvement and adequacy of their new level of understanding.

Performance Objective

This can be considered the degree to which actual resource and time requirements (cost and time) initially estimated by the consultant equalled actual project requirements. This is consistent with many authors' writings on project success factors.

Performance Satisfaction

The client may experience satisfaction or dissatisfaction regardless of the consultant time and cost performance. Dissatisfaction may arise as a result of a client's perception of poor value for money ('benefits per dollar', Fornell et al., 1996; Zeithaml, 1993), that the consultant did not demonstrate necessary expertise or experience, or did not keep the client adequately informed. Conversely, clients may experience satisfaction despite poor schedule / budget performance. If a client is satisfied with the consultant's overall performance, the engagement can be considered more successful - thoughts common in the general service literature, when Zeithaml et al. (1993) state "it is the performance of the service that separates one service from another; it is the performance of the service that creates true customers".

Content Validity

Gable (1996) posits the a priori model to reflect a comprehensive set of dimen-

sions of engagement success where an external consultant is engaged to recommend a solution to a problem. It is hypothesised that all the dimensions are distinct but relate measures of success, and that all are positively correlated with each other and with overall success. Gable (1996) explains that as the model proports to be complete and the dimensions are hypothesised to be positively correlated, the dimensions are also posited to be additive, and thus can be summed to yield a valid measure of overall success.

Methods employed by Gable (1996) to assess the content validity of the model included: semi-structured interviews of case study companies and consultants; development of a detailed case narrative to facilitate feedback from the pilot case; a publication of early problems and issues identified; pilot testing of instruments on three of the five companies; presentation of early observations to a meeting of local associations; and presentation of the a priori measures of success at a refereed conference. All suggested that the a priori model was ostensibly complete.

Applying the Model to the Client / Project Manager Relationship with Construction

It is acknowledged by Gable that his model should be adapted to suit the contextual situation, if the practising manager is to derive meaningful information from its application. Despite Gable producing a revised model the author argues that his A Priori Model is more suited to the client / project manager relationship.

Given the author's background it was deemed appropriate to investigate the construction client / project manager relationship therefore let us now consider its suitability and adaptability for that purpose.

The Suitability of Gable's Model

As shown earlier, the unique characteristics of the client / project manager relationship, and more specifically, the construction client / project manager relationship, render many models extracted from the general service literature unsuitable for satisfaction assessment within project management. Gable's (1996) Model - see Figure 3 - proves itself most suitable to adaptation as a

tool for client / project manager satisfaction assessment within the construction industry for the following reasons:

Subject Matter

Perhaps one of the most obvious reasons that Gable's (1996) model proves suitable to adaptation is the strong parallels between both subject matters. Gable's (1996) investigation into client satisfaction when engaging external consultants, has obvious similarities to the construction client / project manager relationship, especially when we consider the increasing reliance the IS client places on the external consultant to implement such complex, technical functions. Gable's (1996) choice, in selecting only clients registered with the Local Enterprise Computerisation Program (LECP), in other words, clients of which the vast majority had little or no previous experience, is also consonant with the view that inexperienced or less frequent clients of construction account for the majority of construction work (DOE, 1995; Kometa et al., 1995; Walker, 1995). This is of course, of the utmost importance when we consider the suggestion by (Latham, 1994) and (DOE, 1995) that the relative ease with which client's requirements are processed, and therefore satisfied, is related to the experience of the client within the industry. Further, it is also interesting to note Gable's (1996) statement of the relationship between clients and external consultants as being perceived as one of 'protagonist versus antagonist' - sentiments concordant with the widely held perception of the often confrontational nature of Western culture.

Areas of Assessment

The primary distinction made by Gable's (1996) descriptive measurement model between results success and performance, in addition to consistency with the general service literature (Zeithaml et al., 1990), lends itself, the author contends, to a most suitable means of assessing construction client satisfaction, through use of the three principal areas of engagement success assessment: consultant recommendations (results satisfaction), improvement in client understanding (results satisfaction), and consultant performance (performance satisfaction). The author believes that the model's use of the six dimensions (allowing both objective and subjective assessment area measurement), contributes largely to its

suitability as a measurement tool for construction client / project manager satisfaction. Of the model's six dimensions, the importance of several as antecedents of project manager service assessment, are recognised in both the general and construction specific project management literature. These include:

Recommendations Satisfaction

Inexperienced clients, as a result of a lack of technical knowledge and their investment in the recommendations of a consultant in terms of fees and resources, may feel compelled to accept, and act upon the recommendations of a consultant, yet experience dissatisfaction with the proposed 'fit'. Thus, the importance of recommendations satisfaction as a contributory factor to an overall perception of client satisfaction is of paramount importance. This proves especially so, in the construction industry, where inexperienced clients often possess insufficient information and knowledge to clearly understand and define their needs, and will therefore depend heavily on the project manager to do so. Any recommendations made by the project manager in this respect will have a major influence on the client's fundamental needs, thus play a major role in overall client satisfaction. Another reason that project managers should attempt to ensure high levels of understanding (and therefore satisfaction) in this dimension, "is that ultimate blame for defective work and /or poor functioning of constructed facilities is usually put on the industry" (Anumba et al., 1996)

Understanding Improvement

Gable (1996) and other authors within IS literature, such as Argyris (1985, cited by Gable, 1996), place an importance on client understanding or client learning as a satisfaction assessment measurement dimension. This importance is consistent with the views of many authors in the field of construction, who all stress that an active client's role is crucial for project success and subsequent client satisfaction. They also advocate the provision of adequate information on the operations of the industry (DOE, 1995; Kometa et al., 1995; Anumba et al, 1996, Latham, 1994; Cherns & Bryant, 1984). Improved client understanding not only improves general independence, but also facili-

tates more effective implementation through an increased understanding by clients of their needs (which Gable (1996) posits, is at the heart of many failed client / consultant relationships).

Performance Objective

The degree to which the actual project resources and time requirements equal those originally estimated is analogous with the writings on project success dimensions in all fields, and hence, is highly applicable to the construction client / project manager context.

Performance Satisfaction

As is the case with performance objective, the subjective measurement of performance satisfaction is equally applicable to all service provision contexts. The author contends that the inclusion of this satisfaction assessment measurement dimension is highly important as it allows the client's overall subjective satisfaction or dissatisfaction with consultant performance (which may be experienced regardless of Performance Objective) to be recorded. This is of equal importance to construction client / project manager satisfaction measurement as it is to all other service encounters.

Satisfaction Conceptualisation

The transactional or 'buyer-seller' view of service provision is an 'arms-length' one, involving well specified rules, which assumes the client (the buyer) is responsible for specifying exactly what it is he/she wants, the conditions and schedule for delivery, and the negotiation of price. Tilles (1961) suggests that such a view of the client / consultant relationship is misconceived, and suggests the relationship more akin to a 'partnership', which Gable's (1996) model takes account of. Such a view is consistent with Johnson et al.'s (1995) suggestion that satisfaction within services such as project management be conceptualised as a cumulative construct, hence the author's belief in the model's suitability as a means of measuring satisfaction within the client / project manager relationship.

The Adaptation of Gable's Model

The author's adaptation of Gable's, (1996) model involved a relatively straightforward process. Each of the satisfaction assessment measurement dimensions was re-phrased, within a ques-

tionnaire based research instrument, for use within a project context.

Empirical Research

Research is on-going into the application of Gable's adapted model within the Irish construction industry. Early results show that the model is both effective and efficient when measuring construction client satisfaction. Utilising a mail questionnaire, a survey sample of 82 construction clients and their project managers were approached, following identification by the purposive method of non-probability sampling in an attempt to select a sample representative of construction clients as identified by DOE (1995). A total of 28 sets of usable client and project manager responses were returned. Data was subjected to both the descriptive and inferential methods of statistical analysis using the SPSS software package. The results obtained were used to compare the difference in attitudes held by both parties towards client satisfaction, and to identify the individual assessment areas which bear the greatest influence on, and association with, overall client satisfaction. First order results indicate the importance of project managers putting in motion a continuous process for (1) monitoring client perceptions of engagement success, (2) identifying the causes of success shortfalls, and (3) taking appropriate action to improve levels of construction client satisfaction. The research conclusions and recommendations will be the subject of future publications.

Conclusion

This paper introduced the reader to the concepts and constructs of customer service, and the general service relationship as found in the service literature. The characteristics of the client / project manager relationship were found to be quite unique when compared to those of the general service relationship, and by the same rationale, the construction client / project manager relationship, by encapsulating a series of complex issues related to satisfying client requirements, can be viewed as quite unique from the general client / project manager relationship. Gable's (1996) model was identified as being suitable for adaptation and utilisation in the measurement of client satisfaction.

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Organizational Change as a Project

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Project management has been studied and its methods developed over many decades. There are, however, many aspects in which an internal change project differs from a traditional delivery project. The philosophy and methods of project management are an important part of the implementation of an internal change project, but the approach and emphasis clearly need to be different. Organizational development and change management skills are needed as well, i.e. change project occupies an area where change management and project management merge. This article discusses the special features of a change project and how project management techniques should be applied in context of organizational or operational change.

Nothing is constant but change

The dynamic business environment today requires frequent changes both in the way organizations operate and in the organizational structure. In a study of changes facing Australian corporations 65 percent of human resource managers estimated that the extent of change their corporation had met during the last three years was either major or radical (Waldersee and Griffiths, 1996). According to survey of over 500 chief information officers (CIOs) in 1993 the average CIO was engaged in 4,4 re-engineering efforts compared to mere 1,6 a year before (Moad, 1993).

Companies all over the world struggle through big re-engineering and organizational restructuring efforts, restructure their management, rationalize and downsize, introduce changes in award-systems and apply flexible work practices, strive for total quality management, try to implement empowered high performance teams and streamline their manufacturing operations. The entire future of these organizations may depend on the success of the change projects and great effort is put into implementing them. Shorter throughput and delivery times, better production planning and control and elimination of non-value adding processes are examples of the typical goals of operative

changes (Salminen and Perkiömäki, 1998). Changes in organizational structure lead towards process organization and breaking down interdepartmental barriers, and team-based organization (Waldersee and Griffiths, 1996).

Despite the importance of the issue and amount of consultants and research organizations offering their help many change efforts fail. They fail to produce the performance enhancements that were planned or they end up months late or with costs remarkably in excess of the budget. Some change efforts die slowly in silence and some can even cause harm to the overall performance of the company (Nortier, 1996). According to a 1991 survey of US electronics companies only 37% of those engaged in total quality programs reported that they had succeeded to improve quality defects by 10% or more (Schaffer and Thomson, 1992). Estimated 50%-70% of re-engineering efforts never reach their goals, (Hammer and Champy, 1993; Revenaugh, 1994).

Whatever the actual failure rate may be, the fact is that many change projects fail for one reason or another. It clearly seems that there is something in the way organizational and operational change is usually managed that leads to these miserable results.

The dominant approach to organizational change

Change in organizations has largely been viewed from two different angles, namely changing the organization and human behavior, and changing the operations and mechanisms of the technical system. In the beginning of the century, when the modern organization started to develop, most of the research concentrated on organizations as purely technical systems, leading to simplistic and mechanistic assumptions about change. Theories of Taylor, Fayol, and Weber, applied most successfully by Henry Ford, represent this early school of managing change in organizations.

As the shortcomings of the mechanistic approach started to become obvious, an opposite school of thought started to conquer the field of organizational research. Kurt Lewin's work in interpersonal, group, intergroup and community relationships built the basis for so called human relations movement. The most established part of this movement is often called organizational development (OD) school. More recent development on this field has led to integration with theories of large scale strategic change (Dunphy and Griffiths, 1998).

The basis of the OD movement lies on the recognition of the fact that

organizations are collections of people, and changing how organizations work is thus fundamentally about changing how people work. People deliver the value to the customer, and ability to deliver value to the customer is what determines the success of any organization. Following this line of though most of the problems in organizations can be traced down to conflicts between people. All changes in organizations and related systems require changes in the way people work. That is why OD theory views management of change always as management of people, motivating them and solving conflicts between them (McCalman and Paton, 1992). Organizational development has been defined as "a planned process of change in an organization's culture through the utilization of behavioral science technologies, research and theory." (Bourke 1987, p. 11). So even though OD involves the element of planning, it clearly concentrates on the use of behavioral and sociological methods, and even the planning aspect deals usually with planning of behavioral interventions.

There are practically no mentions about systematic controlling of implementation of changes in the OD literature, and when the issues of control and monitoring are addressed, the message seems to be that project management is too technical and bureaucratic in flexible and complex framework of human organizations. McCalman and Paton (1992) have addressed the application of project management methodology to management of change as an alternative for traditional OD approach. But they seem to regard project management as something that can not be fully integrated with organizational development methodology and is to be used predominantly in simple and mechanistic, technically biased change.

It seems however, that one possible reason for the high failure rate of the change projects is the failure to treat them as projects. In our recent study of 27 change projects the only variable out of thirty correlating statistically significantly with the success of the project was the coordination and monitoring of the project (Salminen et al., 1999). An earlier study revealed that the factors most strongly connected to change project success were associated with project control, training, and general project management practices (Salminen and Perkiömäki, 1998).

Project is a project is a project…

A project is often defined as a unique piece of work with predefined start and end dates, objectives, scope, and budget, performed by a temporary organization. PMBOK makes a distinction between projects and operations - though admitting that these two can overlap - on basis of continuity and uniqueness. According to this definition a project is "a temporary endeavor undertaken to create a unique product or service" (PMBOK 1996, p. 4). Temporary means here that each project has a definite end, which is reached when the objectives of the project are reached. Uniqueness of the results means that no other product or service of exactly the same nature has been produced before.

Project management literature is traditionally built around a life-cycle model of a project and tools, methods and techniques needed to carry out the project management task in context of this life-cycle. The phase of the life-cycle determines which activities and what work should be carried out, and to certain degree also who should be involved (PMBOK 1996). The activities of each phase are described in detail in many sources, and numerous tools and methods are provided by the literature. The skills, knowledge and methods required from a project manager can be formulated as necessary capabilities that form the project management body of knowledge. The strength of the project management discipline is in its ability to provide a systematic framework for planning and implementing one-time efforts in limited time-frame.

There are relatively few publications on the role of project management in managing change, and practically no empirical research data on the issue seems to exist. The traditional project management has concentrated on core projects delivering products or services to outside customers and only recently has the orientation turned into internal support projects - such as marketing projects and OD projects - as well (Gareis, 1998). Cleland (1994) and Boddy and Buchanan (1992) are some of the few authors on the field of project management openly addressing the issue, giving implementation of industrial automation and new strategy as examples of typical internal projects.

On basis of the definitions given above it is clear, however, that any op-erational or organizational change is a project. Individual change effort is a one-time task that has predefined schedule, goals, and scope and is usually carried out by a temporary project organization. Even though the history of the project management is connected with management of large-scale product development or capital investment projects, recently some authors have explicitly addressed the fundamental role of projects in producing change. Cleland (1996, p. 35) goes as far as defining project as "something that brings about change in an organization" and has, in addition to features outlined in definitions given earlier, "complexity, scope, or innovation beyond the operational work of the enterprise, a key role in preparing the organization for its future, significant contributions by two or more functional units of the organization, an a direct contribution to the success or failure of the organization." He also claims that project management constitutes one of the main forms for converting an organization from one state to another.

One of the possible reasons for the bad reputation of the project management discipline in managing change is that during the past decades it has been too often degraded to a collection of planning and control techniques and tools, and seen as highly bureaucratic. But as early as 1959 Gaddis (as quoted in Cleland, 1994) referred to project management not in terms of techniques, but in multitude of approaches including cross-functional teams and importance of communication.

Another reason for neglecting the project management issues in change projects and organizational development activities may be the fact that many specialists of organizational change have a background on organizational psychology, leadership theories and human resources management, not in engineering or project management. Also the person in charge of a change effort is typically either a line manager of the organization or a specialist from human resources function, internal development function or quality department. These people are experts in their own special field of knowledge, for example day-to-day production activities, quality management, flexible manufacturing systems or logistics, but have often very little previous experience in project management.

Specific features of change projects

Even though change clearly should be managed as a project, organizational change projects differ from traditional "hard" projects in many ways. Turner and Cochrane (1993) have classified projects to four categories according to clarity of goals and methods used, as presented in Figure 1. The complexity of change project raises from the ill-defined goals and methods, as it is not always clear what the actual outcome of the project will be and how it will be attained. Even when the goals of a change effort are measurable performance improvements, the what can still be unclear in the sense that the design of the actual organizational and operational solutions leading to these goals is in itself an important part of the project.

The most significant feature distinguishing internal change projects from external projects is the fact that the organization is changing itself, i.e. the members of the organization are both suppliers and customers of the project. This can lead to difficulties for instance in determining project success or customer satisfaction and makes responsibilities somewhat unclear. As the goal is unclear and there are usually different opinions about what actually is the product of a change project - quite contrary to traditional engineering projects - and the customer is not performing any final tests to approve the product, the question of how to actually determine the success of a change project becomes crucial.

According to a study of internal development projects - i.e. product development, software development and organizational development - and project manager's role the three major differences between internal and external projects are (Mikkelsen et al., 1991):

- Weak initial foundation of internal projects. Internal projects are not based on a clear contract and there are conflicting ideas and ambitions about the project inside the organization
- Organizational development content. Development of organization and personnel and learning are among the most important tasks in internal projects.
- More competition of resources with day-to-day operations in internal projects.

The lack of contract is actually a manifestation of the ambiguity in definition of customer. In addition to this internal projects can be initiated from any organizational level, and they sometimes start as small-scale improvement activities gradually turning to major change projects. This can lead to difficulties in attaining a project sponsor or project champion. Mikkelsen et al. (1991) emphasize that a clear vision and strong management support in combination with participative planning and implementation are the key success factors of internal projects. While traditional methodology concentrates on the project life-cycle and the hard dimensions of project management, such as budgeting and scheduling, change project management needs to emphasize the human, organizational and political aspects of the change as well (Boddy and Buchanan, 1992).

According to Boddy and Buchanan (1992) distinctive features characterizing management of internal change projects include lack of earlier experience from similar projects and difficulties in determining resources and time required, sometimes even difficulties in determining the results of the project. Change projects tend to induce new change needs in other parts of the organization and thus make the scope management difficult. In addition to this the costs can be difficult to evaluate (Mitilian, 1998), as the bulk of the costs can occur as internal labor costs of people attending development meetings and training sessions. Boddy and Buchanan (1992) also claim that changes are usually implemented in clusters and there may be multiple change efforts simultaneously under way. This might be true but it hardly can be considered as a specific character of internal projects these days, as that is exactly the way most project-based companies operate.

In addition to these slow emergence of cultural and economic results makes organizational change projects more complex than traditional projects. The more complex and people oriented a change project is, the more it calls for organizational development tools and techniques instead of hard systems centered project management tools (McCalman and Paton, 1992). It seems, however, unjustified to totally discard the project management approach and replace it with organizational development methodology in such cases. Quite contrary, the more complex a project is in terms of ambiguity of objectives, number of activities, unclarity of activity boundaries and sequences, indeterminate duration and resource requirements of activities, non-technical orientation, and activity success largely dependent upon motivating people, the more systematic the planning and control efforts should be. At the same time

		Goals Well Defined	
		Yes	**No**
Methods Well Defined	**No**	Type 2 Project Product Development	Type 4 Project Research & Organizational Change
	Yes	Type 1 Project Engineering	Type 3 Project Applications Software Development

Figure 1. Goals-and-Methods Matrix (Turner and Cochrane 1993)

Life-cycle Model

Conceptual	Planning	Change	Conclusion
• Identify and communicate need for change • Carry out analysis • Estimate available resources • Sell the project to key personnel • Ensure management support	• Define organization • Define vision and goals • Define & allocate tasks & resources • Schedule • Build project team	• Ensure participation • Motivate people • Implement changes • Coordinate and monitor progress • Train • Communicate changes	• Consolidate changes • Transfer responsibilities • Ensure follow-up • Terminate project • Evaluate the project • Reward personnel • Feedback

Table 1. Life-cycle model of change projects

it is naturally necessary to bear in mind the flexible and living nature of such projects and allow for changes and iteration.

Project Management for Change Agents

According to the authors' experience of organizational and operational change projects from varying fields of industry and of varying scope and goals, a great deal of "good old" project management is always needed to achieve the planned performance improvements. But the special features of change projects have to be acknowledged. The critical success factors of change projects and the skills required from a change project manager are somewhat different from the success factors of traditional external projects. These differences are reflected in the change project life-cycle model presented in Table 1. It is based on the four-phase project life-cycle model of Adams and Barndt (1983), but the activities in each stage are supplemented by change management and organizational development methods.

In addition to the clear change management issues that naturally have to be added to the agenda of a change project manager - just as a software development manager have to add software development issues to his - emphasis and nature of some basic project management methods have to be altered somewhat for a better fit with the change management context.

There are at least three practical implications that have to be accounted for when applying project management in change projects. First of all a special emphasis should be put on goal setting of the project to ensure that everyone in the project has the same idea of the objectives. Secondly, when plan-

ning the project, a special attention should be paid to resource allocation and scheduling to assure sufficient resources and enough time for learning. Third characteristic feature of change projects is the high emphasis on motivational issues in project control.

Setting the goals

The goals of any change effort must be in line with the company vision and strategy. It is important that the change project drives the company to the direction described in its vision statement. The connections with the vision will also make it easier to justify the goals to people dealing with the project and helps them commit themselves to the objectives.

As the progress usually can not be measured in terms of materials assembled, it is crucial that the goals themselves are measurable either in terms of performance improvements or as clearly defined structural and operational changes. Otherwise it is difficult to determine whether the project team is going to the right direction at a sufficient pace, whether the actions taken have had the desired effect and, finally, whether the goal has ultimately been reached. It is not rare to come across internal change projects of which nobody can tell whether they were ever completed or not

People readily commit themselves to clear goals if they have participated in setting them up and have had the opportunity to influence the contents of the project. When planning a change project it is beneficial to have representatives from all stakeholder groups involved in the process. A brainstorming session or some other participative method is a good way to scan the main development needs of the different personnel groups and integrate them to the overall goals.

Planning the project

The ultimate purpose of a change project plan is to describe the project so that all those involved understand what the project is all about. Anyone ever involved in a delivery project of a paper machine knows roughly what is involved in a delivery project of some other paper machine, even though the machines and projects may be very different in many respects. But a person who once participated in a re-engineering project may have a completely wrong picture of some other re-engineering effort, as the terminology and methodology of organizational change is not well established. The problem is often how to describe the different phases of the project and the methods used so that everyone understands them similarly and knows what is anticipated of them. How is layout design carried out in practice? What does it mean to be assigned to a development team, and what are the tasks of different teams? Why should the shipping department supervisors participate in planning the operating principles of the assembly department?

An important part of planning and managing any project is dividing it into manageable sub-projects and individual tasks. This is done to ensure that all the necessary actions are included and to form a realistic basis for scheduling, resource allocation and budgeting. Errors in dividing the project into suitable entities are directly reflected as errors in cost estimates and scheduling. Composing a work breakdown structure (WBS) is a standard part of the toolkit of every project manager, yet far too often neglected completely in internal change projects. A change project is primarily dealing with people, not with tangible products and tasks with well-defined deliverables, which makes the composing of WBS more difficult, but more, not less important than in less complex projects.

In addition to WBS, previous experiences on corresponding projects should be used as a basis of scheduling and resource allocation as far as possible. However, the problem with change projects is that they are usually concerned with new and unproven concepts and methods, with which nobody in the organization has ever dealt with before. It is then naturally difficult to assess the workloads and the time needed for different tasks. The situation is

further complicated by difficulties in estimating time and resources it takes from different individuals to learn new things.

Getting sufficient resources in respect of personnel, material and money is a prerequisite for a successful change project. More often than not the amount of work needed on an extensive internal change project is underestimated by a factor of ten. Changing internal processes requires a lot of time and effort, for even if it would be easy to change the systems themselves, changing the personnel's ingrained working habits and deep held beliefs takes time.

As most personnel resources assigned to a change project work for the project on part-time basis on top of their daily duties, it is important to specify the resource-plan down to the level of the individual person. This is again a routine task in many external projects, but practically unheard of in the context of internal change projects. For every subproject, the time usage of every member of the team is examined: how much time the members can allocate to the project? Any problems should be brought forward at an early stage in order to secure additional resources in good time.

Controlling the project

In practice, a change project is usually coordinated and controlled in regular monitoring reviews or meetings, and not even basic project management software tools are used. In the review every part of the project should be considered from the viewpoint of schedules and progress attained. With delays in schedule, also expenses tend to go up due to the resulting inefficiencies. Especially in a change project costs are often directly related to its duration, as the wages of the people tied to the project can be the most significant part of the total expenditure. With a delay in the completion of a task, it is good to require the person responsible for the task to produce a clear plan of how he or she intends to rectify the situation. Far too often change project are sloppy and uncontrolled, as no explicit effort is made to control the progress, make adjustments to schedules as deviations from plans occur, or reallocate resources as needed.

Merely monitoring adherence to schedules is, however, not enough. Most important function of project control

in change projects is to motivate people to strive for the project goals. A construction worker usually does his part of the construction project even without any extra motivating efforts or incentives, as he gets paid for the project work. In the internal change project most of the people get their pay from taking care of their daily line responsibilities and keeping the customers happy, not from the development work done for the project. It is the foremost responsibility of the project manager to motivate people and make them do their best for the project.

Active and open communication about progress and schedules is also an important part of personnel motivation, as most people are enthusiastic to see that the project is running well. If people don't know what has been achieved, they might feel that all their efforts have been in vain. Positive feedback is crucial. In contrast to a construction project where the daily progress of the work is clearly visible to everyone, in a change project it may seem that nothing concrete happens for a long period of time, as most of the work might be training and designing of new systems. It is thus important to try to visualize the progress of the project through some sort of project chart that is frequently updated and accessible by all involved.

Conclusions

The need for understanding and mastering of all the techniques and methods of project management is perhaps not as critical in internal change projects as it is in large external projects. Nevertheless, every company engaging itself to a change effort should make sure that the project manager they assign for the project understands that she is managing a project and has the capability of doing that in a systematic manner.

Organizational and operational change projects call for a combination of knowledge and skills derived from both project management and change management. Neither the existing change management practices nor the project management body of knowledge form a sufficient presentation of skills required from a qualified change project manager. Change projects should be managed as projects with thorough planning and strict coordination, but bearing in mind that organizational change always deals with changing the way people behave and thus unavoida-

bly also with the sociological and psychological issues.

The article addressed the dominant human centered approach to managing organizational change, and argued that more, not less, systematic approach to planning and controlling of change efforts is needed. The basics of project management were then briefly discussed and it was shown that any organizational change effort fulfills the definition of a project. Some probable reasons of organizational change usually not being treated as a project were discussed.

The specific features of change projects from project management point of view were then discussed. Internal change projects are often unclear in what is to be done and how it should be done, do not have a clearly defined customer, are highly dependent on peoples ability and motivation to learn, and are not the priority number one for the company. On basis of this a life-cycle model of change projects was introduced. The model combines issues of project management and change management in a systematic manner. Then three key features of this model were discussed in more detail: 1) goal setting of the project to provide well understood and manageable targets, 2) resource allocation and scheduling to assure sufficient resources and enough time for learning, and 3) motivational issues in project control.

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Factors Impeding Project Management Learning

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The article presents learning as a critical factor of success for project-oriented organizations. When new project situations require unique adaptations, learning becomes imperative to understanding and deriving improved responses to what will be taking place. Learning involves moving to higher levels of abstraction, in order to evaluate a subject against its context. This fosters the processes of renewal and innovation, and responds to the growing need for project self-regulation. Complex conceptions of learning and confusion about its process can, on the other hand, impede it. Additional forces also impede learning to do things in a better, more useful way. The purpose of this article is to describe practices of individual and organizational learning for use at a company level above projects, yet keep a connection to individualized learning at the project manager level. The authors believe that the project managers, those who carry out the tangible company assignments, are the best suited to illustrate the advantages of learning for a forward-looking company. The article draws from a study of industry-wide adaptation and learning activities. Titled Conditions of Success, it was carried out with 60 international project-based firms. The results illustrated the evolutionary role of learning and the business significance of it for firms that manage large, diverse projects.

Challenges of a Changing Project Context

Project management education and execution often begins with definitions similar to that found in the PMBOK (1996):

> "*Project management is the application of knowledge, skills and tools, and techniques to project activities in order to meet or exceed project objectives and stakeholder needs and expectations from a project. Meeting or exceeding stakeholder needs and expectations invariably involves balancing competing demands…*"

Project management is thus seen to include a wide variety of subjects. These range from projects for developing a new good or a service, projects for developing or modifying a social organization to projects for relating a technical system to a natural setting. A project can be set up to produce or modify infrastructures, factories or buildings, or to bring new business processes into existence. This variety makes it difficult to describe projects in a way that is sufficiently wide to be inclusive, yet focused enough to be useful. To further complicate the defining process, project environments can quickly get caught up in rapid change processes.

There is much that managers can do to manage projects in a more systematic and integrative manner, yet they are often encouraged to restrict themselves to the tangibility of what is known and hope for luck. Projects present interesting circumstances that challenge reason while inviting luck. Recent articles in the Harvard Review and a management book by Eisenhart (1998) discuss the phenomenon of rapid change linked to the desirability of getting people to embrace it and "compete at the edge of change." We believe there is a need to go further than this by preparing project managers with new theories for how best to manage changing practice at the edge of their reality. In this article theory and practice are seen as mutually important to improvements in project management. Either acting alone is seen as deficient to growing challenges. We base these comments on the legendary dictum of the famous social scientist Kurt Lewin (1951), "there is nothing so practical as a good theory." In the telecommunications project industry, for example, ignoring theory would be to exclude knowledge as to how best to move from second to third generation systems, while excluding practice would have bypassed the experience for why a move was essential to the continuance of the industry.

It seems appropriate to apply Lewin's sage wisdom to finding ways to improve the practice of project management. We strive to support project managers who seek innovative ways to re-

spond to change they know is important, yet don't fully understand. An array of forces are behind these change dynamics, including a continual shift from projects based on goods to those focusing on services, growing technological sophistication of the production, delivery and operation systems, and an emerging decentralization of traditional hierarchical management structures. The complexity grows as the dynamics of change overrun the remaining islands of stability. So too does the gap between the situations that we passively occupy, and ones in which we would prefer to be active participants. We propose that learning is the most effective means to manage complexity and bridge the gap to improvement.

Looking at the shifting themes of professional management meetings illustrates the current rate of change. These meetings are shifting from fixed supply-chain analysis, and mechanisms for its prediction, command and control to much more fluid means to manage that which appears too complex to understand and too exciting to ignore. This can be seen in the theme of the 1999 annual conference of the Strategic Management Society SMS (1999), a widely-respected management meetings. Titled "Winning Strategies in a Deconstructing World" the conference is about deconstructing contemporary theories of the firm and the corporate strategies that guide them.

> "*Deconstruction forces a fundamental rethinking of some of the basic principles of strategy with potentially broad impact on concepts of the portfolio, forms of organizational structure, styles of leadership, mechanisms for acquiring and managing knowledge, and approaches to uncertainty and risk.*" (SMS 1999).

Formal Education vs. Genuine Learning

There is uncertainty as to what knowledge is, and which skills and tools will best complement future project manager work. Perhaps the most we can say at this time is that, under conditions of change, learning is very important while being able to move to a higher level and learning to learn, may be critical. If the intent is to improve project results, as was stated above, through "meeting or exceeding project objectives and stakeholder needs and expectations" then the support framework needs to include more than the limited knowledge of formalized education systems. They are too fixed to tradition and slow to respond. With the objective of expanding such limits, learning herein signifies upgrading the larger cognitive context by accessing higher level thinking activities.

Learning requires higher level processes than education. Education is a formal process that has long helped members of society to acquire knowledge. Its primary means are memory expansion and analytical exercises. Learning processes transcend memory and analysis. They improve knowledge by questioning the viability and validity of what is known; i.e., always seeking to improve cognitive quality. Herein there are two major ingredients to the cognitive qualities of learning: rationality and non-rationality. All project events are presumed to contain a mixture of both. Rationality is the process of reasoning with oneself or others to arrive at a logical framework. This is important for communication and formalization of common objectives and activities to achieve them. Rationality allows for clear identification of what is formally known and what can be done with this knowledge. Reason points to opportunities that can be realized, and risks that can be reduced or avoided. The danger is that project managers come to believe that projects only involve the rational, or at least a manager should restrict his considerations to that which is clearly rational. A large world exists beyond the limits of reason, and it can have significant impacts upon situations and how they improve, deteriorate or otherwise change. This is the area of the non-rational and includes politics, religions, aesthetics, and something project managers call luck. It is easy to describe the educational process for acquiring things of reason, but negotiating with the non-rational requires more; it requires learning. The question then becomes how do you learn about luck?

Luck is an everyday form of pre-destination. Risks of circumstance and matters of timing are filed under good or bad luck. As such, humans feel there is little they can do to change, control or manage such non-rationality. Herein, learning is developed as a means to deal with the non-rational domain and make it more susceptible to human capabilities. There is a rich body of scientific literature emerging in this area that combines recent knowledge of biology, chemistry, computer design and electrical engineering. The award winning science book of Steven Pinker (1997), How the Mind Works, outlines the most recent developments. The essence of the book is that we must learn to entertain questions that change the frame of reference, not just the details in a continuing frame. We have the capability to do so, but the pervasive attitude is that we shouldn't. Pinker argues that we have much greater capabilities than we use. We can simultaneously deal with very fuzzy and very clear things, yet the normal mind prefers to simplify around what is known. Project managers prefer decisions made on economic, technical or similar narrowly-derived grounds. Messy combinations are avoided. Managers generally prefer clear decisions that are wrong, to ambiguous decisions that have a good chance of being right.

Leading companies now pay a premium for graduates who have developed their abilities in learning to learn, instead of the traditional educational emphasis on developing skill in prediction and control. Learning is one of the most desirable doorways into the future. It is an accepted prerequisite for success in a project company, as emphasized by Artto, et. al. (1998) where they introduced the concept of learning loops. The learning, innovation and creativity loop in project companies emphasizes the crucial importance to project companies fostering their people to develop self-regulating and innovative activities. Instead of reliance on fixed management methods, a project company must employ knowledge intensive and flexible business practices so as to ensure adaptation to new situations. There must be room for innovative and creative solutions.

A distinction was made at the outset between processes for education and the learning process. Via education, assumptions about reality are acquired. For the second, the same assumptions are questioned and criticized. Under conditions of stability, education is efficient and effective. Under dynamic conditions, effectiveness requires learning. Loop learning theory illustrates this. It is able to encourage exploitation of experiences and business practices that further facilitate learning by the organization. A new management paradigm in a project-oriented company, with a specific emphasis in learning, is suggest-

ed by Gareis (1996). It contains a distinction between individual learning and closely related team and organizational learning schemes.

The authors of this article recognize the importance of organizational learning and intend to address it, however, the basic hypothesis behind the content, as based on the authors' experience, is that important strategic and forward-looking decisions generally occur at project manager and operative levels. Thus, the purpose of this article is to provide a theory for introducing the practices of organizational learning into a company at an organizational level just above projects. To do this effectively, we feel that the organizational learning must accommodate the central problems of project managers' and respond to their needs for individual learning. Project managers are increasingly important in the current climate of needing to decentralize authority. A project, for purposes of this article, is an organized, multiple-person, set of activities directed towards improving the situation of those involved. In this way it excludes individual actions directed at narrowly-defined self-fulfillment. Project management learning, obviously needs to result in improved management of projects, but this may increasingly involve learning to managing projects in non-traditional ways.

Project management research generally concentrates on issues of efficiency in answering questions as given. It generally avoids challenging the underlying questions of what is project management and why is it different from other forms of management, e.g., managing repetitive manufacturing regimes. We attempt to open up some deeper questions that address the effectiveness. They can generate significant debate and chances for significant progress, but tend to get "sticky" for those involved. Some stickiness is acceptable and needed to see if the right questions are being asked. The alternative is to continually improve the efficiency in answering the wrong question. We need to reconsider the questions that project management asks. This builds on the Peter Morris (1998) Project Management article and the Karlos Artto (1998) editorial. Their concern is less with improving projects under conditions of stability, and more towards creating a better future during states of change.

An Evolutionary Perspective on Learning

A new context for learning is needed. An initial attempt is outlined in this section in order to support learning and help improve project management at a higher level. Developed several decades ago, it presents a different sense of what learning does. Generally neglected, often forgotten and frequently misinterpreted, this frame is used here instead of its recent prodigy because it provides more insight for responding to change. The newer "translations" lose something and can lead to tangents and dead-ends. Some aspects of the work of Schon and Argyris (1976), and Nonaka (1996) illustrate this. The frame begins with Kurt Lewin's model that links the concepts of learning and change (Lewin 1951, p. 66):

> Within what is called learning, we have to distinguish at least the following types of changes: (1) learning as a change in cognitive structure (knowledge), (2) learning as a change in motivation (learning to like or to dislike), (3) learning as a change in group belongingness or ideology (this is an important aspect of merging into a culture), (4) learning in the meaning of voluntary control of the body musculature (this is one important aspect of acquiring skills, such as speech and self-control).

All four changes can be important to improving a project manager's activities. The improvements range from high-level negotiations with that which leads to significant change in the cognitive context, to simple accommodations of minor modifications to movement. All four types are interesting but the emphasis in this article lies in this first area, in the changing of cognitive structure. A small elaboration on each of the other three is given in the following before returning to the first type.

1. Change in cognitive structure sponsors innovative, and unpredictable, behavior and is perhaps the most critical to changing structures in project management activities. This is important when structural change is needed to meet the challenges of complexities and environmental shifts. This can be seen in project situations that require shifting from strict British hierarchical chains of command to Japanese autono-

mous work groups.

2. Change of motivations, and finding new motivations, is especially critical to keeping project quality at a high level. This is where a practice, or result, that was previously considered acceptable is seen in a new light that reclassifies it as substandard.

3. Changing group culture is a means for individuals to find new ways to work systemically within a group, a project team, and a company culture, and is one of the long-standing factors of success for a project manager. The interested reader is advised to consult Lereim (1997) for recognition of different groups and related cultures such as different engineers' groups, culture of the company, and individuals'/people's own culture.

4. Changing ergonomic tangibility is always helpful for certain tasks. Traditional measures of project productivity arose from this area of learning. Many decades ago young students were given tests in this area to help determine what kind of profession or trade they should be directed towards in their later studies. Via the growth of importance of computer driven work these tests have been largely suspended.

The first Type of learning, change in cognition that underlies knowledge, appears to provide a fruitful platform for improving the current project environment. This is because cognitive change is the most significant, and a significance is needed to respond to the high change-rate now taking place in project initiation and execution. Even though cognitive learning operates at a high level it has obvious links to traditional project management concerns, e.g., it helps with finding the best traits of a new employee? It is better to seek employees that illustrate a depth of knowledge in a specialty, or to find people with less depth but are able to learn fast? The answer of course also depends on contextual issues of company characteristics, location and expectations. Successful project management firms illustrate success through emphasizing both extremes. A very successful major international firm that participated in the study described in the next section hires from both extremes, although they are

now shifting to the learning side. Their choice was initially based on the country in which the individuals will work but is now trying to respond to the project change rates in most countries.

The model of learning presented here clearly favors finding employees with abilities for learning to learn, over capabilities in knowing. There are several reasons for this, where the most important one may come from the limits of pragmatism. This dilemma confronts the historic limits of knowledge. The dictum of pragmatism has been, "If it works, use it!" The dilemma is what happens when it doesn't work? Project pragmatism worked very well in the 1950s, and later, but has gradually became less and less successful. In the turbulence of the 1990s it has almost been abandoned. The philosophy of pragmatism, especially American pragmatism of the 1930s as described by Will James, John Dewey and Singer, provided a profound foundation for American project, business and educational development. James (1978) illustrates this most clearly in his work in the 1930s. He found what worked and helped to place it in practice. The American approach to industrial management and development made rich use of this philosophy, but the dilemma for the school, and for America, eventually arose when "what worked" was no longer so obvious. U.S. Society then had to turn back once again to its base in research and theory building. While initially done for security and space exploration reasons, the knowledge gained therein has found its way into project management.

The following outlines a theory of learning that was important to U.S. self-criticism and the push to develop research. It emphasized Lewin's first type of change, as outlined above, "Learning as a change in cognitive structure." This is a change in the cognition of what is and isn't. It helps in responding to situations where "practice doesn't work." And fundamentally new knowledge is needed. This need is presented in five different levels in the following, where the progression is from less to more significance.

The essence of this theory of learning is learning by asking questions at ever-higher levels. Using this, a project manager could manage change by the questions he asked. Known as the Socratic method, where the essence is on dynamic thinking so as to be more sympathetic to the process of change, this activity avoids formalization and fixations. It has long been the underlying method of developmental science. The anthropologist Gregory Bateson (1973) was the author of the structure of the theory of learning used in the following.

Learning at Different Levels

Five levels of learning are suggested in the following. They lead up to the cognitive changes suggested by Lewin outline in the previous section. They are:

Zero learning - No learning takes place here. The activity is characterized by simple and direct responses, which, regardless of whether they are right or wrong, are not subject to any change or correction. (For example, there is a command and control simplicity, where hierarchical orders are given and taken without question.)

Level I learning - This is change in aspects of specific responses. Correcting errors of choice is allowed, but only within a narrow range of alternatives. (For example, alternatives to a set of project specifications are allowed, or given.)

Level II learning - This is change in the process of Level I; such as making a corrective change in the set of alternatives from which a choice is made, or change in how the sequence of experiences are punctuated. (For example there is a moving between assignments, or learning to do a variety of jobs)

Level III learning - is change in the process of Level II, e.g., a corrective change in the system of sets of alternatives from which choice is made. (We shall see later that to demand this level of performance of some men and some mammals is sometimes pathogenic. This could involve redefining the sexual habits of men in a protestant community, or to have those building nuclear power stations to switch to photovolteic stations.)

Level IV learning - is a change in Level III, but probably does not occur in any adult living organism on this earth. Evolutionary process has, however, created organisms whose ontogeny brings them to Level III. The combination of phylogenesis with ontogenesis, in fact, achieves Level IV. (This would involve people learning to not go to war, to achieve a new relationship to nature.)

Learning is a vehicle for building, upgrading and setting aside fixed knowledge, and making room for new knowledge. In this way knowledge is placed in a context where it can be evaluated and improved. This differs from how knowledge might be conceived in a process such as competence building, where the act of questioning is given a low priority. In the above model, learning begins at level II. The learning first examines the presuppositions about an action to be taken, just like Socrates delving into ever-deeper levels of what is known, in order to access the mind. This is like a project manager asking why something is being done instead of how to do it? It opens up a new area of human potentiality but can easily lead to confusion associated with accompanying dilemmas, double binds and contradictions without obvious exits.

Double binds, as first identified by Bateson (1973) are situations where in a project situation you must give a "gift" in order to gain a contract, yet your home country's laws say it is illegal to give any such "payment" to potential clients. Closely related to this, but in a much more popularized manner was the key concept of Joseph Heller (1994), called Catch-22s. These are similar to double binds, except more ironic and dynamic. In a Catch-22 situation the rules keep changing, yet the participants don't know why or how. Studies of the design process illustrate how creativity is directly linked to effective generation of responses to double binds and Catch 22s. Perhaps this is why design is increasingly seen as an important skill in many firms in most industries. (Hawk, 1992) The logic for Learning II helps set the basis for this by assessing what we think we are capable of, and then eliciting creative responses to change the basis of these thoughts. This has been used to help project managers and other kinds of workers deal with change. (Hawk, 1992)

Learning III is different. It offers high learning rewards once accessed, but humans have great trouble accessing it. One reason is that humans tend to be tied to hierarchical processes that in fact probably don't exist in the mind, and this kind of learning is non-hierarchical. The limitation is greatly eased here when humans leave behind the security of hierarchical structures. Leading international firms, e.g., ABB, illustrate some of what this means. This is

consistent with current developments in management theory where hierarchical structures are being broken down, or left behind. Non-hierarchical forms of learning begin to emerge in level II learning but are not critical until level III. Bateson argues that there is no evidence of any humans being capable of accessing learning in level IV. He believes that only evolutionary development in nature illustrates this learning form.

Firms are looking for ways to manage the challenges they face when traditionally separated business practices become ever move tightly woven into a systemic fabric. Magazines and journals commonly refer to this as increasing complexity. Emerging models of project management parallel this development and reach for ways to deal with growing site chaos and complexity. Increasing sophistication, technological complexity, and continuous environmental change challenge discipline-based approaches. This may help explain the growing importance of the project concept in helping to cope with growing complexity. Recent articles (Runeson and Skitmore 1999, Stocks and Singh 1999, Price and Mangin 1997) illustrate the need to go much further and move to higher levels of learning. Our objective is a model of learning that supports this work.

Learning Inputs: Data, Information and Knowledge & Wisdom

It is important to distinguish between what is and is not learning. Part of this can be seen in the shifting focus of concern for learning over the years. Shifts have been taking place in universities and companies since the 1950s. IBM illustrates this clearly. The sixties, was truly an age of data. Data collection was the prime objective. More data was always better. IBM seized the conditions to attain tremendous growth by helping people collect data. During the early seventies the focus shifted from data to its organization. IBM's worked to redefine itself around what they thought would be an emerging era of information. They articulated the key concepts of management information systems (MIS) as designed systems to organize data and give information. The era of MIS continued into the late eighties, when it was discovered that having more information was not the same as

	Inputs	Activity	Objective
1	Data	Collecting	To acquire
2	Information	Organizing data	To inform
3	Knowledge	Organizing information	To know
4+n	Wisdom	Seeking meaning	To unlearn

Figure 1. Learning Stages

being more informed. Issues of knowledge and competence were beginning to enter the discourse. "Knowledge creating firms" and "knowledge assets" began replacing the MIS terminology.

It is likely that this progression will continue. If so, it is possible that wisdom may become an emphasis in the future. Knowledge is organized information, and information is organized data, but wisdom is not hierarchical, cumulative, linear, obvious nor organized knowledge. In fact, it may begin with the disorganization of what is known, and a discarding of some knowledge. The search for wisdom will not be so easy.

As Figure 1 illustrates, the key to moving from one stage of an operation to another is to shift to a higher form of organization. Organized data becomes useful information, just as organized information becomes knowledge, and organized knowledge allows access to wisdom. The above schema illustrates the depth of the problem, not the solution. Those devoting their lives to data end up finding small challenges. They can live with an easy belief that more is better - a million data points is obviously superior to a hundred thousand. Much of the work of Wharton's Larry Klien, and more recently Harvard's Michael Porter, illustrates the tendency to seek knowledge from assembling data, but not organizing it. This well-grounded approach was handed to the social sciences from classical physics in the last century. The world of pre-Heisenburg, pre-chaos and pre-complexity allowed data to rest in positivistic objectivity so that truth might arise from it. Modern science has become much more skeptical and demanding. It looks for qualitative differences in data, makes the filters for seeing it more explicit, and requires more innovative methods for giving it a sense of organization.

A fascination with the idea of "information" is more recent, but here too,

there was a belief that more is better, although the believers had to work harder to remain faithful to the ideology. When they came to believe that information is everywhere, and everything is information, and via the use of advancing technology they can eventually gather and organize all information ad infinitum they eventually began to ask deeper questions. The Human Genome Project (the US National Institutes of Health project to find and classified all DNA) exemplifies this.

It is interesting to note that the early development of information systems began with discussions about the difference between information and wisdom. Data was presumed to simply be there as a resource. Several of the early Bell Labs people concentrated on the information level via their theory about the importance of getting the message between A and B. Simultaneously, Norbert Wiener, Gregory Bateson, et.al., (1972) tried to redirect concern from information and to meaning via cybernetics means to clarify meaning and improve human wisdom. Bateson in particular argued for rising above the limits of rational human thought in order to get beyond what he then called "unaided rationality." This was an early articulation of Nobel Prize winner Herbert Simon's concern about operating within "bounded rationality." Within a decade both concerns were buried under a quest for data, and technologies for its management. This was the hardware problem that IBM eventually turned into a 1974 software problem with design of the MIS challenge. This became the doorway into IBM's soft underbelly that Microsoft since took such great advantage of. Many tools for project management were developed along the way of this evolution, but all have been disappointing.

Reaching Towards Wisdom

Interest in information is the current

focus of information sciences and some areas of management theory. It is here that the dilemma of meaning surfaces. While those lower on the information food chain concentrate on how to make men think like machines, those at a higher level try to make machines think like men. In his development of heterarchical and N-Form (knowledge-seeking) organizations Gunnar Hedlund, (1994) attempted to avoid both groups and look instead at the bio-chaotic, holographic processes involved in learning. This work could be very helpful to managing projects, as it has been in firms like ABB.

During the past years, management concerns have moved towards the idea of knowledge creation, with concern as to what knowledge is. The work of Hedlund (1991) and Nonaka (1996) illustrates this emergence. They began with the model of learning used herein but then developed it in a direction that allowed it to initially seem more optimistic, but eventually was seen to lack the potential of the initial model. They avoided the highest level of human achievement, called wisdom, in that they felt it was too difficult for humans to relate to. Based on work in a Lucent Bell Labs project, e.g, Hawk (1994), it may be that they were right, and that wisdom may be of a very different logical type than knowledge, but it remain as important. Meaningless knowledge can in fact be shown to get in the way of wisdom, and meaningful knowledge requires avoiding of useless information. This is consistent with the Japanese belief that it is important to forget what was known in order to learn to do things in new ways. The key question then become, if learning is such an obviously good idea, why is it not an integral part of business organizations?

Heresy often accompanies wisdom, in that wisdom is often preceded by the asking of questions about the most closely held beliefs in a given system. Heresy is where a member of a "church" ask fundamental questions about the basis of the church; e.g., "what do of rules of the church really mean?" Whitehead and Russell, in, Principia Mathematica (1997), set the stage for this process when they established the theory of different logical types. The content of Figure 1 is set up as a logical typing model, not a hierarchical scheme. It is a logical framework that allows modeling of the resources that

can go into learning as segmented or integrated inputs. Whitehead and Russell saw learning as a doorway into ways to organize and then question closely held assumptions. Their model was instrumental to early development of ideas about communication and information technology.

In an era of increasing applications of information technology, and thus increasing the importance of self-regulation and decentralization of authority and information, theories such as Whitehead and Russell's are important to decentralized discourse. This sets the stage for significant innovation and variety. Eric Trist's afterword in Cal Pava's (1983) book on how information technology decentralized the management of work addresses this point in an especially helpful manner. This work introduces the concept of deliberation as a key aspect of improved operations and management, where information technology is especially adapt at increasing the possibilities for project deliberations around alternatives and improvements. This can be helpful to project management firms that must prepare their employees for these new contingencies, potentialities and dangers. As Trist pointed out, the stumbling block is the conventional industrial model of control that has great difficulty with complexity.

> *"In conventional technocratic and bureaucratic organizations the structural foreground is occupied by static positions that delineate the responsibilities of the office-holders and their authority to discharge them. These positions confer ownership of expertise and access to privileged knowledge in ways the falsely politicize the resolution of complex issues dependent rather than on pooled knowledge and interpositional collaboration."* (1983, p. 167)

Impediments to Project Management Learning

The model of learning described and discussed herein is for project managers and firms who are driven to find ways to improve what they do and how they do it. Many firms are members of this group, and they wish to respond by experimenting with innovative learning processes. What then stands in the way they and their most motivated employees fully embracing the learning proc-

ess described in the prior section? What are the impediments to learning?

Human endeavors are exceedingly complex phenomena. They are complicated to begin with, and then after we invest a great deal in understanding them, they seem to move and change into something else entirely. An early impediment to learning thus becomes the notion that "learning isn't worth the time and trouble it takes." This is soon countered by a realization that the change process itself must be learned about so it can be managed, thus learning needs to be moved to a higher level where it can in some ways anticipate change. This sometimes leads to attempts to manage change, thus calling for learning at an even higher level of operations.

There are other impediments to project management learning that, when examined more closely, become strong arguments for learning. One of these is the strategy for dealing with growing complexity by avoiding it. Project managers have widely noted that the projects must manage appear to be getting ever more complex, and increasingly difficult to comprehend and manage. This is due to the growth in number of project parts and the increase in relationships between parts. The concern is highest when complexity is directed linked to an expensive project failure that resulted from a failure to understand. Many believe the only response to this is to invest more hours, thus leaving no "spare time" available for "learning." Research illustrates that a simple addition of more hours seldom aids in management of complexity. When we say something is complex, it's a sign that we don't understand how it is organized, thus we need to learn about organizational principles and other things at a level above the project. Since complexity is generally in the eye of the beholder, not the phenomenon being viewed, it is the viewer's vision that needs improved, not his work efficiency. The complexity argument that normally inhibits learning then becomes a key argument for why learning is essential.

An additional class of impediments is just as important although less obvious. These impediments can include how a method for doing something in a closely specified way can become a rationale for not doing it better. This can also be called attitude, where

method and attitude can reinforce the weaknesses of each, especially if both are conceived as closed systems. A new method can temporarily open up the process, but often ends as up as another fixed recipe. It too can quickly lose its capacity to handle new inputs. The history of operations research (OR) illustrates the process.

Impeded Operations Research as Impeded Learning

Much can be learned by looking at the history of a significant discipline that has long been important to project management education and practice. Called operations research, it has passed through a life-cycle of birth, rapid rise, stagnation and fall from grace. Examining it illustrates the process of knowledge building, organizing and obsolescence.

OR methods have been used throughout project management. Early OR leaders believed that its seven prescribed problem-solving methods could be used to solve all human problems. The creative challenge was to describe problems so that they could be fitted into a method's framework. The most innovative stage of OR development came out during the life-threatening urgencies of World War II. It saw rapid improvement during the 1950s and by the 1960s was common to most conceptual and operational decisions of leading organizations. By the 1970s, leading firms had begun to move from a focus on OR, where those most skilled in its methods were placed at the organization's margin. Firms were by then looking for methods and people that were systematic, systemic and strategic.

A great deal of effort was put into applying systems theory, communication theory, management information systems, and strategic warfare scenarios to the emerging challenges of business. Change has continued where current attention is now with use of neural networks to design and manage projects. It seems that just as a set of concepts become clarified and operational, i.e., rationally useful, they are no longer capable of accommodating change. Since change seems endemic to the project process what should project managers do? Analyzing the development of one of the leaders in the initial effort to apply OR, and then to abandon it, may help highlight the process.

Russell Ackoff was centrally responsible for bringing science to project and operations management via development of operations research. His various text-books on different operations research (OR) techniques and their applications to business needs have been used throughout the industrial world. His 1962 book, Scientific Methods, was translated into 26 languages during its first two years (Ackoff, 1962). It became a model for modeling efficiency and quality analysis in many industries in many countries.

Ackoff turned away from this tradition in 1974, and left its focus on positivism, quantification, CPM and PERT charts. He then published an alternative to traditional project operations management which he called "project redesign." (Ackoff, 1974) Instead of struggling with management of the more problematical aspects of projects, he advocated their redesigning. He argued for tapping into the underlying human capabilities linked to learning and innovation. He criticized his earlier OR methods for having become too focused and fixed, and unable to respond to the dynamics from growing challenges. He argued that business problems were changing more rapidly than the methods set up to manage them. He felt that OR had stopped learning, and that this had happened due to the arrogance it attained from its early gains.

Proactivist Attitudes as an Impediment to Learning

Attitude can also be an impediment to learning. "Proactivism," while effective under some conditions, can impede the will to learn new things. Ackoff illustrated this for managers in terms of the model in Figure 2. He wanted to encourage an interdisciplinary, interactive approach to problem and project management but found that certain attitudes would get in the way. Figure 2 illustrates this in terms of four different approaches to dealing with the future. These approaches can also be called "postures." They are the reactivist, inactivist, proactivist and interactivst.

- Reactivists were those who felt the best future and best chance for them lay in a context that resembled the past. Thus, each decision they would make would be an incremental effort to bring the past into the future. They often

prefaced a decision-point with the comment: "In the good old days, we…"

- Inactivist preferred the sanctuary offered by the present. Their decisions, and work, attempted to keep things from changing. They rely heavily on committees to slow down, or eliminate good ideas, and "keep things from happening."

- Proactivists were quite different. They either longed for the hope that could be offered by the future, or felt it was inevitable and thus they should improve their role in it by getting there prior to others. They continually searched for the next wave heading for the future, where these were primarily structured by new technology.

- Interactivists were of a different type. They felt that the prediction and forecasting basis of the other three was counter-productive to the dynamics of living systems. Instead of building better information for a more efficient central control, they seek to decentralize responsibility so individuals can work out the qualities of information in real time. They are more interested in "creating" a future that ought to be, instead to trying to predict what is assumed to inevitable. The interactive participants are to be members of the other three groups, since those represented all available people.

Figure 2 is not from Ackoff's model but illustrates how attitudes towards time can become an impediment to learning. Ackoff's model points to the importance of problem solving that can step outside the limitations associated with time. There is a deeply seated tendency to rely on time to resolve problems, such as difficulties in project management. Via prediction, forecasting and/or simply waiting, it is hoped that a resolution will occur. This is one of the most important and most common characteristics of problem solving methods. It can be avoided, thus encouraging a more active, innovative and integrative stance.

The Ackoff scheme is growing in importance just now. This may be because the proactive manager is currently the object of affection in most magazines and consultant recommendations. Managers are counseled to become "more proactive" in what they do. A

	Past	Present	Future	Outside time
REACTIVE	✔			
INACTIVE		✔		
PROACTIVE			✔	
INTERACTIVE				✔

Figure 2. Attitudes for Solving Problems

proactive person is thought to be the most ideal form of manager in 1999. In the original 1974 Ackoff model, the proactive person was thought to be far too compliant and complacent. He depicted proactivists as closely tied to prediction and control strategies, and unwilling to tap into the significant potentials in redesigning and reinventing improved futures. Proactive choices, as defined by the author of the concept, were intrinsically linked to and limited by time.

An interesting question is why, in the later 1990s, does management embrace part of the Ackoff model but only first three-fourths of it? In a context of there being many possibilities for future development, due to technological (internet) and managerial changes (decentralization of control), it seems that the interactive posture is now much more appropriate and viable. It provides great potential for improved project management. There are many additional impediments to learning that need to be considered. Three examples are.

1. Comfort can get in the way of learning. Being comfortable has often been an impediment to learning. When we accept the status quo we are no longer very motivated to change it or prepare ourselves to deal with unexpected change in the future.

2. Client beliefs can impede learning. Clients are not always right. It has become fashionable to say that a decision depends on the client but this in fact has become an easy way out of a situation that demands more of the project manager. Often a client does not know what to do. That is sometimes why a project is launched in the first place, and why it must be innovative.

3. Profit is seldom complementary to learning. Profit is not the most important aspect of a project. Assuming that a project is set up to accomplish some improvement, in not profit the objective of the project, but a reward for accomplishing it. This is a critical distinction. The idea that we are out to make a profit is often used for ignoring learning, research and development activities.

Information about these and other impediments to learning was gained from a study project done at the Stockholm School of Economics under the title of Conditions of Success (Hawk 1992). It involved 60 international project-based firms and is outlined in the following section.

Examples of Project Learning from the Conditions of Success Study

A major international management study, titled "Conditions of Success," was carried out by Hawk (1992) during the period from 9/89 - 6/92. It was set up to help the participants better understand what their world would be like at the end of the century, and how best to locate themselves and their companies within it. The work was funded and directed by the participating companies, which included 60 major international firms from seven countries: England, Finland, France, Germany, Japan, Sweden and the United States. Eighteen of the world's largest construction firms participated, as did several large engineering, design, component manufacturing, materials and financial organizations. A few major clients were also involved. The essence of the project was an action research venture to help participants learn how best to internationalize as they studied what it meant for

their industry. Incorporating learning came to be an important subject in the study.

The study was of company internationalization in an industry organized around project business. The industry had been slow to consider the consequences of globalizing its business methods and operations. The participating companies defined their industry as one that provided building, water, energy and information infrastructures so as to support the activities of other industries.

The study began with a presumption that no human activity is successful, or unsuccessful, in abstraction. Success factors depended upon the relationship of an act to a set of conditions within which the act is carried out. The complexities increase as the conditions change, which generates new acts, and leads to new relationships, which in turn can generate new conditions. Surviving in this environment requires continuous learning, where learning is different than the process of continuing education.

One example from the study centered on the practice of construction management (CM), as it began in the 1970s, as a form of project management. For some applications CM was the right approach, while for others it was distinctly wrong. The complexity was that any use of CM, right or wrong, could lead to changes in context. This meant that CM success in the short term depended on the conditions where it was applied, yet over the longer term a minor or even wrong application of CM could then spread to generate new conditions where CM was highly successful. An example of this is outlined in the following.

A large Swedish construction firm, participating in the study, argued that construction management might sometimes be helpful, but that it shouldn't be allowed in Sweden. "In Sweden only general contracting should be allowed." CM, as it was used in the project, refers to the principle where a contractor has a very different relationship to a client. They take responsibility for a project in the form managing the work of sub-contractors to achieve a fixed price delivery of set objectives. General contracting, in the Swedish context of the time involved having legions of internally employed workers carrying out a cost-plus or related

scheme. Risk and responsibility management were handled very different in the two approaches. This situation of this major firm being fervently against CM was especially interesting to the other participants in the study, since outside of Sweden the same firm had switched to only doing contracts via the CM process. Participants were interested as to why the difference?

The answer came from understanding the conditions of national and industrial structure, and how income was accrued in the Swedish construction industry at the time. The firm could, at least for a few years beyond the study, resist the obvious conclusions that construction management was a good idea for clients although it would create new challenges for construction in Sweden. As long as they could control the national context, and keep the advantages of general construction, they would. They could not do this internationally. In other countries they did not have the control option and had to be more adaptive. Over the next five years they developed a very high form of CM in non-Swedish projects; i.e., they learned a great deal. The same firm is now much more successful in their international work than the work they do in Sweden. Officers in this company recently discussed this "lag in learning" in their home context, and the long-term price they had paid for short-term risk reduction at home. They are thankful for their international operations. This illustrates a clear difference between the educated knowledge of what to do at home and learning that had to be done to meet new challenges and risks abroad.

The study focused on the issue of learning at the level of the executives that participated in it. This was to set the stage for learning within their companies and their industry. The study was structured around concepts of product development, since most other industries had already internationalized via these concepts and thus a great deal was known about what worked and what didn't, but these were brought down to helping to manage projects. In this framework the study worked to identify the best information, knowledge and need for learning over the next decade. A hint of this can be seen in what the industry felt to be the most promising business development ideas over the next decade. This was then used for the

industry to identify its main research priorities during the same period. Finally, this was seen in light of the critical factors to applying or not-applying the new knowledge that had been gained. This collection of information was then to be used as a basis for learning. The stream of the inquiry is indicated by the conclusions outlined in Figures 3-5.

In the figures, the information is arrayed in terms of national clusters, pointing to differences and similarities between countries. This was because the individual company responses needed to be kept confidential and thus grouping them with others from their own nation made them opaque yet provided rich information with which each could ascertain where they stood.

Figures 3, 4 and 5 offer some results from information generated in the study. The three charts focus on the learning aspect of organizational and industrial development as it was defined within the study. The numbers represent composite scores for all studied companies from each of the seven countries. They were combined to mask their individual identities, while presenting a national perspective towards the various topics being studied.

The numbers represent the priorities of each category. Number one is the highest priority and number seven is the lowest. The dash line means that the topic, while proposed by the composite group, was not under active consideration by country group. The category of "other" refers to something a national set of firms was looking at, although it had not been included in the formal list from the composite industry.

For example, "lateral thinking" was thought to be the most promising business idea for the UK and US firms, and "decentralization" was the least promising area for future business development of UK firms. Meanwhile, Swedish firms were looking into "other." The figures point to individual and organizational learning as critical to successful internationalization of the industry studied. There was a consensus that the "industry" would need to help the companies and their people move beyond formal education and towards "learn to learn."

> *"Construction firms traditionally would hire people with a moderate education, depending on where they were to be placed in the value-adding stream, and count on*

> *those people to function reasonably well in a relatively stable environment. The environment now changes too rapidly for this tradition. Employees need to enter with higher degrees of training and need to have access to a continual learning system while on the job. Some firms do this with internal corporate programs. Others rely on continuing education in outside institutions. Most do neither. It is imperative that a learning system be an integral part of the industry and its companies. The industry will need to have a system that rivals what is found in advanced technology industries. Therefore, learning to learn is a critical attribute of future firms in the industry."(Hawk, 1992, p. 10)*

Implications from Conditions of Success

The results suggest a number of implications. A most general one was that a firm's internal "radical" thinking, which they had tried to keep secret, was in fact widely known and even appreciated in the larger industry. Once this was discovered, the problem shifted from secrecy to one of how to develop a collective basis for high-level, mutual and individual learning. They soon found that there was much that they could do to help each other while not interfering with individual rights to pursue a "competitive advantage." A small group even proposed shifting from competing against each other, and move to learning how to jointly compete against industry-wide ignorance. To successfully operate in the global conditions of this industry firms felt they must find new ways to learn new things. They moved to reach this in ways that included questioning existing practices and developing fluid approaches to embracing risk. One conclusion in this regard was that "globalization is happening, and learning is critical to successful participation in the dynamics of the process, but participation is not for all firms."

The essence of Figure 3 is that the majority of the firms were looking to areas for learning as the most promising basis for future business during the next decade. "Intelligent systems" and "lateral thinking" were seen as the most fruitful areas. The more pragmatic concerns of possible business development opportunities, e.g., "developing leisure-

	Leisure-time facilities	Creating Owners	Intelligent Systems	Environmental Concerns	Decentralization	Lateral Thinking	Other
American	-	5	2	3	4	1	6
English	3	2	4	5	6	1	-
Finnish	5	-	1	3	6	2	4
French	-	5	1	2	4	3	6
German	-	5	4	1	2	6	3
Japanese	4	5	1	3	6	2	7
Swedish	7	5	4	6	1	3	2

Figure 3. Most Promising Business Ideas for Next 10 Years

	New Materials Development	Old Materials Development	Building Production Technologies	Building Operations Technologies	Management Information Systems	Environmental Technologies	Other
American	5	6	1	3	2	4	7
English	6	5	4	1	2	3	-
Finnish	4	5	1	3	2	6	7
French	6	5	3	1	2	4	7
German	7	5	3	6	4	1	2
Japanese	2	7	3	4	5	6	1
Swedish	-	3	5	6	1	4	2

Figure 4. Research Priorities for Next 10 Years

	Organizational Communication	Organizational Synergy	Knowing Customers	Cost-Benefit Analysis	Management Systems	Perception of Difficulty	Other
American	4	2	3	1	5	6	-
English	2	-	3	1	4	5	-
Finnish	2	1	-	3	4	5	-
French	3	4	2	-	1	5	6
German	-	5	4	3	6	1	2
Japanese	4	2	1	-	5	3	6
Swedish	1	-	5	3	2	4	6

Figure 5. Impediments to Applying R&D Knowledge

time facilities," that were initially assumed to be the "best" targets, ended up with a very low priority. Only the Swedish firms differed and felt that future business development would first need organizational restructuring via "decentralization," prior to focusing concern on learning. The second priority for Swedish firms', noted as "other," was development of future business by moving into creating "industrial learning environments" for customers.

The essence of Figure 4 is that the research priorities in most of firms were directed at topics that required significant learning. At the time of the beginning of the study management information systems were defined to include information and communications technology, knowledge management systems, and training of personnel in all of the above. For most of the firms, the area became a very high priority for research investments. The exceptions were German firms, that were going to concentrate on environmental concerns, and Japanese firms, that were going to concentrate on intelligent technologies, that they wanted to define in a way that did not fit with the larger group.

The essence of Figure 5 illustrates what firms felt to be the largest impediments to their being able to apply what is learned in research. It is important to note that there is no clear pattern in the responses. This is very interesting in that the impediments to learning seem not to be industry-wide. They instead appear to be culture-based. As the figure illustrates, the reasons for not implementing an improved practice can include almost anything. The reasons come from what was previously called the non-rational domain. Knowing this often elicits a response that we should thus ignore them. This is dangerous. These impediments in fact can be seen as "culturally-based" and can thus be effectively dealt with on their own terms. Learning is important to this. Several companies ended up setting up or modifying their own R&D and learning centers after the research to help employees better deal with future contingencies. In some instances these complemented their prior educational centers, and in other instances they replaced them. Many participating firms have since worked out joint ventures, mergers and acquisitions with each other to better share mutual resources.

In addition, the participants learned a great deal about the variety of attitude and skill types that were needed in a successful project. The following is an abstraction of this work as it comes from the study. It points to four different kinds of people that are commonly found in a project. At first glance most would argue for one or two of these as most critical to a project's success. In fact, due to the divergence of belief between the companies, as to which type was the best to hire, it was decided that all were valuable. What was instead needed was a more sophisticated management model that could include variety, so as too best meet the objectives of a project, instead of current emphasis on one type of person.

Careful consideration of each illustrates that it offers a unique set of attributes, but emphasizing any one in isolation becomes dangerous to the firm and the project. Learning is different for each, but mutual learning helps all. This is similar to the problem posed in the Ackoff model in Figure 2, where a focus on the assumed advantages of the proactivist project manager can turn out to be as large of an obstacle as were the known limitations of the reactivist and inactivist attitudes. How to manage their interactions is more important to success than selection of a preference.

I. Strategist - Knows, but doesn't implement. Currently the most sought after type of project manager. In practice perhaps the greatest problem for longer-term project management. This person's actions eventually come to illustrate why successful strategy is always deceit, but that deceit is eventually counter-productive. Also illustrates how learning to uncover deceit becomes learning to deceive at a higher level.

II. Servant - Knows, and does, in predictable, dependable style. This is the individual that tries to be as dutiful as possible in carrying out the assigned tasks. Hired with the presumption that he knows how to do certain tasks very well, and will carry them out to the best of his ability with limited management. Little management is needed, except instructions. This person is generally not expected to learn, and doesn't. Seen as a tremendous short-term asset but becomes a longer-term liability.

III. Innocent - Doesn't know, and doesn't do. Seemingly a problem but in fact can be a valuable resource to successful project management. Can become a learning benchmark.

IV. Inventor - Doesn't know, yet works to invent ways to do. This individual, when challenged by not knowing, finds a way out. Some expense, and risk, is involved but depending on the circumstances the cost can be worth the effort. In each industry there is a presumption that internal development takes place via these people. When noticed, they are often removed from project work and placed in R&D. This is not a good use of their capabilities. Little management is needed or helpful to these people. This individual manifests the essence of one aspect of learning, but needs to be with the other types.

Conclusions

Learning is clearly a necessary feature to any forward-looking project-oriented organization. Being a vehicle of change, it can help to mobilize an organization's people to work together by giving them renewed purpose, yet being able to accommodate wide differences. To do both learning needs a common framework for organizing innovation as well as the differences that innovation encourages. We presented a model of learning in this article that focused on the importance of questioning and criticizing business as usual. Through continually challenging the usual, best practices are strengthened and worst practices can be improved or replaced. On the other hand, this is not an easy process. Serious impediments stand in the way of attempts to improve via questioning the practices and norms of current operations.

Conceptions of learning can be impediments. One of these is where learning is too closely associated with the limits of traditional classroom events and the weaknesses of the formal educational process. Resources for learning can also form impediments. Inputs such as data, information and knowledge can become rigidly structured in an organization or project. Project learning, as it was presented here, needs to be associated with much more dynamic inputs and processes. In this way learning is more consistent with the needs of managing projects are continually unique and constantly changing. Even the widely accepted concept of time, where dreams about past, present and future events become sanctuaries from efforts of genuine problem-solving, can stand in the way of learning. A framework for interactive problem-solving, as distinct from its more popular proactive form was introduced. Via inter-personal interaction, e.g., using internet-based real-time systems, time is no longer the central issue, as either an asset or a limitation.

A study of 60 project-based companies demonstrates the above points and points to the growing importance of learning as an asset to leading firms. This is due to the growing complexity of projects and project-based firms, and their need to invent ways to operate in an increasingly complex international
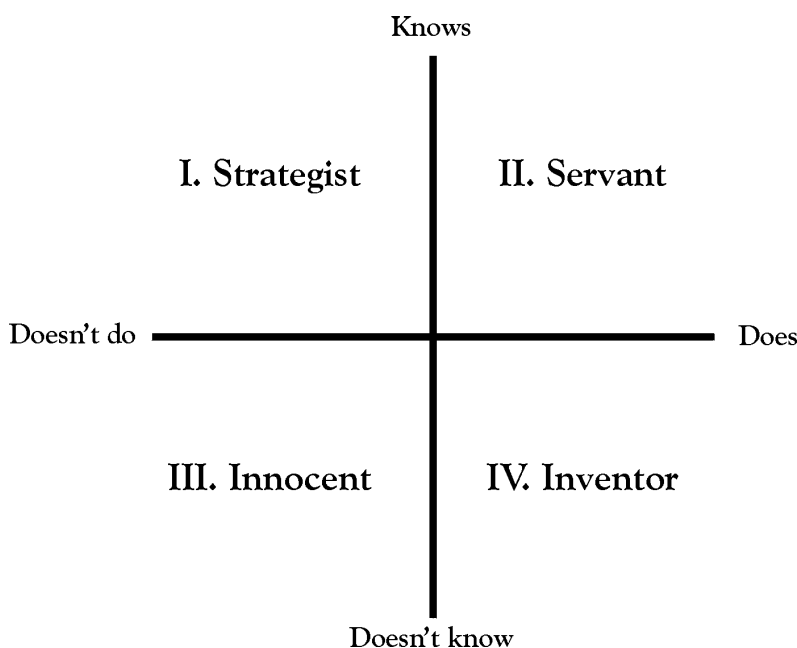

Figure 6. A Constellation of Project Participants

Knows

I. Strategist   II. Servant

Doesn't do —————— Does

III. Innocent   IV. Inventor

Doesn't know

environment. The Conditions of Success study, and other referenced works, illustrate that learning occurs most clearly when experiences gained from working are evaluation at higher levels of abstraction. In this way practice can be better understood, and improved practices initiated. This best takes place in an environment of self-regulation that fosters decentralization. The innovative aspects of knowledge intensive project organizations are thus encouraged.

The article introduced learning at a company organization level, that is above projects, but the focus began and ended with individual learning at the project manager level. In the end, these are the individuals who will conduct the strategic forward-looking activities in a company that will promote organizational learning. This takes place in terms of the resources known as data, information, knowledge, and wisdom. Traditional modes of education, as related to traditional conceptions of data, information and knowledge, while emphasizing their separations, are obstacles to wisdom-seeking, innovative, creative solutions. This is while learning often requires unlearning what is known. Wisdom is the most difficult yet attractive. It appears to involve learning but learning that is neither hierarchical nor cumulative.

Finally, the article presents a constellation of personality types that appear in virtually all projects. Project managers, and those they manage, can be categorized as strategists, servants, innocents or inventors. The essence of learning presented in this article is to find ways to accommodate and integrate all four, plus more, and not allow any one to either be excluded or given sole authority over a situation. Letting a personality type, or a narrowly defined specialty, assume emphasis in a situation is to restrict that situation to limited improvement, or serious problems. Just now it is popular to manage people as strategic resources that know, but we feel it is more rewarding to instead find innovative ways to manage resources to help people learn to learn.

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A Model for Supplying with Constrained Resources in Project Management under Random Disturbances

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A resource supportability model for network projects with random activity durations is considered. Two types of resource are imbedded in the model:

Firstly, highly expensive and rare resources which are not at the PM disposal and can be obtained from outside for a short time. Such resources have to be delivered at a pregiven date that has to be determined before the project's realization. Thus, the problem is to determine a resource delivery schedule for certain project activities which consume such costly resources. The objective is to minimize the average expenses which comprise: a) penalties for the idleness of rare resources, i.e., when an activity starts later than the corresponding resources are delivered, and b) costs of utilizing unrestricted and non-costly resources by other activities, within the period of the project's realization.

The problem is solved by a combination of simulation modeling and a non-linear programming method.

Secondly, constrained renewable resources which are in limited supply at the PM disposal. Most project activities require such resources either with fixed or with variable capacities. The problem is to develop a decision-making model to reallocate available resources among activities which are waiting to be supplied and to start processing. The objective is to minimize the average project's duration. The solution is obtained by using a simulation model together with a knapsack resource reallocation problem.

Both problems offer practical solutions in real projects and are considered for a modified version of a PERT type project which comprises a broad spectrum of various time-oriented logical links. A numerical example is given.

Introduction

In modern Project Management (PM), a broad variety of network projects is realized under random disturbances. This occurs, for example, in opto-electronics and in aerospace and defense related industries, when designing and creating new machines and installations which have no similar previous prototype. For example, in the process of designing new aircraft or missiles, operations on proving grounds are usually of random duration, as are various machin-ing operations on numerical control machines, etc. Many random disturbances usually occur in these operations, such as repetition due to low-quality, delays in tool replacement, etc. For some operations, there are continuous stochastic changes in the processing speed during the opera-tion. Due to such random influences, projects are often not realized and frequently not delivered to customers on time, even when using various scheduling techniques As a result, solving the problem of increasing those random projects' delivery performance becomes essential.

One of the most immediate and important problems in the area of planning, scheduling and monitoring network projects with uncertainty, is the problem of supplying certain project activities with highly expensive and rare resources which are not at the PM disposal and are delivered from outside. These resources can usually be obtained only for a short time within the time span of the project. If, for example, a

certain activity has to be realized by testing on a proving ground that is seldom open, or with the help of technical experts who work on many projects, such resources have high priority and should be monitored closely, because shortages might significantly affect the project's schedule. On the other hand, due to the high cost of such resources, they must not be idle for a long time when waiting for the moment the corresponding activity can start processing. Note that, due to random disturbances, it is unknown beforehand when a certain activity will actually be ready to begin. Nevertheless, such resources have to be delivered at a pregiven date that has to be determined beforehand, i.e., before the project starts to be realized. Thus, the problem is to determine a schedule of delivering resources for certain project's activities. Note that an activity cannot start before its corresponding planned moment when activity resources are ready and delivered.

We suggest using the cost objective to minimize the average expenses which comprise:

a) penalties for all delays of activities, and

b) costs of utilizing non-constrained and non-costly resources by other activities, within the period of the project's realization.

The problem's solution is obtained by a combination of simulation modeling and a very effective non-linear programming method, namely, the cyclic coordinate descent algorithm. The latter has been successfully used in many similar problems (see, e.g. Golenko-Ginzburg and Gonik (1997)).

The considered problem of resource supportability for network projects under random disturbances is a realistic problem which stems from practical requirements (Golenko-Ginzburg and Gonik, 1997 a, Sitniakovskii, 1998).

Another problem which is well-known to a broad PM community, is as follows. Consider a network project under random disturbances which consumes constrained renewable resources, which are available in limited quantities throughout the project's planning horizon (e.g., a fixed workforce or various items of equipment). Each project activity requires these resources either with fixed or with variable capacities. Such resources have to be hired at the beginning of the project's realization and have to be maintained and moni-

tored until the project is accomplished. It is widely known in PM (see, e.g., Willis, 1985) that shortening the project's duration results in decreasing the expenses of utilizing those resources, and, thus, increases the PM net profit. We suggest developing a decision-making model to reallocate available resources among activities (which are waiting to be supplied and to start processing) in order to minimize the average project's duration. The solution is based on using a simulation model together with a knapsack resource reallocation algorithm.

Both problems are considered for a modified version of a PERT type model, which has been described by Voropajev et al. (1997). The model is, in essence, a unification of the construction model GNM suggested by Voropajev (1975), and the PERT network model. The GNM model comprises a broad spectrum of various time-oriented logical links and is a deter-ministic, finite, oriented, cyclic network. A unification of the GNM and the PERT network model results in developing a network model with random activity durations and a broad variety of logical relations and technological links.

Description of the Network Model

The network model here presented is a unification of PERT and GNM networks. It can be regarded as a particu-

lar case of the network outlined in (Voropajev et al., 1997) but, unlike the latter, the presented network does not comprise alternative branchings. A fragment of the network model (we will henceforth call it RGNM-a random generalized network model) is presented in Figure 1.

Various logical restrictions are implemented in the model, namely:

1. Consider two activities, (i_1, j_1) and (i_2, j_2), entering the RGNM. Activity durations $t(i_1, j_1)$ and $t(i_2, j_2)$ are random values. Call $(i, j)_r$ a sub-activity which, being the first part of activity (i, j), contributes r percent of the total volume of that activity. Call, further, $F(i, j)_r$ the actual moment $(i, j)_r$ is finished processing. A restriction is introduced such that the difference between $F(i_2, j_2)_{r_2}$ and $F(i_1, j_1)_{r_1}$ has to be not less than a deterministic time $d(r_1, r_2)$, i.e.,

$$(1) \quad F(i_2, j_2)_{r_2} \geq F(i_1, j_1)_{r_1} + d(r_1, r_2)$$

holds, where (i_1, j_1), (i_2, j_2), r_1, r_2 and $d(r_1, r_2)$ are pregiven. It goes without saying that restriction (1) does not refer to any couple (i_1, j_1), (i_2, j_2), but only to certain activity couples entering the network.

2. For a certain set of activities $\{(i, j)\} \subset RGNM$ its starting and finishing times $S(i, j)$ and $F(i, j)$
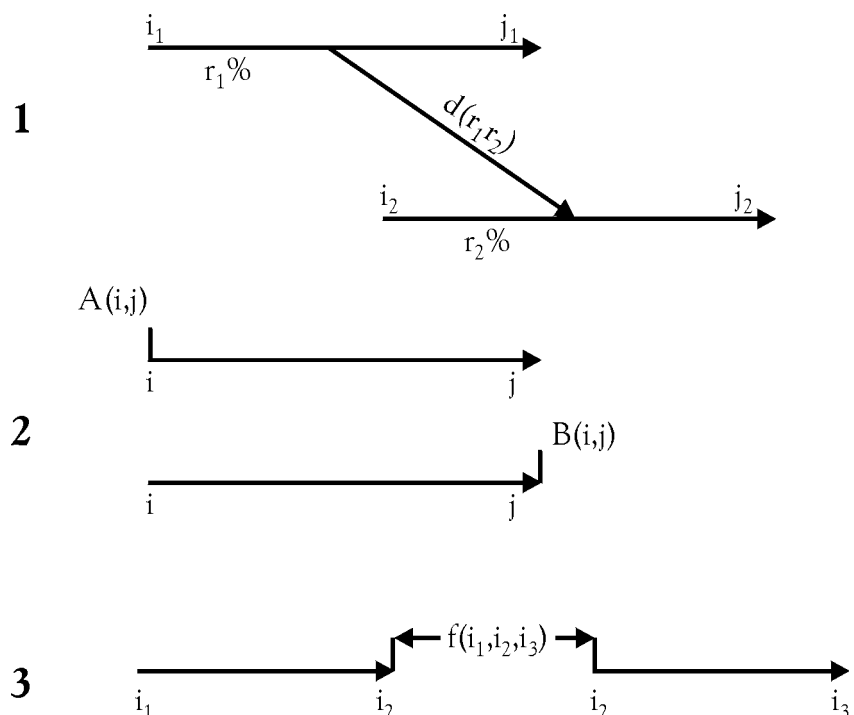

Figure 1. Various fragments of RGNM

may be restricted from above or from below, e.g.,

$$(2) \quad \begin{array}{l} S(i,j) \geq A(i,j) \\ F(i,j) \leq B(i,j) \ , \end{array}$$

where $A(i,j)$ and $B(i,j)$ are pregiven deterministic values. Note that $S(i,j)$ and $F(i,j) = S(i,j) + t(i,j)$ are usually random values.

3. For certain pairs of consecutive activities (i_1,i_2), (i_2,i_3), the starting time of activity (i_2,i_3) must not exceed the finishing time of (i_1,i_2) by more than $f(i_1,i_2,i_3)$, where f is a pregiven deterministic value. Thus,

$$(3) \quad S(i_2,i_3) \leq F(i_1,i_2) + f(i_1,i_2,i_3)$$

Examples (1-3) are only a part of various possible restrictions which can be incorporated in the RGNM.

Assume, further, that there is a subset of q activities (a_1,b_1), (a_2,b_2), $\ldots,(a_q,b_q)$ entering the RGNM, which are operated by using rare and costly resources. The latter cannot be idle for a long time and have to be delivered at pregiven moments $T(a_1,b_1)$, $T(a_2,b_2)$, $\ldots,T(a_q,b_q)$. The resource delivery schedule has to be predetermined, i.e., before the project's realization. Denote

$$c(a_\xi,b_\xi) \quad 1 \leq \xi \leq q$$

the resource idleness expenses per time unit of the activity's (a_ξ,b_ξ) delay, i.e., within the period $\left[T(a_\xi,b_\xi),S(a_\xi,b_\xi)\right)$

As to other activities, they are processed by utilizing non-constrained resources which are available for a cost and are at the PM disposal. Assume that in the course of the project's realization, the cost of such resources does not undergo drastic change and is $\bar{c}$ on the average. Denote the moments the project actually starts and is completed, by S and F, respectively. Thus, the cost of utilizing unrestricted resources can be approximately calculated and its value is $\bar{c}(F-S)$.

The Problem

The problem is to determine values

$$T(a_\xi,b_\xi) \quad 1 \leq \xi \leq q$$

to minimize the average total cost of rare and expensive resource idleness for activities (a_ξ,b_ξ) , $1 \leq \xi \leq q$,together with the cost of utilizing unrestricted and non-costly resources for other activities. The cost objective for an

RGNM project is

$$\bar{C} = \underset{\{T(a_\xi,b_\xi)\}}{Min} E \left\{ \sum_{\xi=1}^{q} \left[c(a_\xi,b_\xi) \right] \left[S(a_\xi,b_\xi) - T(a_\xi,b_\xi) \right] + \bar{c}(F-S) \right\}$$

where
$$S = \underset{\{i,j\}}{Min} S(i,j), \quad F = \underset{\{i,j\}}{Max} F(i,j) \quad (4)$$

Restrictions $\quad S(i,j) + t(i,j) = F(i,j) \quad (5)$

and $\quad S(i,j) \geq T(i,j), \quad (i,j) \in$ RGNM $\quad (6)$

have also to be imbedded in the model.

It can be well-recognized that decreasing values $T(a_\xi,b_\xi)$ results in increasing the resource idleness expenses, i.e., the first additive of objective (4), together with decreasing the project's duration, i.e., the second additive of (4). Thus, a trade-off can be realized by varying decision variables $T(a_\xi,b_\xi)$ $1 \leq \xi \leq q$.

Problem (4-6) is a complicated stochastic optimization problem. The general idea of solving similar problems is outlined in (Golenko-Ginzburg and Gonik, 1997 a, Sitniakovskii, 1998).

It can be clearly seen that for a set of fixed values $T(a_\xi,b_\xi)$, $1 \leq \xi \leq q$, calculating (4) can be carried out via simulation. The simulation model (SM) calculates value (4) of the RGNM within a simulation run. Realizing the simulation model many times with fixed values $T(a_\xi,b_\xi)$, to obtain a representative statistics, enables value $\bar{C}$ to be calculated. The simulation model is, thus, the backbone of the algorithm to solve (4-6).

The Problem's Solution

Since objective $\bar{C}$ is a complicated non-linear function of decision variables $T(a_\xi,b_\xi)$, we suggest that problem (4-6) be solved by using the cyclic coordinate descent method (Golenko-Ginzburg and Gonik, 1997 a, Sitniakovskii, 1998). To solve the problem, we use the simulation model SM to simulate the project's realization, *at each search step of variables* $T(a_\xi,b_\xi)$. Thus, we suggest a two-stage algorithm as follows:

At the external stage a cyclic coordinate descent method is used to determine the optimal moments for delivering expensive resources from outside. The general idea of the method is to arrange a local search for each coordinate $T(a_\xi,b_\xi)$ independently, while

- in the course of that search all previous coordinates are fixed and remain unchanged, and

- all next coordinates (which did not as yet undergo optimization) have to be updated in

accordance with (5-6).

At the interior stage the algorithm calculates value (4) by using the simulation model.

Extensive experimentation for medium size network and job-shop models have illustrated the efficiency of the cyclic coordinate descent algorithm (Golenko-Ginzburg and Gonik, 1997 a, Sitniakovskii, 1998).

A Resource Constrained Project Scheduling Model

As outlined above, the resource constrained project scheduling models are widely used in PM (see, e.g. Lorterapong (1994), Ulisoy and Ozdamar (1995), Schonberger (1981), Willis (1985), etc.) However, those papers deal only with deterministic models, while the number of publications on resource constrained project scheduling models under random disturbances, e.g. on resource constrained network models with random activity durations, remains very scanty (see, e.g. Golenko-Ginzburg and Gonik (1997, 1998), Sitniakovski et al. (1998)). Thus, undertaking research in that area is promising both from the theoretical and applied points of view, since newly-developed models enable monitoring real projects with random parameters.

Consider the RGNM model outlined in Section 2. Several renewable activity related resources, such as machines or manpower, are imbedded in the model. Each activity in a project requires resources of various types with fixed capacities. Each type of resource is in limited supply, with a resource limit that is fixed at the same level throughout the project duration. For each activity, its duration is a random variable with given density function. The problem is to determine starting time values $S(i,j)$ for each activity (i,j) entering the project, i.e., the timing for feeding-in resources for that activity. Values $S(i,j)$ are not calculated beforehand and are random values conditional on our decisions. The model's objective is to minimize the expected project duration. Determination of values is carried out at decision points when at least one activity is ready to be operated and there are free available resources.

If, at a certain point of time, more than one activity is ready to be operated, but the available amount of resource is limited, a competition among the activities is carried out in order to choose

those activities which can be supplied by the resources and which have to be operated first. We suggest carrying out the competition by solving a zero-one integer programming problem to maximize the total contribution of the accepted activities to the expected duration of the project. For each activity, its contribution is the product of the average duration of the activity and its probability of being on the critical path in the course of the project's realization. Those probability values are calculated via simulation. Solving a zero-one integer programming problem at each decision point results in the following policy: the project management takes all measures to operate first those activities that, being realized, have the greatest effect of decreasing the expected project duration. Only afterwards, does the management take care of other activities. For a simpler network model of PERT type, the problem has been effectively solved in (Golenko-Ginzburg and Gonik, 1997 b).

In recent years we have come across much more complicated but realistic network projects (mainly from the defense related industries), when each project's activity (i,j) requires resources of various types with variable capacities and is operated at a random speed which depends linearly on the resource amount rijk assigned to that activity. We have formulated the problem to determine for each activity (i,j) the starting time S(i,j), i.e., the timing of feeding-in resources, and the assigned resource capacities r_{ijk}. The objective is to minimize the expected project duration.

In order to solve the resource-constrained project scheduling problem with variable capacities, we have formulated the general stochastic optimization problem with decision variables S(i,j) and r_{ijk} (call it henceforth problem A) (Golenko-Ginzburg and Gonik, 1998). Values S(i,j) and r_{ijk} are not calculated beforehand and are random variables conditioned on our future decisions. The problem is too complicated to be solved in the general case. To simplify the problem, we replace it by another one, namely, by the knapsack non-linear resource reallocation problem (call it problem B). Such a replacement is based on various heuristic assumptions, e.g., that minimizing the average project duration results in reallocating available resources at a routine decision point among those activi-

ties (ready to be operated) which deliver the maximal total contribution to the expected project duration. Thus, a stochastic optimization problem is substituted for a deterministic one. The decision variables of problem B are the chosen activities to be supplied by resources and the resource capacities assigned to those activities.

However, even such a simplified model is essentially more complicated than the zero-one integer programming model which was presented in (Golenko-Ginzburg and Gonik, 1997 b) for a PERT network project scheduling with fixed resource capacities (call it problem C). The classical zero-one integer programming algorithm, which delivers an optimal solution to that problem, cannot be applied to problem B. Since problem B is NP-complete, its optimal solution can be obtained only by realizing a lookover algorithm to single out all the feasible solutions. We have developed such an algorithm for the case of a PERT network (Golenko-Ginzburg and Gonik, 1998) and we suggest using that algorithm for cases of small and medium size projects of RGNM type.

For cases where the number of possible feasible solutions becomes very high and much computational time is needed to realize a lookover, we have developed a new heuristic algorithm to solve problem B (Golenko-Ginzburg and Gonik, 1998).

Problem B has to be solved at each decision point, when at least more than one activity is ready to be operated but the available amount of resources is limited.

Numerical Example

We will illustrate the efficiency of the resource delivery model, outlined in Sections 3 and 4, by a medium size network project of PERT type which has been carried out in one of the defense related industries. The project's initial data is given in Table 1. Activities (5,8), (7,11), (9,13) and (12,13) utilize rare and costly resources, while other activities consume non-restricted resources. Values $c(a_\xi, b_\xi)$ are as follows: c(5,8) = 100, c(7,11) = 200, c(9,13) = 160, c(12,13) = 120.

Other parameters are as follows: relative accuracy $\varepsilon = 0.01$, search step $\Delta t = 2$, value $\bar{c} = 50$.

The algorithm is written in Turbo Pascal 7.0 and is implemented on a

Pentium PC. Two alternative distributions are considered:
- all activities' durations t(i,j) have a normal distribution with mean values

$$\mu(i,j) = 0.5\big[a(i,j) + b(i,j)\big]$$

and variances

$$V(i,j) = \frac{1}{36}\big[b(i,j) - a(i,j)\big]^2$$

, and
- values t(i,j) are distributed uniformly in the interval

$$\big[a(i,j), b(i,j)\big]$$

The number of simulation runs (300 runs) at step 3 (see Section 4) was determined by applying the classical estimation theory (Walpole and Myers, 1978). The results of the experimentation are presented in Table 2.

The following conclusions can be drawn from the table:
1. The cyclic coordinate descent algorithm performs well for both normal and uniform distributions. The decrease of the average total expenses between the initial and the first iteration show 53% versus 1.2% between the first and the second iteration (for the normal distribution) and 50% versus 4.6% for the uniform distribution. Two iterations are enough to realize the optimization process.

2. The decrease in the average total expenses in the course of the optimization is achieved by a drastic decrease of the penalty expenses (97% for the uniform distribution and 99.8% for the normal distribution), while the hiring and maintaining expenses do not show essential changes. To all intents and purposes, nor has the average project duration been changed.

3. It can be clearly recognized that using the normal distribution results in lower expenses than for the uniform distribution. Thus, practically speaking, the algorithm performs better by using normal distribution for project activities' durations.

Conclusions and Future Research

The following conclusions can be drawn from the study:
1. The random generalized network

No.	I	j	a_{jb}	b_{jb}
1	1	2	20	27
2	1	3	19	28
3	1	4	10	15
4	2	3	8	14
5	2	6	25	33
6	3	5	15	23
7	3	7	23	31
8	4	7	33	39
9	4	10	24	30
10	5	6	11	18
11	5	8	19	24
12	6	9	25	33
13	6	13	19	27
14	7	8	20	26
15	7	11	21	27
16	8	9	9	16
17	8	12	18	24
18	9	12	10	16
19	9	13	31	37
20	10	11	25	32
21	10	14	15	21
22	11	12	13	20
23	11	14	6	15
24	12	13	12	18
25	12	15	28	35
26	13	15	7	15
27	14	15	26	33

Table 1. The Initial Data

(i,j)	Distribution					
	Uniform			Normal		
	$T(i,j)^{(0)}$ (initial search point)	$T(i,j)^{(1)}$ (1st iteration, 30 points)	$T(i,j)^{(2)}$ (2nd iteration, 6 points)	$T(i,j)^{(0)}$ (initial search point)	$T(i,j)^{(1)}$ (1st iteration, 30 points)	$T(i,j)^{(2)}$ (2nd iteration, 6 points)
5,8	43	49	53	43	67	65
7,11	51	71	71	51	65	67
9,13	80	100	102	80	103	101
12,13	90	119	119	90	119	118
Average Total Expenses	16103	8041	7671	15763	7415	7329
Penalty Expenses	8814	653	270	8583	13	16
Hiring and Maintaining Expenses	7289	7388	7401	7180	7402	7313
Average Project's Duration	145.7	147.7	148.0	143.0	148.0	146.2

Table 2. Determining Resource Delivery Schedule T (i,j) by the Cyclic Coordinate Descent Method

model (RGNM) can be used for both resource supportability problems outlined above. The model outlined in Section 5 has been successfully used for small and medium size projects of PERT type.

2. The developed resource delivery schedule for the problem outlined in Sections 3-4 pre-sents an efficient solution to minimize the average expenses, comprising penalty costs together with the costs of utilizing non-constrained and non-costly resources. For a medium size network project with random activity durations, two cycle iterations resulted in a decrease of more than 50% in the initiated average expenses and were enough to realize the optimization process.

3. The developed resource supporta-bility model for rare and costly resources is suitable for resource scheduling in stochastic network projects, when the processing of certain activities is based on delivering resources with high idling penalties, e.g. high technol-ogy projects, defense related industries, opto-electronics, aerospace, etc.

4. Both models outlined above are easy to use and can be easily implemented on a PC.

5. Future research can be undertaken in several directions:

5.1 New objectives, together with taking into account other sources of expenses, can be used;

5.2 The RGNM may be expanded to more universal models, e.g. by implementing alternative branching nodes of random and deterministic nature outlined in (Voropajev et al., 1997), etc.

5.3 Both models outlined in Sections 3 and 5 may be unified in order to obtain a more generalized resource supporta-bility model.

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A Multi-Criteria Framework for Competitive Bidding

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Competitive bidding is a kind of auction in which each potential contractor submits a bid in compliance with the owner's product/service requirements. The most competitive bid, according to the owner's evaluation, is awarded the contract. Literature on competitive bidding generally proposes models for the appraisal of bids' competitive value based only on the evaluation of factors which have an immediate financial impact. Such models are hardly applicable in environments in which increasing competition and customer expectations have broadened the number of non-financial factors which should be considered in the evaluation of the "best" bid.

The paper describes a multi-attribute decision making (MADM) approach to competitive bidding based on the Analytic Hierarchy Process (AHP). The model is applied to a case in which contractors compete for the design and construction of a process plant. The competitive value of each bid is assessed with respect to a number of relevant factors for the owner. The existence of inter-relationships (or dependencies) between competitive factors is recognised and various approaches to handle them are suggested.

Introduction

Competitive bidding, in the sense of standard sealed bidding, is a kind of auction, the major characteristics of which are:

- the owner states the product/service requirements
- each contractor arranges a sealed bid
- competing bids are opened simultaneously
- the owner selects the contractor offering the "best" bid

Competitive bidding involves two kind of actors, the owner and the contractors, and consequently two points of view. Each potential contractor has to decide whether to take part in the auction or not and, in the affirmative case, to arrange a bid aimed at winning the competition, without overbidding. The competitive value of each bid depends on the importance the owner gives to the bid competitive factors (i.e. price, delivery time, etc.) and on the specific features of the other competing bids submitted to the auction. In preparing their bids, contractors should base the bid on the most recent assumptions about main competitors' bidding policy and assess the priority of competitive factors aiming to conform to the owner's selection criteria through an "educated guess"-based process. In fact, the bid arrangement process involves a progressive revision of the contents in the light of the learning process regarding the owner's orientation and the possible courses of action taken by the competitors. The owner faces a dual problem: the most competitive bid must be selected from those joining the auction. The problem is simplified as the owner works on data rather than assumptions. Common aspect of both the contractor's and the owner's point of view is the need for an evaluation model which is able to assess the bid competitive value. The bid appraisal is in general a multi-criteria decision problem where both economical (e.g. price, terms of payment, financial package) and technical elements (e.g. process technology, safety, dependability) must be considered. In fact, due to the complexity of the offered "product", bids may conform differently to the specific requirements and be non-homogeneous in their technical, financial and service-related aspects. Moreover, over the last years, the growing level of competition together with increased customer expectations have broadened the number of service and financial aspects which are used to differentiate competing bids. Since only rarely a bid dominates the others according to all the owner's most important selection criteria, the competitive value results from trading off high performances according to some criteria and low performances accord-

ing to the remaining criteria.

Taking the owner's point of view this paper presents a multi-attribute decision model (MADM) based on the Analytic Hierarchy Process (AHP) (Saaty, 1980) which provides a decision support tool in the selection of the "best" bid. The model gives an integrated indicator of competitive value, combining performances on all relevant competitive factors, and relies on an appraisal scheme which can be easily up-dated and reviewed on the basis of the progressive availability of new information.

Literature Review

Techniques so far applied to assess the competitive value of alternative bids can be classified according to the kind of competitive factors which can naturally be taken into account. Three classes of competitive factors can be discerned:

- factors which offer quantifiable financial support to the bid's competitive value, e.g. price, terms of payment, financial package
- factors which offer quantifiable non-financial support, e.g. delivery time, plant dependability, safety level, process technology performance
- factors whose effect is mainly qualitative, e.g. utilisation of local vendors, conformity to contractual terms proposed by the owner, technology transfer

The distinction between these classes depends not only on the intrinsic nature of each factor, but also on the quantity and quality of information available for each factor and on the amount of resources which can be employed to quantify their contribution to the competitive value of the bid. For instance, the environmental impact of different technologies can be quantified by developing an environmental balance. However, its preparation requires time and money. Moreover, quantifying the environmental impact provided by each competitor requires the decision-maker to have access to environmental data-bases and detailed data about the technological process of each bid.

With reference to the above classification of competitive factors, models so far developed to assess the bid competitive value may be grouped into two major categories:

1. financial techniques, i.e. techniques aiming to assess the monetary value of each bid by quantifying in monetary terms the effect of as much factors as possible (MIL-HDBK-259, 1983; VDV Communications, 1998; Fabrycky and Blanchard, 1991; Caron et al., 1996; Asiedu Y. and Gu P., 1998). These techniques are accurate in considering financial factors (e.g. price, terms of payment, etc.), but less accurate in considering quantitative non-financial factors, since various levels of performance according to the latter factors must be translated into monetary effects by identifying the financial equivalent of a unit of performance. For instance the monetary equivalent of a day delay in delivery time must be assessed

2. MADM techniques, i.e. techniques that see bid appraisal as a multi-attribute decision making (MADM) problem, in which bids are evaluated on the basis of multiple factors considering the main aspects which take value for the owner (Simmonds, 1968; King and Mercer, 1985; Ward and Chapman, 1988; King and Mercer, 1988)

It is possible to indicate distinctive areas of application of financial and MADM techniques, in terms of the specific decision context. In auctions where the main selection criteria are financially quantifiable, and the price offered is the most important competitive factor, the application of financial techniques is justified. However, in decision contexts with a number of relevant non-financial competitive factors, the MADM techniques should be preferred since they can easily handle non-financial factors and integrate these with quantitative financial data. In such environments, bid selection based on the application of financial techniques generally leads to one of the following shortcomings:

- some relevant factors whose monetary impact is hardly quantifiable are excluded from consideration and the evaluation is therefore incomplete
- the monetary effect of some relevant factors is assessed by means of complex models and is based on hardly justifiable

assumptions (i.e. risk of forcing financial quantification)

The main advantage of MADM techniques is thus the opportunity of focusing attention on completeness, taking into account all different kinds of factors relevant in the evaluation of the "best" bid. Even though MADM techniques seem to be particularly suitable to many decision contexts, and their area of application will probably extend in the future, there are few examples of multiple factor evaluation (see, for instance, Seydel and Olson, 1990; Titolo, 1994). This paper aims to fill this gap by focusing on the application of an AHP (Saaty, 1980) framework to competitive bidding. The model is presented with reference to a real-world case, i.e. design and construction of a process plant.

A multi-criteria framework for competitive bidding

In the previous section it was recognised that bids should be evaluated on the basis of multiple factors considering the main aspects which take value for the owner. From the owner's point of view, the application of MADM techniques in the competitive bidding context requires the following steps:

1. identification of all the factors supporting bids competitive value. These factors will constitute the set of evaluation criteria the owner uses to compare bids. Possibly the evaluation criteria are organised into a hierarchy
2. assessment of the importance given to each criterion
3. evaluation of competing bids with respect to each criterion
4. calculation of the priority index representing the relative competitive value of each bid

In industrial practice (e.g. Titolo, 1994) scoring methods are commonly adopted since they are simple, flexible and capable of integrating non-homogenous information (quantitative and qualitative, objective and subjective), taking advantage of the full spectrum and variety of information available from managers' and practitioners' expertise and perception.

The AHP is a robust and flexible MADM technique which formulates the decision problem in a hierarchical structure and prioritises both the evaluation criteria and the competing al-
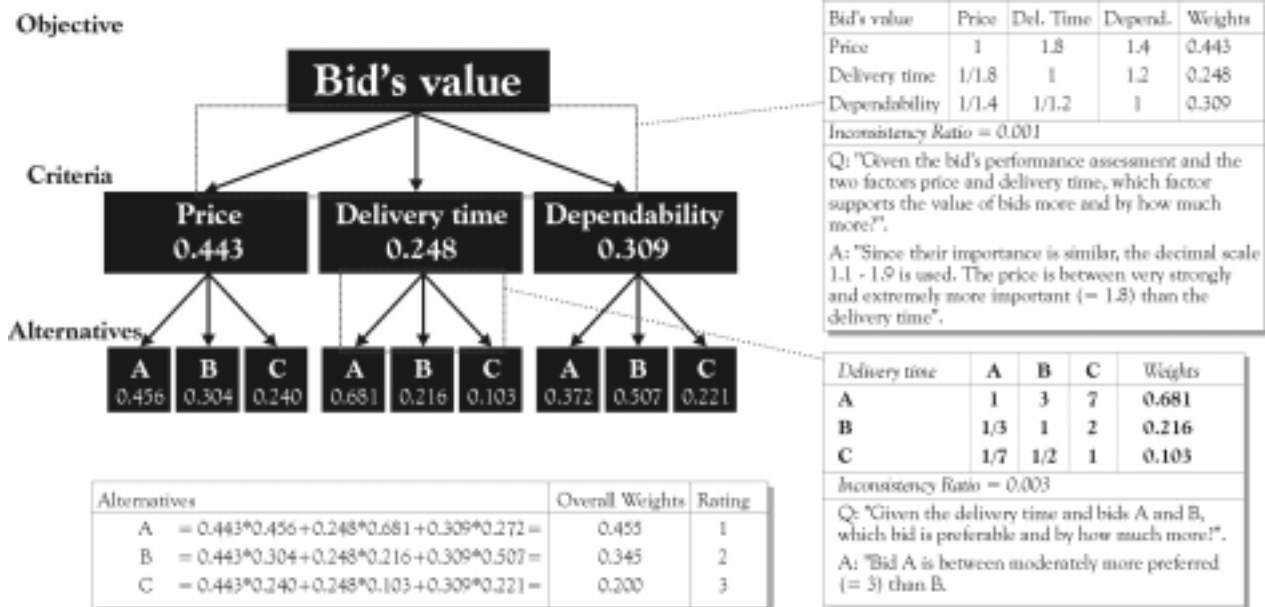
Figure 1. Example of AHP application to a simplified bid evaluation case

ternatives by pairwise comparison. The top level of the hierarchy reflects the overall objective of the decision problem (see the simplified hierarchy for bid evaluation in Figure 1). The factors influencing the decision are represented in the intermediate levels. The lowest level comprises the decision alternatives. The application of AHP to competitive bidding is promising considering that AHP has the same strengths of scoring methods and gives a better decision support, since:

1. it effectively manages to organise the decisional problem into a hierarchical structure. Structuring any decision problem hierarchically is an efficient way of dealing with complexity and identifying the major components of the problem

2. the methodology is reliable due to the pairwise comparison process and the consistency check tool. It is common experience that estimates based on pairwise comparison are more reliable than direct absolute estimates. This is even more true for qualitative factors and also for quantitative factors where insufficient data is available to make absolute estimates. In addition, the elicitation of redundant judgements, which characterises the standard application of AHP, is useful to check the consistency of the decision maker's opinion. The level of inconsistency can be calculated and, if it exceeds a given threshold (i.e. 0.1; Saaty, 1980), the expert must review judgements more carefully (see the inconsistency ratio in tables on the right in Figure 1)

3. it deals effectively with group decision making (Ramanathan and Ganesh, 1994)

A significant number of applications in similar decision contexts (Saaty, 1980; Saaty, 1994; Armacost et al., 1994; Min, 1992; Mustafa and Al-Bahar, 1991) confirm the potential of the methodology.

The identification of the relevant factors which can be used to assess the bid competitive value and the structuring of the decisional hierarchy is the first and most important step in the evaluation process. This step should pursue the following objectives:

- completeness, i.e. it is important to identify all main relevant factors

- single counting, i.e. factors should be considered only once

- comparability, i.e. it should be easier to compare the alternatives with respect to the last-level factors than with respect to the first-level factors

In other words, the set of decisional factors should be complete, factors should preferably be mutually exclusive and the decomposition process should continue down until alternatives can be easily compared.

Once the hierarchy has been constructed, the decision maker begins the prioritisation procedure to determine the relative importance of the elements (factors or alternatives) in each level of the hierarchy (see Figure 1). Competitive factors at the first level are pairwise compared with respect to their contribution to the bid competitive value and sub-factors are compared with respect to their contribution to the upper level competitive factor. The last-level sub-factors represent the criteria which are used to pairwise compare the performance of the alternative bids (A, B and C).

The comparison takes the form: "How important is element 1 when compared to element 2 with respect to the element in the immediately upper level?" The decision maker can express his preference between each couple of elements verbally as: equally preferred (or important or likely), moderately preferred, strongly preferred, very strongly preferred or extremely preferred. These descriptive preferences would then be translated into absolute numbers 1, 3, 5, 7 and 9, respectively, with 2, 4, 6, and 8 as intermediate values expressing a compromise between two successive qualitative judgements. The verbal scale used in AHP enables the decision maker to incorporate subjectivity, experience and knowledge in an intuitive and natural way. Pairwise comparisons are structured in matrices and the eigenvector method is used to derive the relative weights of the elements at each level with respect to the element in the adjacent upper level (Saaty, 1980). The overall weights of the decision alternatives are then determined by aggregating the weights through the hierarchy. This is done by following a top-down path through the

hierarchy and multiplying the weights along each segment of the path. The outcome of this aggregation is a normalised vector of the overall weights of the alternatives.

The use of the AHP to model and analyse real world problems can be made much easier using a software implementation of the method such as Expert Choice (Forman et al., 1983). It makes structuring and modifying the hierarchy simple and quick and eliminates tedious calculations.

The case study

The case refers to the evaluation of three short-listed contractors (namely A, B and C) competing to be awarded a contract for the design and construction of a process plant in a developing country. The relevant evaluation criteria, i.e. competitive factors, have been identified through direct interviews with a number of potential owners and contractors. The primary research question has been: "How should contractors performances be evaluated? What distinguishes excellent performance from mediocre or poor performance? What factors are the determinants of high competitive value?". The answer to these questions may depend upon the stakeholder who is asked. Although the owner is the one that actually assesses contractor competitive value, contractors may capture some additional crucial points in the evaluation process that owner may have failed to consider. The participants were briefed on the objectives of the study and on the use

Delivery time	Time interval between the coming into force of the contract and the plant start-up.
Technical assistance	Maintenance service offered to the owner after plant start-up.
Technology transfer	Training service to help operators and managers in effectively running the plant.
Process technology	Process features influencing plant performance (quality, efficiency, ...).
Dependability	Plant performance in terms of reliability, maintainability, availability and supportability.
Safety	Plant performance in terms of operators safety and environmental impact.
Price	Monetary value of the offered plant.
Terms of payment	Time profile for the owner expenditures.
Financial package	Capacity of proposing convenient financial sources to the owner.
Utilisation of local vendors	Share of local goods and services within the bid scope of work.
Contractors co-operation	Measure of the overall financial solidity and technical capability provided by contractors co-operation (consortium, joint-venture, ...).
Conformity to tender documents	Measure of the accomplishment of contract clauses specified in tender documents.
Liquidated damages clause	Penalty the contractor commits to pay in case of damages for the owner due to delay in plant start-up time.

Table 1. Relevant factors in competitive bidding

of a MADM technique, and then provided a list of potential performance evaluation criteria, among which to choose the 10 most important according to their opinion and experience. Table 1 provides an overview of the main competitive factors identified with specific reference to the design and construction of a process plant in a developing country.

The identified competitive factors and the three short-listed bids have been arranged by experts into the hierarchy shown in Figure 2. Competitive factors have been grouped by experts into homogeneous macro-criteria (service level, plant performance, financial conditions, contractual conditions). Experts were also asked to express their point about interrelationships between factors (i.e. dependencies) and the possible effects on the bid evaluation process (see the following section). The three short-listed bids have been finally assessed on the basis of the competitive factors identified. The outcome of the evaluation process is presented in Figure 2, in which only the importance weights of the competitive factors are reported.

Discussion: dependencies among competitive factors

There is a dependence between competitive factors if it is possible to identify a common "driver" which partly explains the importance of both factors. For illustrative purposes, delivery time and liquidated damages clause are mutually dependent, since there is a common driver, i.e. risk endured by the contractor, that determines somehow the importance of both factors (Figure 3). In fact, the contractor offers delivery
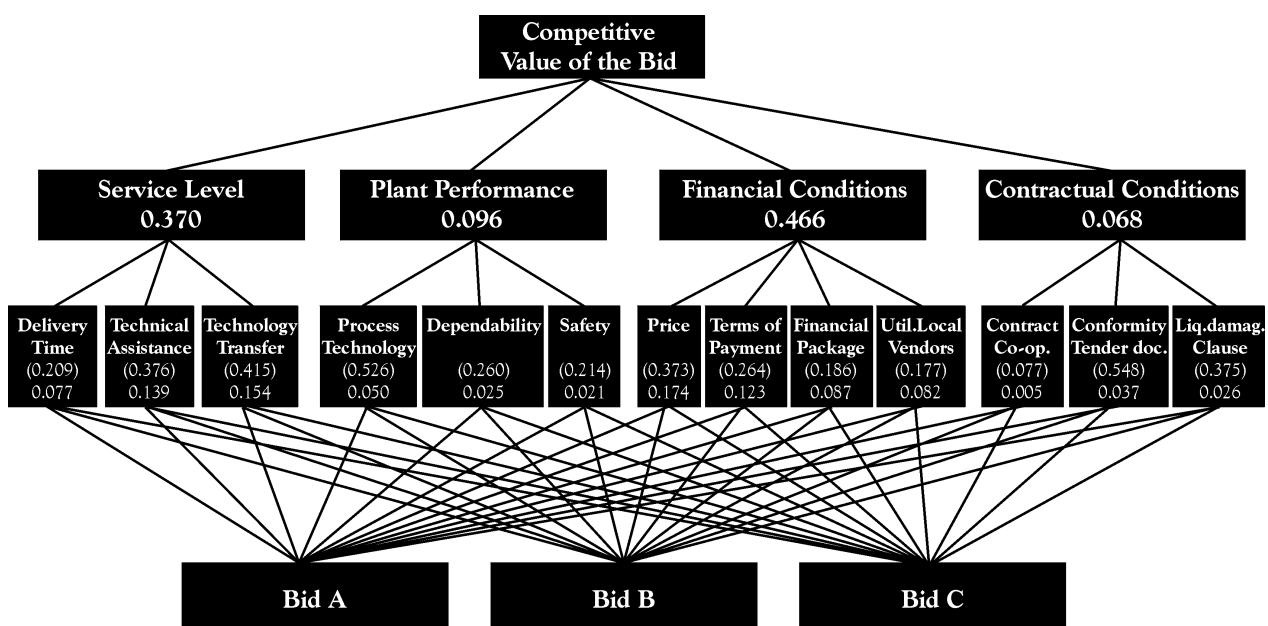
Figure 2. Hierarchy of the competitive factors (with weights) and bids in the case study
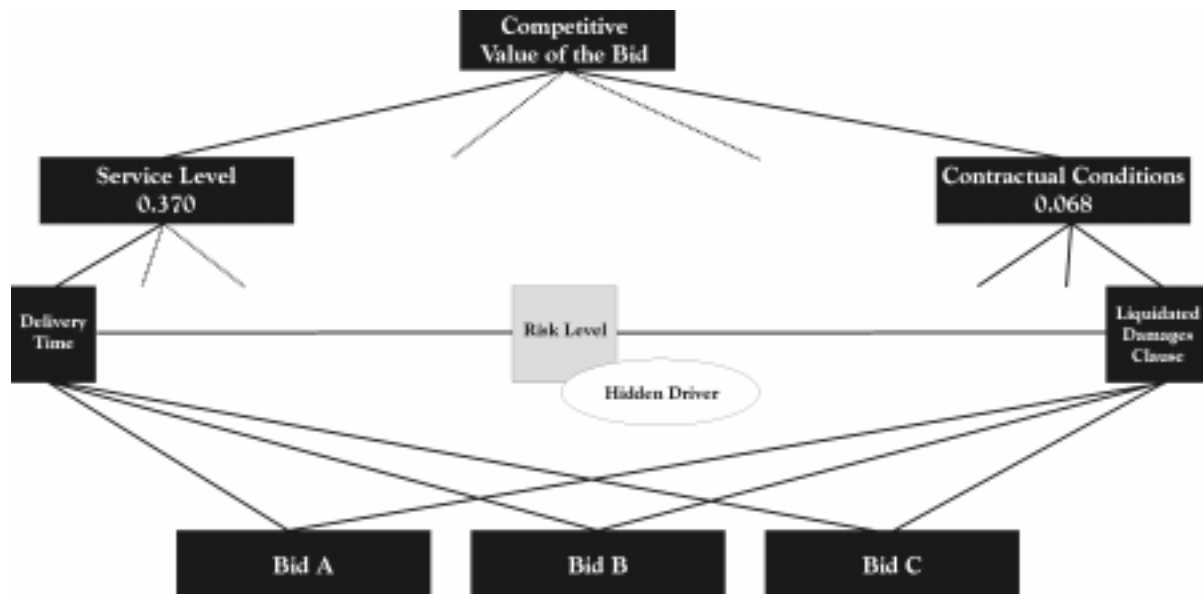
Figure 3. Example of common driver between evaluation criteria: dependence deployment

time and liquidated damages penalties conditions in line with its highest acceptable risk level, that may be translated in shorter delivery time with lower penalty (lower delivery time reliability), or longer delivery time with higher penalty (higher delivery time reliability).

The existence of dependencies does not usually generate any ambiguity in the expert judgement when dependent factors are direct competitive factors, i.e. it is easy to assess their contribution to the bid competitive value, and decisional criteria for bid evaluation as well, i.e. it is easy to compare alternative bids with respect to these factors. In fact, dependence is implicitly considered when factors are assessed with respect to their relative contribution to the bid competitive value and when alternatives are compared with respect to each factor. The latter is the case when considering, for instance, delivery time and liquidated damages penalties. In fact, the expert can easily express the relative importance of those competitive factors with respect to the bid competitive value assuming the

same hypothetical risk level and it is easier to compare alternative bids with respect to delivery time and liquidated damages clause than with respect to the risk level.

On the other hand, dependencies may generate ambiguity when there is some inconsistency in the construction of the decisional hierarchy. It generally happens in two different cases:

a) when a sub-factor influences a large number of competitive factors so as to become a competitive factor itself in the mind of the expert

b) when a competitive factor represents a driver for many other factors, giving a decisive contribution to their performance (for instance, personnel training may enhance safety and availability performance of the plant) and it is difficult to implicitly consider all dependencies

By way of example, the production performance is certainly a competitive factor concerning plant performance; nevertheless, since it is difficult

to compare bids with respect to such an aggregate factor, the expert generally refers to two different sub-factors (Figure 4): target production rate and plant dependability.

Indeed the former measures the ideal level of plant production while the latter is an estimate of the plant capability of being run with a given production rate. Generally, the target production rate is a design requirement strictly fixed by the project tender documents and it is hardly useful to differentiate competing bids. The expert therefore tends to substitute the plant production performance factor with plant dependability in the hierarchy. Unfortunately, since plant dependability is a critical driver for some other competitive factors such as safety (cf. Figure 4), training and technical assistance, the above substitution introduces a potential ambiguity in the hierarchy. If the expert considers dependability as a proxy of production performance in the assessment of importance weights, he will probably understate the importance weight of plant dependability not considering it is a driver for other factors.
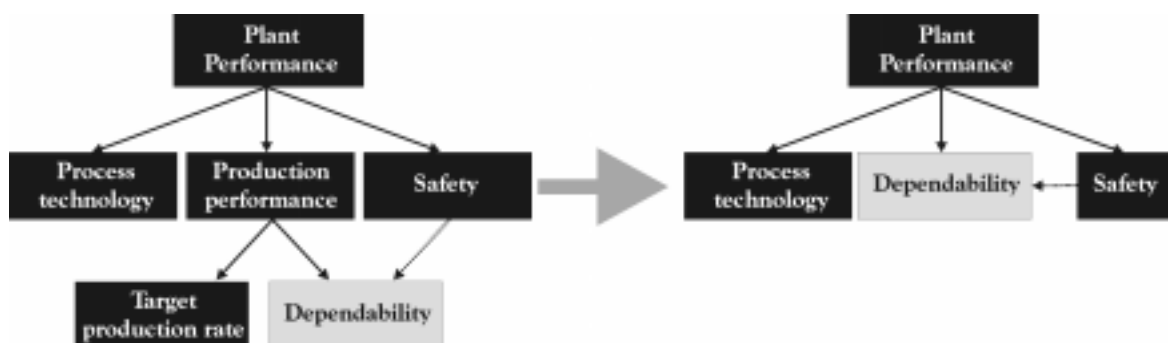

Figure 4. Partial hierarchy with inconsistency: dependability substitutes production performance

It is possible to manage the dependencies between competitive factors in three different ways:

1. relying on the ability of the expert to take implicitly account of possible dependencies in the elicitation of the importance judgements (e.g. the case of delivery time and liquidated damages clause factors)

2. deploying the hierarchy in order to include all relevant drivers, making explicit the existence and the nature of dependencies among competitive factors

3. considering techniques for dependence analysis within an AHP framework (e.g. Saaty, 1996; Saaty and Takizawa, 1986)

The choice of the most suitable approach should be made in the light of the nature and number of dependencies in the hierarchy and on the base of the level of complexity characterising the above approaches. As the number of relevant dependencies increases, and especially those between factors belonging to different macrocriteria, it is progressively more risky to rely, for dependence consideration, only on the expertise of the owner. It would be better to further deploy the hierarchy and show the most important common drivers. The subsequent phases, i.e. weight attribution and bid assessment, would benefit an improved clarity and transparency. Unfortunately the latter approach may be hardly applicable when the number of relevant dependencies is very high, due to an explosion of the levels and elements of the hierarchy, and it should be preferable to resort to techniques for dependence analysis in an AHP framework. These techniques need a specific expert knowledge concerning AHP advanced techniques and thus only complex decision contexts justify their adoption.

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Managing Change in the Workplace - a 12-step program for success

Santa Clause is coming to town ... but what if he does not do it in time? Or what if his deliveries include damaged goods or altogether wrong products? This is the starting point for this short, easy-to-read book about managing change in the organizations. Santa Clause has loads of unsatisfied customers and complaints are coming all around the world - to stay in business, the way things are done around in the Santa's workshops must be changed radically.

The authors take the reader through the change project by telling the story of how old Santa little by little learns the essentials of managing the change and empowering his people. The story is divided into 12 chapters, each presenting one of the "twelve C's of Christmas" - i.e. critical success factors of a change project as the authors see them. Each chapter is concluded with checklists of the issue at hand to guide the reader around the obstacles to change.

Does the cover story sound ridiculous? Well that's how it feels when you read it: a naïve story about redesigning the toy factory of Santa Clause with lots of supposed-to-be-funny anecdotes and simplistic solutions with less than plausible links to the real life situations we are facing when changing our organizations. Some of the dialogue and the instructive situations are more sickening than entertaining, and all this is topped up with clumsy drawings that are neither funny nor illustrative.

Yet there is much more to this little book than the sugar coated gingerbread that is offered on the outset. The description of the process of managing change from the early identification of changed customer needs and the challenge placed by them all the way to the celebration of the achievements and continuation of the development process is one of the more complete and thorough in contemporary change project literature. The sequence of actions rolls out logically and the approach offered is a well-balanced mix of people centered organizational development issues, project management, and general management issues. The treatment of the subject shows exceptional maturity and deep knowledge of the authors, only the wrapping of this present is somewhat annoying.

Establishing the need for change through common understanding and analyses, participating key stakeholders, and creating a vision, deducting measurable goals from it and finally planning and scheduling the project are all dealt with. Communication, managing changes in the project, coping with resistance to change and conflicts, training, monitoring the progress, dealing with cultural issues, and defining roles are other issues that are addressed. The book finishes with celebration of achievements and acknowledgement of the importance of continuous improvement. All this is far more than most other change management books can offer. Unfortunately some of these issues are hidden in the Santa Clause fairytale, some are addressed only in the checklists, and some in the introductory paragraphs to the chapters. All the ingredients are there, the book just fails to utilize them to full, as they are presented somewhat inconsistent manner.

There are also some minor irritating discrepancies that tend to take the attention away from or blur the valuable contents of the book. Forcing all the lessons to c-words confuses rather than provides a memory rule: the chapter dedicated to importance of training is labeled "Coping", as "understanding that timely, targeted, effective training is one of the most prudent investments for coping with change". The important issue of coordinating and monitoring the progress of a change project is hidden in the checklist of the "Concentration" chapter, which mostly deals with setting priorities and focusing on the most important issues. And being a Finn I can't help mentioning that the real Santa lives in the Finnish Lapland, not in the North Pole, there are no reindeers nor daylight in January in the North Pole, and the Arctic Circle does not cross the Arctic, let alone the actual North Pole.

All in all, the book has an important message to tell and it would be recommended easy reading for anybody dealing with changes in organizations if it only was written in more tolerable manner. And I don't mean that this kind of book should not be funny or easy-to-read, only that a little bit less naïve approach could help to reach far more readers. There is clearly a market for this kind of book, especially with this kind of insight, but I'm afraid this is not the book to fill that market need.

Antti Salminen

Book Review
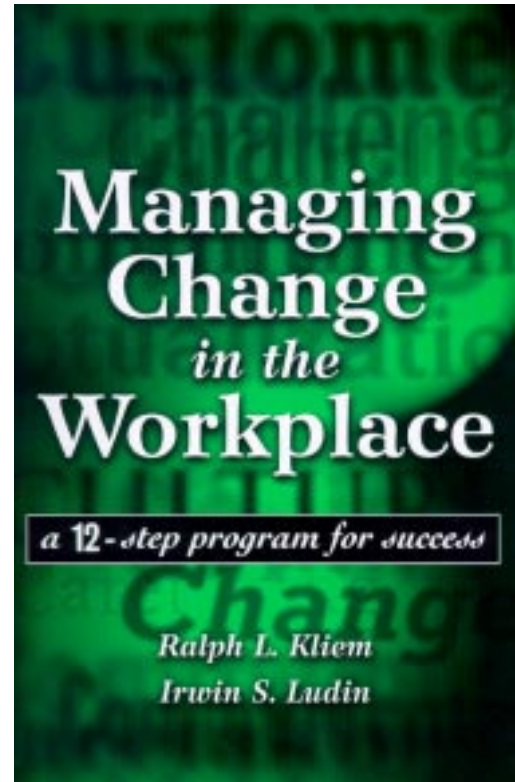
Project Management: Planning and Control Techniques

Rory Burke
Third Edition, John Wiley & Sons Ltd, Chichester, England, 1999
ISBN 0-471-98762-X, 343 p.

"Project Management: Planning & Control Techniques" is a techniques book designed for university degree programs, executive management training courses, planning software courses, and professional certification. There is also an Instructor's Manual available for lecturers. The book is aligned and structured in line with the Project Management Body of Knowledge (PMBOK) standard by Project Management Institute (PMI), USA.

The book starts with an introductory chapter, a project management history review chapter, and a chapter on project life-cycle. The first three chapters clearly put the project in place in the organizational context with stakeholders and their different needs, and introduce project management in relation to the general management and technical management disciplines. The history part with its short and clear visual illustrations of network computing methods and organization charts - among others - conveys effectively the operational technique-based basic foundations of the project management discipline. Current international project management associations are mentioned and a related discussion of project manager's role, project management as a profession, and project management certification schemes are introduced. Project management computing is recognized as an important area witch deserves a separate dedicated chapter at the end of the book. The project life-cycle chapter illustrates the important time-phased aspect and timely dynamics in a project.

The first three chapters discussed above make a good and compact start for the book with an overview of project management and techniques in the field. The chapters are enjoyable reading for a practitioner in the field for providing a compact and short explanation of the overall foundational setting. However, for a reader with no prior knowledge in the field nor any business experience, the list-like presentation with a large magnitude of definitions and terms without proper discussion about their content might not suffice for adapting to the content properly. The compact writing style with a handbook type presentation and use of lists to convey the appropriate fact-based content to the reader is maintained in the whole book. In general, it can be considered as a beneficial feature, and in the rest of the chapters (where techniques and methodologies are explained) the style might appear even more effective also to an inexperienced reader. Due to the course book nature, the use of references and reference notations is not systematic nor accurate. However, at the end of each chapter the interested reader is provided with hints about further reading on the chapter topic.

The next two chapters dedicated on feasibility and project selection techniques provide a good content and reflect the author's justified choice to emphasize the importance of managing the early stages in a project. The succeeding estimating and planning and control cycle chapters provide some further important application areas of project management techniques. The rest of the chapters of the book then provide the reader with techniques in traditionally recognized application areas that can typically be identified in the content of PMBOK and other project management standards.

The selection of the overall structure in terms of chapter topics and the contents of chapters are well designed. In the last chapter on project management computing, however, one would have appreciated more discussion on functionality characteristics of information processing applications, whereas the chapter content now builds mostly on aspects of software implementation, vendor selection, education and training on using a software, and benefits of a software. In this respect, the promise to 'cover the latest project management software with explanations of the calculations that happen behind the computer screen' is implicitly fulfilled rather in the techniques-oriented discussion in all of the previous chapters than in the last computing chapter.

The content of the book provides an effective fact-based entity and introduces many aspects and issues that are based on the author's practical experience in the field. The technique side is introduced by practical examples that help understanding the empirical application of the techniques introduced. However, due to the compact writing style, a wide variety of terms, concepts and other included ingredients are partly left without proper explanation.

Finally, the freshness of the book lies in the overall structure and content that reflects author's practical experience in the field. The structure of the book builds a foundation of major important issues in the beginning, and then gradually takes the reader through by well selected themes in subsequent chapters. The content of the book reflects well many concrete technique-related issues that are based on the author's practical experience in the field. The book deserves my recommendations. It is worth reading for anyone belonging to the potential audience of project management planning and control techniques course books.

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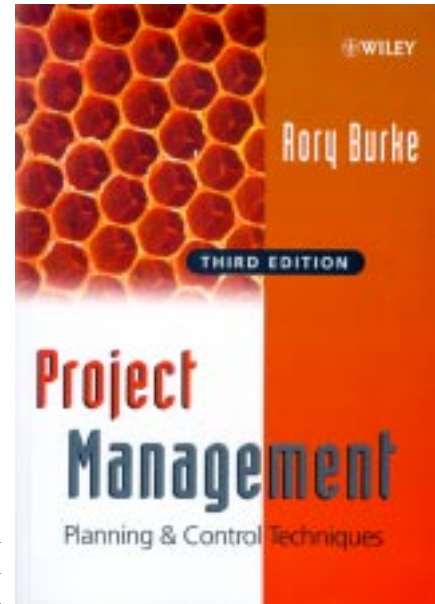
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